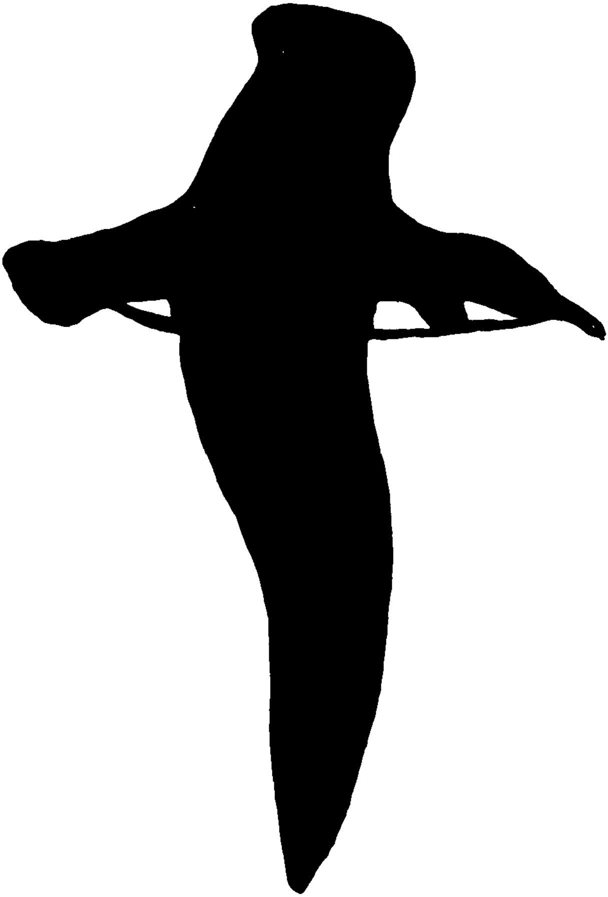
SEABIRD 7



SEABIRD GROUP — No. 7 : 1984

SEABIRD 7

Editors:
P. G. H. Evans and T. R. Birkhead

Produced by
The Seabird Group

Previous issues of this journal were called the *Seabird Report:* the last to be issued was No. six (1982).

CONTENTS

EDITORIAL

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P. G. H. Evans
T. R. Birkhead

NOTICE TO CONTRIBUTORS

Seabird publishes original contributions relating to any aspect of seabird ornithology as full-length papers (preferably not exceeding thirty manuscript double-spaced pages) or short notes. Although a portion of the journal will be of particular interest to UK members, contributions are welcomed on aspects of seabird ornithology from any part of the world so long as they are likely to be of general interest.

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Contributions should be submitted in the same format as used by *Ibis,* and this is outlined (with slight modifications) below:

All submissions, of which *three* copies are required, must be typewritten, on one side of the paper, with double spacing and adequate margins. The approximate position of figures and tables should be indicated in the margin. Authors are advised to consult a recent copy of *Ibis* and follow the conventions for section headings, tables, captions, references, quotation marks, abbreviations, etc. The Editor may return without consideration any submission that departs from the *Ibis* form of presentation. Spelling should conform with the preferred, i.e. first-cited spelling of the *Shorter Oxford English dictionary.* Hyphenated terms commonly used include: body-weight, breast-band, cross-section, eye-ring, tarsus-length, wing-length, wing-moult, tail-coverts. Details of experimental technique, extensive tabulations of results of computation procedures, etc. are best presented as appendices. A full-length paper must include a summary not exceeding 5% of the total length.

On first mention a bird species should be designated by an English vernacular name drawn from *The status of birds in Britain and Ireland,* or from an authorative faunistic work treating the appropriate region, followed by the systematic binomial; author and date need be cited only in taxonomic papers. Thereafter only one name should be used, preferably the English one. Capitals should be used for the initial letters of all single words or hyphenated vernacular names (e.g. Great Black-backed Gull, White-eyed Gull) but not in a group name (e.g. gulls, terns). Trinomials should be used only if the identity of specimens has been verified by critical comparison and if the subspecific nomenclature is relevant to the topic under discussion.

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Underlining is used for all words of foreign languages, including Latin, other than those which have been adopted into English. Underlining should also be used for phonetic renderings of bird vocalizations. Underlining is not needed for emphasis.

Measurements should be given in SI (International system of units), but if the original measurements were made in non-SI units, the actual values and units should be given, with SI equivalents inserted in parentheses at appropriate points. Measurements may be given in cm.

Figures and diagrams should be drawn in black ink on white board, paper or tracing material, with scales (for maps), and lettering given in Letraset. In designing drawings, authors are asked to note the page-size and shape of *Seabird;* originals should be 1½-2 times final size. Tables should be typewritten and spaced appropriately.

References should be quoted in the text in the format indicated by the following examples: Harris 1980, Cramp & Simmons 1980, Monaghan *et al.* 1980. References at the end of the paper (following acknowledgements) should be given in the following format:

COULSON, J. C. and WOOLER, R. D. 1976. Differential survival rates among breeding Kittiwake Gulls *Rissa tridactyla* (L.) *J. Anim. Ecol.* 45: 205-213.

The author's name should be placed beneath the title of the paper and again at the end, together with the address, after the references.

Twenty-five offprints (40 if more than one author) of each original contribution will be supplied free. Additional copies can be supplied on payment; orders will be required at the time of proof-correction. Reprints of book reviews will only be supplied if a request is submitted with the original copy; in this case the full number will be charged at cost.

Status of Guillemots and Razorbills in Britain and Ireland

T. J. Stowe and M. P. Harris

This paper presents recent counts of Guillemots *Uria aalge* and Razorbills *Alca torda* at a number of colonies in Britain and Ireland to show their current status and general population trends. It also attempts to encourage counters to visit other colonies.

THE COUNTS

Counts were made in June or early July, the period recommended for census work (Cramp *et. al.* 1974, Evans 1980).

We have taken counts made during Operation Seafarer in 1969/70 as a baseline, extracting data from summary sheets compiled by the organisers. A few counts are suspect due to incomplete coverage or from being made late in July when many birds would have left the colonies; these counts are placed in parentheses or, where possible, replaced by counts made one or two years before. The counts are compared with the most recent we can find in published sources including Scottish and county Bird Reports (cited), records of the Royal Society for the Protection of Birds (RSPB) and unpublished sources (name of observer). Only colonies counted in or after 1974 are included.

It is not always clear for counts made during Operation Seafarer whether birds were counted as individuals, occupied sites or pairs, or how the figures for pairs were obtained. For Razorbills we have assumed that counts made in 1966/70 were of occupied sites, irrespective of whether one or two birds were present, except where numbers of individual birds are clearly stated in the summary sheet.

We assumed the counting unit for Guillemots to be the number of individual birds on the ledges since Cramp *et. al.* (1974) stated that direct counts of birds present were used in Operation Seafarer. For consistency we adopt the convention that Guillemot figures expressed as pairs were the same as the totals of individuals counted on the assumption that only one member of a pair was present during the count. On a few occasions the original recording cards were available to provide a check. The recommended counting unit for these auks is now the individual bird (Evans 1980) and most recent counts use this. If they do not, we give the units used by the observer.

RESULTS

Details of the counts are given in Table 1, and the location of colonies in Figure 1.

Guillemot

Scotland

Eleven of the 12 colonies in Shetland which were recounted showed considerable increases which appear to be continuing. For example, there were 1750 pairs at Sumburgh Head in 1967, c.7000 birds in 1974 (Harris 1976) and 13675 birds in 1982. Numbers have also increased at many Orkney colonies although there has been an apparent decline at Noup Head, Westray. Only part of the colony at Costa Head was counted in 1969/70 so the scale of the change there cannot be assessed.

Recent counts at east Caithness were all much higher than those made previously. Increases had certainly occurred but a more thorough coverage of the coastline in 1977 than in 1969/70 may account for some of the differences (Mudge 1979). Further south, in

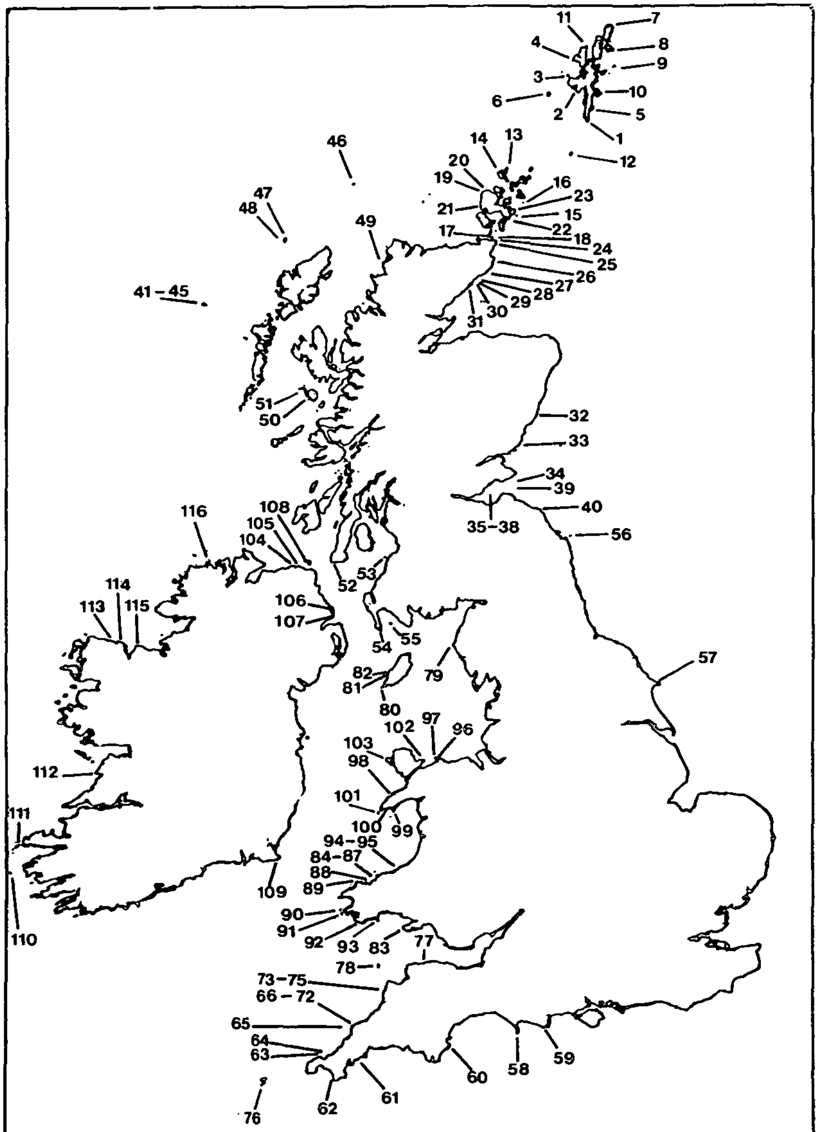

Figure 1. Location of recently counted Razorbill and Guillemot colonies listed in Table 1.

the Firth of Forth and Berwickshire, numbers have increased greatly during the last decade. However, such increases are not evident in north-west Scotland where numbers on St Kilda and Handa have not changed noticeably.

England and Channel Islands

On the Farne Islands, Northumberland and at Bempton, Humberside numbers have shown an increase similar to that of colonies in south-east Scotland. Although the colonies in southern England are now mere remnants of the large colonies found earlier this century, only a few have shown further serious declines. Many of these populations are small and within and between year fluctuations in numbers may be large; but for the first time this century there is hope that the species will not become extinct in this area.

Wales

Numbers appear to have changed little in mainland Dyfed, but Guillemots are now more numerous on Skomer and in north Wales than in 1969/70.

Ireland

Most recent counts are higher than those in 1969/70 with particularly large increases being recorded at Great Saltee and Cliffs of Moher. Although the figure for Co Sligo was lower in 1981 than in 1969/70, detailed monitoring showed statistically significant increases between 1971 and 1978 (Stowe 1982).

Razorbill

The difficulties of counting Razorbills accurately and the different units used make interpreting counts extremely difficult. The populations at several large Shetland colonies, eg Sumburgh, Foula, Fair Isle and at east coast colonies from Kincardineshire to Humberside have all increased, as has that on Canna. The counts suggest that Orkney populations have declined although two separate appraisals of a monitoring scheme suggest that numbers have increased in recent years (Stowe 1982, Wanless *et. al.* 1982).

Except for Horn Head and Skokholm southern colonies generally show little change. At Horn Head numbers declined from 45,000 ± 10,000 sites in 1969/70 to 12,400 individuals in 1980, but this remains one of the largest colonies of Razorbills. The decrease of c.300 pairs on Skokholm was more than made up by an increase in numbers on neighbouring Skomer.

Rate of change

An annual rate of change was calculated for each of the 104 Guillemot colonies where the units counted were the same in 1969/70 and more recently as follows. The most recent count was divided by the Seafarer count to give a proportional increase and the *n*th root (where *n* is the number of years between counts) was taken. The difference from 1.00 was the annual increase. For example, 24155 Guillemots were counted on Noss in 1969 and 63837 in 1981 — a proportional increase of $63837/24155 = 2.643$ over 12 years; $\sqrt[12]{2.643} = 1.084$ or an annual increase of 8.4%. This assumes that the annual rate of change was constant. Although theoretically unlikely, this does seem to have held in some colonies counted regularly (RSPB unpublished data). The mean annual rate of change for all 104 colonies was +5.1% (± s.e. 0.8). The great variability in colony attendance and confusion over counting units prevented a meaningful figure being calculated for Razorbills.

TABLE 1. COUNTS OF RAZORBILLS AND GUILLEMOTS IN BRITAIN AND IRELAND

	Razorbill		*Guillemot*		
	1969/70 (sites)	*Latest estimate* (birds)	*1969/70* (birds)	*Latest estimate* (birds)	*Sources*
SHETLAND					
1 Sumburgh Hd	400pr (1967)	819 (1974)	1750pr (1967)	13675 (1982)	M. Carins, M. Heubeck
2 Vaila	14 (on sea)	72 (1974)	350	436 (1974)	Harris 1976
3 Papa Stour	Order 2	10 (1974)	1534	1814 (1974)	Harris 1976
4 Eshaness & Islands	110b	43+ (1974)	4571	3064 (1974)	Harris 1976
5 No Ness	Order 1	96 (1974)	470	1024 (1974)	Harris 1976
6 Foula	3000b (1968)	10373 (1976)	25000 (1968)	60021 (1976)	Furness 1981
7 Hermaness	2144b	1378 (1978)	15983	22760 (1978)	de Camera *et al.* 1978
8 Fetlar (part)	130b	—	200	500 (1976)	R.S.P.B.
9 Out Skerries	40	18	14	25 (1974)	Harris 1976
10 Noss	3120b	1432 (1981)	24155	63837 (1981)	Scottish B. R., N.C.C.
11 Ramna Stacks	—	100+ (1981)	Order 3	4460 (1981)	McKay *et al.* 1981
12 Fair Isle	1200	2500pr (1975)	10000	19200 (1975)	F.I.B.O.
ORKNEY					
13 Papa Westray	358b	150 (1981)	2903	2070 (1981)	R.S.P.B.
14 Westray (Noup Head)	2580b	1248 (1978)	56462	40348 (1978)	R.S.P.B.
15 Copinsay	300	186 (1979)	9000	23640 (1979)	R.S.P.B.
16 Auskerry	103	100 (1977)	6	90pr (1980)	Scottish & Orkney B. R.
17 Switha	156	121 (1977)	65	280 (1977)	Scottish & Orkney B. R.
18 Pentland Skerry	?	40 (1982)	50	22 (1982)	Orkney B. R.
19 Marwick Hd	1000	297 (1981)	Order 5	18000 (1981)	Wanless *et al.* 1981
20 Costa Hd	(40)	771 (1981)	(550)	7504 (1981)	Wanless *et al.* 1981
21 Row Hd	41b	189 (1981)	3215	6921 (1981)	Wanless *et al.* 1981
22 Gultak	276	387 (1981)	1780	2105 (1981)	Wanless *et al.* 1981
23 Mull Hd	267	84 (1981)	962	1390 (1981)	Wanless *et al.* 1981

	Razorbill		Guillemot		
	1969/70 (sites)	*Latest estimate (birds)*	*1969/70 (birds)*	*Latest estimate (birds)*	*Sources*
CAITHNESS					
24 Stroma	20	400pr (1974)	4400	5000pr (1974)	Scottish B. R.
25 Duncansby Hd & Skirza Hd	2332	1922 (1977)	7553	18776 (1977)	Mudge 1979
26 Wick area	10	120 (1977)	40	126 (1977)	Mudge 1979
27 Wick-Lybster	2222	4391 (1977)	10600	37431 (1977)	Mudge 1979
28 Lybster-Janetstown	—	—	0	47 (1977)	Mudge 1979
29 Janetstown-Dunbeath	—	—	100	1068 (1977)	Mudge 1979
30 An Dun area	4750	4305 (1977)	15390	18357 (1977)	Mudge 1979
31 Inver Hill & Badbea	3410	3458 (1977)	15800	50433 (1977)	Mudge 1979
KINCARDINESHIRE					
32 Fowlsheugh	5507	8000 (1982)	32772	39000 (1982)	R.S.P.B.
ANGUS					
33 Auchmithie	89b	108 (1974)	177	213 (1974)	J. J. D. Greenwood
FIFE					
34 Isle of May	341b	2085 (1981)	9000	16310 (1981)	Harris and Galbraith 1983
LOTHIAN					
35 Inchkeith	1	25s (1982)	0	12 (1982)	R. W. J. Smith
36 Fidra	0	33s (1982)	0	116 (1982)	R. W. J. Smith
37 Lamb	16	18s (1981)	97pr	1060s (1981)	R. W. J. Smith
38 Craigleith	30	57s (1982)	620	1900 (1982)	R. W. J. Smith
39 Bass Rock	<20	45 (1977)	500	2800 (1980)	Scottish B. R.
BERWICKSHIRE					
40 St Abb's Head	257	702pr (1978)	6731	14790 (1978)	da Prato & da Prato 1980

	Razorbill		Guillemot		
	1969/70 (sites)	*Latest estimate* (birds)	*1969/70* (birds)	*Latest estimate* (birds)	*Sources*
WESTERN ISLES					
41 Hirta	90pr	500pr (1977)	10000	10930 (1977)	Harris and Murray 1978
42 Boreray and Stacs	—	—	5500	3609 (1977)	Harris and Murray 1978
43 Dun	2500	1634 (1977)	1450	3806 (1977)	Harris and Murray 1978
44 Soay and Stacs	—	—	4860	3710 (1977)	Harris and Murray 1978
45 Levenish	?	1pr (1977)	70	30 (1977)	Harris and Murray 1978
46 North Rona	(334)	1653 (1976)	6810	8931 (1976)	Evans unpubl.
47 Flannan Is. (Eilean Mor)	?	338 (1975)	c3000	1720 (1975)	Hopkins unpubl.
48 Flannan Is. (Other Is.)	?	?	6549	7890 (1975)	Hopkins unpubl.
WEST SUTHERLAND					
49 Handa	8367b	9000pr (1977)	30790	25000pr (1977)	R.S.P.B.
WEST INVERNESS					
50 Rhum	413	451 (1981)	935	3591 (1981)	J. A. Love
51 Canna	433+48b	960 (1975)	727	1100pr (1975)	R. L. Swann
ARGYLL					
52 Sanda	Order 3	1200pr (1980)	Order 2	135pr (1980)	Scottish B. R.
AYRSHIRE					
53 Ailsa Craig	2276	<2500pr (1980)	4177pr	<5000pr (1980)	Gibson 1981
WIGTOWNSHIRE					
54 Mull of Galloway	151	189pr (1975)	620	613 (1975)	R. G. Dickson
55 Scar Rock	74	100 (1979)	1200	1200 (1979)	Scottish B. R.
NORTHUMBERLAND					
56 Farne Islands	7	39pr (1981)	2935pr	6299pr (1982)	National Trust

	Razorbill		Guillemot		
	1969/70 (sites)	*Latest estimate* (birds)	*1969/70* (birds)	*Latest estimate* (birds)	*Sources*
HUMBERSIDE					
57 Bempton	1470	3000 (1978)	10950	13250 (1978)	R.S.P.B.
ISLE OF WIGHT	6	1pr (1979)	65	245 (1979)	Stafford 1980
DORSET					
58 Portland Bill	6	14pr (1980)	35	50 (1980)	Portland B. O.
59 Purbeck Cliffs	16b	19b (1980)	498	561 (1980)	W. T. Haysom
SOUTH DEVON					
60 Berry Head	6	0 (1982)	420	467 (1982)	K. Partridge
CORNWALL					
61 Gull Rock, Gerrans	Order 1	32pr (1981)	Order 2	75pr (1981)	Birds in Cornwall
62 Gull Rock, Mullion	4	4 (1980)	4	13 (1980)	Birds in Cornwall
63 Navax Pt — Hells Mouth	20 (1967)	20 (1978)	15 (1967)	1 (1978)	Birds in Cornwall
64 Hells Mouth	26	10 (1978)	59	59 (1978)	Birds in Cornwall
65 Trevose Head	16	18 (1978)	Order 1	8 (1978)	Birds in Cornwall
66 Trevone	7	18 (1978)	3	8 (1978)	Birds in Cornwall
67 Gunver Head	7		6	10 (1976)	Birds in Cornwall
68 Gulland	30		25	10 (1976)	Birds in Cornwall
69 The Moules	20	60 (1981)	60	28 (1979)	Birds in Cornwall
70 Camhead area	27	13 (1981)	27	44 (1981)	Birds in Cornwall
71 Bounds Cliff	22	80 (1978)	0		Birds in Cornwall
72 Tresungers Point, St Isaacs	16	20 (1978)	?	10 (1978)	Birds in Cornwall
73 The Sisters, Tintagel	10		151	57 (1981)	Birds in Cornwall
74 Lye Rock, Tintagel	22		3	40 (1981)	Birds in Cornwall
75 Long & Short Islands, Tintagel	74	37 (1981)	35	19 (1981)	Birds in Cornwall (Short Is. only)

	Razorbill		*Guillemot*		
	1969/70 (sites)	*Latest estimate* (birds)	*1969/70* (birds)	*Latest estimate* (birds)	*Sources*
76 ISLES OF SCILLY	400	134pr (1974)	60	36pr (1974)	R. W. Allen
NORTH DEVON					
77 Trentishoe-Lynton	428	333 (1982)	245	352 (1982)	C. Manning
78 Lundy	584	982 (1981)	1607	2165 (1981)	R.S.P.B.
CUMBRIA					
79 St Bees Head	55	150 (1980)	2602	2500 (1980)	R.S.P.B.
ISLE OF MAN					
80 Calf of Man	150	149 (1982)	375pr	325 (1982)	A del Nevo
81 Contrary Hd — Glen Maye	38	63 (1981)	21	28 (1981)	Peregrine
82 Contrary Hd — Peel	74	159 (1981)	197	515 (1981)	Peregrine
WEST GLAMORGAN					
83 Worms Head	70b	40 (1980)	140	120 (1980)	Gower Birds
DYFED					
84 Carregysbar	8	9 (1979)	130	136 (1979)	Paynter 1979
85 Carregysbar — Carregbica	40	34 (1979)	74	71 (1979)	Paynter 1979
86 Pwll-coch & Foel Goch	40	51 (1979)	—	—	Paynter 1979
87 Morfa Hd	53	23 (1979)	—	—	Paynter 1979
88 Needle Rock, Dinas	63	151 (1979)	20	65 (1979)	Paynter 1979
89 Dinas Hd — Fishguard	5	146 (1979)	23	111 (1979)	Paynter 1979
90 Skomer	1493	2262pr (1982)	3925	4711 (1982)	M. Alexander
91 Skokholm	675	350pr (1981)	120pr	108pr (1981)	Skokholm B. O.
92 Elegug Stacks	141	187 (1982)	610	922 (1982)	D. Henshulwood
93 St. Margarets Is.	104	79 (1982)	118	297 (1982)	S. J. Sutcliffe
94 New Quay Hd (part)	35	25 (1980)	252	230 (1980)	P. Davis
95 Lochtyn	14	18 (1980)	162	279 (1980)	P. Davis

	Razorbill		Guillemot		
	1969/70 (sites)	Latest estimate (birds)	1969/70 (birds)	Latest estimate (birds)	Sources
GWYNEDD					
96 Little Orme	49	31 (1980)	251	441 (1980)	N.C.C.
97 Great Orme	75	119 (1981)	736	597 (1981)	N.C.C.
98 Carreg-y-llam	95	203 (1979)	2750	3486 (1979)	N.C.C.
99 Trwyn Cilan	92	155 (1974)	1200	1736 (1974)	N.C.C.
100 Gwylan Island	172b	200 (1974)	57	60 (1974)	N.C.C.
101 Bardsey	162	446 (1980)	30	95 (1980)	Bardsey Observatory Report
102 Puffin Island	114	109 (1975)	269	550 (1982)	R. Arnold
103 South Stack	454b	691 (1981)	1424	1511 (1981)	R.S.P.B.
CO. ANTRIM					
104 Sheep Island	59	457 (1977?)	100	125 (1977?)	Housden & Browne 1979
105 Carrick-a-rede	29	103 (1977?)	62	99 (1977?)	Housden & Browne 1979
106 Muck Island	178	265 (1977?)	270	460 (1977?)	Housden & Browne 1979
107 The Gobbins	78	600pr (1978)	260	600pr (1978)	Housden & Browne 1979
108 Rathlin Is.	3148	7007 (1977)	21575	28229 (1976)	R.S.P.B.
CO WEXFORD					
109 Great Saltee	5805	5636 (1980)	9675	12897 (1980)	Lloyd 1982
CO KERRY					
110 Puffin Island	677	800pr (1981)	350	472 (1981)	Brazier unpubl.
111 Inishvickillaun	166	225 (1980)	11	0 (1980)	Brazier unpubl.

