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The invertebrate fauna of High Arctic seabird nests: the microarthropod community inhabiting nests on Spitsbergen, Svalbard

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Abstract The invertebrate fauna of the nests of three seabird species, black-legged kittiwakes (*Rissa tridactyla*), common eider (*Somateria mollissima*) and glaucous gull (*Larus hyperboreus*), were sampled in Kongsfjorden, Spitsbergen, Svalbard. The invertebrate community was species poor, consisting predominantly of the flea, *Mioctenopsylla arctica arctica* (Insecta: Siphonaptera), but with six species of oribatid mite (Acari: Oribatida), *Diapterobates notatus*, *Oribatula tibialis*, *Ameronothrus lineatus*, *Hermannia reticulata*, *Trichoribates trimaculatus* and *Ceratoppia bipilis*, plus an occasional mesostigmatid mite. No Collembola or ticks (Acari: Ixodidae) were observed. With the exception of *M. arctica arctica*, the fauna of seabird nests consisted of opportunistic microarthropod species rather than specialised nest-dwelling or bird parasitic species. Species diversity of soil oribatid mites was greater in nests of the common eider than compared to nests of the black-legged kittiwake, which may be related to the ground nesting behaviour of the common eiders. No rare or unusual microarthropod species for Svalbard were found in the seabird nests. The contentions that nests may facilitate microarthropod colonisation of High Arctic regions via bird phoresy by providing a high-quality habitat at the point of arrival, or that there might be a specialised microarthropod fauna exploiting this habitat, were not supported in this study. These are amongst the first data on the microarthropod community of seabird nests in the High Arctic.

Keywords Arctic · Svalbard · Nest seabird · Invertebrate · Spitsbergen

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Introduction

Bird nests contain a rich and diverse invertebrate fauna (Hicks 1959, 1962, 1971 and references therein; Turienzo and Di Iorio 2007; Krumpal et al. 1988; Majka et al. 2006; Bajerlein et al. 2006). However, there have been few studies of the invertebrate fauna of bird nests in the polar regions (Convey and Quintana 1997; Ohyama and Hiruta 1995; Sinclair and Chown 2006) and only two from the High Arctic archipelago of Svalbard (Elton 1925; Mehl 1992). We here detail the invertebrate fauna of the nests of three seabird species, the black-legged kittiwake (*Rissa tridactyla*), common eider (*Somateria mollissima*) and glaucous gull (*Larus hyperboreus*) from Svalbard.

The importance for the flora and invertebrate communities of nutrient input from bird colonies, especially in nutrient-limited ecosystems, has long been recognised (Anderson and Polis 1999; Klekowski and Opalinski 1986; Odasz 1994). However, the most heavily bird influenced 'soil' is the nest substrate itself. Many species of seabird show high

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nest-fidelity, the same pair returning to the same nest on successive breeding seasons and therefore the nest grows in size with each year creating a distinctive habitat for invertebrates. The nest habitat may provide several advantages for the invertebrates, for example, a mild thermal microclimate during the incubation period due to the breeding birds occupying the nest (Sinclair and Chown 2006; Tryjanowski et al. 2001) as well as a rich nutrient input in the form of guano, food scraps and, for ectoparasites, the adult birds and chicks themselves. Moreover, the role of bird dispersal in creating Arctic soil invertebrate diversity has recently attracted increased attention. Recent studies suggest that bird dispersal may be more important for soil invertebrate dispersal than has been previously accepted (Lebedeva and Krivolutsky 2003; Lebedeva et al. 2006; Lebedeva and Lebedev 2008). In any event, it is clear that phoresy is important for the geographic dispersal of soil invertebrates and that the first point of arrival for many of the dispersing invertebrates is likely to be the nest. Hence, a thermally ameliorated nest with high nutrient input may provide conditions facilitating the initial establishment of microarthropods dispersing to High Arctic latitudes. In addition, current climate change models suggest large changes in the Arctic climate (IPCC 2007), changes which are likely to have a significant impact on the future invertebrate fauna of Arctic bird nests.

