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Pitfall trapping at Gården Under Sandet (GUS) 1995, Western Greenland

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During archaeological excavations on the site of the Norse farm at Gården under Sandet (GUS), in Ameralik Fjord, south-west Greenland, the opportunity was taken to sample the modern ground-living insect fauna by pitfall trapping from a range of natural habitats for comparison with fossil assemblages from the medieval farm and its midden. Two species, the predatory bug *Nabis flavomarginatus* Scholtz, 1847 and small ladybird *Nephus redtenbacheri* Mulsant, 1846 are recorded for the first time in this part of Greenland, although there are earlier records from the sediments associated with medieval farms in the region and both have been regarded as Norse introductions. The minute staphylinid *Mycetoporus nigrans* Mäklin, 1853, added to the Greenland list from this material by Peter Hammond (in Buckland *et al.* 1998), was found to be common in most natural habitats around GUS. Grids of eight traps, four at ground level and four on posts, were set out in six localities defined by their vegetational characteristics and emptied three times over the month-long sampling period. The cicadellid *Psammotettix lividellus* (Zetterstedt, 1840) appeared in all ground traps being particularly abundant on the dwarf birch and sedge dominated floodplain, to which the polyphagous mirid bug *Chlamydatus pullus* (Reuter, 1870) appears confined.

Key words: Greenland, Ameralla, pitfall traps, Coleoptera, Hemiptera.

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Introduction

The fjord Ameralik / Ameralla, extends inland from south of Nuuk in southwest Greenland, almost to the inland ice. At its head by the site of the former Norse farm at Sandnæs (Kilaarsarlik), the main valley turns sharply southwards, taking the silt-laden drainage from a now rapidly receding glacier feeding down from the icecap. Above a major constriction in the sandur marked by a series of rapids, the plain widens again and on the north side lies the site of a medieval farm (Lat. 64° 6’ 3” N; Long. 50° 4’ 30” W), named Gården Under Sandet (GUS, for short) by the archaeologists (Figure 1). Archaeological excavations, undertaken over a period of years in the mid 1990’s (Arneborg & Gulløv 1998), have shown that the site was occupied from the eleventh to the fourteenth century. The archaeological team consisted of scientists from Denmark, Iceland, the United Kingdom, Canada and Greenland across a range of disciplines and the multidisciplinary project aimed to discover as much as possible about the life of a large farm, the remains of which, buried in the sandur, were rapidly being eroded by the changing course of the river. As part of the

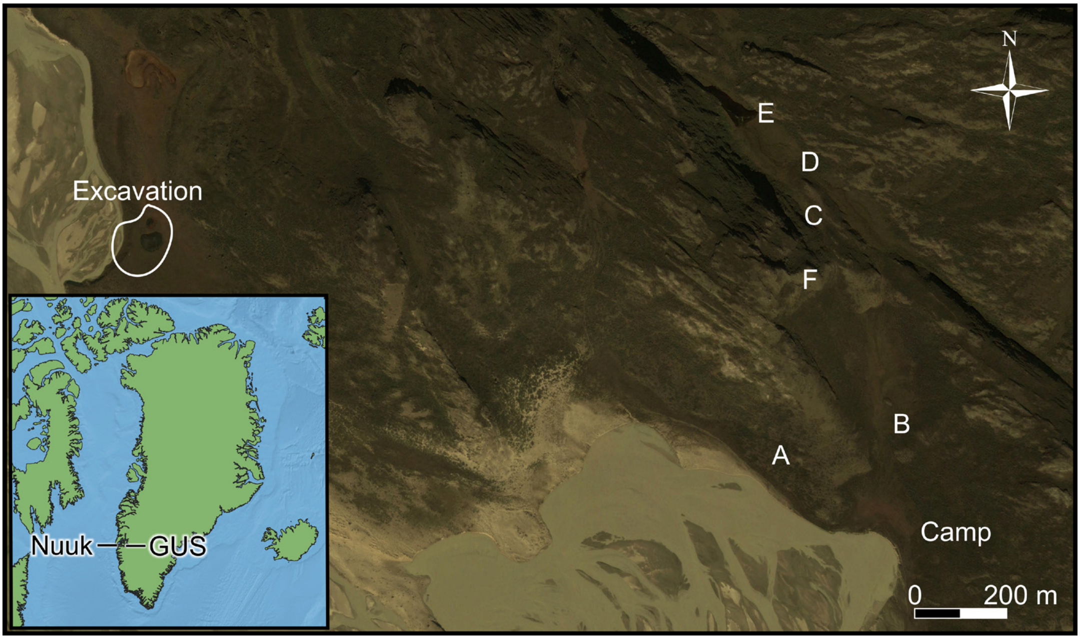

FIGURE 1. Location map showing the area of the traps in relation to the archaeological excavation and camp. Satellite image Google Earth © 2022 Maxar Technologies. Inset map made with Natural Earth.

research the modern flora and fauna, principally the insects, were recorded during the early summer of 1995 and numerous samples were extracted from archaeological and surrounding contexts for the purpose of palaeoentomology and palaeobotany (cf. Panagiotakopulu *et al.* 2007). A record of the existing insect fauna formed an important element in the archaeological work, in that not only did it provide evidence of the ecology of several species present in the archaeological samples, but it also helped to illuminate factors such as the persistence of species inadvertently introduced by the Norse farmers and also how well, if at all, species had survived after the loss of features, such as mown hayfields and middens, created by humans.