	Razorbill		*Guillemot*		
	1969/70 (sites)	*Latest estimate* (birds)	*1969/70* (birds)	*Latest estimate* (birds)	*Sources*
CO CLARE					
112 Cliffs of Moher	1571	2831 (1980)	5902	12794 (1980)	R.S.P.B.
CO MAYO					
113 Downpatrick Hd	13b	14 (1981)	740	752 (1981)	R.S.P.B.
114 Creevagh	48b	21 (1981)	554	961 (1981)	R.S.P.B.
CO SLIGO					
115 Aughris Head	Order 2	117 (1981)	2000	1361 (1981)	R.S.P.B.
CO DONEGAL					
116 Horn Head	45000	12400 (1980)	10000	5550 (1980)	Watson & Radford 1982
CHANNEL ISLANDS					
117 Jersey	5	5 (1980)	0	?	E. Buxton
118 Jethou	4 (on sea)	3pr (1980)	0	0	T. J. Bourgaize
119 Herm & Islands	22 (on sea)	9 (1974)	24	11pr (1974)	R. Burrow
120 Alderney	12+	30 (1982)	30	60 (1982)	N. V. Mendham

NOTES: 1. b = individual birds; pr = pairs; s = sites; (   ) = incomplete count
2. Order 1 = 1 - 9, Order 2 = 10 -99, 3 = 100 - 999, 4 = 1000 - 9999, 5 = 10000 - 99999

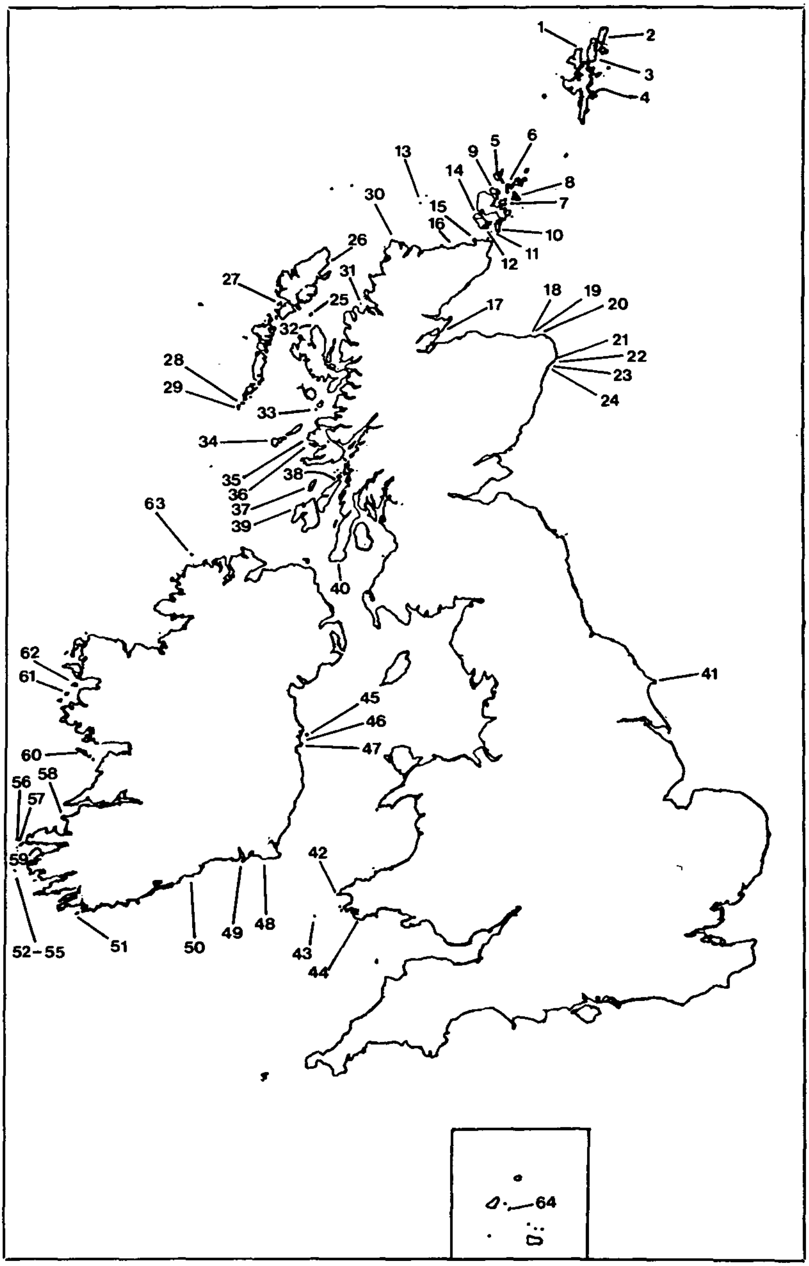

Figure 2. Location of Razorbill and Guillemot colonies, listed in Table 2, which require counting.

TABLE 2. ORDERS OF MAGNITUDE OF COUNTS OF RAZORBILL AND GUILLEMOT COLONIES IN 1969/70 FOR WHICH NO RECENT COUNTS ARE AVAILABLE. LARGE OR GEOGRAPHICALLY DISTINCT COLONIES ARE LISTED. SMALL AND/OR CONTIGUOUS COLONIES ARE AMALGAMATED. SOURCE: OPERATION SEAFARER SUMMARY SHEETS.

Order 1 = 1-9
Order 2 = 10-99
Order 3 = 100-999
Order 4 = 1000-9999
Order 5 = 10000-99999

	Razorbill	*Guillemot*
SHETLAND		
1. Uyea Is.	3	4
2. Unst	4	5
3. Yell	3	2
4. Bressay	2	
Others	3	4
ORKNEY		
5. Westray (excl. Noup Head)	4	5
6. Eday & Calf	3	4
7 Shapinsay	2	2
8. Stronsay	3	4
9. Rousay	2	4
10. S Ronaldsay	3	4
11. Swona	2	2
12. S Walls	3	3
13. Sule Skerry & Stack	3	3
14. Hoy	3	4
Others (mainland)	3	3
CAITHNESS		
15. Dunnet Head	4	4
16. N coast	4	4
EAST ROSS		
17. N. Sutor	2	3
BANFFSHIRE		
18. Troup Head	3	4
19. Lions Head	3	4
Others	2	2
ABERDEENSHIRE		
20. Pennan Head	2	3
21. Bullers of Buchan	3	3
22. Miekle Dunmeath	2	3
23. Dunbuy Is.	2	3
24. Whinnyfold	2	4
Others	3	3
KINCARDINESHIRE	4	3

	Razorbill	*Guillemot*
ANGUS	2	
WESTERN ISLES		
25. Shiant Is.	4	4
26. Isle of Lewis		3
27. Isle of Harris	2	
28. Mingulay	4	4
29. Berneray	4	4
WEST SUTHERLAND		
30. Clo Mor	5	4
Others	3	4
WEST ROSS		
31. Priest Island	1	
WEST INVERNESS		
32. Skye	3	3
33. Muck	3	3
ARGYLL		
34. Tiree	3	
35. Treshnish Is.	3	4
36. Mull Is.	2	2
37. Colonsay	3	4
38. Jura	1	
39. Islay	3	3
40. Mull of Kintyre	3	2
WIGTOWNSHIRE	2	2
KIRKCUDBRIGHT	3	3
NORTH YORKSHIRE	1	
HUMBERSIDE		
41. Flamborough Head	3	4
SOUTH DEVON	1	1
CORNWALL	4	3

	Razorbill	*Guillemot*
ISLE OF MAN	3	3
DYFED		
42. Ramsey Is.	3	3
43. Grassholm	2	2
Other Islands	3	2
44. Stackpole Hd	3	3
Others (mainland)	3	3
GWYNEDD	3	3
CO ANTRIM	1	
CO DUBLIN		
45. Lambay Is.	4	5
46. Irelands Eye	3	3
47. Howth Hd	3	3
CO WICKLOW	1	
CO WEXFORD		
48. Little Saltee	2	
49. Hook Head		2
CO WATERFORD		
50. Stradbally-Ballyvoyle Hd	3	3
Others	3	3
CO CORK		
51. Cape Clear	3	3
52. Cow Rock	3	4
53. Bull Rock	3	3
Others	3	4

	Razorbill	*Guillemot*
CO KERRY		
54. Skellig Michael	3	3
55. Little Skellig	2	3
56. Inishnabro	3	3
57. Inishtearaght	3	2
58. Kerry Hd	3	2
59. Doulous Hd	3	4
Others	2	1
CO CLARE	2	4
CO GALWAY		
60. Inishmore	3	4
Others		2
CO MAYO		
61. Inishturk	3	3
62. Clare Is.	4	4
Others	3	2
CO DONEGAL		
63. Tory Is.	3	3
Others	1	2
CHANNEL ISLANDS		
64. Sark	1	2

DISCUSSION

In recent years, emphasis has been put on developing methods of monitoring changes in the numbers of auks present in clearly defined study plots within a colony. However, these plots may not always be representative of the total population in Britain and Ireland. For instance, a monitored colony could decline as birds move to another (probably unmonitored) colony so that the total population of the area changed little. A wide survey of colonies can check, albeit at a crude level, whether this has happened.

Single counts of Guillemots and Razorbills at the same place made on different days can vary by up to 26% and 46% (Lloyd 1975) so that the actual totals given above must be used with extreme caution.

However, it appears as though there has not been a major change in the numbers of Razorbills in Britain or Ireland (144,000 pairs in 1969/70), except for a decline at Horn Head. The Guillemot population has certainly increased, most notably in the north east of Britain, whilst at the southern end of its range the southern form (*Uria aalge albionis*) appears to be maintaining its numbers. The total count of all Guillemots in 1969/70 was

577,000 birds, expressed directly as pairs and colonies including about three quarters of these birds have since been recounted. If the calculated rate of increase of 5.1% was typical over the whole period 1969-82 and was representative of the colonies not counted, then the British and Irish population has approximately doubled to 1.1 million individuals since 1969.

THE FUTURE

We recommend that:-

1. Attempts are made to count individual Guillemots and both individuals and occupied sites of razorbills at colonies listed in table 2, and whose locations are shown in Figure 2.
2. A detailed survey is made of the smaller southern colonies to check whether recent declines have finally halted.
3. A full survey of all auks is made within the next five years.

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The migration of Gannets *Sula bassana* past Gibraltar in spring

James Clive Finlayson and John Emmanuel Cortes

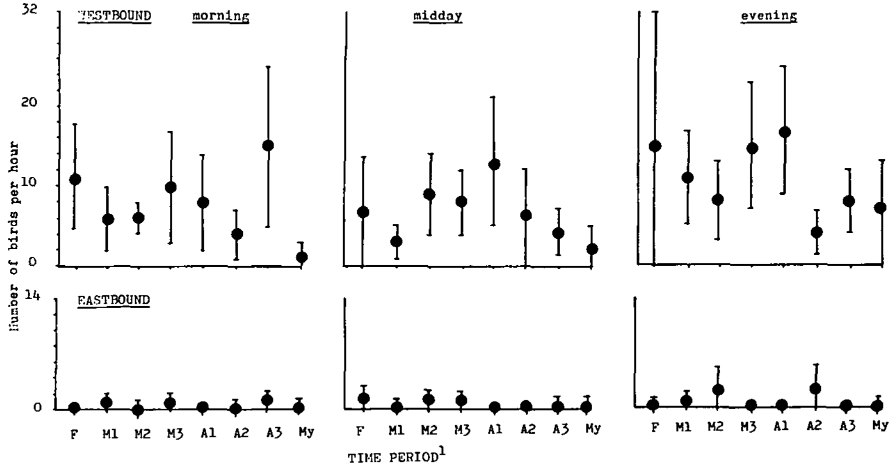
INTRODUCTION

Gannet *Sula bassana* passage out of the Mediterranean Sea via the Strait of Gibraltar takes place between late February and June, with a peak in March and April (Garcia 1973, Cortes *et al.* 1980). Recent observations suggest that passage west may commence in mid-January (pers. obs.). The maximum recorded rate of passage is 14 per hour (Cortes *et al.* 1980). The aim of this paper is to add to these records by presenting estimates of the numbers of Gannets wintering in the Mediterranean Sea, based on observations of westward migration, and by presenting details of Gannet spring migration off Gibraltar.

METHODS

Observations, using 8 x 30 and 10 x 50 binoculars, were made from Europa Point, Gibraltar. Regular observations were commenced on 19 February 1980 and ended on 19 May 1980, by which time fewer Gannets were in evidence. Incidental observations were carried out in January and June 1980. Up to three 1 h watches were conducted each day; a morning one within 4 h after sunrise; one at midday; and a third in the evening within two hours of sunset.

Figure 1. Numbers of Gannets counted flying past Europa Point during the spring of 1980.



[1]Time Periods divided throughout the study into 10 day intervals, except March (3) which had 11 days.

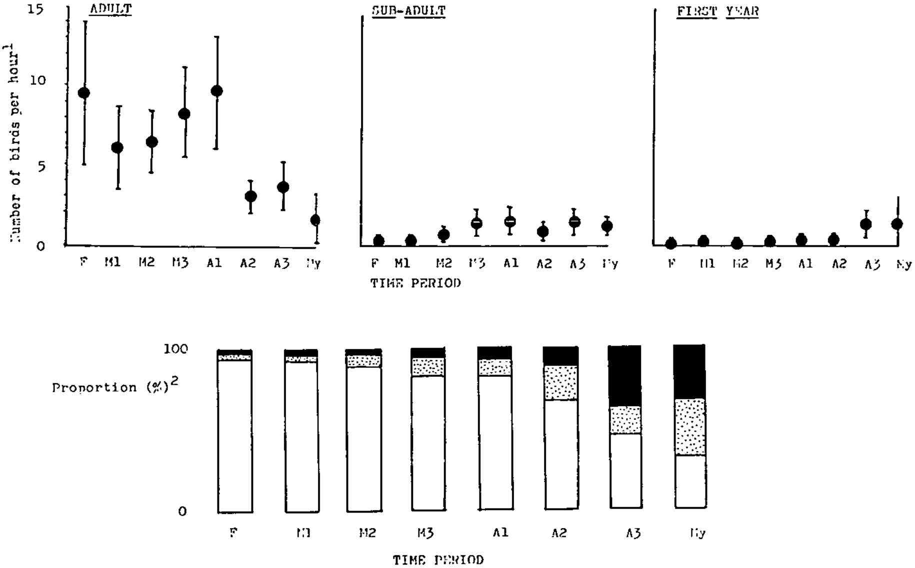
[2]All data are mean $\pm\ _2$ s e

RESULTS

During January 1980, Gannets were regularly seen off Gibraltar, but there was no evidence of any westward migration. Groups of up to 54 Gannets were recorded fishing together at this time. Of 137 Gannets observed in January, 123 (90%) were adults, eight (6%) were subadults (i.e. over 1 year old but not adult) and six (4%) were first-year birds.

Regular westward passage of Gannets was taking place, on a small scale, when systematic observations commenced. Gannets were still passing in small numbers on 19 May. Westward passage of mostly first-year birds continues through June (pers. obs.). There was no difference between the mean number of Gannets counted per hour during morning, midday and evening watches on any date within the study period (Fig. 1.). There was no difference in the rate at which Gannets passed on different dates although the rate declined off by May (Fig. 1). and there was no detectable peak in westward migration. The number and proportion of adult birds decreased as the season advanced, whilst there was an increase in the proportion of first-year birds observed (Fig. 2). Subadult birds were seen more frequently towards May (Fig. 2). The westward migration of the Gannet therefore consisted of two phases, adult birds passing mainly in March and early April, and immatures in late April and May.

Figure 2. Age composition of migrating Gannets past Europa Point in spring 1980. Westward passage.



[1] Data are mean ± 2 s e

[2] Black = First year; stippled = sub-adult; White = adult.

Five hundred and one (36%) Gannets of all ages were observed migrating singly and 888 (64%) were observed with one or more other individuals. Of 297 groups seen, 198 (67%) consisted of individuals of the same age class. There was no evidence that any age class was more likely to be seen migrating singly. The proportion of mixed groups increased as the season progressed (Table 1), probably due to the increase in immature birds late in the season. There was no trend for group size to change within the season.

TABLE I. PROPORTIONS OF MIXED (ADULT AND IMMATURE) AND UNMIXED GANNET GROUPS OBSERVED DURING THE STUDY PERIOD.

Time Period	*Unmixed Groups Number*	*Mixed Groups Number*	*Proportion mixed*
Feb	51	0	0.00
Mar (1)	34	4	0.11
Mar (2)	28	9	0.24
Mar (3)	28	15	0.35
Apr (1)	29	17	0.37
Apr (2)	10	12	0.55
Apr (3)	12	34	0.74
May	6	8	0.57

$x^2_7 = 80.33 \quad p < 0.001$

Small numbers of Gannets were recorded flying eastwards into the Mediterranean but with no detectable change in numbers between days (Fig. 1). For each day, the totals of Gannets flying east into the Mediterranean were subtracted from the totals of Gannets flying west. It was assumed that eastbound Gannets eventually returned west. The data in Figure 1 were extrapolated for the total number of daylight hours in each time period and the totals then lumped to give an estimate of the Gannet population wintering in the Mediterranean. The estimate is probably well below the actual figure as it assumes all westbound Gannets were visible from Gibraltar. Assuming that Gannets seen flying west left the Strait, since regular eastbound movements in spring have not been noted elsewhere in the Strait (Garcia 1973), the total estimate is 7500 (95% confidence intervals 4000-11000).

DISCUSSION

The possibility of estimating seabird populations wintering or breeding in the Mediterranean Sea by counting migrants passing the Strait of Gibraltar has only ben realised recently (Telleria 1980). The present work suggests that the number of Gannets wintering in the Mediterranean Sea is higher than previously thought (Garcia 1973), although it constitutes only a small fraction of the North East Atlantic population of the species (Bourne 1978, Nelson 1978a), probably about 4%.

Weather conditions are known to affect the migration of Gannets (Nelson 1978b). Our data did not show any weather effect though Gannets passed closer inshore during south-west and west winds than in calm weather, and even farther out during north-west winds. Weather variables probably biased the estimates by increasing the variability of counts from the shore. The variation in passage rate from day to day was high (Fig. 1) and peaks were difficult to discern.

The tendency to migrate is strongest in Gannets during the first year of their life; most adults disperse in home waters outside the breeding season (Thomson 1939); the proportion of adults off Senegal is at most 25% (Brown 1979). At Gibraltar, about 80% of all the Gannets recorded between February and May were adult (Fig, 2). The small eastbound movements noted throughout the period probably included birds which spent the winter in the Atlantic south of Gibraltar, since Gannets leave Senegal in March (Brown 1979). The daily spread in the numbers of Gannets observed was unusual. Gannets almost everywhere move early in the morning (Nelson 1978b) but off Gibraltar passage continued evenly all day.

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Non-haematophagous ectoparasite populations of Procellariiform birds in Shetland, Scotland.

J. A. Fowler and C. J. Miller

Ectoparasites are known to occur widely on seabirds (Rothschild and Clay, 1952) but very few investigations have extended beyond a simple collection of samples for identification. A notable exception is the study of feather lice (Insecta: Mallophaga) found on auks (Alcidae) in Newfoundland (Eveleigh and Threlfall 1976) — a study which depended on sacrificing a large number of wild birds. The killing of birds to obtain their parasites would not now be considered acceptable in the United Kingdom and this may, indeed, be one reason why studies on the biology of bird ectoparasites have been so few.

A method described recently permits the rapid removal of ectoparasites from batches of up to 20 live birds without harming them (Fowler and Cohen 1983). This method was adopted to determine the incidence of ectoparasites infesting Fulmars *Fulmarus glacialis*, Manx Shearwaters *Puffinus puffinus*, Storm Petrels *Hydrobates pelagicus*, and Leach's Petrels *Oceanodroma leucorhoa* captured in Shetland during July 1981. The results provide a basis for investigations into host-parasite relationships and enable a comparison to be made with the studies on auks by Eveleigh and Threlfall (1976).

METHODS

Fulmars were captured by hand or by fowling hook around the coastline of Yell; Manx Shearwaters were taken from burrows in the small colony reported on Yell by Fowler (1980); Storm Petrels were lured to mist nets by means of tape recordings as described by Fowler et al. (1982); Leach's Petrels were caught in mist nets near the colony discovered on Gruney (Fowler and Butler 1982). Delousing was conducted for 20 minutes in chloroform chambers by the method described by Fowler and Cohen (1983). The delousing time was restricted to 20 minutes as it has been shown (Fowler, *et al.* in press) that in this period statistically identical samples of ectoparasites are removed from equivalent batches of birds, and extension of the time removes very few more. There are recognised limitations to the method: it is known that certain feather louse species are commonly associated with the feather tracts of the head and neck and, as these tracts are excluded from the delousing chamber, those species will be under-represented in the sample. For this reason the interpretation of frequency distributions with high zero-class frequencies has to be undertaken with caution.

It has been shown (Fowler and Cohen 1983) that the delousing of Storm Petrels by means of chloroform vapour does not affect their recapture rates when compared with non-deloused birds.

The ectoparasites thus removed were carefully collected and preserved in 80% ethanol and classified into adult males, adult females and nymphs (unsexed). Representative samples of feather lice were cleared in potassium hydroxide (10%) and terpineol, mounted on glass slides in Canada balsam and identified at the British Museum (Natural History). Feather mites, whose taxonomy is difficult, were not identified beyond genus and, in this investigation, are considered collectively as a single taxonomic unit.

RESULTS

A total of 240 Storm Petrels, 35 adult and 9 unfledged Fulmars, 7 Leach's Petrels and 4 Manx Shearwaters were deloused, resulting in the collection of 1564 feather lice of 8 species (Table 1). The feather lice species were readily sorted on the basis of head shape (Fig 1). In addition, 381 feather mites were collected from Storm Petrels, and a single one from a Leach's Petrel. All belonged to the order Astigmata, Superfamily Analgoidea (genus *Zachratkinia*). No haematophagous ectoparasites, e.g. fleas (Insecta: Siphonaptera) or ticks (Acarina: Ixodoidea) were present in the collections.

TABLE 1. SPECIES AND NUMBERS OF FEATHER LICE (MALLOPHAGA) COLLECTED FROM FULMARS, MANX SHEARWATERS, STORM PETRELS AND LEACH'S PETRELS IN SHETLAND DURING JULY 1981. MALLOPHAGA WERE IDENTIFIED BY C. LYAL, BRITISH MUSEUM, (NAT. HIST.).

