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 Thrall 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 Thrall (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 terpinene, 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.

<table>
<thead>
<tr>
<th>Host</th>
<th>Number of birds deloused</th>
<th>Species of feather louse</th>
<th>Number collected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Storm Petrel</td>
<td>240</td>
<td>Amblonyca: Austromenopon sp.</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ischnocerca: Halipeurus pelagicus</td>
<td>1353</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Denny, 1842)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ischnocerca: Philoceanus robersti</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Clay, 1940)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ischnocerca: Saemundssonia thalassidromae</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Denny, 1842)</td>
<td></td>
</tr>
<tr>
<td>Fulmar</td>
<td>34</td>
<td>Ischnocerca: Perineus nigrolimbatus</td>
<td>91</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Giebel, 1874)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ischnocerca: Saemundssonia occidentalis</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Kellogg, 1896)</td>
<td></td>
</tr>
<tr>
<td>Leach's Petrel</td>
<td>7</td>
<td>Ischnocerca: Halipeurus pelagicus</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Denny, 1842)</td>
<td></td>
</tr>
<tr>
<td>Manx Shearwater</td>
<td>4</td>
<td>Ischnocerca: Halipeurus diversus</td>
<td>38</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Kellogg, 1896)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ischnocerca: Trabeclus aviator</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Evans, 1912)</td>
<td></td>
</tr>
</tbody>
</table>

(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 Analoidea (genus Zachratkinia). No haematophagous ectoparasites, e.g. flea (Insecta: Siphonaptera) or ticks (Acarina: Ixodoida) were present in the collections.

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 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 tendency for the most heavily infested individuals to carry more than one species ($x^2 = 10.39$, P<0.001). 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 "ellegant" 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 depaeritising 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 $x = 5.75$ and the variance $s^2 = 13.48$. The variance to mean ratio is significantly greater than unity ($s^2 / \mu = 2.34$), 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
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 ($\chi^2 = 9.59$, $P<0.01$).

The 35 Philoecus robusti 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 ($\chi^2 = 14.5$, $P<0.01$).

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 unfeathered birds. All lice, except a single individual, belonged to the species Perineus nigrolineatus, of which 43% were males, 34% were females and 23% were nymphs; the sex ratio of the adults does not significantly differ from unity ($\chi^2 = 0.70$, $P>0.05$). 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 (6.67:2.74) 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 ($\chi^2 = 0.906$, $P>0.05$; Fig. 2c).

Manx Shearwater

The four adult shearwaters examined were infested with 9, 13, 17 and 27 feather lice (mean 16.5). Two species of lice, Philoecus diversus and Trabeculus avitator, were obtained, whose frequency distribution were, respectively, 7 and 2; 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, Philoecus pelagicus, of which 9% were males, 19% 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 (Philoecus, Perineus, Philoecus,
Saemundssonia, Trabeclus and Austromonopon) were collected from the Proculliferiformes examined. There are few published data with which to compare these results, but Halipleurus, Pertines, Philocoleus and Trabeclus have only been reported to occur on Proculliferiformes. Saemundssonia and Austromonopon have additionally been found on Alcidae (Waterston 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 exist in a fairly innocuous relationship with their hosts. Their populations are normal to 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 irritation 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 depauparitising 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 (Halipleurus pelagicus and aggregated mites on Storm Petrels, and P. nigrolimbatus on Fulmars) to the negative binomial distribution of great interest. Crofton (1971) has suggested that the negative binomial is a fundamental model of parasitism, and so it is described as 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 desaturation effects of the parasite on the host population, and is related to the relative reproductive rates of the parasitoid 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 Halipleurus pelagicus which was found both on Storm Petrels and Leach’s Petrel. Even though these birds belong to different genera, it is well-known that their breeding habitats may overlap (Sharrack 1976) where actual contacts could result in the transfer of ectoparasites. This is not unprecedented (Post and Enders 1970) describe the occurrence of the same species of lice on two species of sparrows which share the same habitat.

Eveleigh and Threlfall (1976) note that burrow or crevice nesting auklets 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 Proculliferiformes; the ledge-nesting Fulmar had a lower infestation level and lower ectoparasite density than both the burrowing Manx Shearwater and Storm Petrel. However, Fulmars do not exhibit as much social contact on ledges as do auklets.

Nymphs were the dominant age class of Mallophaga found on Storm Petrels and Leach’s Petrels; this contrasts with auk mallophaga in which adults were invariably 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 Mallophaga population with a high proportion of adults to nymphs indicates an old, declining population. The observed difference in population structures between the

Mallophaga on auk and petrel hosts may reflect no more, therefore, than asynchronous sampling. Only in the case of Trabeclus aviator did the sex ratio differ significantly from (Marshall 1981).

No Mallophaga were recovered from the downy Fulmar chicks examined. Eveleigh and Threlfall (1976) note that auks chick had received ectoparasites from their parents; it 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 do not directly in competition for resources, in which case a negative association might be expected to occur.

The collection of Philocoleus robertsi from Storm Petrels is of exceptional interest as it has previously been 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 found together at sea. It is not known how far south Storm Petrels wander in the northern winter, but Leach’s Petrels have been known to be found as far as 44°S (Timber and Lovegrove 1982). When it is also taken into account that Storm Petrels can be attracted to the calls of Wilson’s Storm Petrels, 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 Halipleurus pelagicus which is clearly actively reproducing.

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SEABIRD


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