There has been relatively little sampling of the insect faunas of the unoccupied inner fjord regions east of Nuuk (see recently Hansen *et al.* 2016a & b) and elsewhere in southwest Greenland systematic pitfall trapping and searching is restricted to the work of Panagiotakopulu and Buchan (2015) around the modern sheep farms near Qassiarssuq much further south. Casual collecting took place around Kilaarsafik and in Austmannadal during July 1984 and this added two species of Coleoptera, *Cercyon obsoletus* (Gyllenhal, 1808), perhaps an accidental import with the archaeologists' stores, and *Simplocaria elongata* J. R. Sahlberg, 1903, previously detected as a fossil, to the Greenland list (Böcher *et al.* 2015). Compared with the outer coast, the inner fjords of southwest Greenland have relatively warm summers with daytime average temperatures in July and August reaching 9^0 C at Kapisillit, the nearest weather station in the fjord north of Ameralla, and daytime ground temperatures of ~ 20^o C were not unusual on site over this period. Temperatures are consistently below freezing, however, from November to April allowing the development of permafrost, although current warming is having a significant impact on its extent, and consequently the preservation of archaeological and palaeoenvironmental evidence for future studies (Hollesen *et al.* 2019). The short warm summer is sufficient for a cool temperate, as opposed to arctic, insect fauna to develop although the biogeographic accidents of introduction limit the range of the native and Norse introduced fauna (cf. Vickers & Buckland 2015, Panagiotakopulu 2021).

Away from the highly mobile sandur,

the landscape is underlain by discontinuous permafrost with fairly continuous vegetation dominated by woody tundra shrubs, dwarf birch, *Betula nana*, various willows, *Salix* spp., and Labrador tea, *Rhododendron* (= *Ledum*) *groenlandicum,* interspersed with moss and grass / sedge dominated areas and numerous small pools. The area is lightly grazed by reindeer (caribou)