Host	*Number of birds deloused*	*Species of feather louse*	*Number collected*
Storm Petrel	240	Amblycera: *Austromenopon* sp.	4
		Ischnocera: *Halipeurus pelagicus* (Denny, 1842)	1353
		Ischnocera: *Philoceanus robertsi* (Clay, 1940)	35
		Ischnocera: *Saemundssonia thalassidromae* (Denny, 1842)	3
Fulmar	34	Ischnocera: *Perineus nigrolimbatus* (Giebel, 1874)	91
		Ischnocera: *Saemundssonia occidentalis* (Kellogg, 1896)	1
Leach's Petrel	7	Ischnocera: *Halipeurus pelagicus* (Denny, 1842)	11
Manx Shearwater	4	Ischnocera: *Halipeurus diversus* (Kellogg, 1896)	38
		Ischnocera: *Trabeculus aviator* (Evans, 1912)	28

Storm Petrel

Two hundred and thirty four (97.5%) of the 240 Storm Petrels deloused were infested with feather lice (mean 6.0 per infested bird, range 1-22). Four species of lice were represented of which *Halipeurus pelagicus* was by far the most numerous and was present

TABLE 2. INFESTATION LEVELS OF FOUR SPECIES OF FEATHER LICE COLLECTED FROM STORM PETRELS IN SHETLAND, JULY 1981.

Feather louse	*% of total collected*	*% birds infested*	*Mean per infested bird (range in brackets)*
Austromenopon sp.	0.3	1.25	1 (1)
H. pelagicus	97.0	97.5	5.8 (1-22)
Ph. robertsi	2.5	11.7	1.25 (1-2)
S. thalassidromae	0.2	1.7	1 (1-2)

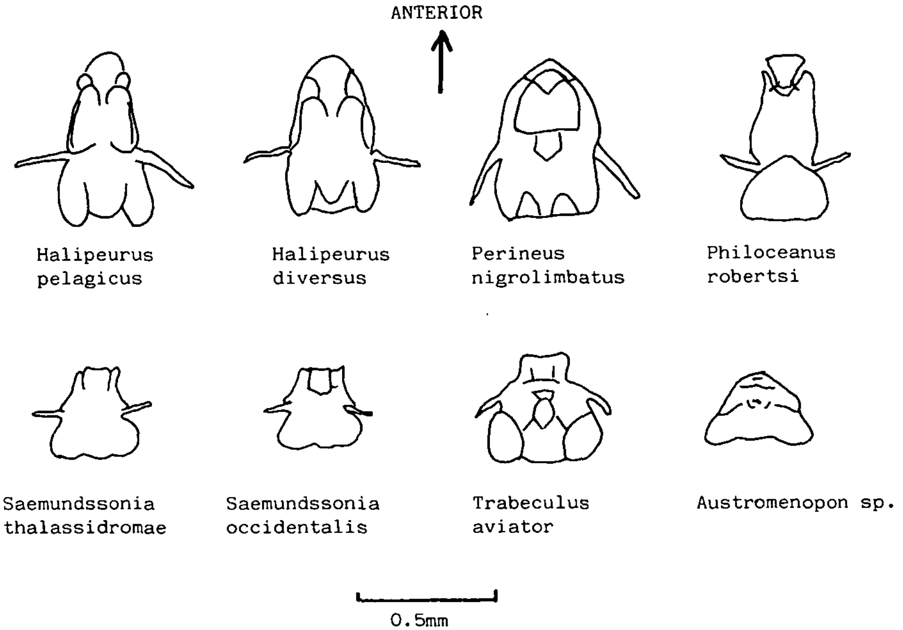

Figure 1. Head shapes (dorsal aspect) of eight species of feather lice (Mallophaga) collected from Procellariiformes in Shetland. This diagram is not a key, but may assist in the preliminary sorting of collections.

on all infested birds. A breakdown of the infestation is given in Table 2. *Austromenopon sp.* could not be identified beyond genus. 203 birds (84.6%) carried 1 species of louse, 30 (12.5%) carried 2 species and only 1(0.4%) carried 3 species, but there was no tendancy for the most heavily infested individuals to carry more than one species ($\chi^2 = 3.49$, $P<0.01$). It is not possible to analyse this relationship further because of the very high zero-class frequency of the rarer species, and the uncertainty of the distribution of *Austromenopon sp.* and *Saemundssonia thalassidromae* on the host's head. *Halipeurus pelagicus*, on the other hand, being one of the "elongate" lice, is known to be associated with the host's wings or back (Clay 1957). This species was often seen to lie along the primary or secondary shafts, especially after a bird had been at rest in a holding box; on handling, the lice would crawl up to hide under the coverts. Because of the greater likelihood of *Halipeurus pelagicus* being shaken free during the deparasitising treatment, and the very low zero-class frequency obtained, greater confidence may be placed in the analysis of the frequency distribution of this species.

Of the 1353 *Halipeurus* collected, 19% were males, 19% females and 62% were nymphs. The frequency distribution (Fig. 2a) is positively-skewed, with the mean $\bar{x} = 5.75$ and the variance $s^2 = 13.48$. The variance to mean ratio is significantly greater than unity ($\chi^2 = 39.9$, $P<0.05$) indicating an overdispersed ('clumped') distribution. Of the various statistical descriptions of overdispersion, that of the negative binomial has frequently proved a useful model on which to base host-parasite relationships (e.g. Anderson and May 1978). Calculation of the binomial exponent $k = 4.27$, and hence the expected

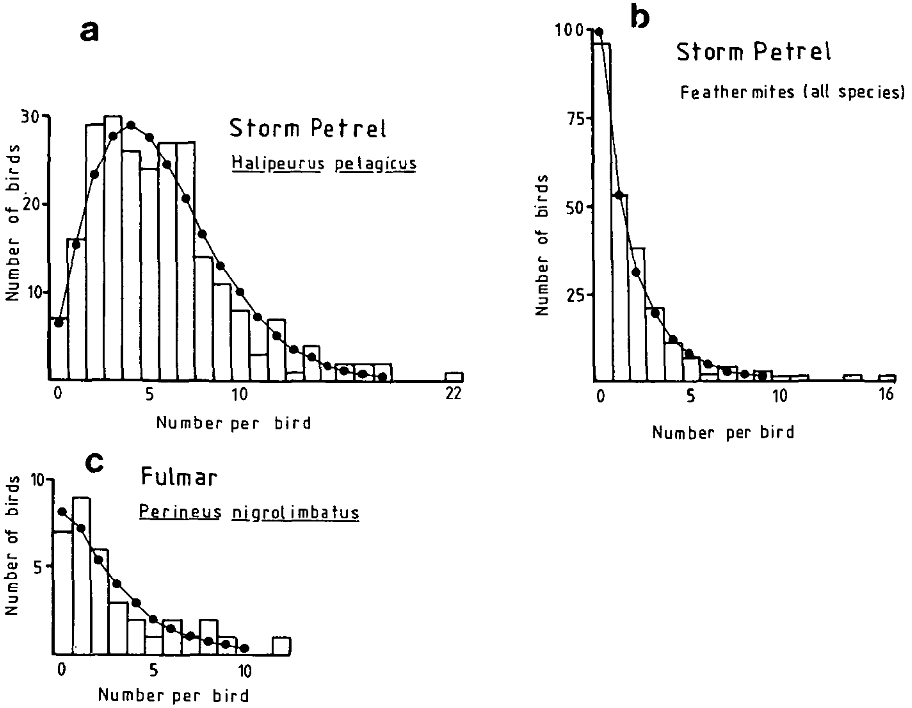

Figure 2. Frequency distributions of ectoparasites on Procellariiformes: (a) *Halipeurus pelagicus* on Storm Petrels; (b) aggregated feather mites on Storm Petrels; (c) *Perineus nigrolimbatus* on Fulmars. Histograms are observed frequencies and joined circles are calculated negative binomial frequencies.

frequency distribution for the negative binomial, enables the model to be tested. The observed and expected frequencies (Fig. 2a) show a close fit, and are not statistically significantly different ($\chi^2 = 9.58$, $P<0.01$).

The 35 *Philoceanus robertsi* were represented by 30 adults and only 5 nymphs. 7 birds carried 2 individuals, the remaining 21 were distributed singly.

144 (60%) of the Storm Petrels were infested with feather mites (mean 2.6 per infested bird, range 1-14). The frequency distribution (Fig. 2b) is of the 'hollow curve' type described by Williams (1964) in which most of the hosts have few parasites and most of the parasites are on few hosts. The variance to mean ratio (4.75: 1.60) is significantly greater than unity ($\chi^2 = 35.8$, $P<0.05$), indicating overdispersion, and the calculated value of the binomial exponent ($k = 0.807$) gives expected frequencies for a negative binomial distribution (Fig. 2b) which do not differ significantly from those observed ($\chi^2 = 3.86$, $P<0.01$).

It would be of interest to know if the individual birds carrying the heaviest *lice* burdens were the same as those with the greatest number of *mites*. Table 3 shows a cross-classification matrix of the lice and mite distributions; however, the relationship between their distributions appear to be random ($\chi^2 = 14.5$, $P<0.01$).

TABLE 3. CROSS-CLASSIFICATION MATRIX OF THE FREQUENCIES OF FEATHER LICE AND FEATHER MITES ON STORM PETRELS. E.G. 4 BIRDS HAD 2 MITES AND 5 LICE.

		Number of mites							
		0	1	2	3	4	5	6	7+
Number of line	0	3	2	1	0	0	0	0	0
	1	5	4	2	0	0	1	0	1
	2	9	6	4	1	2	1	1	0
	3	9	9	3	4	3	0	0	1
	4	12	5	2	3	0	2	0	2
	5	9	3	4	4	1	1	0	0
	6	11	4	8	1	1	0	0	3
	7	9	8	4	3	0	0	0	0
	8	6	6	4	2	1	0	0	1
	9+	15	9	4	1	3	2	1	4

Fulmar

Twenty-eight (80%) of the 35 adult Fulmars examined were infested with feather lice (mean 3.29 per infested bird, range 1-22). No ectoparasites were collected from the unfledged birds. All lice, except a single individual, belonged to the species *Perineus nigrolimbatus,* of which 43% were males, 34% were females and 23% were nymphs; the sex ratio of the adults does not significantly differ from unity ($\chi^2 = 0.70$, $P<0.01$). This species is an 'elongate' louse, associated with the wings or back, and is therefore likely to be sampled representatively by the method. The frequency distribution (Fig. 2c) is positively-skewed, with a variance to mean ratio (8.67 : 2.74) that is significantly greater than unity ($\chi^2 = 34.8$, $P<0.05$), indicating over-dispersion. The calculated value of the binomial exponent ($k = 1.27$) gives expected frequencies for a negative binomial distribution which are not statistically significantly different from the observed frequencies ($\chi^2 = 0.906$, $P<0.01$; Fig. 2a).

Manx Shearwater

The four adult shearwaters examined were infested with 9, 13, 17 and 27 feather lice (mean 16.5). Two species of lice, *Halipeurus diversus* and *Trabeculus aviator,* were obtained, whose frequency distribution were, respectively, 7 and2; 11 and 6; 10 and 3; 10 and 17. The percentages of males, females and nymphs of each species were, respectively, 18%, 37%, 45% and 11%, 64%, 25%. The sex ratio in the latter species is significantly different from unity ($\chi^2 = 9.2$, $P<0.01$).

Leach's Petrel

Five (71%) of the 7 Leach's Petrels examined were infested with feather lice (mean 2.2 per infested bird, range 1-5). All were of a single species, *Halipeurus pelagicus,* of which 9% were males, 18% were females and 73% were nymphs. The sex ratio does not differ significantly from unity. It is noteworthy that the species was the same as the most numerous one found on Storm Petrels.

DISCUSSION

Eight species of Mallophaga belonging to six genera (*Halipeurus, Perineus, Philoceanus,* *Saemundssonia, Trabeculus* and *Austromenopon*) were collected from the Procellariiformes examined. There are few published data with which to compare these results, but *Halipeurus, Perineus, Philoceanus* and *Trabeculus* have only been reported to occur on Procellariiformes. *Saemundssonia* and *Austromenopon* have additionally been found on Alcidae (Waterson 1914, Eveleigh and Threlfall 1976). Feather mites were found only on Storm Petrels and a Leach's Petrel; the absence of mites on Fulmars is in accordance with the observations of Fisher (1952).

All of the ectoparasite types which were collected are generally non-haematophagous, feeding principally on sloughed off skin and feather debris, and they exist in a fairly innocuous relationship with their hosts. Their populations are normally at low levels on healthy wild hosts, and high levels are seldom a cause of poor health but rather a symptom of it (Marshall 1981). Haematophagous ectoparasites, on the other hand, may cause great irritations which can be aggravated by scratching and become vulnerable to secondary infections; occasionally they may cause catastrophic damage to host populations as vectors of disease. Blood-sucking ticks are not removed by the deparasitising method adopted in this study as their mouthparts may be embedded in the host's skin, but the absence of fleas in the samples undoubtedly reflects a low incidence on the seabirds as they are known to be readily removed from birds by the method (Fowler et al. 1983).

The close relationship of the frequency distributions examined (*Halipeurus pelagicus* and aggregated mites on Storm Petrels, and *P. nigrolimbatus* on Fulmars) to the negative binomial distribution is of great interest. Crofton (1971) has suggested that the negative binomial is a 'fundamental model' of parasitism in so far as it describes the distribution of parasites among hosts, and has postulated a series of situations in which such a distribution could arise in nature. According to Anderson and May (1978) the value of the binomial exponent k gives some indication of the destabilising effects of the parasite on the host population, and is related to the relative reproductive rates of the parasite and host.

Host-parasite specificity has often been implicated in the suggestion of taxonomic relationships between species of higher animals (e.g. Rothschild and Clay, 1952). Different species of feather lice were found on each bird species examined except for *Halipeurus pelagicus* which was found both on Storm Petrels and Leach's Petrels. Even though these birds belong to different genera, it is well-known that their breeding habitats may overlap (Sharrock 1976) where casual contracts could result in the transfer of ectoparasites. This is not unprecedented: Post and Enders (1970) describe the occurrence of the same mallophagan species on two species of sparrow which share the same habitat.

Eveleigh and Threlfall (1976) note that burrow or crevice nesting auks had lower infestation levels than those which nested on ledges; they speculate that opportunities for ectoparasite transfer would be greater on ledges where there may be social contact between birds. This situation was not reflected among the Procellariiformes: the ledge-nesting Fulmar had a lower infestation level and lower ectoparasite density then both the burrowing Manx Shearwater and Storm Petrel. However, Fulmars do not exhibit as much social contact on ledges as do auks.

Nymphs were the dominant age class of Mallophaga found on Storm Petrels and Leach's Petrels; this contrasts with auk mallophagan populations in which adults were invaribly the dominant age class (Eveleigh and Threlfall 1976). It is difficult to interpret these results until the various life histories are elucidated, but Marshall (1981) points out that a Mallophagan population with a high proportion of adults to nymphs indicates an old, declining population. The observed difference in population structures between the

Mallophaga on auks and petrels may reflect no more, therefore, than asynchronous sampling. Only in the case of *Trabeculus aviator* did the sex ratio differ significantly from unity; the most likely explanation for this is a differential mortality rate between the sexes (Marshall 1981).

No Mallophaga were recovered from the downy Fulmar chicks examined. Eveleigh and Threlfall (1976) note that auk chicks had received ectoparasites from their parents; it is possible that young Fulmars do not attract Mallophaga until the down pumage is replaced by feathers.

The random association of feather lice and feather mites on Storm Petrels suggests that the two occupy separate "niches" on the host and are not directly in competition for resources, in which case a negative association might be expected to occur.

The collection of *Philoceanus robertsi* from Storm Petrels is of exceptional interest as it has been previously reported only from Wilson's Storm Petrels *Oceanites oceanicus* (C. Lyal, *pers. comm.*). The breeding ranges of these two hosts do not overlap (indeed, the Antarctic breeding range of Wilson's Storm Petrel is about as far away from the Storm Petrel's as it is possible to get), but there is considerable overlap in non-breeding ranges (Nelson 1980) when birds of each species could at times be together at sea. It is not known how far south Storm Petrels wander in the northern winter, but Leach's Petrels have been found ashore as far as 44°S (Imber and Lovegrove 1982). When it is also taken into account that Storm Petrels can be attracted to the calls of Wilson's Storm Petrels (Zonfrillo 1982), it is not difficult to speculate a chance encounter between the two species. The very high proportion of adults to nymphs in the sample suggests that the species is not actively reproducing in July, and it is tempting to speculate that its life cycle is regulated to be out of phase with the rather similar *Halipeurus pelagicus* which is clearly actively reproducing at that time. It would be fascinating indeed to sample Storm Petrels during our winter months to seek an understanding of the dynamics of the ectoparasite community.

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SUMMARY

Feather lice and feather mites were collected from Procellariiform birds in Shetland during July, 1981. Lice were found on 80% of the 44 Fulmars examined, 100% of the 4 Manx Shearwaters, 97.5% of the 240 Storm Petrels and 43% of the 7 Leach's Petrels. *Halipeurus pelagicus* was collected from both Storm Petrels and Leach's Petrels, and *Philoceanus robertsi,* previously reported only from Wilson's Storm Petrels, was found on Storm Petrels. Frequency distributions of the numerous ectoparasite species conformed well with a negative binomial distribution. The population structures and ecology of the ectoparasites are discussed.

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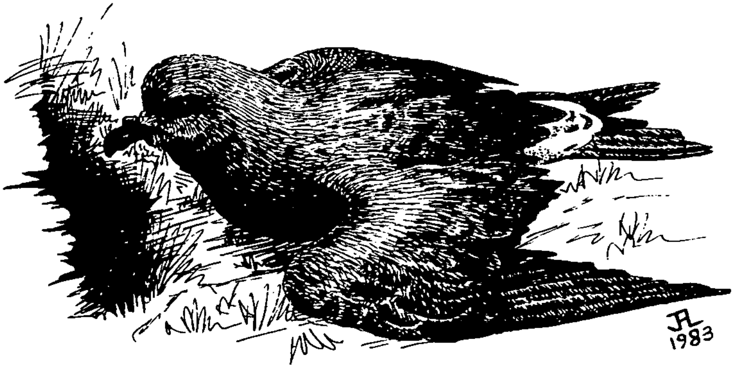

Tick-borne viruses in seabird colonies

P. A. Nuttall

SUMMARY

Tick-associated viruses found in seabird colonies are reviewed with regard to their geographical distribution, type of tick vector, and seabird host on which the ticks feed. The occurrence of related viruses in widely distributed seabird colonies indicates that seabirds transport viruses over vast distances. In contrast, the antigenic integrity of viruses within a seabird colony reflects the restricted habitat that seabird colonies provide. The effect of virus infection on seabird populations is difficult to assess. Circumstantial evidence implicates several tick-associated viruses as the cause of disease of seabirds and of man.

INTRODUCTION

A large number of viruses have been isolated from "seabird ticks": in some cases they have been shown to infect seabirds. This article attempts to provide ornithologists with knowledge of the current status of work on tick-borne viruses of seabirds, examining the important question — do viruses transmitted by ticks pose a threat to seabirds (and people who work with them)? — and discussing data from virus isolations that provide information on the habits and movements of seabirds.

ARBOVIRUSES

Viruses are relatively simple, submicroscopic particles. They do not possess the machinery by which to reproduce themselves and, therefore, are totally dependent on infecting a living cell in order to replicate. A large group of viruses are arboviruses (*ar*thropod-*bo*rne viruses): they replicate in a blood-sucking arthropod (the virus vector) and are transmitted to a vertebrate host (e.g. seabird) when the arthropod takes a blood meal. The virus then replicates in the infected vertebrate and is transmitted to another arthropod when it feeds. Factors affecting the transmission of viruses to vertebrates by ticks are reviewed by Nuttall (1984). More than 400 arboviruses have been described. Some of the best known are yellow fever and dengue, both mosquito-borne viruses, and tick-borne encephalitis virus. Viruses described in this paper are assumed to be arboviruses.

TICKS

Two different families of ticks feed on seabirds: the Ixodidae or hard ticks, and the Argasidae or soft ticks. Hard ticks derive their name from their hardened (sclerotized) cuticle whereas soft ticks have a leathery integument. The life cycle of ticks comprises 4 distinct stages — egg, larva, nymph, and adult; generally, a blood meal is required before moulting to the next stage. The life cycle may be completed within the breeding season of the seabird host, or (more commonly) may involve succeeding generations of the host. The various species of ticks that feed on seabirds, and their geographical distribution, are reviewed by Clifford (1979).

SEABIRD COLONIES

Almost all seabirds are colonial (Lack 1968). Seabird colonies provide restricted habitats that are generally ideally suited to shelter-seeking ticks adapted to feeding throughout their life-cycles on the host(s) typical of the habitat (Hoogstraal 1973). Moreover, they virtually guarantee a source of 'food' for ticks, at least during the breeding season. It is not surprising, therefore, that many seabird colonies support large populations of ticks. The role of traditional communal roosts as sites for ticks requires investigation (Feare & Feare 1980). In polar and subpolar regions seabird colonies are often infested by hard ticks whereas colonies in the tropics and subtropics tend to harbour soft ticks. An exception is the hard tick, *Amblyomma loculosum*, which infests seabirds nesting on islands in the Indian and Pacific Oceans, and the Coral Sea (Hoogstraal *et al.* 1976).

TICK-BORNE VIRUSES FROM SEABIRD COLONIES

Like other arboviruses, tick-borne viruses associated with seabirds are usually named after the location from which the ticks were collected. This can lead to confusion since it results in a growing collection of virus names (Tables 1 and 2), some of which may represent the same (i.e. serologically indistinguishable) virus. Viruses that are shown to be related by complement fixation tests form a common serogroup. Serogroups are usually named after the "type species" of the group e.g. the Kemerovo serogroup (which comprises many seabird-tick-borne viruses; Fig 1) is named after Kemerovo virus, a virus originally isolated from *Ixodes persulcatus* and from human patients in the Kemerovo region of the USSR (Chumakov *et al.* 1963).

TABLE 1. VIRUSES FROM HARD TICKS

Virus[1]	*Group*[2]	*Seabird host*[3]	*Location*
		Ixodes (Ceratixodes) uriae	
1. Tick-borne encephalitis	B	*U. aalge**	USSR (NW)
2. Tyuleniy	B	*U. aalge*, P. pelagicus, Lunda cirrhata*, R. tridactyla*, F. arctica.*	USSR (E, NW), USA (Oregon), Norway (Røst Is.)
3. (Macquarie Is.)	B	*E. chrysolophus*	Subantarctic
4. (Arbroath)	KEM	*F. arctica*	Scotland
5. Bauline	KEM	*L. argentatus*, F. arctica*, O. leucorhoa**	Canada (Newfoundland)
6. Cape Wrath	KEM	*U. aalge*	Scotland
7. (Farne Is.)	KEM	*U. aalge*	England
8. (Foula)	KEM	*U. aalge*	Shetland
9. Great Is.	KEM	*F. arctica*, L. argentatus*, O. leucorhoa**	Canada (Newfoundland)
10. (Great Saltee Is.)	KEM	*U. aalge*, P. aristotelis, R. tridactyla*	Eire
11. (Isle of Man)	KEM	*U. aalge*	Scotland
12. Mykines	KEM	*F. arctica*	Faeroe Is.
13. Nugget	KEM	*E. schlegeli**	Subantarctic (Macquarie Is.)
14. Okhotskiy	KEM	*U. aalge*, F. glacialis*, P. pelagicus*	USSR (E, NW), USA (Alaska)
15. Poovoot	KEM	*U. aalge**	USA (Alaska)
16. (Røst Is.)	KEM	*F. arctica*	Norway
17. (Saint Abb's Head)	KEM	*U. aalge*	Scotland
18. (Shiant Is.)	KEM	*F. arctica*	Hebrides
19. (Tillamook)	KEM	*U. aalge*	USA (Oregon)
20. Tindholmur	KEM	*F. arctica*	Faeroe Is.
21. Yaquina Head	KEM	*U. aalge**	USA (Oregon, Alaska)
22. Avalon	SAK	*F. arctica*, O. leucorhoa*, L. argentatus**	Canada (Newfoundland)

23. (Cap Sizun)	SAK	*R. tridactyla*	France
24. Clo Mor	SAK	*U. aalge*	Scotland
25. Paramushir	SAK	*U. aalge*	USSR (E)
26. Sakhalin	SAK	*U. aalge*, Lunda cirrhata*, F. glacialis*, R. tridactyla, Ph. lobatus**	USSR (E, NE)
27. (Shiant Is.)	SAK	*F. arctica*	Hebrides
28. Taggert	SAK	*E. schlegeli**	Subantarctic (Macquarie Is.)
29. (Arbroath)	UUK	*F. arctica*	Scotland
30. (Cape Sizun)	UUK	*R. tridactyla*	France
31. (Farne Is.)	UUK	*U. aalge**	England
32. (Great Saltee Is.)	UUK	*U. aalge, R. tridactyla**	Eire
33. (Isle of May)	UUK	*U. aalge*	Scotland
34. (Marsden)	UUK	*R. tridactyla**	England
35. (Oceanside)	UUK	*U. aalge*	USA (Oregon, California)
36. (Røst Is.)	UUK	*F. arctica*	Norway
37. (Runde Is.)	UUK	*F. arctica*	Norway
38. (Saint Abb's Head)	UUK	*U. aalge*, R. tridactyla**	Scotland
39. (Soay)	UUK	*F. arctica*	St. Kilda
40. Zaliv Terpeniya	UUK	*U. aalge*	USSR (E, NW)
41. Runde	?	*F. arctica*, A. torda*, U. aalge**	Norway

Ixodes (Scaphixodes) signatus

42. Kenai	KEM	*U. aalge*	USA (Alaska)
43. Okhotskiy	KEM	*U. aalge*	USSR (E)
44. Kachemak Bay	SAK	*U. aalge*	USA (Alaska)
45. Paramushir	SAK	*P. pelagicus*	USSR (E)

Ixodes (Multidentatus) eudyptidis

46. Saumarez Reef	B	*L. novaehollandiae*	Australia (Tasmania)

Ixodes (Multidentatus) rothschildi

47. (Great Saltee Is.)	UUK	*A. torda*	Eire

Amblyomma (Adenopleura) loculosum

48. Aride	?	*S. dougallii*	Seychelles

[1] Virus generally named after site from which ticks were collected; those in parenthesis have not been registered.