The invertebrate fauna of the nest may also have health implications for breeding birds since parasitic species often have a deleterious effect on the host (Merino and Potti 1996). The seabirds of Spitsbergen are known to carry a wide range of lice (Insecta: Mallophaga) (Mehl et al. 1982) as well as fleas (Insecta: Siphonaptera) (Mehl 1992; Kaisila 1973) and the tick *Ixodes uriae* (Coulson et al. in press).

Nonetheless, despite the considerable importance and distinctiveness of the seabird nest invertebrate fauna, there is comparatively little information documented and, with the exceptions of Mehl (1992), Elton (1925) and Lebedeva and Lebedev (2008), nothing from High Arctic localities. The aim of this study was fourfold: (a) determine the community structure and document differences between the nests from different seabird species, (b) determine differences between cliff nesting and ground nesting seabird species, (c) determine whether there were invertebrate species inhabiting these specialised microhabitats not known from other localities in Svalbard and (d) determine if the nests facilitated invertebrate colonisation of Svalbard.

Materials and methods

Spitsbergen is the largest island of the Svalbard archipelago and lies in the Norwegian High Arctic at approximately 76.5–80° North, 10–21° East (Fig. 1a), 700 km north of Norway. The archipelago has a land area of 61,200 km^2 of which over 60% is permanently covered by snow and ice (Hisdal 1998). Nests of black-legged kittiwake (*Rissa tridactyla*) and common eider (*Somateria mollissima*) together with that of one glaucous gull (*Larus hyperboreus*) (Fig. 1, Table 1), were sampled in Kongsfjorden (79° North, 12° East) between 9th and 13th July 2007 using a battery-powered pooter (Hausherr's Machine Works, USA). In order to keep disturbance of the birds to a minimum, time at each nest was necessarily limited, as was the number of nests that could be sampled. Six black-legged kittiwake nests were sampled from the colony at Krykkjefjellet, five from Blomstrand and two from Observasjonholmen. One glaucous gull nest was investigated at Observasjonholmen. A total of 10 common eider nests were sampled from Storholmen (Table 1, Fig. 1). With an area of only 0.3 km^2 and between 750 and 800 breeding pairs common eiders, this island has a particularly high density of common eider nests. Nests of the cliff nesting black-legged kittiwake and glaucous gull were reached from below using a ladder. Each nest was thoroughly searched with the pooter for approximately 2 min. The collecting vial on the pooter was changed midway through the search to avoid clogging the pooter with nest detritus. Nests of the black-legged kittiwake are comprised principally of compacted or interwoven plant material, mainly moss. Within the nest bottom, there was a loose collection of feathers and other organic material. The nest material was dry and friable, and hence suitable for sampling by pooter. The glaucous gull nest was similar but located on a rock ledge, larger and more open with some organic soil surrounding it. Common eider ducks nest in shallow scoops in the ground filled with down. Both the down and the soil surface under the down were thoroughly sampled by pooter. Large quantities of nest debris were drawn into the pooters from all the nests. Hence the samples were kept cool and returned to the University Centre on Svalbard (UNIS), where the invertebrate fauna was separated in soil microarthropod extractors (MacFadyen 1961).

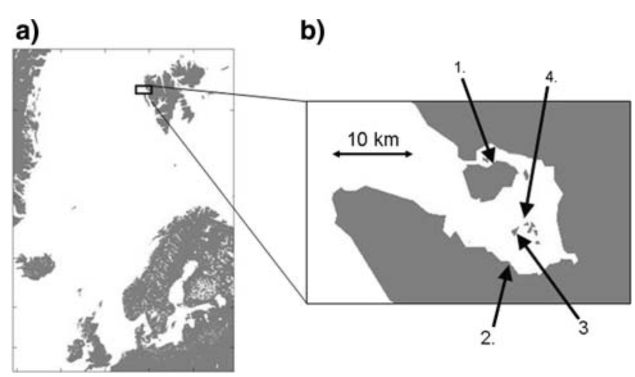

Fig. 1 Location of the colonies, Spitsbergen, Svalbard. **a** location of Svalbard, **b** location of the colonies in Kongsfjord, (1) Blomstrandhalvøya, (2) Krykkjefjellet, (3) Storholmen and (4) Observasjonholmen