[2] Virus serogroup: group B, Kemerovo (KEM), Sakhalin (SAK), Uukuniemi (UUK), ungrouped (?).

[3] Razorbill, *Alca torda;* Royal Penguin, *Eudyptes chrysolophus;* Puffin, *Fratercula arctica;* Fulmar, *Fulmaris glacialis;* Herring Gull, *Larus argentatus;* Silver Gull, *L. novaehollandiae;* Tufted Puffin, *Lunda cirrhata;* Leach's Petrel, *Oceanodroma leucorhoa;* Shag, *Phalacrocorax aristotelis;* Pelagic Cormorant, *P. pelagicus;* Red-necked Phalarope, *Phalaropus lobatus;* Kittiwake, *Rissa tridactyla;* Roseate Tern, *Sterna dougallii;* Guillemot, *Uriae aalge.*

*evidence of infection by virus isolation from blood or organs of bird and/or detection of antibodies in serum of seabird.

HARD TICKS

The majority of viruses from hard ticks have been isolated from a single species, *Ixodes uriae* (Table 1). This species has a remarkable bipolar distribution which has been attributed to dispersal by seabirds (Zumpt 1952). In temperate zones the life cycle of *I. uriae* takes 1 to 2 years to complete in contrast to 6 to 8 years in the subarctic (L'vov *et al.* 1975). The main hosts of *I. uriae* in the northern hemisphere are guillemots (*Uria aalge*), and in the southern hemisphere, penguins (Spheniscidae). *I. uriae* will feed on numerous other species, however, evidence from viral infections indicate that this may be due to the close association of other seabirds with guillemots. For example, in the USSR, the frequency of antibodies to Tyuleniy virus (Table 1) was similar in isolated colonies of guillemots and in colonies where guillemots and kittiwakes (*Rissa tridactyla*) were mixed; in contrast, in kittiwakes from mixed colonies the frequency of antibodies to Tyuleniy virus was greater than in colonies not shared with guillemots (Bekleshova *et al.* 1971).

SOFT TICKS

Viruses from soft ticks associated with seabirds have been isolated from ticks of the *Ornithodoros capensis* group (Table 2). A possible exception is Mono Lake virus isolated from *Argas cooleyi* collected from an inland nesting colony of gulls in California (Johnson & Casals 1972). *O. capensis* group ticks frequent a variety of habitats: colonies of cormorants and ground-nesting terns in tropical and sub-tropical regions, gull and cliff-nesting guillemot colonies in more temperate zones.

TYPES OF VIRUSES

The type of virus infecting ticks in a seabird colony appears to vary according to the type of tick found in the colony. Thus, viruses of the Sakhalin and Uukuniemi serogroups (Figure 3) have been isolated from hard ticks, whereas the Hughes (Figure 2), Quaranfil, Nyaminini and Upolu groups (Figure 4) have been isolated from soft ticks (Tables 1 and 2) (although Hoogstraal and Feare (in preparation) reported the isolation of Soldado virus (Hughes group) from the hard tick, *Amblyomma loculosum*). This virus-tick relationship may be due either to "selection" of viruses by ticks (ticks supporting replication only of certain types of viruses), or to geographical distribution (viruses infecting ticks when their distributions overlap). Seabird colonies generally harbour only one tick species. However, where the zoogeographical distribution of *Ornithodoros* and *Ixodes* species overlap, both types can be found, for example, on islands off the coast of Oregon, north-west USA (Clifford *et al.* 1970), Brittany (Chastel *et al* 1981), Great Saltee Island, Eire (Kelly 1982), and St Abb's Head, Scotland (Kelly & Nuttall in prep). In these colonies, where a geographical barrier does not exist, virus-tick specificity is still maintained. This suggests that ticks are vectors only of specific viruses. In order to confirm these findings studies must be made, in the laboratory, of the ability of various viruses to replicate in, and be transmitted by, different types of ticks.

In the case of the Kemerovo and group B serogroups it appears that virus-tick

TABLE 2. VIRUSES FROM SOFT TICKS

Virus[1]	*Group*[2]	*Seabird host*[3]	*Location*
		Ornithodoros (Alectorobius) amblus	
49. Huacho	KEM	*P. bougainvillii, Sula variegata*	Peru
50. Punta Salinas	HUG	*P. bougainvillii, Sula variegata*	Peru

		Ornithodoros (*Alectorobius*) *capensis*	
51. Saumarez Reef	B	*S. fuscata*	Australia (Queensland)
52. West Nile	B	*L. argentatus*	USSR (Caspian Sea)
53. Soldado	HUG	*S. fuscata**, *A. stolidus*, *L. cirrhocephalus*, *Sula dactylatra* *P. carbo*, *P. capensis*, *P. africanus*	Trinidad, USA (Texas), Senegal, Seychelles, Ethiopia, Hawaii, S. Africa
54. Baku	KEM	*L. argentatus**	USSR (Caspian Sea)
55. Midway	NYM	*S. fuscata*, *L. crassirostris**	Central Pacific Is., Japan
56. Johnston Atoll	QRF	*S. fuscata*, *Sula serrator**, *P. capensis*	Central Pacific Is., Australia, New Zealand SW Africa[4]
57. Aransas Bay	UPO	*Pelicanas occidentalis*	USA (Texas)
58. Upolu	UPO	*S. fuscata*	Australia
		Ornithodoros (*Alectorobius*) *denmarki*	
59. Hughes	HUG	*S. fuscata*, *A. stolidus*	Trinidad, USA (Florida) Cuba
60. Soldado	HUG	*S. fuscata*, *A. stolidus*	Trinidad
61. Raza	HUG	gulls and terns	Mexico, USA (California)
62. Midway	NYM	*S. fuscata*	Central Pacific Is.
63. Johnston Atoll	QRF		Central Pacific Is.
		Ornithodoros (*Alectorobius*) near *denmarki*	
64. Farallon	HUG	*L. occidentalis*	USA (California, Oregon), Mexico
		Orithodoros (*Alectorobius*) *maritimus*	
65. (Great Saltee Is.)	HUG	*U. aalge**, *P. aristotelis**, *R. tridactyla*	Eire
66. Puffin Is.	HUG	*L. argentatus*	Wales
67. Soldado	HUG	*L. argentatus*, *P. aristotelis*	France (Brittany), Morocco
68. (Great Saltee Is.)	KEM	*U. aalge**, *P. aristotelis*, *R. tridactyla**	Eire
69. Caspiy	?	*L. argentatus**	USSR (Caspian Sea)
		Orithodoros (*Alectorobius*) *muesebecki*	
70. Zirqa	HUG	*P. nigrogularis*	Persian Gulf
		Argas cooleyi	
71. Mono Lake	KEM	*L. californicus*	USA (California)

[1] see Table 1.

[2] Virus serogroup (see Table 1): Hughes (HUG). Nyamanini (NYM), Quaranfil (QRF), Upolu (UPO)

[3] (see also Table 1): Brown Noddy Tern, *Anous stolidus;* California Gull, *Larus californicus;* Grey-headed Gull, *L. cirrhocephalus*; Black-tailed Gull, *L. crassirostris;* Western Gull, *L. occidentalis;* Brown Pelican, *Pelicanus occidentalis;* Reed Cormorant, *Phalacrocorax africanus;* Guanay Cormorant, *P. bougainvillii;* Cape Cormorant, *P. capensis;* Great Cormorant, *P. carbo;* Socotra Cormorant, *P. nigrogularis;* Sooty Tern, *Sterna fuscata;* Gannet, *Sula bassana;* Blue-faced booby, *S. dactylatra;* Australian Gannet, *Sula serrator;* Peruvian Booby, *Sula variegata;*

[4] Yunker, C. E. *pers. comm.*

*see Table 1

Figure 1. Distribution of viruses of the Kemerovo serogroup. (Numbers refer to Tables 1 and 2).

Figure 2. Distribution of viruses of the Hughes serogroup. (Numbers refer to Table 2).

specificity does not occur since members of both groups have been isolated from both hard and soft ticks (Tables 1 and 2). However, for both serogroups, viruses infecting hard ticks can be distinguished serologically from members of the group infecting soft ticks; members of the Kemerovo serogroup isolated from hard ticks form the Great Island complex whereas those from soft ticks belong to the Chenuda complex (Gorman *et al.* 1983). We have found a possible exception on Great Saltee island where Kemerovo group viruses infecting *I. uriae* and *O. maritimus* were serologically indistinguishable (Nuttall *et al.* 1984).

Figure 3. Distribution of viruses of the Sakhalin and Uukuniemi serogroups. (Numbers refer to Table 1).

Figure 4. Distribution of viruses of the B, Nyaminini, Quaranfil and Upolu serogroups, and ungrouped viruses. (Numbers refer to Tables 1 and 2).

PERSISTENCE OF VIRUSES IN SEABIRD COLONIES

The repeated isolation of viruses from ticks collected in seabird colonies indicates that seabird colonies can be persistent foci of virus infection. For example, ticks from a guillemot colony at St Abb's Head, Scotland collected in 1974, 1975 and 1979 were shown to be infected by related viruses (Nuttall *et al.* 1981); a similar situation has been demonstrated in guillemot colonies on the nearby Isle of May. In contrast, Yunker (1975) reported that at Dry Tortugas, Florida, numerous ticks infected with Hughes virus (Table 2) were collected in 1962 (Hughes *et al.* 1964) whereas ten years later, few ticks were found at the site and there were no reported isolations of virus. The author suggested that the low-lying site at Dry Tortugas had been washed by high seas resulting in decimation of the tick population. In contrast, a colony of brown noddy terns (*Anous stolidus*) on Soldado Rock, Trinidad, represented a stable focus of infection by Hughes group viruses (Table 2). Yunker (1975) suggested that permanent foci of virus infection, such as Soldado Rock, may be a source of infection or re-infection of other seabird colonies.

The persistence of viruses in seabird colonies is supported by the ability of viruses to "overwinter" in ticks during their diapause stage, and at a time when environmental conditions and/or the absence of a vertebrate host preclude active virus transmission (Reeves 1974). Trans-stadial and trans-ovarial transmission also help maintain viruses in a tick population. Trans-stadial transmission is the "transmission" of a virus from one stadium to the next during the tick life-cycle. In the case of *I. uriae*, the isolation of a virus from adult males indicates trans-stadial transmission since adult male *I. uriae* do not take a blood meal. Trans-ovarial transmission occurs when a virus is transmitted from the adult female to the eggs. This is a form of vertical transmission and can greatly enhance the survival of a virus population (Fine 1975). Trans-ovarial transmission has not been demonstrated for all tick-borne viruses.

TRANSPORTATION OF VIRUSES BY SEABIRDS

Seabird colonies in widely separated geographical locations have been shown to harbour related viruses (Clifford 1979). For example, Soldado-like viruses (Chastel *et al.* 1983) have been isolated from ticks collected in seabird colonies in Trinidad, Texas (USA), Hawaii, Eire, France, Senegal, South Africa, Ethiopia and the Seychelles (Le Lay-Roguès 1980). The obvious explanation for the wide distribution of certain viruses in seabird colonies is that seabirds transport viruses. Many seabirds only visit land to breed and usually breed in successive years in the same colony. Transportation of viruses, therefore, is probably mediated by immature birds which tend to wander further than breeding birds and may visit other colonies (Tuck, 1960), or by secondary hosts such as gulls (Clifford, 1979). Viruses may be carried in the form of infected ticks attached to seabirds, or as infections of seabirds (viraemic birds in which virus is present in the blood and therefore available for transmission to feeding ticks). Evidence from the isolation of viruses associated with seabirds in Britain indicates that both methods can occur. Viruses indistinguishable from those infecting ticks were isolated from the blood of kittiwakes from Marsden and St Abb's Head, and viruses were isolated from three adult female *I. uriae* removed from a dead full-grown puffin (*Fratercula arctica*) found on the beach at Arbroath (Table 1). Although these results do not provide evidence that viruses are transported over large distances by seabirds, they demonstrate that, potentially, both mechanisms of transportation can operate.

RESTRICTED HABITAT

Serologically-related viruses from different seabird colonies (and even within colonies) can be distinguished from each other. This antigenic integrity of viruses provides evidence of the restricted habitat that seabird colonies provide (Main 1978). Thus a virus introduced into a "new" colony may become established at that site, changing its antigenic structure until it can be readily distinguished from the original virus (Doherty *et al.* 1975). The variation in antigenicity of virus strains within a seabird colony occurs readily and is ongoing. At a seabird colony in Scotland, Kemerovo-group viruses were isolated on 4 occasions from ticks and a kittiwake collected during a period of 5 years: each isolate could be distinguished from the others by serological tests (Nuttall *et al.* 1981). Whether this variation is due to natural changes occurring within the resident virus population of a seabird colony, or whether it is due to constant or regular introduction of viruses from other colonies which become mixed within the resident virus pool, is not known.

DISEASE

Tick-borne viruses have not been shown, conclusively, to cause disease following natural infections of seabirds, but circumstantial evidence implicates viruses in a few cases. The most notable is that of the Soldado virus group. On Bird Island, Seychelles, abnormalities and deaths were observed in sooty tern (*Sterna fuscata*) chicks heavily infested with *O. capensis* (Feare 1976) from which Soldado virus was isolated; experimental infection of chicks (*Gallus domesticus*) using Soldado virus-infected ticks resulted in deaths (Converse *et al.* 1976). Several viruses have been isolated from apparently sick seabirds. Caspiy virus was isolated from a clinically ill herring gull (*Larus argentatus*) (L'vov *et al.* 1975); viruses of the Uukuniemi serogroup have been isolated from the brain of a kittiwake from St Abb's Head (Nuttall *et al.* 1981), and from brain, spleen, lung, kidney, liver, hindgut and blood of a kittiwake from Marsden: both birds appeared sick. Berezina *et al.* (1974) described clinical signs resembling encephalomyelitis in gulls and auks following experimental infection with Tyuleniy virus. Clinical signs shown by tick-infested seabirds, particularly chicks (Hoogstraal & Feare in preparation), may be due to ex-sanguination. In addition to disease, virus infection and/or tick infestation may result in desertions at seabird colonies and, consequently, may have a significant effect on colony structure (Feare 1976; King *et al.* 1977a, b).

Two viruses isolated from "seabird ticks" — tick-borne encephalitis and West Nile (Table 1 and 2) — are known pathogens of man. However these viruses are not generally associated with seabirds. Some more typical "seabird" viruses have been asociated with disease of humans working in seabird colonies. For example, Zirqa virus (Table 2) may have been the cause of illness in petroleum workers visiting Zirqa island (Persian Gulf) where the virus infects *O. muesebecki* which normally feed on Socotra cormorants (*Phalacrocorax nigrogularis*) (Hoogstraal *et al.* 1970; Varma *et al.* 1973). In Peru, workers collecting guano from a seabird colony became ill after being bitten by *O. amblus*; Punta Salinas and Huacho viruses were isolated from these ticks (Clifford *et al.* 1980) (Table 2). Tyuleniy virus, which circulates in seabird colonies in the USSR and USA, is strongly suspected of causing human illness (Hoogstraal 1980), as is Soldado virus (Chastel *et al.* 1981). Tick bites *per se* may cause severe clinical reactions (Hoogstraal & Gallagher 1982).

CONCLUSIONS AND FUTURE WORK

Many seabird colonies throughout the world have been shown to harbour viruses; the viruses are transmitted to seabirds by ticks. Generally, tick-borne viruses do not appear to cause signs of overt disease in seabirds. However, the effect of viruses on seabird populations is difficult to assess. Studies are required of breeding success in relation to virus infection. In seabird colonies that are persistent foci of tick-borne virus infections, the resident seabird population presumably will have a high level of immunity (including maternal antibody in chicks (Nuttall *et al.* 1984)) to the resident viruses, protecting the colony against outbreaks of disease. High levels of immunity in resident seabird populations imply that birds at greatest risk from disease are non-immune vistors to the colony. If this is the case, and viruses mediate selection against non-resident seabirds, do viruses influence the coloniality of seabirds?

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The effects of disturbance on survival, age and weight of young Guillemots *Uria aalge*

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INTRODUCTION

This study weighed young Guillemots *Uria aalge* the few days before they left the breeding ledges for the sea and measured the effect of human disturbance on the weight, wing length and survival of the studied birds. Some workers have attempted to minimize this disturbance by weighing young every second or third day (Birkhead 1977, Hedgren and Linnman 1979) but this results in very imprecise estimates of the weights at which young leave. We were interested in the weights of young when they have actually left the colony so we weighed young daily.

METHODS

About half the young in a small group of c. 100 breeding pairs on the Isle of May, Firth of Forth, Scotland were weighed and measured in 1982. The group consisted of three distinct but adjacent areas.

i. A steep chimney and a few broad ledges which could be approached from below so that chicks could not escape. This was visited daily from 16 June until 4 July (when the last young fledged). After the first two visits all the adults left the area on our arrival, apparently scared off by the alarm calls of the numerous Herring Gulls *Larus argentatus* which nested nearby. This area is called the Disturbed Area. We were usually in the area for 20-30 min. It was impossible to see when the adults returned but disturbance would have lasted for 60 min at the maximum.

ii. A superficially similar crack some 5m away which was visited only on 20 June and daily 1-5 July when the chicks were judged about to leave.

iii. A flat area above the other two areas where young could be removed and replaced using a 3m bamboo pole with a 30 cm wire hook at the end. Most adults remained as the selected young were removed and the few that were disturbed soon returned. All young were weighed on 25 June and daily from when the individual young were almost old enough to leave. Areas ii. and iii. are considered Undisturbed Areas.

Young were weighed to the nearest g using a Pesola balance. The maximum wing length (to tips of wing coverts) was measured every other day using a stopped rule to nearest mm when the young seemed ready to leave. Last wing lengths refer to measurements on the day of leaving (if made that day) or the day before. Hatching dates were not known but wing length is linearly correlated with age (Birkhead 1977). Young were considered to have left successfully if they disappeared over-night when the body feathers were completely grown and the wing length was at least 55mm. The sample included all the young leaving the area in 1982.

An additional 49 young elsewhere on the island were weighed and measured once. Data on when undisturbed young left the colonies and on breeding success were collected by daily visual observations at three other study areas.

RESULTS

Eleven of 16 (69%) young hatched in the disturbed area left successfully (and one late egg was deserted) as did eight of nine (89%) and 28 out of 32 (87.5%) in the Undisturbed Areas ii. and iii. The difference between the disturbed and the other two areas was not quite significant ($\chi^2 = 2.9$, P<0.1>0.05). Overall the success rate was significantly lower ($\chi^2 = 12.5$, P<0.001) than the control areas elsewhere which were never disturbed and where 405 out of 427 (94.4%) young which hatched left the colonies safely.

There were no significant differences between the weights and wing lengths of chicks in the two Undisturbed Areas (Table 1) so the results were combined. The wing lengths of the young in the Disturbed Area were significantly shorter than those in the Undisturbed Area, both at leaving (t = 3.3; 30 df; P<0.05) and at last measurement (t = 4.6; 34 df; P<0.001), i.e. disturbed young appeared to leave when slightly younger. The difference between the two sets of means was equivalent to about 4 days growth (Birkhead 1977). The weights at leaving showed a similar difference with the mean for disturbed young (229.9 g) being significantly lower than the mean for the undisturbed young (249.1 g) (t = 2.4; 45 df; P<0.02). The mean weight of the 19 young from the Undisturbed Area which has also been weighed when their wing lengths were 60-63 mm was 244.1 g (s.e. 5.3). This was heavier than the mean of young from the Disturbed Area (229.9 g), but the difference was not statistically significant (t = 1.6; 28 df; P<0.1> 0.2). Therefore it was not clear whether the growth of disturbed young had been adversely affected.

TABLE 1. WEIGHT (g) AND WING MEASUREMENT (mm) OF YOUNG GUILLEMOTS WHEN THEY LEFT THE BREEDING SITES.

	Weight at fledging (g)		*Wing at date of leaving (mm)*		*Last wing (mm)*[1]	
Area	*n*	*mean ± s.e.*	*n*	*mean ± s.e.*	*n*	*mean ± s.e.*
i. Disturbed Crack	11	229.9 ± 7.6	5	61.8 ± 2.2	11	60.1 ± 1.5
ii. Undisturbed Crack	8	253.5 ± 7.5	6	67.3 ± 1.2	8	67.0 ± 0.9
iii. Undisturbed Top	28	247.9 ± 4.3	21	70.1 ±1.1	27[2]	68..9 ± 1.1
ii. + iii. All Undisturbed	36	249.1 ± 3.7	27	69.5 ± 0.9	35	68.5 ± 0.9

Notes 1. Last wing includes measurements the day before leaving.

2. One remaining chick had a wing of 62 mm five days before leaving. Comparison with other young suggests a wing of c. 75 mm at leaving.

The young from the Disturbed and Undisturbed Areas left the colony between 19 June and 6 July (n = 47, median 2 July) compared to extremes of 18 June and 11 August (median 30 June) for 397 control young. Hedgren (1979) found that the mean leaving weight declined by 2.6 g/day after the median leaving date at a Baltic colony. A decline was not apparent in our weighings (Fig. 1). The number of times a chick had been weighed had no significant effect on its weight at leaving so we assume that the adverse effect was due to our disturbance of the adults rather than handling the young.

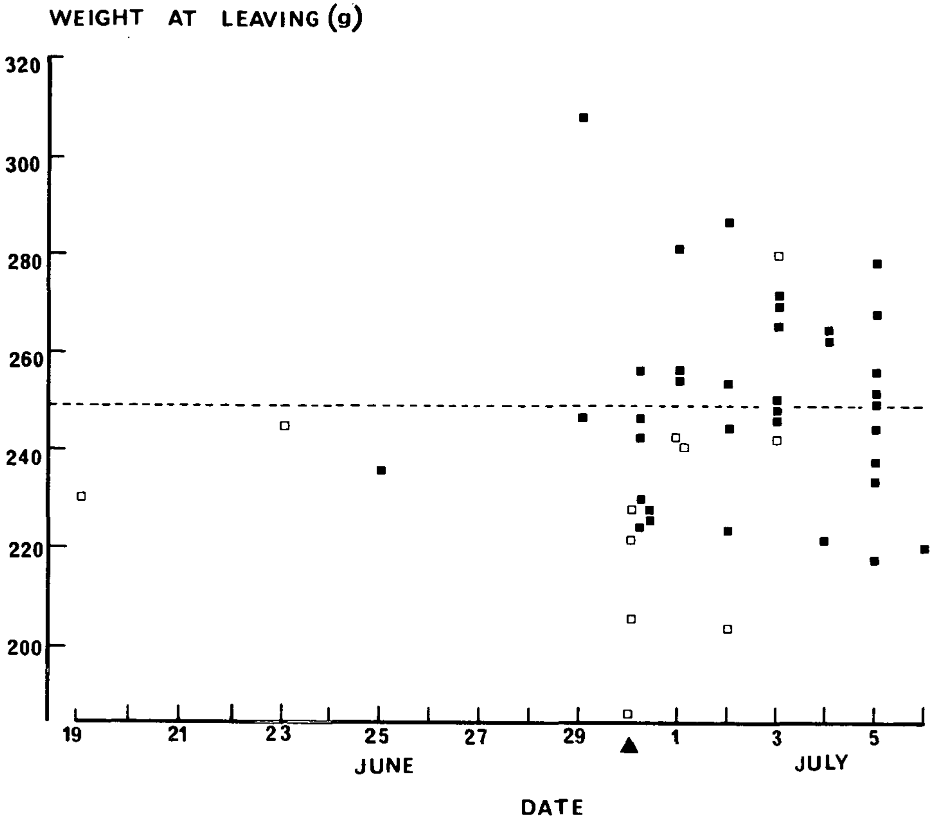

Figure 1. Weights at leaving of disturbed (open squares) and undisturbed (solid squares) young Guillemots in relation to date. The dotted line is the overall mean weight, the triangle is the median date of leaving for the Isle of May in 1982.

Hedgren and Linnman (1979) found that late hatched young (n = 45; mean = 222.0 g; s.e. 5.7) were significantly lighter at leaving than early young although of similar age. Our data did not show this but perhaps the spread of leaving dates (18 days for all the young in the area) was too small.

The weighings of 49 additional young elsewhere suggested a normal leaving weight of c. 250 g (Fig. 2). The range of weights at any wing length was sufficient to mask the reductions due to disturbance if the last measurements and weights of the disturbed young were plotted on the same graph, presumably because the main difference was due to the chicks leaving when younger. This effectively removes a potentially useful way of checking the effect of human disturbance.

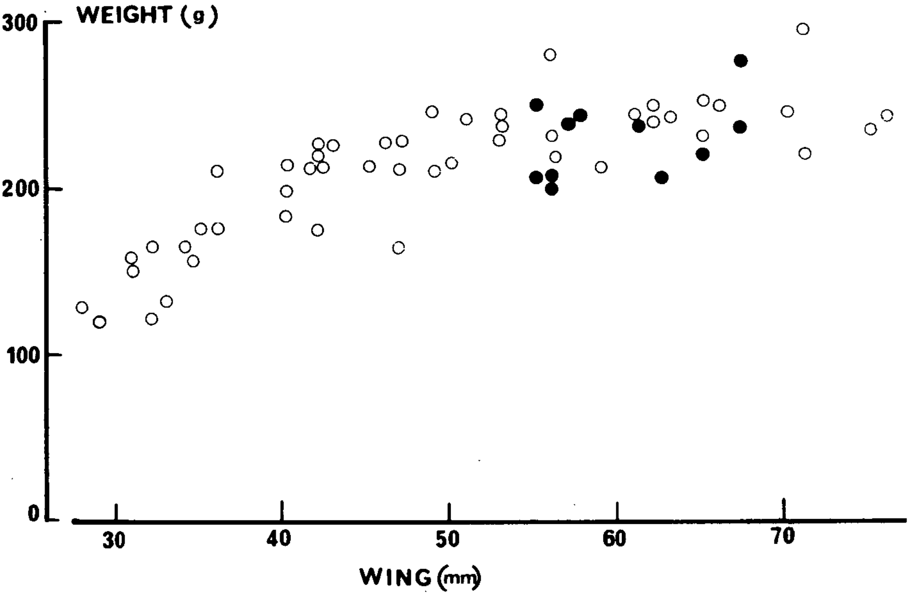

Figure 2. Relationship between weight and wing of young Guillemots. Solid circles are the last measurements of 11 regularly disturbed young, open circles are measurements of young disturbed only once.

DISCUSSION

Young Guillemots in an area where the adults were scared off once each day left the colony at significantly lower weights than those from two adjacent areas. One of these areas was superficially very similar which suggests that this effect was not due to differences in nesting habitat. The disturbed young also had shorter wings which suggests that they were younger. The possibility that both increases in weight and wing length had been slowed down cannot be discounted. However, the daily increase in wing length of disturbed young was similar to that of other young and in seabirds wing growth is one of the last things to suffer if the chick is starving (Harris 1966, Nettleship 1972) and our disturbed young were certainly not starving.

Sixty-one young weighed once every three days by Hedgren and Linnman (1979) left the ledges with a mean weight of 256.0 g (s.e. 2.9) which compared with a mean weight of 253.7 g (s.e. 0.3) for 14,511 young caught immediately after they had left the breeding ledges (Hedgren 1979). Birkhead (1976) noted that regular visits he made to Guillemot colonies resulted in the parents leaving their young even when he was 20-30 m away, apparently after hearing gull alarm calls. Subsequently he restricted his weighings to every other day. Comparison of his alternate day weighings with the weights of young visited only once (his Fig. 4.8) show clearly that the growth of the young visited regularly was reduced. Eleven disturbed young had a mean weight at leaving of 214.9g (s.e. 7.8) whereas less disturbed young probably left at 230-260 g. From this, we conclude that disturbance every day or every other day causes an appreciable reduction in time that a Guillemot chick spends on its natal ledge, and possibly slows down its rate of increase in weight, whereas weighing every third day apparently does not. The problem is that such infrequent weighings result in imprecise data on growth. The only solution seems to be to weigh young without disturbing the adults. Although time consuming, this can be done.

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SUMMARY

Daily disturbance of a Guillemot colony resulted in reduced nesting success and young leaving at significantly lower weights and with significantly shorter wings than adjacent less disturbed young.

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A comparison between the percentage of Seabirds reported as oiled from Ringing Recoveries and from The Beached Bird Survey

Stephen R. Baillie and T. J. Stowe

The proportion of dead seabirds whose plumage is contaminated with oil is frequently used as a measure of the importance of oil pollution in causing seabird mortality (Bourne and Bibby 1975, Andrews and Standring 1979, Mead and O'Connor 1980, Stowe 1982). Despite the difficulties in interpreting such data due to post mortem oiling (Kuyken 1978, Stowe 1982) and to differences in the toxicity of oils ingested by birds (Brown 1982) the proportion of corpses oiled does provide a useful measure of temporal and geographic variation in oil-related mortality of different seabirds species.

Since 1971 regular surveys of beached birds have been organised in Britain on five dates each winter by the Royal Society for the Protection of Birds and the Seabird Group. Observers are instructed to count all corpses on the beach and also to record the number which are oiled. Recovery reports of ringed seabirds received by the British Trust for Ornithology frequently include information on the apparent cause of death, including whether or not the bird was oiled. Thus although such ringing recovery data are chiefly of value for investigations of dispersal patterns and mortality (e.g. Mead 1974, Galbraith *et al.* 1981), they also provide information on the frequency with which birds are contaminated with oil.

Participants in the beached bird survey are specifically instructed to record whether corpses are oiled, whilst finders of ringed birds do not always provide this information. In this respect ringing recovery data are less reliable than those from beached bird surveys, but they are frequently available for areas and times when beached bird surveys have not been carried out. The object of this study was to determine whether such data from ringing recoveries can be reliably used to measure variations in the proportion of seabird corpses which are contaminated with oil.

METHODS

We compared the proportion of corpses that were recorded as oiled by the beached bird survey with the proportion from ringing recoveries in different regions, months and years. Very few of the ringing recoveries used here were recorded on the beached bird surveys so the data sets should be relatively independent. Ringing recoveries of birds reported as shot or caught in fishing nets were excluded from the analysis.

The main beached bird surveys were carried out on the last weekend of September, November, January, February and March, but some data have also been collected at other times. Approximately 2000 km of beach were examined on each survey. Full details of beached bird survey methods are given by Stowe (1982). Ringing recoveries are received continuously throughout the year.

The data presented here are from the winters of 1971/72 to 1979/80, winter being taken as the months of September to April inclusive. Seasonal comparisons were restricted to the five months when the main beached bird surveys were carried out. Three regions were defined as follows:

West Britain	Lands End, Cornwall to Whiten Head, Highland Region but excluding Ireland.
East Britain	Whiten Head, Highland Region to Dungeness, Kent including Orkney but excluding Shetland.
South Britain	Dungeness, Kent to Lands End, Cornwall including the Scilly Isles.

Our analyses were restricted to five species prone to oiling for which adequate samples of ringing recoveries were available. These species were Gannet (*Sula bassana*), Cormorant (*Phalacrocorax carbo*), Shag (*P. aristotelis*), Eider (*Somateria mollissima*) and Guillemot (*Uria aalge*). A total of 2156 ringing recoveries and 15,159 corpses counted on beached bird surveys were included in the analysis (Table 1). All the analyses for Eider refer to East Britain, as few ringed Eiders have been recovered from other parts of Britain.

Statistical methods follow Sokal and Rohlf (1981). All percentages were normalised using the arcsine transformation before statistical calculations were carried out. For the analyses of regional and seasonal variation it was necessary to remove the differences between species. This was done by expressing each value as the number of normal deviates (standard deviations) from the overall mean percentage oiled for that species. These calculations were carried out separately on the data from the beached bird survey and from the ringing recoveries.

RESULTS

Differences in absolute values

The overall percentage of birds reported oiled on beached bird surveys is significantly higher than that from ringing recoveries (Table 1). This is to be expected as an unknown proportion of reporters of ringing recoveries do not say whether the bird was oiled, either because they did not notice the oil or because they did not consider it to be important. Thus ringing recoveries cannot be used to obtain an absolute value for the percentage of corpses which are oiled. However, provided failure to report oiling of ringed birds does not vary with time or place, it may still be possible to use ringing recoveries to examine factors affecting the number of corpses which are oiled.

TABLE 1. SPECIES DIFFERENCES IN PERCENTAGE OILED BETWEEN RINGING RECOVERIES AND BEACHED BIRD COUNTS

	Percentage oiled from ringing recoveries	*Percentage oiled from beached bird survey*	*Test between methods*
Gannet	13.7 (124)	28.0 (1339)	$x^2 = 11.108$ ***
Cormorant	5.3 (507)	16.9 (1353)	$x^2 = 40.839$ ***
Shag	7.8 (997)	16.2 (1213)	$x^2 = 34.817$ ***
Eider	12.1 (363)	28.0 (608)	$x^2 = 32.273$ ***
Guillemot	41.2 (165)	58.7 (10,646)	$x^2 = 19.832$ ***

Sample sizes (total number of birds examined) are given in parentheses.

*** $P<0.001$

Species differences

The vulnerability of birds to oil pollution varies greatly between species, diving birds such as auks being particularly vulnerable (Andrews and Standring 1979). There is a high correlation ($r_3 = 0.989$, $P<0.01$) between ringing recoveries and beached bird surveys in the proportions of the different species which were reported as oiled (Table 1).

Regional differences

The regional percentages of oiled birds are given for Gannet, Cormorant, Shag and Guillemot in Table 2. There is significant agreement between species and methods in the ranking of the three regions according to the percentage of corpses which were oiled (Kendall's coefficient of concordance = 0.89, P<0.001).

TABLE 2. REGIONAL DIFFERENCES IN PERCENTAGE OILED BETWEEN RINGING RECOVERIES AND BEACHED BIRD COUNTS.

		Percentage oiled from ringing recoveries	*Percentage oiled from beached bird survey*
Gannet	West Britain	10.5 (38)	24.5 (640)
	East Britain	10.6 (66)	24.3 (602)
	South Britain	30.0 (20)	74.2 (97)
Cormorant	West Britain	3.3 (210)	10.9 (771)
	East Britain	6.1 (231)	19.3 (497)
	South Britain	9.1 (66)	57.6 (85)
Shag	West Britain	5.4 (390)	14.7 (447)
	East Britain	9.3 (582)	15.3 (687)
	South Britain	12.0 (25)	44.9 (49)
Guillemot	West Britain	31.8 (85)	33.9 (3335)
	East Britain	46.5 (43)	68.2 (6643)
	South Britain	56.8 (37)	89.1 (668)

Sample sizes (total number of birds examined) are given in parentheses.

An analaysis in which species differences were removed was also carried out (Figure 1). Each point in the Figure represents one species in one region. There is a highly significant correlation between the two methods (r_{10}= 0.933, P<0.001).

TABLE 3. COMPARISONS OF SEASONAL VARIATION IN THE PERCENTAGE OILED BETWEEN RINGING RECOVERIES AND BEACHED BIRD SURVEYS.

	Correlation coefficient$_1$.	*G for 3 way contingency table*$_2$.
Gannet	0.206	0.075
Cormorant	—0.489	7.207**
Shag	0.665	1.004
Eider	0.742	1.230
Guillemot	0.765	0.066

** P<0.01 All other values not significant

1. N = 5 months, September, November, January, February and March.
   The percentages were arcsine transformed before calculating the correlation coefficient.
2. Contingency table with oiled, not oiled, ringing, beached bird survey; and September and November, January — March. G is a test for three way interactions, i.e. that the relationship between oiling and period depends on method.

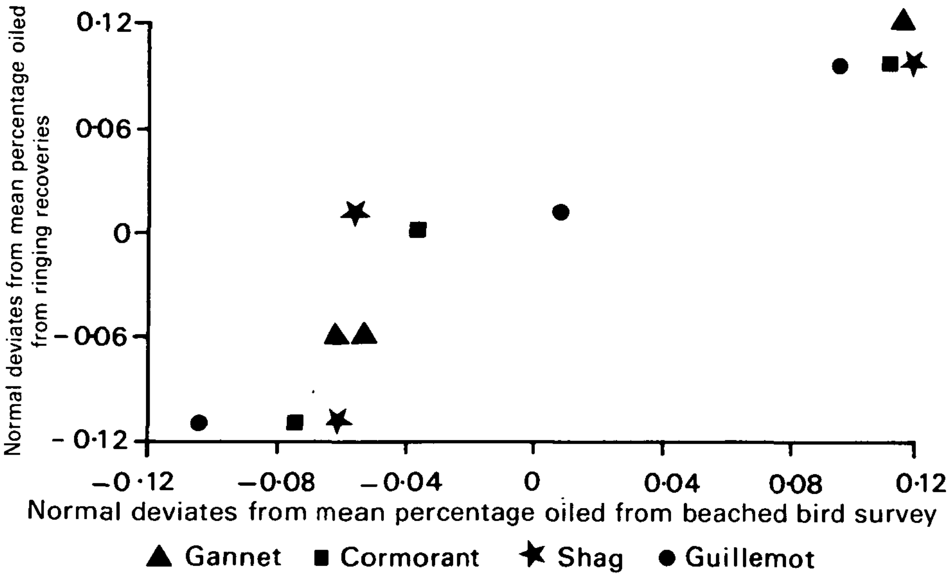

Figure 1. Relationship between regional variation in percentage oiled from ringing recoveries and beached bird counts. Each point represents one region for the species concerned $r = 0.933$ $P<0.001$. Both axes show normal deviates from the mean percentage oiled. The data were normalised using the arcsine transformation before means and normal deviates were calculated. For further details see text.

Seasonal differences

Both beached bird surveys and ringing recoveries indicate that more birds are found oiled in winter than in summer (Bourne 1976, Andrews and Standring 1979, Mead and O'Connor 1980). However, as extensive beached bird survey data are only available for the months of September, November, January, February and march, the comparisons presented here are restricted to seasonal variation within winters.

Both methods show that the percentage oiled increases over the winter (Figure 2). Species differences were removed by calculating normal deviates as outlined above. The slope of the regression of normal deviates from the mean percentage oiled against month was steeper for the beached bird survey than for ringing recoveries ($t_{35}= 2.053$, $P<0.05$), but both slopes were significantly greater than zero (beached bird survey $t_{23}= 8.488$, $P<0.001$; ringing recoveries $t_{23}= 2.289$, $P<0.05$) (Figure 3). The correlation between normal deviates from the mean percentage oiled from the two methods was not significant ($r_{23}= 0.378$).

Correlations between the percentage oiled from the two methods for individual species suggest good agreement for Shag, Eider and Guillemot, poor agreement for Gannet and no agreement for Cormorant (Table 3). None of these correlations is significant, but the sample size is only five months. As some of the ringing recovery samples are small the poor correlations could be due to individual data points having wide confidence intervals. Analysis of 3 way contingency tables indicated that only for Cormorant did the relationship between oiling and season depend on method (Table 3). For this species

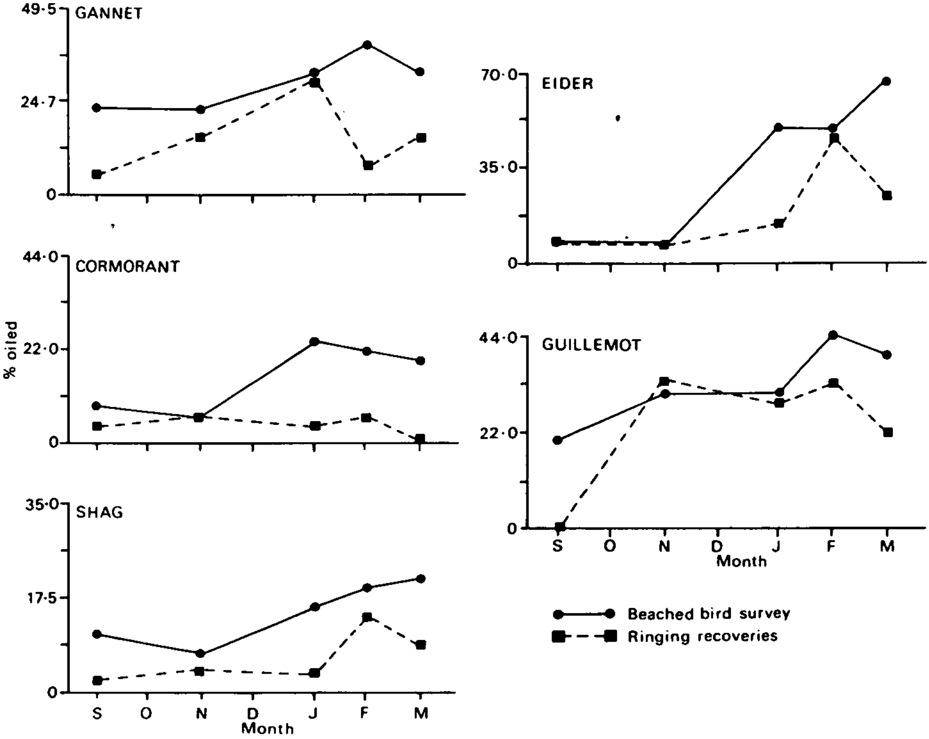

Figure 2. Seasonal variation in the percentage oiled from ringing recoveries and beached bird surveys.

ringing recoveries show no difference in the percentage oiled between September/November and January — March (6.0% v 4.8%; x^2_1= 0.109 NS) whereas the beached bird survey shows a marked increase (7.3% v 21.6%; x^2_1= 38.079, $P < 0.001$).

If Cormorant is excluided from the analysis the correlation between normal deviates from the mean percentage oiled from the two methods becomes significant (r_{18}= 0.594, $P < 0.01$). The slopes of the regression of mean percentage oiled against month become 0.370 for the beached bird survey and 0.283 for ringing recoveries, and are no longer significantly different (t_{30}= 1.035).

Annual differences

This section excludes Gannet since there are not enough recoveries of this species to calculate the percentage oiled for each winter. There is no significant correlation between annual percentages oiled from the two methods for any of the four species. However, a three way G test revealed a significant difference between the two methods only for Shag (Table 4). Neither method showed a significant trend of change in the percentage of corpses oiled for any of the four species, and for no species was there a significant difference between the slopes obtained from the two methods (Table 5).

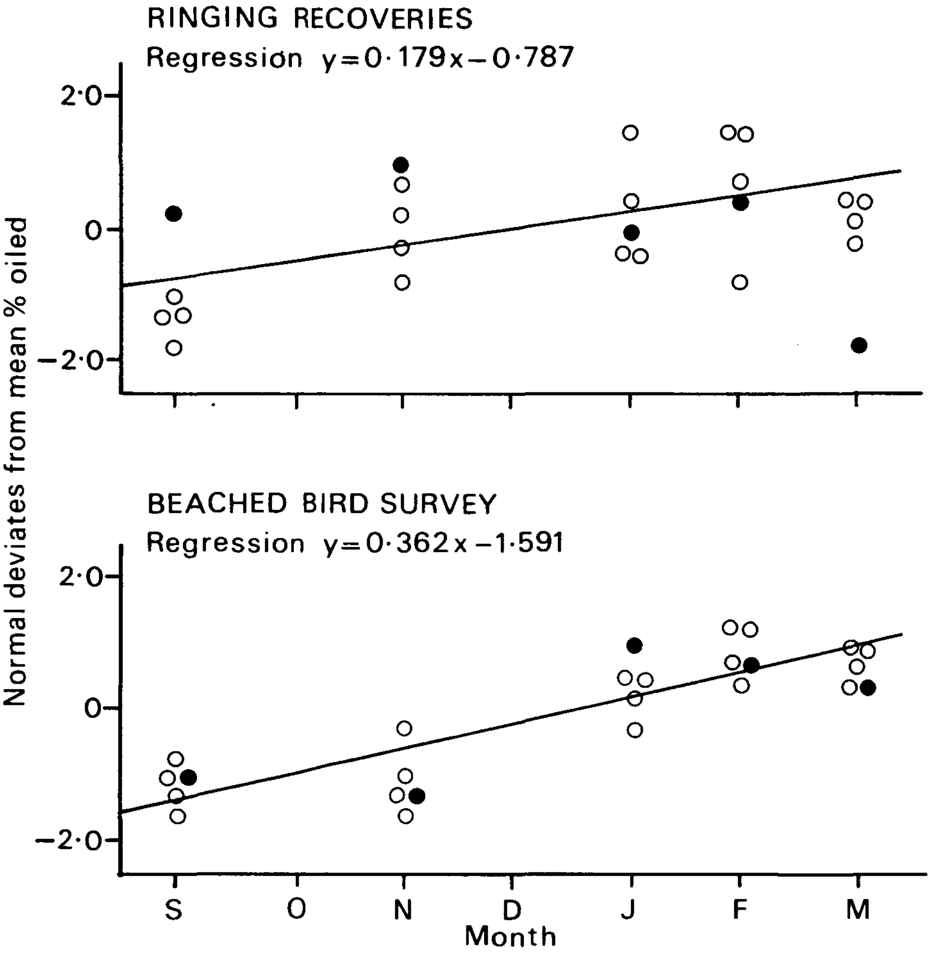

Figure 3. Seasonal variation in the percentage oiled from ringing recoveries and beached bird surveys — data from all species combined. Each point represents one species in one month. Filled circles Cormorant. Open circles other species. The data were normalised using the arcsine transformation before means and normal deviates were calculated. For further details see text.

Differences in the percentage oiled between years were examined by constructing two by nine contingency tables of oiled or not oiled by years. Significant annual differences were detected for all four species using the beached bird survey data, but only for Shag and Eider using the ringing recovery data. Thus ringing recovery data may be useful for detecting long term trends, but sample sizes are often too small to examine levels of oiling in individual years. An exception to this was the winter of 1980/81 when extensive oil pollution resulted in a threefold increase in the recovery rate of Guillemots (Baillie and Mead 1982).

TABLE 4. RELATIONSHIP IN ANNUAL VARIATION IN THE PERCENTAGE OILED BETWEEN RINGING RECOVERIES AND BEACHED BIRD SURVEYS.

	Correlation coefficient (n = 9) 1971-1979	*G. for 3 way contingency table 1*	*Years used in contingency table 2*
Cormorant	— 0.141 NS	3.037 NS	72,75,76,77
Shag	0.264 NS	19.884 *	71-79
Eider	0.576 NS	1.803 NS	71,73,76,77,79
Guillemot	0.142 NS	8.027 NS	72-79

1. Contingency table with oiled, not oiled; ringing, beached bird survey; and years. G is for a test for three way interactions i.e. that the relationship between oiling and year depends on method.
2. Years with small expected values were omitted.

Years run from September to April i.e. 71 means September 1971 to April 1972.

TABLE 5. REGRESSION OF PERCENTAGE OILED AGAINST YEAR.