Table 1 Summary of the colonies studied and the nest fauna of seabirds from Kongsfjorden, Svalbard

Bird species and colonies	Black-legged kittiwake												Common eider				Glaucous gull
	Blomstrandhalvøya, $N = 5$				Observasjonholmen, $N = 2$				Krykkjefjellet, $N = 6$				Storholmen, $N = 10$				Observasjonholmen, $N = 1$
Position	78°9.6′ N, 12°07.0′ E				78°56.4′ N, 12°16.9′ E				78°53.7′ N, 12°11.7′ E				78°55.8′ N, 12°13.1′ E				78°56.4′ N, 12°16.9′ E
Aspect	NNW				N				NNE								N
	Total ind.	Min	Max	Median	Total ind.	Min	Max	Median	Total ind.	Min	Max	Median	Total ind.	Min	Max	Median	Total ind.
Insecta																	
M. arctica arctica																	
Adults													1	0	1	0	7
Larvae	62	0	30	12.5	16	0	16	8	79	0	55	2	54	0	32	0.5	4
Acari																	
D. notatus																	
Adults	1	0	1	0					1	0	1	0	8	0	7	0	
Nymphs	2	0	2	0									14	0	14	0	
C. bipilis																	
Adults													1	0	1	0	
O. tibialis																	
Adult													2	0	2	0	6
T. trimaculatus																	
Adult													1	0	1	0	
H. reticulata																	
Adult																	1
A. lineatus																	
Adults					3	0	3	0									
Immature Oribatidae													7	0	7	0	2
Mesostigmata									1	0	1	0					

Total total number of individuals collected in all nests at one location, *min* minimum number of individuals in a nest, *max* maximum number of individuals in a nest, *median* median number of individuals per nest, *N* number of nests sampled at each location

The weather during the collecting period was stable with an above average mean temperature of 6.4°C (1961–1990 mean at Ny-Ålesund for July 4.9°C, Norwegian Meteorological Institute), mostly clear skies and low wind speeds.

Results

The invertebrate fauna was sparse with only four species being found in the nests of the black-legged kittiwake and glaucous gulls (Table 1). Six species were found in the nests of common eider. Densities were not subjected to detailed statistical analysis due to the small sample size, aggregated dispersion and the consequent large variances.

Black-legged kittiwakes

Invertebrates were found in 10 of the 13 black-legged kittiwake nests. The invertebrate community was dominated by flea larvae, *Mioctenopsylla arctica arctica* Rothschild, 1922 (Table 1) at all the three colonies. Flea larvae were not identified to species but assumed to be the same species as the adult fleas observed in the nests of glaucous gull and common eider. Flea larvae occurred in 69% (9 of 13) of the black-legged kittiwake nests but with great variation in number per nest at between 0 and 55. No adult fleas were observed in the nests. Two species of oribatid mite were found to be present, *Diapterobates notatus* (Thörell, 1871) and *Ameronothrus lineatus* (Thörell, 1871). In addition, one unidentified juvenile mesostigmatid mite was found. There were no large differences observed in the black-legged kittiwake nest faunas amongst the three colonies.

Glaucous gull

The single glaucous gull nest revealed a microarthropod fauna consisting of seven adult fleas, four flea larvae and eight oribatid mite species consisting of six adult *Oribatula tibialis* (Nicolet, 1855) one adult *Hermannia reticulata* Thörell, 1871 and two unidentified immatures (Table 1).

Common eider

Flea larvae were observed in 50% of the nests (five from 10 examined), while one nest provided one adult individual. As with the nests from black-legged kittiwakes, aggregation of *M. arctica arctica* was high with one nest returning 32 larvae compared to a mean density of 5.5 individuals per nest (Table 1). The common eider nests displayed a greater diversity than the nests of black-legged kittiwakes or the glaucous gull with four different oribatid species present, *D. notatus*, *Ceratoppia bipilis* (Hermann, 1804), *O. tibialis* and *Trichoribates trimaculatus* (C. L. Koch, 1835) plus seven unidentified juveniles.

Discussion

The few studies of the invertebrate fauna of glaucous gulls, black-legged kittiwakes and common eider nests indicate a restricted nest fauna consisting of the flea *Ceratophyllus vagabundus* in glaucous gull nests (Hicks 1959) while *C. vagabundus*, *C. garei* and *M. arctica* are recorded from black-legged kittiwake nests (Hicks 1959, 1962, 1971). In addition, Elton (1925) records Diptera and Collembola from black-legged kittiwake nests on Bjørnøya but does not describe which species. The fauna of the common eider nests is slightly more diverse including *C. garei*, *C. vagabundus*, beetles (*Staphylinus* sp.) and several species of Collembola (Hicks 1959, 1962, 1971). The invertebrate community sampled in this study was likewise meagre, consisting of only six species of oribatid mite, an unidentified mesostigmatid mite and dominated by the flea, *M. arctica arctica*, but still greater than previous records. The small sample size and the consequent large variances negated detailed statistical analysis, nonetheless, patterns were discernable. This species of flea is a common ectoparasite of birds and has been recorded previously on Svalbard (Kaisila 1973; Mehl 1992). While according to Brinck Lindroth and Smit (2007), *M. arctica arctica* is host specific on black-legged kittiwakes, this flea was also found in the nests of both glaucous gull and common eider. The fleas in the glaucous gull nest may have dispersed there from neighbouring black-legged kittiwake nests, or been brought in on dead black-legged kittywakes being fed to the glaucous gull chicks. However, it seems likely that *M. arctica arctica* in the common eider nests were using the common eider as a host. Dispersion of the flea larvae was extremely aggregated varying between 0 and 55 larvae per nest. Such an aggregated dispersion is often seen with juvenile insects hatching from egg batches (Southwood and Henderson 2000). Few adult fleas were pootered and during collection, no adults were seen. While air temperatures were warm, the black-legged kittiwake colonies studied had a northerly aspect and so were in shadow during the day. As a result, they were cool and little invertebrate activity was obvious in the nests. It is hence unlikely that the adult fleas were sufficiently active to avoid capture, especially given that adult fleas from the nests of glaucous gull and common eider were caught under similar weather conditions.

Soil mites have not previously been recorded from the nests of black-legged kittiwakes, glaucous gulls or common eider nests. In this study, we observed six species of oribatid mite and one unidentified mesostigmatid mite. The mite faunas of the nests of black-legged kittiwake and common eider were similar but nonetheless reflected the different locations of the nests, that is on a cliff ledge or a shallow scoop in the soil. That the oribatid mite, *A. lineatus*, was observed in the nests of black-legged kittiwakes but not of common eiders agrees with the littoral habit of this species (Søvik et al. 2003), frequently found under stones in the vicinity of bird cliffs. It is not, for example, generally found amongst the soil fauna of the island where the common eider nests were sampled from, Storholmen (Hodkinson et al. 2004). However, the mites, *C. hoeli* and *D. notatus*, are often found in organic soils (Hodkinson et al. 2004; Webb et al. 1998) in Kongsfjorden, and it is not surprising to find these species in the nest of common eider which are scoops in the ground. Such a relationship with ground nesting birds has been observed previously (Norton 1980). The glaucous gull nest was located on a large soil-covered ledge midway up the cliff and this might explain the presence of two species of soil oribatid mite present in this nest.