	Ringing Recoveries Slope ± SE	*Beached Bird Survey Slope ± SE*
Cormorant	0.25 ± 0.76	— 0.98 ± 0.56
Shag	1.13 ± 0.61	1.20 ± 0.57
Eider	0.86 ± 1.16	0.24 ± 1.20
Guillemot	3.22 ± 1.79	0.86 ± 0.95

All sample sizes are 9 years

Percentages were normalised using the arcsine transformation before these regressions were calculated.

None of these slopes is significantly different from zero.

DISCUSSION

Ringing recoveries cannot be used to measure the absolute proportion of corpses which are contaminated with oil. However, there is a high degree of consistency in specific and regional variation in the percentage oiled as measured by ringing recoveries and by the beached bird survey. This suggests that ringing recoveries can provide a useful measure of variation in the percentage of corpses which are oiled.

Within winters there is agreement in the seasonal pattern of oiling for four of the five species. The increase in the percentage oiled between early and late winter agrees with more extensive analyses of beached bird survey data, and also with the percentage of beaches contaminated with oil (Stowe 1982). Why this increase in oiling is not shown by the Cormorant ringing recoveries is unclear. Movement to areas where there is less oil pollution does not account for the lack of an increase, as there is no difference in the distribution of Cormorant recoveries between early and late winter. The percentage of Cormorants oiled is the lowest of the five species. The overall percentage of Cormorants recorded by the beached bird survey as oiled is 3.2 times that from ringing recoveries, as opposed to values of 1.4 to 2.3 times for the other species. This suggests that recovery reports of oiling of these dark plumaged birds may be less reliable than for the other species. Ringing recoveries from Cormorants recovered inland, and from birds which were shot but not reported as such, may have contributed to the difference, but are unlikely to have caused most of it.

Ringing recovery samples are rarely large enough to measure differences in the percentage oiled between individual years, but might provide information on long term trends. As none of the data sets presented here shows a significant trend of change with time, it is not possible to assess fully the reliability of trends from ringing recoveries. However there is little evidence of differences between the two methods when the data are analysed on an annual basis.

Our results indicate that ringing recovery data can provide a valid measure of variation in the percentage of corpses which are oiled. Thus when beached bird survey data are not available, analyses of ringing recoveries may provide useful information. However such data are not an adequate substitute for properly organised beached bird surveys.

ACKNOWLEDGEMENTS

We thank the many ringers and participants in beached bird surveys who carried out the fieldwork on which this paper is based. The staff of the B.T.O. ringing office and R.S.P.B. computer department prepared the data for computer analysis. Dr. Raymond O'Connor and Chris Mead made helpful comments on earlier drafts. Stephen Baillie was supported by a grant to the British Trust for Ornithology and Aberdeen University from B.P. Petroleum Development Ltd.

SUMMARY

Data on the percentage of corpses reported as oiled from the beached bird survey and from ringing recoveries were compared for five species — Gannet, Cormorant, Shag, Eider and Guillemot. The percentage oiled from ringing was significantly lower than that from the beached bird survey for all the five species. There were high correlations between the two methods when the data were analysed by species and by regions. Beached bird surveys and ringing recoveries showed an increase in the percentage oiled between early and late winter for four of the five species, but for Cormorants this increase was only shown by the beached bird survey. Ringing recovery samples were rather small for annual comparisons, but there were no differences in the nine year trends shown by the two methods. No significant trends of change could be detected using data from either method.

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Comparative notes on eggs, chick growth and fledging of the Razorbill *Alca torda* in north Norway

Robert T. Barrett

INTRODUCTION

The breeding biology of the Razorbill *Alca torda* has been well described in Britain (e.g. Plumb 1965, Lloyd 1976a, 1979, Hudson 1982), Ireland (Lloyd 1982), Canada (Bédard 1969, Chapdelaine and Laporte 1982), Denmark (Paludan 1947) and Russia (Belopol'skii 1957, Bianki 1967) but little is known of the species in Norway where an estimated 12% of the world's population breeds (Lloyd 1976b). This paper presents data on the timing of breeding, egg size and chick growth of Razorbills at Hornøy, a small island off the north-easternmost tip of Norway (70°22'N, 31°10'E) in 1980-1982.

MATERIAL AND METHODS

Forty three and 49 numbered nest sites with eggs were followed from 13 June until 6 Aug. 1981 and 7 June until 26 July 1982 respectively and their contents were recorded. In 1981 nest sites were visited every 3 days until the chicks were 15-17 d old after which they were visited every day. In 1982 nest sites were visited every 3 d except during the periods of hatching and fledging, i.e. after the chicks were 15-17 d old, when each nest was checked daily. The maximum length and breadth of eggs were measured to the nearest 0.1 mm using vernier calipers and their volumes were calculated using the equation $V=klb^2$ (Coulson 1963) where V=volume cm^3, k=0.54 (Lloyd 1979), l=length cm and b=breadth cm. Chicks were weighed to the nearest 5 g every 3 days until day 15-17 (day of hatching =1) and thereafter every day until fledging. Culmen lengths (from the edge of the feathers to the tip) and tarsus length (in 1982 only) were measured to the nearest 0.5 mm. Wing length (maximum flattened chord) was measured to the nearest 5 mm using a wing rule when downy and to the nearest 1 mm after the eruption of the primary coverts. Adults were weighed to the nearest 10 g. Their culmen, tarsus and wing lengths were measured in the same way as for the chicks while gonys depth was measured to the nearest 0.5 mm.

Hatching dates were categorized into early, middle and late (see Plumb 1965 and Lloyd 1979).

RESULTS

The mean hatching dates on Hornøy were 7 July 1981 (n = 29, St. dev. = 4.7 d, range 29 June — 22 July) and 1 July 1982 (n = 35, St. dev. = 6.8 d, range 18 June — 25 July). On the basis of this data and an incubation period of 35 d (Lloyd 1979) the peak laying period on Hornøy was around the end of May and the beginning of June.

The mean length, breadth and volume of eggs laid on Hornøy were 77.0 ± 2.9 mm, 48.9±1.8 mm and 99.6 ± 7.9 cm^3 (n = 154) respectively. There was no seasonal change in the size of eggs hatching in the period 20 June — 11 July 1982 ($r = 0.08$, $n = 32$, $p > 0.1$), the only year during which such data was collected. Nor was there any difference in the size of eggs laid in 1981 and 1982 ($t = 1.45$, $p > 0.05$, $n = 135$) despite the difference in hatching periods.

Thirty of the 43 (69.8%) eggs regularly checked in 1981 hatched successfully, one chick died while hatching and the remaining 12 disappeared. In 1982 35 of the 49 (71.4%)

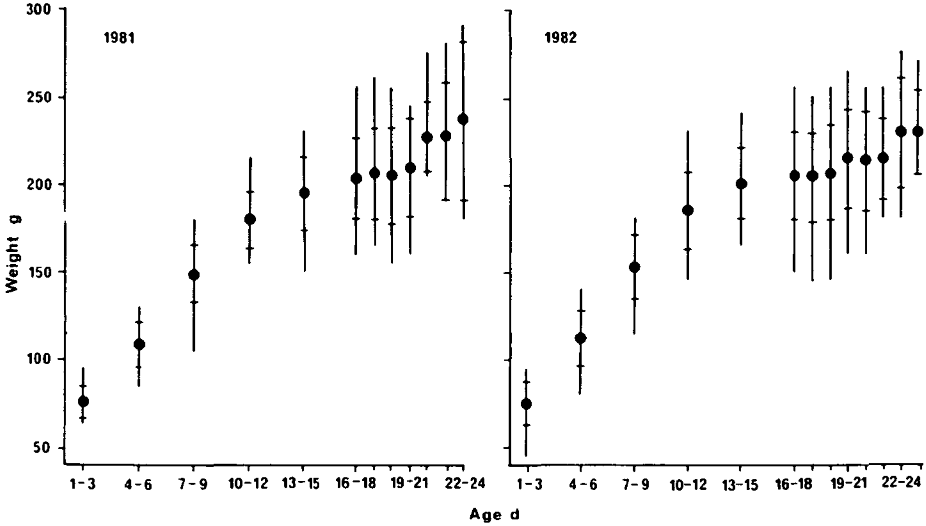

Figure 1. The increase in weight of Razorbill chicks on Hornøy in 1981 (n = 30) and 1982 (n = 30). (mean ± st. dev. and range).

controlled eggs hatched, 1 was addled and the remaining 13 were lost. Regular checks of the nest sites did not start until ca. 10 d after the mean laying date so these figures underestimate egg loss, perhaps by as much as a factor of two (Lloyd 1979).

Four lost eggs were replaced. The mean interval between loss and replacement was 14.2±2.9 d (range 12-18 d), a result consistent with the literature, e.g. Kartaschew (1960) 12-18 d, Plumb (1965) 13-18 d or Lloyd (1979) 14.1±1.5 d. Two of these were later lost and two were still being incubated at the end of the field season. Two were smaller (2.4% and 3.2%) in volume and 1 was 1.0% larger than the first eggs laid. The fourth pair was not measured.

All 30 chicks which hatched in 1981 fledged (i.e. were found missing at an age and/or stage of development at which they would be expected to have fledged) and 31 out of 35 (88.6%) chicks fledged in 1982. The loss of the four chicks occurred within 2 d of hatching. The overall fledging success (chicks fledged/chicks hatched) in 1981 and 1982 was thus 94%.

The growth of chicks was very similar in both years (e.g. weight Fig. 1) and the growth of their wing, bill and tarsus are illustrated for 1982 only in Fig 2. There was a positive correlation between the volume of eggs and the weight of chicks up to 6 d old (1-3 d, $r=0.60$, $p<0.001$, $n=29$; 4-6 d, $r=0.39$ $p<0.05$, $n=30$) but not afterwards. Chicks reached a mean peak weight of 220.2±29.9g (n=53), and most (83%) chicks lost weight at an average rate of 5.5 g/d during the last 3 d before fledging. The remaining 17% reached a peak weight of 223.1±24.8 g (n=11).

Chicks fledged at mean ages of 21±1.7 d in 1981 and 23±3.1 d in 1982. The difference is significant (Table 1). In 1982 the age at fledging was independent of the date of hatching ($r=0.26$, $t=1.21$, $p>0.1$). There was no significant difference between the mean weights or bill lengths of the chicks the day before fledging in 1981 and 1982 although the difference

TABLE 1. AGE, WEIGHT AND MEASUREMENTS OF FLEDGING RAZORBILL CHICKS ON HORNØY, ($\bar{x}$ = MEAN, N = SAMPLE SIZE).

		Age *d*	*Weight* *g*	*Wing* *mm*	*Culmen* *mm*
1981	$\bar{x}$	21.4	201.7	85.5	19.0
	St. Dev.	1.7	30.3	6.3	0.8
	n	30	30	30	30
1982	$\bar{x}$	23.2	214.1	90.4	19.2
	St. Dev.	3.1	37.3	6.4	1.1
	n	24	23	23	23
	t	2.16	1.35	2.78	0.79
	p	0.05	0.10	0.01	0.10

TABLE 2. WEIGHTS AND MEASUREMENTS OF ADULT RAZORBILLS CAUGHT IN JUNE AND JULY ON HORNØY, (∓ = MEAN, N = SAMPLE SIZE).

	Weight *g*	*Wing* *mm*	*Culmen* *mm*	*Gonys* *mm*	*Tarsus* *mm*
∓	713.6	211.6	34.2	22.9	36.7
St. Dev.	52.3	5.9	1.5	1.3	1.9
n	73	73	74	75	6

in wing lengths was significant (Table 1). The weight of fledging chicks was equivalent to 29% of that of adults weighed on Hornøy while the lengths of their wings, bill and tarsi are equivalent to 41%, 56% and ca. 91% respectively (Table 2).

There was no seasonal change in the weights of chicks either soon after hatching (age 4-6 d, ANOVA, 1981 F=0.2, n=19, 1982 F=1.78, n=29, $p>0.1$) or at fledging (1981 F=1.67, n=20, $p>0.1$).

DISCUSSION

The laying period of Razorbills in East Finnmark was very similar to that reported by Belopol'skii (1957) along the Murmansk coast and by Ingold (1974) in Lofoten, N.W. Norway. Further to the east, in the White Sea, Razorbills lay about 10 days later (Bianki 1967) while further to the south, in Britain (Plumb 1965, Lloyd 1979) and Denmark (Paludan 1947), they lay a week to 10 days earlier. That climatic conditions are an important factor determining the timing of breeding was illustrated on Hornøy in 1981 when a late spring and late-lying snow delayed breeding, not only of Razorbills but also of Kittiwakes *Rissa tridacyla,* Puffins *Fratercula arctica* and Shags *Phalacrocorax aristotelis* (pers. obs.) by ca. 10 d. Similar delays due to bad weather have also been reported in Russia (Belopol 'skii 1957), Britain (Lloyd 1979) and Denmark (Paludan 1947).

The eggs laid on Hornøy were slightly larger than those laid by other northerly populations along the coast of Russia and much larger than eggs laid in Denmark and Britain (Table 3). However, when expressed as a percentage of adult weight, egg weights were constant throughout the geographical range. A seasonal decline in the size of eggs (or clutches) is a common feature of seabird breeding biology (see Nelson 1966, Barth 1968, Coulson et. al. 1969, Parsons 1972, Mills 1979, Runde and Barrett 1981). It may be partly

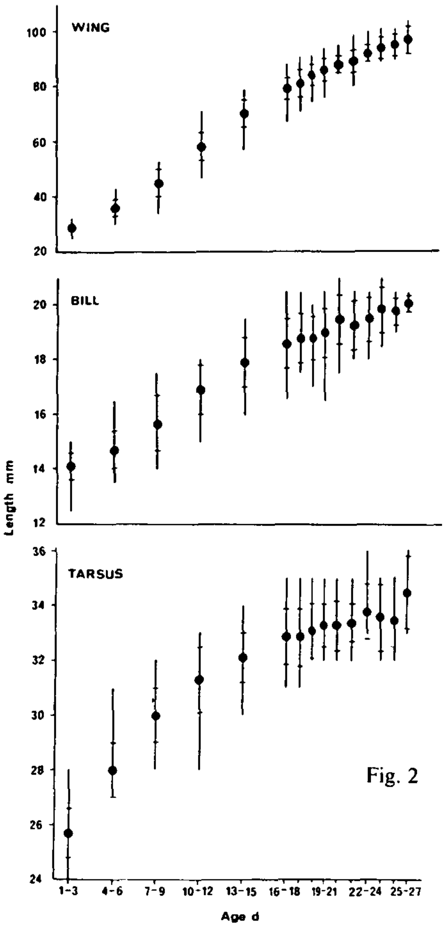

Fig. 2

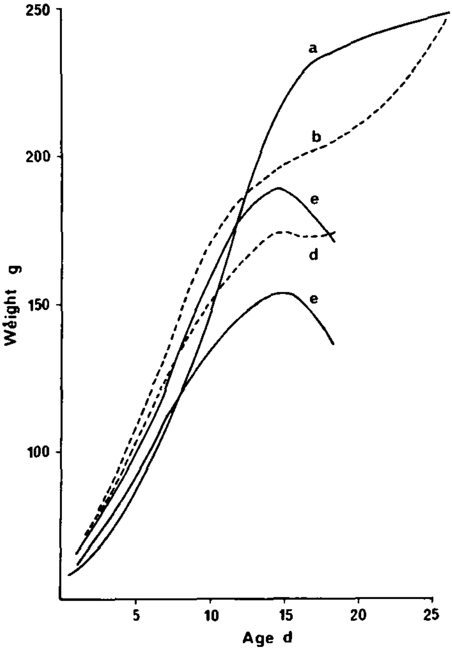

Fig. 3

Figure 2. The growth of wing, bill and tarsus of Razorbill chicks on Hornøy in 1982 (n=30), (mean ± st. dev. and range).

Figure 3. Geographical variation in the growth (weight increase) of Razorbill chicks. a. Murmansk coast (Belopol 'skii 1957), b. Hornøy (present study), c. White Sea (Bianki 1967), d. Britain (Lloyd 1979), e. Gulf of St. Lawrence (Bédard 1969). See Tab. 3 for adult weights.

a result of younger birds laying later in the season e.g. Razorbill (Lloyd 1979). Birkhead and Nettleship (1982) suggest that, irrespective of the age of the female, a reduction in egg size later in the season is an "adaptive response to a seasonal deterioration in environmental conditions", i.e. a decline in food availability. On Hornøy no such seasonal change in egg size was detected, either in the Razorbill or in the Puffin and Kittiwake (pers. obs.). Nor was there any indication that a delay in breeding through late-lying snow (in 1981) resulted in smaller eggs being laid that year (cf. Bianki 1967).

TABLE 3. GEOGRAPHICAL VARIATION IN THE SIZE OF ADULT RAZORBILLS AND THEIR EGGS (FRESH WEIGHT (FW) = $0.554lb^2 - 1.99$ BIRKHEAD AND NETTLESHIP IN PRESS).

Locality	*Ad. wt. (AW) g*	*n*	*Length mm*	*Breadth mm*	*FW g*	*n*	*FW/AW*	*Source*
White Sea	701	50	76.4	48.2	96.3	188	13.7	Bianki 1967
Murmansk Coast	723	221	76.5	48.4	97.3	197	13.5	Bianki 1967
North Norway	714	73	77.0	48.9	100.0	157	14.0	This study
Gulf of St. Lawrence	686	7	74.5	48.5	95.1	100	13.9	Bédard 1969 Johnson 1944
Denmark	—	—	75.0	48.1	94.1	15	—	Paludan 1947
Britain	630	56	73.4	47.2	88.6	543	14.0	Lloyd 1976, 1979
Britain	624	73	73.6	46.6	86.6	16	13.9	Furness 1983

The first few days after hatching are often critical for young seabirds which are totally dependent on their parents for protection and warmth and, in many species, mortality rates of young birds are high (e.g. Kittiwake (Barrett and Runde 1980), Razorbill (Lloyd 1979, this study), Puffin (Nettleship 1972), Brunnich's Guillemot *Uria lomvia* (Gaston and Nettleship 1981)). This study and that of Lloyd (1979) show that the weight of Razorbill chicks is related to egg size during the first week of life such that the advantages of a large egg are obvious. The lack of a seasonal decrease in egg size on Hornøy suggests that food was readily available in at least 1981 and 1982, a suggestion which is strengthened when the growth of chicks on Hornøy is analysed (see below).

The loss of eggs on Hornøy was greater than that recorded in earlier studies. Although the observed hatching success was similar to the usual 70-80% (e.g. Plumb 1965, Bianki 1967, Bédard 1969, Lloyd 1979, Chapdelaine and Laporte 1982) the real figure was almost certainly below this value and probably approached Lloyd's (1982) "low" of 53-59% in Ireland. However a fledging success (chicks fledged/chicks hatched) of 94% is similar to that recorded elsewhere (see Chapdelaine and Laporte 1982 Table 3, Lloyd 1982). Over 90% of the eggs which failed to hatch were probably taken by Herring Gulls *Larus argentatus* which were often seen attempting to take eggs from Razorbills, Guillemots and Kittiwakes. I do not think however that my disturbance of the Razorbills resulted in an unnatural increase in such predation. Gulls were also considered the main cause of egg loss in the White Sea (Bianki 1967) and in Wales (Lloyd 1979, Hudson 1982) where corvids were also a common predator.

Although the final fledging weight of Hornøy chicks in relation to adult weight is similar to that of more southerly populations viz. 25-30% (Paludan 1947, Plumb 1965, Lloyd 1979) their absolute growth rate was greater than previously recorded and reached a peak matched only by Belopol 'skii's (1957) chicks on the Murmansk coast (Fig. 3). In addition the chicks on Hornøy (and the Murmansk coast) stayed on their nests longer (>20 d) than elsewhere (<20 d e.g. Paludan 1947, Bédard 1969, Ingold 1974, Lloyd 1979). Sealy (1973) and Birkhead (1977) believe that the advantages of taking the young to their food source (i.e. precocial and "intermediate" forms of development) outweigh those offered by the protection and safety of the nest and that e.g. Razorbill and Guillemot chicks leave their nests when the cost of feeding them becomes too high. I assume that since Razorbill chicks grew faster, reached higher weights and remained longer on Hornøy (and Murmansk) and since there was no seasonal change in egg size or chick weight there was an abundance of food in the nearby waters. Sand Eels *Ammodytes sp.* and Capelin *Mallotus villosus,* both of high nutritional value (Harris and Hislop 1978, Henderson et. al. in press) were the main diet of seabirds on Hornøy in 1980-1982 (pers. obs.) and Murmansk (Belopol'skii 1957). Both Capelin and Sand Eels spawn along the the coast of N. Norway and personal observations of Puffins returning to Hornøy with living fish indicate that the adults did not need to forage far such that relatively little time and energy were expended during the feeding of the young. Under such conditions it is possible that Razorbill chicks remain longer on their nests and thereby gain the advantages of a slightly larger wing-area: weight ratio (see Birkhead 1977) before they leave the cliff.

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SUMMARY

The results of a study of the breeding biology of Razorbills on Hornøy, N. Norway in 1980-1982 are compared with other studies of the species. That no seasonal decline in the size of eggs or the weight of chicks was detected, that chicks grew rapidly reaching a peak weight of ca. 220 g and that their fledging period was longer than that of chicks at more southerly latitudes all point towards an abundance of food in north Norwegian waters.

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The growth and food of young Gannets *Sula bassana* on Ailsa Craig

S. Wanless

INTRODUCTION

Compared with other sulids, young Gannets *Sula bassana* grow quickly. This has been documented on the Bass Rock, east Scotland (Nelson 1964) and Bonaventure, Canada (Poulin & Moisan 1968) but there is little information on the weight and calorific values of feeds given to young. This paper reports on the growth and food received by young Gannets on Ailsa Craig, west Scotland, from hatching to the time they leave the nest.

Gannets have a single egg clutch, but pairs on the Bass Rock had little apparent difficulty in raising artificially increased broods probably due to very favourable food conditions in the North Sea (Nelson 1964). This experiment was repeated on Ailsa Craig to see if conditions were similarly favourable in south-west Scotland.

METHODS

The study was carried out on Ailsa Craig, Firth of Clyde, Scotland (55°15'N, 05°07'W) between 1974 and 1976. The Gannet population was increasing at 3.4% per annum between 1947 and 1976 and was estimated at 14500 occupied sites in 1975 (Wanless 1979). to the nearest 50 g every 7 days from soon after hatching (day of hatching = Day 1) to approximately Day 60. Bill length (tip of the mandible to the base of the feathers) and wing length (maximum chord) were measured to the nearest mm. A few measurements were obtained from older chicks but after Day 60 the chances became unacceptably high of young jumping from the cliffs and systematic measurements were discontinued. In 1974 and 1976 single extra chicks (1-3 days old and hatched within 36 hours of the recipient chick) were donated to eight and 22 nests repectively. Eight of those pairs of twins were weighed and measured. Ten of the 1976 sets of twins were left completely undisturbed and all observations were made from a distance.

Fish regurgitated by young were collected, weighed to the nearest 10 g and, where not too digested, identified. Their weight was included in the weight of the young. Additional information on fish regurgitated by young was collected by B. Zonfrillo on 13 July 1981 and 4 July 1983.

In 1975 six young which had fallen from their nests were hand-reared. They were aged using the following equation calculated from the 32 young which were regularly measured in the colony

$$\log_e \text{bill length (mm)} = 0.016 \text{ age (days)} + 3.561$$
$$(r = 0.85, P<0.001)$$

They were subsequently weighed and measured daily until they went onto the sea. The daily food intakes (both weight and species of fish) of two of these young were monitored from Day 20 to 82, and Day 37 to 59 respectively. The first young was usually fed until satiated, but I was often unable to obtain enough fish to satisfy the other whose intake was severely limited. The use of growth data from hand-reared animals is often questionable but the chick given food *ad libitum* was caught alive in Morocco five weeks after leaving Ailsa Craig which suggests that development was not impaired by captivity.

The frequency and timing of feeds given to groups of approximately 20 young of known age were recorded during four watches, one each in July and August 1975 and 1976.

Watches started from before light and continued until it was too dark to see the birds clearly. I assumed that no feeds were given in the hours of darkness (2300-0300) when no observations were made. A few chicks could have been fed then, even though birds did not come into the colony in the dark because adults can regurgitate several hours after returning. There was no significant monthly or annual difference, so the data were lumped. One feeding bout included all the times a young pushed its head into the adults bill or throat during a discrete feeding session. This could involve up to 15 food transfers (all normally within one hour of the adults return from the sea).