Given that Collembola have been observed in seabird nests previously (Elton 1925; Hicks 1959) and the number of soil oribatid mites, both adults and nymphs, present in the common eider nests, the lack of Collembola from the nests studied was especially unexpected. However, Collembola are desiccation susceptible (Harrisson et al. 1991; Hopkin 1997) and perform poorly in dry environments (Coulson et al. 1993; Convey et al. 2003). At the time of sampling, the nest material was extremely dry and it seems possible that the habitat was too dry for desiccation susceptible microarthropods such as Collembola to inhabit in high numbers. An excessively high nitrogen input may also play a role in determining the nest fauna. The role of high guano input and age influencing invertebrate community diversity has been demonstrated previously for bat guano (Bernath and Kunz 1981; Ferreira et al. 2007).

The lack of invertebrate species diversity is probably the result of the unique habitat of the nest and the challenges this represents. Bird nests form a specialised microhabitat with periodic high nutrient input and often a diverse commensal invertebrate community (Majke et al. 2006). The nesting seabirds abandon the nest at the end of the breeding season and the length of nest occupation is species specific. The common eider leaves the nest after between 25 and 30 days since the young wander from the nest soon after hatching. Glaucous gulls and black-legged kittiwakes, however, occupy their nests longer, up to 120 days until fledging. Hence, invertebrates establishing in the seabird nests are required not only to survive the period that the birds are on the nests but also the significant period when the nest is unoccupied.

Differences in observed invertebrate densities between nests and seabird species may also be due to an artefact of the sampling process; pooting in a mass of loose eider down or dry friable nest detritus is not efficient in capturing mobile invertebrates. Moreover, although a standardised approach was taken to all nests, it was not possible to sample each nest identically and hence the data cannot be regarded as qualitative but are descriptive. It would have been preferable to remove the entire nest and fully expel the invertebrate fauna extract using traditional heat extraction techniques (Southwood and Henderson 2000). However, since we were working on nests with incubating and brooding birds, such a destructive approach was not possible. Despite these sampling concerns, heat extraction of recently abandoned nests by Berlese funnels has shown that not all nests are inhabited by arthropods (Tryjanowski et al. 2001). The same percentage of nests was found to be occupied by invertebrates in both the study of Tryjanowski et al. (2001) and this study, 75%. In addition, soil cores from under the common eider duck nests were not taken, and it is possible that the soil fauna here may be subtly different from in the surrounding area.

In conclusion, the microarthropod fauna of nests of black-legged kittiwake, glaucous gull and common eider on Spitsbergen is sparse and broadly similar to previous observations at other localities. Nonetheless, seven soil mite species not previously recorded from nests of these seabirds were identified. We hypothesised that the fauna might comprise specialised microarthropod species due to (a) the distinctive environment of the nest and (b) favourable congenial conditions in the nest facilitating the establishment of new species linked to bird dispersal of microarthropods. However, these contentions were not supported. Rather, with the exception of the bird flea, that the nests of High Arctic seabirds are inhabited by opportunistic species found more generally amongst the soil microarthropod fauna (Coulson 2007; Coulson and Refseth 2004). This is also supported by Lebedeva and Lebedev (2008), who found four species of soil-dwelling oribatid mite in snow bunting (*Plectrophenax nivalis*) nests on Svalbard. The snow bunting is a ground nesting bird often selecting protected nesting sites under rocks and stones. Similarly, as no rare or new species to Spitsbergen were recorded from the nests, there is no evidence that nests facilitate invertebrate establishment. Nonetheless, of the four species of soil oribatid mite reported by Lededeva and Lebedev (2008), two were new records for Svalbard (*Damaeus onustus* and *Carabodes marginatus*) and hence, since our sample size was small, the possibility of unrecorded invertebrate species inhabiting nests at other locations cannot be excluded. These are among the first data on the nest microarthropod fauna of seabirds at a High Arctic location.

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