Disturbance associated with repeated weighings caused some losses of young so data on the length of time the young spent in the nest and the proportion which left successfully were collected at 350 undisturbed nests.

Unless disturbed, young Gannets do not normally move out of the nest until they depart for the sea. Once having departed they do not return, so the period spent in the nest is clearly delimited. Young were considered to have left successfully if they were over 75 days old and were free of down. Departure from the nest is preferred to the term "fledged" since the young glide down to the sea but cannot take off again because of substantial fat reserves and incompletely grown primary feathers. Throughout this paper the term signifcant means statistically significant at the 5% level.

RESULTS

Growth

The normal young spent a mean of 88 days (s.e. 0.3, n = 181) in the nest. There were no significant differences in the growth rates of any of the parameters measured in 1974 or 1976 so the data have been pooled.

Weight

The mean weight of young increased from 193 g (s.e. 33.3, n= 3) on Day 4-6 to 4150 g (s.e. 50.0, n = 2) on Day 61-63. Weight increase was linear during the period Day 4-56 such that

$$\log_e \text{wt (g)} = 0.055 \text{ age (days)} + 5.70 \ (r = 0.91, n = 93, P<0.001).$$

Young reached mean adult weight (3090 g, s.e. 25, n = 118) about Day 40. The rate of increase decreased after Day 56 when the young weighed c. 3800 g (Table 1). Weights for young after Day 60 are mainly the six hand-reared young. There was no significant difference in the growth of these young and those in the colony up to this time and it is assumed that subsequent growth rates were also similar. The age at which young reached maximum weight (mean 4130 g, s.e. 146, n = 5) varied from Day 67 to 75. Between Day 65 and the young going to sea, c. 20 days later, there was a small, although not significant, decrease in weight and the mean weight at leaving was 3850 g (s.e. 183, n = 5).

Bill length

The rate of increase was highest between Day 1-40 and growth was virtually complete by Day 55. Between Day 1-40 the increase in length was linear such that

$$\log_e \text{bill length (mm)} = 0.043 \text{ age (days)} + 2.85 \ (r = 0.94, n = 86, P<0.001).$$

The mean bill length of the captive young did not increase significantly from Day 60 until they left (when the mean length was 96.1 mm (s.e. 0.7)). The mean bill length of other young in juvenile plumage found dead at the base of the ciliffs which had apparently misjudged their descent onto the sea was 94.6 mm (s.e. 0.3, n = 108), significantly shorter than adult bill length (98.4 mm, s.e. 0.2, n = 144).

TABLE 1. MEAN WEIGHTS AND INSTANTANEOUS GROWTH RATES (R) OF YOUNG GANNETS. THE DATA HAVE BEEN COMBINED INTO THREE DAY PERIODS BETWEEN DAY 4-6 AND DAY 64-66.

Age (days)	*Mean weight (g)*	*s.e.*	*R*	*n*
4-6	193	33.3		3
7-9	300	25.2	0.15	3
10-12	366	37.5	0.07	6
13-15	613	16.5	0.17	4
16-18	765	102.8	0.07	4
19-21	1006	111.3	0.09	5
22-24	1158	81.8	0.05	6
25-27	1743	111.0	0.14	8
28-30	1993	61.2	0.04	7
31-33	2529	136.2	0.08	7
34-36	2722	64.1	0.02	9
37-39	3040	51.0	0.04	5
40-42	3000	147.2	-0.004	4
43-45	3260	156.8	0.03	5
46-48	3386	68.8	0.01	7
49-51	3633	147.6	0.02	6
52-54	3500		-0.01	1*
55-57	3794	104.1	0.03	8
58-60	3750	150.0	0	2
61-63	4150	50.0	0.03	2
64-66	3900		-0.02	1*
Mean			0.058 s.e. 0.012	18

Note * Not included in the calculated mean R value.

Wing length

Wing length increased during the time the young were in the nest and primaries were still growing when the young left. The primaries erupted between Day 28-35 when the wing length was 135-150 mm. Increase in wing length was linear from Day 1-64,

$$\log_e \text{wing length (mm)} = 0.057 \text{ age (days)} + 2.99 \ (r = 0.98, n = 76, P<0.001).$$

The increase was also linear for captive young from Day 60 onwards although the rate of increase was less than previously,

$$\log_e \text{wing length (mm)} = 0.016 \text{ age (days)} + 4.77 \ (r = 0.98, n = 81, P<0.001).$$

Their mean wing length at leaving was 425 mm (s.e. 6.0).

Weight and wing lengths of young leaving the nest

The captive young were not confined in any way but when they were c. 85 days old they suddenly refused to stay in one place and constantly moved towards the sea. I took this to

TABLE 2. THE NUMBER OF FEEDS BROUGHT TO YOUNG GANNETS. THE OBSERVATIONS ARE GROUPED INTO TWO-HOURLY INTERVALS. ALL NESTS WERE WATCHED FROM BEFORE DAWN UNTIL AFTER DUSK.

	Age of young (days)			
	1-30	*31-60*	*More than 61*	*Total*
No. of young	*12*	*42*	*36*	*90*
0401-0600 hrs	0	0	2	2
0601-0800 hrs	8	6	2	16
0801-1000 hrs	4	10	10	24
1001-1200 hrs	0	4	8	12
1201-1400 hrs	2	6	6	14
1401-1600 hrs	0	4	2	6
1601-1800 hrs	4	4	6	14
1801-2000 hrs	0	0	4	4
2001-2200 hrs	4	6	4	14
Total	22	40	44	106
Mean feeds/day	1.8	0.9	1.2	1.2

mean that they wanted to leave and allowed them onto the sea. Young accepted food in the days prior to leaving and their weight was relatively stable, although individual weights varied from 3500 to 4200 g, i.e. 113%-135% of mean adult weight. Their primary feathers were still growing at a mean rate of 4 mm/day. Wing length at leaving varied from 405 mm - 440 mm, 82%-89% of mean adult length. One hand-fed young recaptured, still unable to fly, three days after it left, had lost 500 g (12% of its leaving weight) while its wing length had increased by 34 mm (9%). If these changes had continued at the same rate the young would have reached mean adult weight and wing length seven days after leaving the nest. This particular young was, however, very heavy when it left, most young probably reach adult weight after 2-3 days on the sea.

Growth and survival of twins

After twinning there was an immediate check in weight increase such that twins at Day 7-9 weighed 197 g (s.e. 28.5, $n = 3$) significantly less than single young at this age ($t = 2.82$, $P<0.02$) (Figure 1). This difference persisted up to Day 60 after which few weighings were made. Similarly the mean peak weight attained by individual twins (3720 g, s.e. 158) was significantly lower than that of singles (4150 g, s.e. 10, $t = 7.85$, $P<0.001$). There were no significant differences in bill and wing lengths of twins and single young. Survival from Day 1-3 to going to sea for undisturbed young was lower for twins than singles (0.60 and 0.92 respectively). However, pairs with twins still reared more young (1.2 young/pair) than normal pairs (0.92 chicks/pair), but it is not known what effects their slightly lower weight would have on their survival after leaving the nest. Twins also spent longer in the nest, a mean of 92 days compared to 88 days. These differences in survival and time spent in the nest were not statistically significant, probably because the sample size for the undisturbed twins was very small.

The results from Ailsa Craig were basically similar to those from the Bass Rock (Nelson 1964). Single young grew at the same rate at both colonies, twins survived less well, stayed

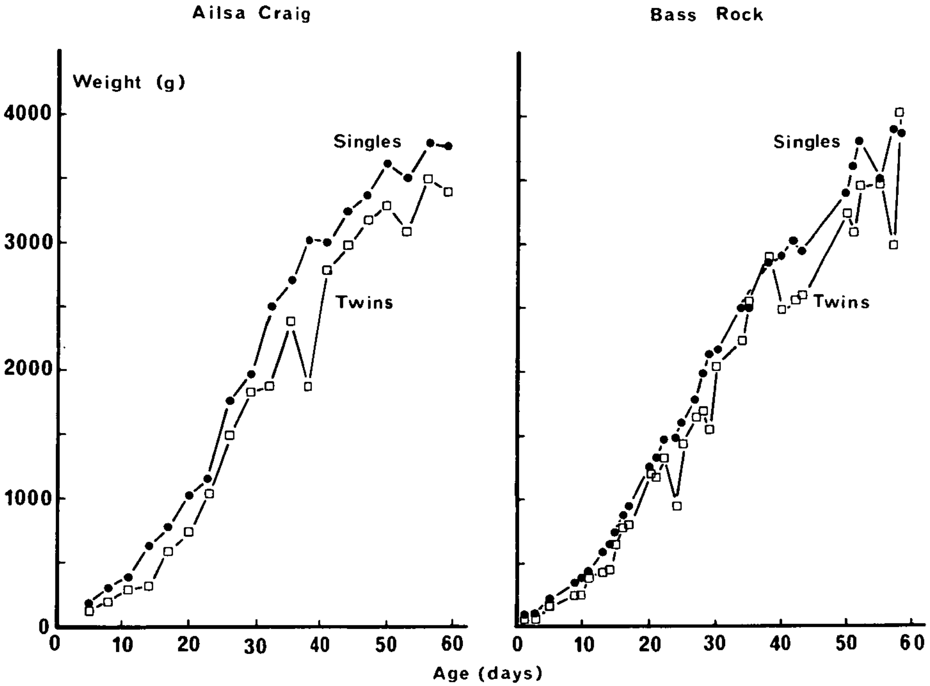

Figure 1. The growth of single chicks and twins from hatching to Day 60 on Ailsa Craig and the Bass Rock. The points for Ailsa Craig twins are based on 16 chicks although not all young were weighed every day. Sample sizes for single chicks are given in Table 1. Data for the Bass Rock are from Nelson (1978.)

longer in the nest and had a similar pattern of growth to single young although their growth rate was slightly retarded. Growth of twins compared to single young (as measured by the area of the growth curves on a linear scale) was 13% lower on Ailsa Craig compared to 9% on the Bass Rock (Figure 1). However, about half the difference between the two colonies was made up by one point for Ailsa Craig on Day 38 when only two young were measured, one of which was very light. On Ailsa Craig the mean weight for twins never exceeded that of singletons of the same age whereas it did so on the Bass Rock. The above results are insufficient to decide whether there were any real differences between the colonies.

Timing and frequency of feeds given to single young

No young was fed until at least 30 min after it was light enough for me to see clearly, and the majority not for a further 60 min. Then there was a peak of feeding with 40 of 106 feeds (38%) occurring between 0601-1000 hrs (Table 2). Feeding continued, but at a slower rate, during daylight in contrast to the Bass Rock and Bempton (North Humberside) where 40% and 48% respectively of feeds were given between 1400-2000 hrs (Nelson 1978, pers.obs.).

TABLE 3. PERCENTAGES BY NUMBER AND WEIGHT OF FISH REGURGITATED BY YOUNG GANNETS ON AILSA CRAIG. DATA FOR 1981 AND 1983 ARE FROM B. ZONFRILLO (pers. comm.).

			Sandeel sp.		*Mackerel*		*Herring or sprat*		*Other species*[2]	
	Number	*Weight*[1] *(g)*	*% (No.)*	*% (Wt.)*	*% (No.)*	*% (Wt.)*	*% (No.)*	*% (Wt.)*	*% (No.)*	*% (Wt.)*
1975	191	20854	0	0	56.0	71.7	5.2	1.1	38.8	27.2
1976	99	14332	0	0	65.7	69.5	0	0	34.3	30.5
1981	150	—	6	—	84.0	—	9.0	—	1.0	—
1983	170	—	76.5	—	11.8	—	11.2	—	0.6	—

Note

[1] Not collected in 1981 and 1983

[2] Other species identified were — 1975, Pollack (58), Cod *Gadus morhua* (1), Wrasse sp. *Labrus* sp. (5) and Saithe (1); 1976, Pollack (21), Saithe (6), Whiting *Merlangius merlangus* (6) and Wrasse sp. (1); 1981, Salmon *Salmo salar* (1) and Common Eel *Anguilla anguilla* (1) and 1983, Saithe (1). In 1975 there were also some completely unidentifiable regurgitations.

Young received an average of 1.2 feeds (range 0-3) each day. This compares with 2.4 and 2.3 feeds/day at Bass Rock and Bempton (Nelson 1978, pers. obs.). The frequency of feeds varied slightly with the age of the chick. Young between Day 1 and 30 received an average of 1.8 feeds/day, whilst between Day 31 and 60 and Day 61 onwards they received 0.9 and 1.2 feeds/day respectively. Young were fed right up to fledging.

The food of young Gannets

Although Mackerel *Scomber scombrus* formed the bulk of the diet in 1975-76 and 1979-82 (Table 3 and B. Zonfrillo pers. comm.), the proportion was reduced to 11% (by number) in 1983 and there was a large increase in the proportion of sandeels *Ammodytes* spp. These fish were not recorded in 1975 and 1976, 9 specimens (6% by number) were identified in 1981 but in 1983 they formed 76% of the diet. In 1975-76 other fish, apparently mainly Pollack *Pollachius pollachius* with possibly a few Saithe *Pollachius virens*, formed c. 30% of both the number and weight of regurgitations but these species were almost entirely absent in 1981 and 1983.

Food intake and growth

Growth of the captive young given unlimited food was not significantly different from young in the colony up to Day 66 and the few comparable later weighings suggested that growth remained similar. The daily intake of food varied considerably during development (Figure 2). At Day 20 the young consumed 110 g of fish/day, subsequently its intake increased to over 800 g/day by Day 47. Over this period there was the following positive relationship between food intake and chick weight,

$$\text{weight of young}^{0\cdot 75}\ (\text{g}) = 0.30\ \text{food intake (g)} + 110.85\ (r = 0.92,\ n = 28,\ P<0.001).$$

The young consumed 13130 g of fish and increased in weight from 650 g to 3010 g. The mean daily food intake of 486 g and growth of 87 g/day suggests a conversion rate of 18%. After Day 47 the growth rate decreased to 70 g/day and food consumption remained high at a mean daily intake of 552 g (s.e. 43.1). Between Day 62 and going onto the sea 20 days later, its weight was relatively steady varying between 3950-4400 g, and its daily food intake decreased significantly ($t = 4.27$, $P<0.001$) to 332 g (s.e. 28.2).

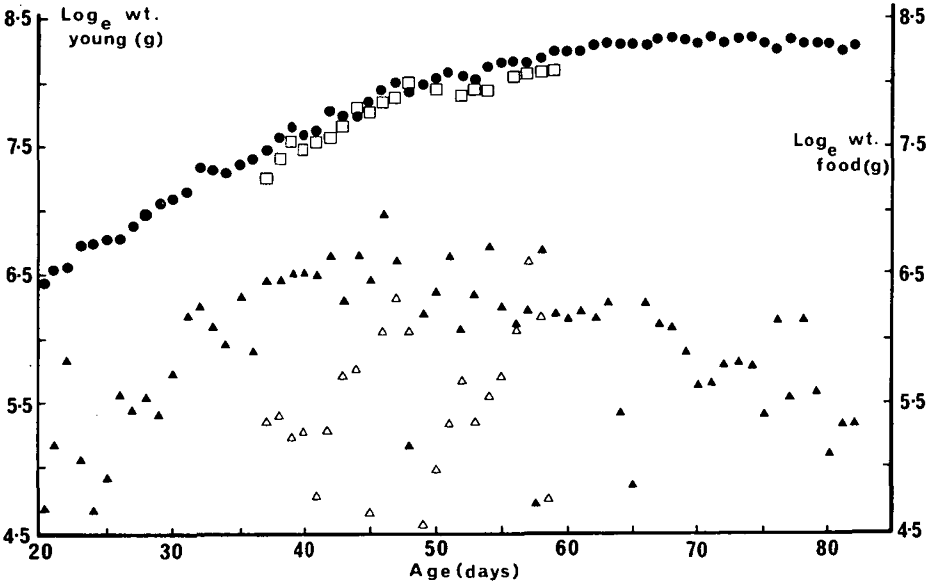

Figure 2. Weight increase and daily food intake of a young Gannet given food *ad libitum* between Day 20-82 and a chick on a limited intake between Day 37-59. Points for weight increase are indicated by ● young food *ad libitum* and ☐ young unlimited food, and daily food intake by △ young *ad libitum* and ▲ young unlimited food. The young on a limited food intake was not weighed on Day 49, 51, or 55.

Mackerel flesh has two to three times the energy value of most other white fish (Murray and Burt 1969; Hardy and Keay 1972). Thus, there can be large differences in the calorific values of feeds of the same weight. In 1975-76 wild young received mainly Mackerel and the bulk of the captive young's diet was also locally caught Mackerel. Between Day 20 and 47 the mean daily energy intake increased from 0.37 KJ to 6.00 KJ, from Day 47-62 the mean daily intake was 4.34 KJ (s.e. 0.32) falling to 2.86 KJ (s.e. 0.27) between Day 62 and the young going to sea.

The growth rate of the young hand-reared on limited food was similar to that of the young given unlimited food over the period it was followed (Figure 2). It increased in weight from 1450 g to 3400 g (mean daily increase 89g) and received 6850 g of food (mean daily intake 311 g). This was a conversion rate of 29%. The young given food *ad libitum* increased from 1800 g to 3900 g (95 g/day) and received 14750 g of food (670 g/day) a conversion rate of 14%. The first young appeared not to utilise all the food it consumed. A maximum conversion rate of c. 30% has also been estimated for wild Puffins *Fratercula arctica* and Guillemots *Uria aalge* (M. P. Harris pers. comm., Birkhead 1976). It was difficult to calculate the food intake of wild young since most fish regurgitated were partly digested. The heaviest regurgitations (commonly 300-400 g, maximum 540 g) came from young 35-42 days old. These values are similar to those for the Cape Gannet *Sula capensis* (Rand 1959).

DISCUSSION

Wild young Gannets on Ailsa Craig received an average of 1.2 feeds/day. The heaviest loads fed to young were 540 g i.e. an estimated maximum daily intake of 650 g. The energy value of this could vary from 2.2 KJ to 5.7 KJ depending on whether Pollack or Mackerel was fed. A captive young given food *ad libitum* sometimes took 50% more than this maximum with no detectable effect on its growth rate. Conversely another captive young which received much less food than young in the colony also grew normally. However, this reduced food intake occurred over a relatively short period and its growth rate might have been affected if the food shortage had continued for longer, or its development might have been impaired in some less obvious way. Young Gannets apparently eat as much as they are given, even if they do not utilise it, perhaps as a safeguard aginst future food shortage. Young Puffins show similar behaviour (Harris in press), so care must be taken in extrapolating natural levels of food consumption using captive birds (even if they are known to survive after release). Given unlimited food a young Gannet consumed 34 kg of fish between Day 20 and 82. Prior to this it had probably consumed c. 1 kg. However wild young received slightly less food so a young Gannet probably consumed c. 30 kg of fish before it left the colony. In 1975 there were c. 8600 young Gannets on Ailsa Craig and the adults must have brought c. 260 tonnes of fish ashore to the colony during the season.

Nelson (1978) considered that Gannets on the Bass Rock in 1962-63 were enjoying very favourable feeding conditions. Most of my results indicated that the situation was similarly favourable on Ailsa Craig 1974-76. First, growth rates and the time spent in the nest by single young and twins were similar at the two colonies. Second, there was no significant difference between rates of growth on Ailsa Craig in 1974, 1976 or 1982 (S. Murray, pers. comm.). Third, the weight increase of a captive young Gannet given food *ad libitum* was very similar to that of wild young. Harris (1978) showed that the growth rates of young Puffins on St Kilda, where they appeared to be short of food, could be substantially increased by giving additional food. Fourth, some Gannets on Ailsa Craig were able to rear twins. Fifth, the estimated daily intake was 400-600 g/day and normal growth could be sustained for at least 20 days by a captive young receiving substantially less than this. Against this, survival of twins from Day 1-3 to leaving the nest was lower on Ailsa Craig, the mean weight of twins at any age never exceeded that of singletons, and the feeding rate was 25% lower. The latter need not, however, indicate a lower daily calorific intake. Comparison of the actual calorific intakes of chicks in the two colonies would need more detailed work. However, the strongest evidence that conditions were favourable for Gannets on Ailsa Craig is the continuing increase in the population. The most recent count 20843 occupied sites (Murray and Wanless 1983) indicates a mean rate of increase of 4.5% per annum since 1976.

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My thanks are due to many people who helped in the field and to the Marquess of Ailsa for permission to work on the island. Dr M. P. Harris and Dr J. B. Nelson improved the manscript. The work was undertaken whilst in receipt of a N.E.R.C studentship.

SUMMARY

The growth and food of young Gannets was studied on Ailsa Craig between 1974 and 1976. Additional data on food are available for 1979-83. Young Gannets had a mean weight of 193 g on Day 4-6 and their increase in weight was linear until Day 56. They reached adult weight c. Day 40 and maximum weight between Day 67 and 75. Mean weight at leaving (of captive young) was 3850 g.

Artificial twins survived less well, spent longer in the nest and showed retarded weight increase compared to single young, but pairs with twins still reared more young than normal pairs.

Mackerel formed the bulk of the diet in 1975, 1976 and 1979-82 but in 1983 sandeels were the dominant species. The intake of a captive young given food *ad libitum* increased from 110 g of fish/day at Day 20 to over 800 g/day by Day 47. Between Day 47 and 62 its growth rate decreased but food consuption remained high, after Day 62 its weight stayed relatively constant but its food intake decreased significantly.

The growth rate between Day 37 to 59 of a captive young receiving limited food was similar to that of the chick on an unlimited diet. The latter apparently did not utilise all the food it consumed.

Wild Gannets received an average of 1.2 feeds/day and a maximum daily intake of 650 g which contained 2.2 KJ to 5.7 KJ of energy depending on whether Pollack or Mackerel was fed. A young Gannet probably consumes c. 30 kg of fish between hatching and leaving the colony.

Feeding conditions for Gannets on Ailsa Craig in the mid 1970s were extremely good.

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Leg injuries in small Petrels

J. A. Love

Both Storm Petrels *Hydrobates pelagicus* and Leach's Petrels *Oceanodroma leucorrhoa* are occasionally found to suffer minor injuries to a leg or foot. The data presented here were gathered during ringing operations on North Rona from 1971 to 1974 (Love 1978) and (with A. R. Mainwood) on Foula and the Summer Isles in 1974 and 1976. All birds of both species were examined and 'processed' by J. A. Love.

TYPES OF INJURY

The most frequent injury encountered was a missing foot, leg or part of leg. Amongst the 58 petrels classed as 'injured' 38 (or 66%) displayed this type of damage. A further 8 (14%) were missing one or two toes on a foot. Two petrels had broken toes and another two had healed fractures of the tarsus: a fifth petrel had what appeared to be a deformed foot. In seven other individuals I had omitted at the time to specify in my notes the nature of the injuries. Threlfall (1974) has illustrated various injuries typical of Leach's Petrels.

INCIDENCE OF INJURIES

Reviewing the situation reported by other authors the proportion of petrels with injuries varies somewhat from colony to colony (Table 1). Also it would seem that Storm Petrels are less prone to injury than Leach's. But the data must be treated with caution. Some observers for instance, may differ in their assessment of what comprises an injury, whilst others may be less scrupulous in recording the incidence, especially when large catches of petrels are being dealt with. The abundant data quoted by Scott (1970) was collected on Skokholm over twenty years by many different people and must surely underestimate the frequency of injury. The proportion of young non-breeding birds in the catch may be important too, since it is not unreasonable that older birds have experienced more opportunities for injury in their lifetime. Such factors may explain the widely differing incidence of injury amongst Leach's Petrels caught in Newfoundland (Threlfall 1974) and Maine (Morse and Bucheister 1977). Even the same observer may be inconsistent. The low incidence of injuries in Storm Petrels on the Summer Isles (compared with my catches on North Rona and Foula) may be due to my missing some

TABLE 1. THE INCIDENCE OF LEG INJURIES TO SMALL PETRELS FROM DIFFERENT COLONIES

Place	*Time of year*	*Leach's Petrel*		*Storm Petrel*		*Source*
		sample	*% injured*	*sample*	*% injured*	
North Rona	late June, July 71-74	1140	2.0	622	1.3	this study
Foula	end July, early Aug 74	41	2.4	654	1.4	this study
Summer Isles	mid-Aug 76	—	—	2742	0.7	this study
St Kilda	May to Aug 61-62	97	2.0	85	0	Waters 1964
Skokholm	all season, mostly July	—	—	10,189	0.4	Scott 1970
Faroe	July 1968	400	3.0	847	2.3	Lovegrove 1968
Newfoundland	all season? 1970	913	5.0	—	—	Threlfall 1974
Newfoundland	all season? 1973	259	4.6	—	—	Threlfall 1974
Maine	all season 1963-76	1254	0.6	—	—	Morse and Bucheister 1977

amongst the large catches made on the Summer Isles, when I had less opportunity to examine critically each bird during times of rush catches in the nets. Indeed I detected more birds (32) with injuries to the right leg (being the one to which I applied the ring) than with injuries to the left leg (17 birds). Furthermore the Summer Isles catches, having been made in mid-summer, may have included more non-breeding young birds.

CAUSES OF INJURY

A Storm Petrel found to have a deformed foot may have had a congenital lesion as was postulated by Waters (1964) for a Leach's Petrel on St Kilda. Injuries to toes and webs could have resulted from disease: one each of Storm and Leach's Petrels from North Rona was found to have blisters on the webs of a foot, typical of Puffinosis. Stewart Murray (personal communication) has encountered a similar affliction in four Storm Petrels from St Kilda, and one other from North Rona.

Threlfall (1974) favoured the view that gulls and Puffins could inflict injury, while Harrison (1955) has added predatory fish such as mackerel. Since feeding petrels habitually patter their feet at the sea surface, they may invite foot damage from small fish, or even death from larger ones. Ritchie (1955) witnessed a shark capturing a Wilson's Petrel *Oceanites oceanicus* as it pattered along the surface of the sea. Differences in such feeding methods could account for the Leach's Petrel seemingly being more susceptible to injury than Storm Petrels.

EFFECTS OF INJURY

Body weights of injured petrels were found to be no different from uninjured ones (Table 2), a situation noted by Lovegrove (1968) amongst his Faroe catches. On Skokholm Scott (1970) retrapped six Storm Petrels, each missing a leg, up to three years after their having been ringed. Allen (1962) and Harris (1969) were able to show that leg injuries did not appreciably impair the breeding success of the Madeiran Petrel *Oceanodroma castro*. Thus it would appear, during the breeding season at least, that injured petrels are not disadvantaged. (However only those birds which have survived the injury are caught, thus it is not surprising that disadvantages of the injury are difficult to determine).

Just prior to their departure from northern waters to spend the winter far to the south, Leach's Petrels may be blown inland or washed ashore exhausted during unusually severe autumn gales. Two large scale 'wrecks' occurred in 1891 and in 1952 (Boyd 1954). There would appear to have been an abnormally high incidence of leg/foot injuries amongst the

TABLE 2. BODY WEIGHTS OF INJURED LEACH'S AND STORM PETRELS COMPARED WITH UNINJURED BIRDS (ALL DATA COLLECTED BY AUTHOR).

Place		*Mean body weight (g)*		*± st. dev. (sample size)*	
		Leach's Petrel		*Storm Petrel*	
North Rona	injured	46.8 ± 5.1	(12)	27.0 ± 1.4	(7)
	uninjured	47.1 ± 3.4	(252)	26.5 ± 2.5	(77)
Foula	injured	47.0	(1)	24.1 ± 0.9	(9)
	uninjured	43.8 ± 3.8	(45)	25.2 ± 2.9	(620)
Summer Isles	injured	—		25.0 ± 1.5	(15)
	uninjured	—		24.7 ± 1.8	(453)

casualties. Wynne-Edwards (1954) noted seven of 27 Leach's Petrels found in Ireland in 1891 to have been injured whilst Harrison (1955) encountered six amongst 25 birds wrecked in 1952. Together these amounted to 24% of the sample compared to 0.6 to 5% incidence at breeding colonies (Table 1). This difference is statistically significant ($x^2 = 549.6$; $p < 0.001$). Storm-wrecked specimens can of course be subjected to a more thorough inspection in the hand than mist-netted birds. In addition, prior to their demise and in such a weakened or disadvantaged state, storm-wrecked birds were seen to have been attacked by gulls. However it could be that, since their feet are used to manoeuvre in flight, those birds with major injuries might suffer some disadvantage causing them to be more easily driven ashore in bad weather.

SUMMARY

The type and incidence of foot injuries of Storm and Leach's Petrels from mist net catches at various colonies are discussed, and possible causes for the injuries are reviewed. Such injuries may not disadvantage birds during breeding but may render them more susceptible to 'wrecking' during autumn gales.

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Abnormalities and diseases of the feet of Storm Petrels

Stuart Murray

In 1975-78, 1681 Storm Petrels and 220 Leach's Petrels were caught on St Kilda, Outer Hebrides. No detailed records were kept but it was noted that some had injured feet. The commonest injuries were torn webs of the foot, and part of the foot, including a toe, missing. Rarely a foot, or even an entire leg was missing. One Storm Petrel had a withered foot. Otherwise all the injured birds appeared healthy and the deformities were assumed to be mechanical rather than due to disease. The situation was different in 1979 when four out of 910 Storm Petrels examined between 23 July and 16 August each had one apparently diseased foot. In the first bird the webs of the foot were split and bleeding and the ankle was swollen.The second bird had separate 'tight' blisters on the upper side of each web which burst when lightly touched; the foot was neither discoloured nor bleeding. The third bird had a whole foot discoloured, spongy and peeling; there were no blisters but the foot was bleeding near the toes. In the last, the foot was swollen, soft and festering.

Waters (1964, *Scottish Birds* 3: 73-81) described three 'injured' Leach's Petrels among 97 caught on St Kilda. One had an atrophied foot, one a leg missing from the upper end of the tarsus and one an opaque eye. When the latter bird had originally been caught at the same site three years earlier eye damage had not been observed. J. Love (pers. comm.) noted damage to the webs and feet of a combined total of 5145 Storm and Leach's Petrels at North Rona, Foula and the Summer Isles, between 1971 and 1976; he suggested that disease may have been responsible for some of the injuries, noting blisters on the web of one foot of one bird of each species.

In 1980, 909 Storm Petrels were caught on St Kilda. These were not examined critically for foot damage but abnormal birds were not noticed. One Storm Petrel among 30 Storm Petrels and 17 Leach's Petrels caught on North Rona in June 1980 had a swollen ankle. The swelling was very obvious and was carefully examined, but did not appear to be the result of a break or dislocation. The skin around the joint was unbroken, and the webs of both feet intact, with no sign of blistering.

The above conditions may be caused by a disease similar or related to the disease, puffinosis, which affects Manx Shearwaters breeding on Skomer and Skokholm Islands (Dane, 1948, *J. Anim. Ecol*, 17: 158-164). Puffinosis-like diseases have been recorded at several Scottish seabird colonies. Davis (1966, *British Birds* 59: 84-85) observed affected juvenile Great Black-backed and Herring Gulls and possibly nestling Shags on Fair Isle each year of 1957-63. It has also been described affecting Fulmars: on North Ronaldsay at least 7 of 68 affected young died after becoming blind and on Fair Isle a few older birds had blistered webs (Macdonald *et al.*, 1967, *British Birds* 60: 356-360). Other species found with similar blistering of the feet include juvenile Black-headed and first year Common Gulls (Jennings & Sonlsby, 1958, *Ibis* 100: 305-312).

The clinical signs of puffinosis in Manx Shearwaters vary with the severity of the disease, the commonest being blistering of the webs of the feet, although conjunctivitis and paralysis of the legs, have also been observed. The disease causes annual and severe mortality of fledgling Manx Shearwaters on Skomer and Skokholm Islands (Dane *et al.*, 1953, *J. Anim. Ecol.* 22: 123-133) but has rarely been found in adults (P. Nuttall pers. comm.). A total of 10,189 Storm Petrels on Skokholm were examined for injuries: 41 had major leg or foot damage but none had blisters on the webs, (Scott, D. Phil. thesis, Oxford 1970). At present the relationship between puffinosis of Manx Shearwaters and the puffinosis-like diseases described above is not known.

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A case of extreme feather abrasion and moult in immature Little Gull (*L. minutus*)

A. Paterson

A flock of first year Little Gulls, up to sixty strong, summer in the area of the Rio Guadalhorce between Torremolinos and Malaga. These birds arrive in late March and early April and at this time many exhibit very visible abrasion of the primary wing feathers and to a lesser extent on the tail. The extent of the flight feather abrasion is at times such that it causes the flight to be laboured.

Abrasion, together with moult, continues as birds remain in the area throughout May and June. Abrasion may be accelerated as the Rio Guadalhorce is heavily polluted by, amongst others, chemical effluent from an ammonia factory.

On 20th June, 1982, one such immature was found in a totally flightless state and the following notes made.

Superficially the bird appeared in reasonable physical condition with no apparent emaciation nor parasitic infestation.

Wings: primaries:- 1 - 6 only present in each wing and these were considerably worn, having only about 50% of the normal surface area. The other primaries were totally absent and there was no sign of pin.

secondaries:- all in a very advanced state of abrasion and showing only the shaft and the terminal dark tip, itself rather reduced in size.

coverts:- some signs of moult and feather tips heavily abraded.

tail:- totally abraded with only shafts showing for ⅔ of length with innermost pair moulted or lost but no new growth in pin.

head and body:- some moult in progress and apparently only just under way on head and back. Heavy wear of feathers on head.

DISCUSSION

This is the most extreme example of feather abrasion noted in the summering flock of Little Gulls seen to date. Although extreme feather abrasion is common, notably of the flight feathers and tail, this is the first instance of a bird being rendered flightless and yet showing no new feather growth. The possibility that extreme chemical pollution may exacerbate the abrasion is noted but not proven.

Andrew Paterson Edificio San Gabriel, 2-4°-A, c/ Escritor Adolfo Reyes, Torremolinos, Malaga, ESPAÑA.

BOOK REVIEWS

GOULD, P. J., FORSELL, D. J. and LENSINK, C. J. 1982. Pelagic distribution and abundance of seabirds in the Gulf of Alaska and Eastern Bering Sea. 38p text, 197 maps and 4 appendices. Biological Service Program of the Fish and Wildlife Service, U.S. Dept. of the Interior. Available from: Dr. P. J. Gould, U.S. Fish and Wildlife Service, 1011 East Tudor Road, Anchorage, Alaska 99507, U.S.A.

The pace of research on seabirds at sea has accelerated considerably over the past decade; there has though been very little actually published on the subject in the form of books of refereed papers. Financially, the biggest seabird research project has been that conducted by the Outer Continental Shelf Environmental Assessment Program off Alaska, and as might be guessed from the number of maps, this is an atlas, mapping many of this project's findings. It is also typically atlas-shaped and is difficult to fit onto the average bookshelf.

After an introductory section covering previous knowledge and a good description of rationale and methods, the Gulf of Alaska and Eastern Bering Sea are treated separately in both text and maps. The text briefly describes distribution patterns for each species seen in each area in one or two paragraphs. The maps are presented in the form of figures printed within rectangles in a grid covering the area surveyed. Each species or species group is shown for the four seasons of the year for both aerial and shipborne survey methods. The figure printed is a density index probably closely related to numbers of birds per km^2. Appendices include a short summary of the status of all marine species of Alaska, and tables of average densities and other parameters for large sub-units of the areas surveyed.

I am not exactly sure who this atlas has been produced for. There are likely to be two main groups of users with differing needs; the managers who need to know the potential impact of oil spills, and ornithologists who would like to know more of the "how and why" of bird distribution. There is little attempt to analyse why birds are located where they were found, this presumably being to reduce the size of the publication; hopefully analyses will be published in the future perhaps by members of the research teams whose data has been used in this compilation. The ornithologist may be able to deduce a certain amount from the detailed maps, but the presentation of the maps makes them difficult to read easily. The figures are presumably shown in the best interests of accuracy, but the maps would surely have been easier to interpret if shading or symbolism had been used; this would not have been impossible using a computer aid.

The text is probably a reasonable length for the manager wanting a concise summary, though perhaps I would have unified the species accounts into one covering both areas surveyed. There is some considerable duplication between the two area accounts at present. The duplication of each species distribution map, one each for the ship-borne and air-borne surveys (while being admirably truthful) has doubled the numbers of maps in the volume. A comprehensive analysis of the differences between the two methodologies, and an attempt to produce a single map for each distribution would perhaps have been preferable. Should this have proved impossible, I would have used only maps from the ship-borne data, with additional comments gained from the aerial data.

Alaskan waters must contain some of the highest densities of seabirds at sea anywhere in the world. The estimate for the summer population of these two areas is over 75 million birds, with higher numbers during the migration periods, particularly during the autumn shearwater influx. One flock of over 1,000,000 dark (Sooty/Short-tailed) shearwaters must have been one of the highlights of these surveys. This rather puts to shame my own North Sea record of 30,000 Fulmars!!! It is a shame that winter coverage was for understandable reasons, quite so bad.

This atlas is in spite of some flaws, a significant contribution to the understanding of this very important area. I for one, am very pleased to see it published at last. Let us hope that future publications will include some more detailed analyses of the patterns discovered.

Mark L. Tasker

TROPICAL SEABIRD BIOLOGY (1984), by R. W. SCHREIBER. Studies in avian biology No. 8. Cooper Ornithological Society, 114pp. ($12.00, from Allen Press, Inc., P.O. Box 368, Lawrence, Kansas, U.S.A.).

Twenty years ago biologists knew far more about seabirds breeding in tropical or subtropical waters than they did about boreal or arctic species. In the last decade however, due to funding via off-shore oil development, the pendulum has swung a long way in the other direction. With all the boreal/arctic seabird studies in progress, tropical species were lucky to get a look-in. It is refreshing, therefore, to see the present volume, which constitutes the proceedings of an international symposium of the Pacific Seabird Group held at Honolulu, Hawaii in December 1982.

This well-produced (soft-back) volume, comprises a very brief introduction and six papers.

Ainley and Boekelheide start by making 'An ecological comparison of oceanic seabird communities of the South Pacific Ocean'. The authors made five cruises through the S. Pacific to Antarctica and found that the transition between subtropical and tropical waters (at about the 23°C isotherm) coincided with a major change in seabird faunas. Tropical waters contained the greatest diversity of seabird species which fed more by dipping, plunging and aerial pursuit than did other avifaunas. Tropical seabirds were also more likely to associate in multi-species feeding flocks. Seabirds in the Antarctic pack-ice tended to feed alone, and more often by pursuit diving. Although the number of species in the latter area was lowest, the total biomass of seabirds there was higher than elsewhere. These observations are consistent with two hypotheses: (1) food for tropical species is relatively less abundant and more patchily distributed than it is for other marine avifaunas, and (2) seabirds are tied by either morphological or behavioural adaptations to specific water types, and that more habitats are available in the tropics. The authors hope to be better able to distinguish between these two ideas once they have looked at water-temperature and salinity relationships for individual species in detail.

The second paper by A.W. Diamond is entitled 'Feeding overlap in some tropical and temperate seabird communities'. Diamond makes some interesting comparisons between two communities in the Indian Ocean and one in the S. Pacific, as well as using data from the classic study by Pearson (1968) at the Farne Islands, N. E. England. The use of overlap indices to examine seabird diets reveals an unexpectedly high degree of dietary overlap between members of tropical communities, given that they rarely experience a superabundance of food. The overlap indices for tropical species are as high or higher than those from the temperate community. This study illustrates very clearly the level of detail at which community biologists working on seabirds need to operate in order to investigate such problems adequately.

Whittow next discusses 'Physiological ecology of incubation in tropical seabirds', in which the factors which influence gas and heat transfer between the egg and its microclimate are reviewed. Some comparisons between tropical and non-tropical seabird eggs are made.

In the next paper 'Growth strategies in marine terns', N. P. Langham compares breeding and growth parameters for temperate and tropical tern species. The paper provides details of clutch-size, success of different sized broods, as well as a detailed examination of growth for *Sterna sandvicensis, S. hirundo, S. dougallii, S. paradisaea* (temperate species), and *S. sumatrana, S. bergii, S. anaethetus* and *Anous tenuirostris* (tropical species). The latter produce smaller clutches and have slower growth rates than the temperate species.

R. E. Ricklefs presents a theoretical model of seabird energetics in the next paper, 'Some considerations on the reproductive energetics of pelagic seabirds'. As the author points out, there have been almost no theoretical advances in seabird biology since the pioneering work of N. P. Ashmole and D. Lack in the 1960s. The aim of the present paper is to provide a theoretical framework within which seabird energetics can be examined. Ricklefs develops a model which matches the energy requirements of reproduction (i.e. of the egg, chicks and adults at the nest-site) to the ability of the parents to transport energy from feeding area to the breeding colony. The main constraint on pelagic seabirds is not their ability to obtain food but their ability to transport enough back to their chicks at the colony. The chick feed-size of pelagic species averages 14 to 18% of adult weight. The paper concludes by suggesting directions for future work, including the idea that seabird biologists should examine both the biochemical composition of feeds and the energy requirements of reproduction.

The final paper in the symposium is by J. B. Nelson and is entitled 'Contrasts in breeding strategies between some tropical and temperate marine Pelecaniformes'. Nelson concludes that there are relatively few features of the biology of this group directly attributable to 'temperateness' or 'tropicalness', but that foraging mode (offshore/inshore) is the critcal factor determining a species 'breeding strategy. This review finishes with some interesting suggestions for future work, including (a) studies of 'breeding stress', (b) reasons for the lack of cooperative breeding in seabirds (this is not strictly true since both Tschanz 1979 (*Z. Tierpsychol.* 49: 10-34) and I have recorded something similar to 'helpers' in Common Guillemots *Uria aalge*). (c) Differences in social behaviour in relation to colony size and density. Nelson ends with a strong plug for his own group: 'Perhaps the most conceptually important data will come from that demanding and time-consuming project, the long-term study of local populations and marked individuals, for which the Pelecaniformes are so well suited.'

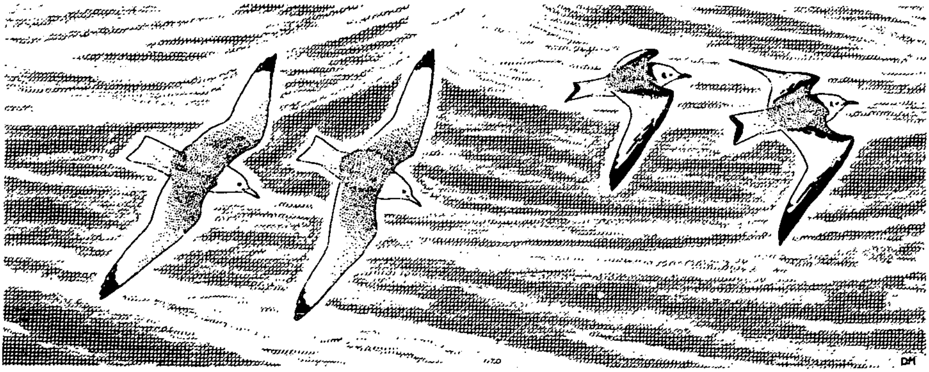
This volume is exceptionally well-produced and good value at $12.00. It contains a range of papers with something for all seabird biologists.

T. R. Birkhead

CAMPHUYSEN C.J. and VAN DIJK J. 1983. (Seabirds and estuary birds along the Netherlands coast, 1974-79). *Limosa 56* (3) : 83-230.

The current activities of the Dutch Seabird Watchers are very reminiscent of those of the Seabird Group before Operation Seafarer. There is much seawatching carried out along their coasts and a comprehensive beached bird survey is conducted. This special issue of *Limosa* is one important difference between the two groups; it contains a comprehensive summary of all observed coastal bird movement between 1974 and 1979, and a good attempt at demonstrating which weather conditions produce the largest movements.

The text, in Dutch with an English summary, is organised in typical bird report style; a summary of the physical features of the North Sea is followed by a section on observing and recording. Data processing has a separate section and there is also a brief summary of weather conditions during the six-year period. The main bulk of the issue is devoted to species summaries. Graphs of movements past three divisions of the Dutch coastline (the Waddensee islands, North Holland and South Holland) are presented for each of the commoner species. The issue is completed with a comparison with other southern North Sea seawatching sites, and a chapter on weather conditions and pattern of occurrence of birds at the coast.



One of the attractive illustrations from this special issue of *Limosa.*

Seabird Group members will be interested in the relatively small number of pelagic species seen off the Dutch coast; for example, the peak number per hour of Manx Shearwaters recorded during the entire six-year period was 50, with the normal hourly mean being considerably less. Gannets were the commonest of the pelagic seabirds, particularly during the autumn migration period. The lack of these seabirds is more than compensated for by the large movements of ducks, inshore seabirds and waders along the coast. An example of this is the Little Gull migration. Large numbers of these move north and east in late April/early May, returning southwards in October and November; movement peaks were over 500 birds/hour on some occasions. Massive movements of Eiders occur during October off the Waddensee islands. Large scale hard weather movements to the south and west are observed for several species if the Waddensee or Ijsselmeer freezes over.

Overall this is an excellent documentation of seawatching results and the authors must be congratulated for completing what must have been an extremely long and arduous task. I feel though that there still has not been enough analysis of the causes and effects of these movements, whether off Holland or Britain. It would be interesting for instance to see a more detailed analysis of wind effects on observed movements — perhaps assisted by computer. Other meteorological factors, such as the approach of a front has been shown elsewhere to have an effect on numbers of birds seen moving; this is not mentioned in the summary of weather effects. It would be interesting to compare numbers of birds observed moving in hard weather with known decreases in numbers in the areas the birds are apparently leaving. Ultimately though there still appears to be little conservation value in seawatching without a more comprehensive knowledge of movements happening elsewhere, whether it be by night, at sea or high overhead. Hopefully the next move from the Dutch will be to make observations out at sea.

Copies of the issue are available from Dr Arie L. Spaans, Research Institute for Nature Management, Kemperbergerweg 67, 6816 RM Arnhem, Netherlands. Price DFl. 25; you will be invoiced with the booklet, do not send money.

Mark L. Tasker

THE SEABIRD GROUP

The Seabird Group was founded in 1966 to circulate news of work in progress on seabirds and to promote cooperative research on them. It is run by an Executive Committee composed of nine elected members and maintains close links with the three major British national ornithological bodies — the British Ornithologists' Union, the British Trust for Ornithology, and the Royal Society for the Protection of Birds. Membership (£5 per annum) is open to all with an interest in seabirds; for details please contact the Secretary (address below) — payment by banker's order and deed of covenant helps the Group.

Newsletter and Meetings. Three duplicated newsletters are circulated each year to members. They contain all sorts of news including reports on research projects (particularly those with a grant input from the Group — see below), details of meetings etc. The usual venue for the Group's annual meeting is the BTO Ringing & Migration Conference but in 1985 the Group will be running its own conference at Denstone College, Uttoxeter (Staffs.), from 15-18th February, entitled 'Population studies and population monitoring'. Information and Booking forms are available on request.

Seabird Group Grants. Each year the Group has some money available to help fund research work conducted by members. All applications for grants should be submitted to the Secretary by the end of January each year and will be considered by the Executive Committee. Certain areas of research may be favoured particularly and details of these will appear from time to time in the Newsletter.

'Seabird' journal, and previous resports. Offers of papers should be sent to Editor of 'Seabird' (see below). Members of the Seabird Group receive 'Seabird' free of charge; additional copies to members, and any copies to non-members, are £5 + 50p postage, from the Secretary. At various intervals in the past the Group has published printed reports (1-6), to which 'Seabird 7' is the successor. Copies of four earlier reports are available from the Secretary as follows: issues for 1969, 1971, and 1975-6, at £2 + 50p postage each; 1977-81 at £3 + 50p. There are no cost concessions for multiple orders. Copies of the Proceedings of the 1982 (Denstone) Seabird Group Conference are also available.

Who to write to. As appropriate, contact the Secretary (for general enquiries about the Group and its activities, request for membership, grants, etc), the Treasurer (for subscriptions, donations etc.), Newsletter editor, or Editor of 'Seabird'. All may be contacted through the following address: Seabird Group, c/o RSPB, The Lodge, Sandy, Beds. SG19 2DL. In mailing your enquiry, please specify which of the Officers above is the intended recipient. Please help the Group to keep its costs down by enclosing a stamped addressed envelope for reply.