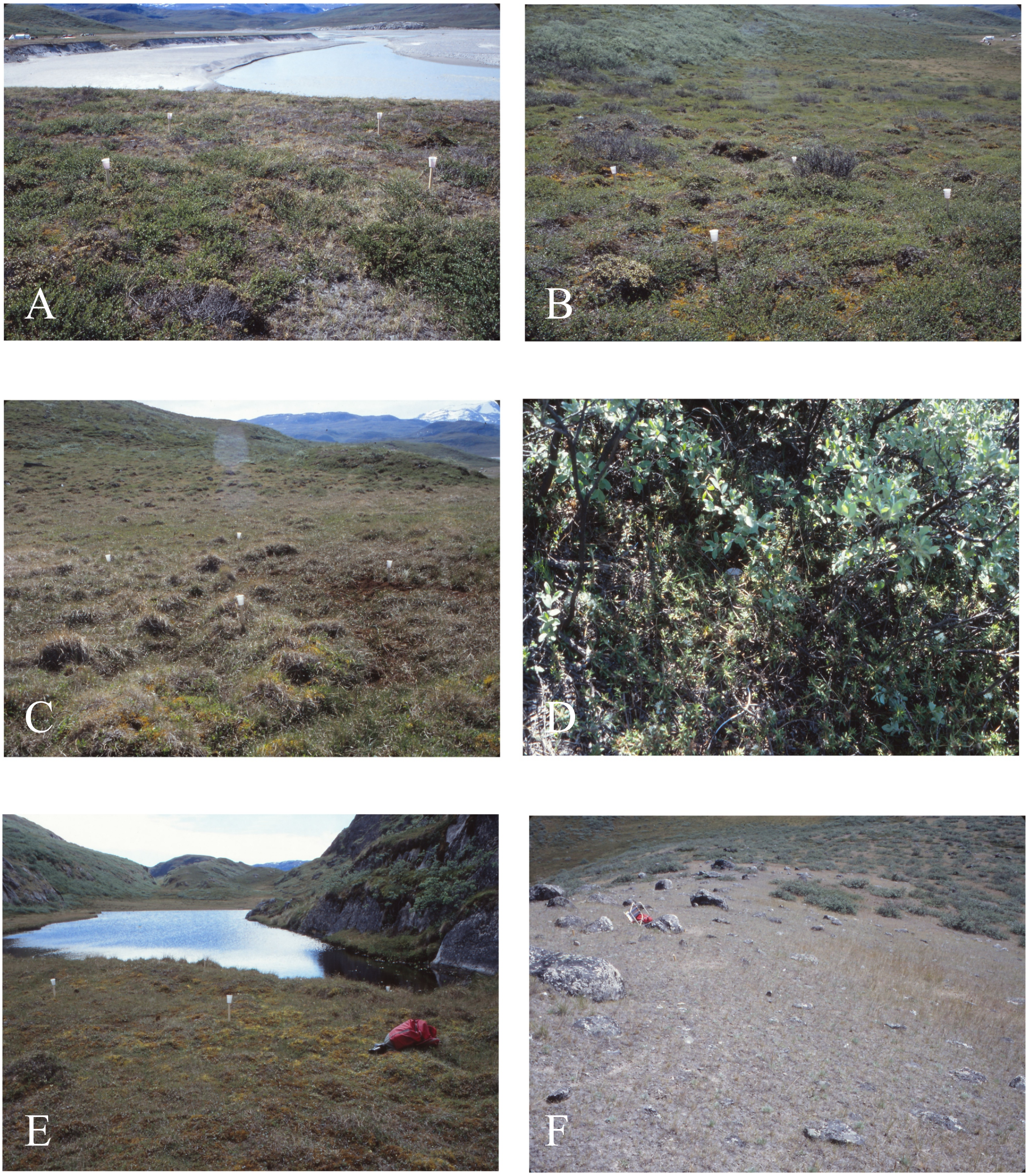

FIGURE 2. Vegetation Zones in the GUS site area, as used in the trapping exercise. **A**. Upper floodplain, very low birch and sedges. **B**. Dwarf birch-rhododendron scrub (*Betula – Rhododendron lapponicum*). **C**. Bog - moss and coarse grasses. **D**. Willow dominated 'woodland' with Labrador Tea undergrowth (*Salix – Rhododendron groenlandicum*). **E**. Pondside marshland, sedge and moss dominated. **F**. Well drained and exposed hillside with sparse grassland.

and arctic hare. Blowouts, bare of vegetation, are created by catabatic winds off the ice cap and silt is frequently picked up by the winds from the sandur and deposited over the vegetated areas. In more sheltered localities, tree birch, *Betula pubescens*, and grey leaf willow, *Salix glauca*, form dense thickets.

Study area and sampling

To ensure the feasibility of handling pitfall traps whilst participating in an archaeological excavation, a range of easily accessible sites were surveyed within 500 m of the expedition campsite (Figure 1). Unfortunately, a GPS was not available for more accurate logging of the trapping sites.

Cursory mapping of the vegetation suggested that a minimum of six zones would be sufficient to characterise the region around the site of the farm (Figure 2), a seventh, the surface of the sandur, was too unstable to allow trapping. Vegetation description was confirmed with the assistance of a botanist (Ross, pers. comm.). Further environmental variables were not collected.

Sampling followed a pattern suggested by the late Peter Skidmore (pers. comm.). This consisted of establishing a rectangular grid of eight traps, 3m apart, in each area, four at ground level and four on poles, as shown in Figure 3. This was adhered to where local topography permitted, and subject to only minor alterations to catch specific local factors. Figure 3 shows the system as used here, but it can be extended to use as many traps as is viable, bearing in mind that after a week specimens start to decay, and that typically it was found that only sixteen traps could be emptied by one person in a working day. Plastic cups were the preferred trapping medium and into each cup a second was placed, to act as the actual trap thus preventing leakage due to damage occurring during securing. Note that in a windy environment like southwest Greenland, cups on poles must be extremely well secured, the approach here was to cut a flap from the outer cup and fold it inwards. However, even this was initially inadequate in Zone F (Figure 2), where two cups were lost due to high winds.

Traps were about 3/4 filled with a weak solution of detergent, which has a lesser surface tension than pure water (in this case only “lemon scented” was available; it is not known what bearing this had on the results). Again, local weather conditions and material availability will influence the specific techniques used. A period of intense dryness and sunshine will increase evaporation and could dry the more exposed traps, thus causing damage to the specimens and reducing the effective trapping time. In this case top up trips may be necessary, or the addition of a viscous liquid such glycerol if practicable. At the other extreme, rain may flood the traps, washing away the contents, and further diluting the detergent solution. In this case overflowed invertebrates can often be recovered, but recovery should be attempted as soon as possible following rain. In Zone E an experimental variation was tested. A trap was set in a wave cut peat platform at water level, the outer cup pierced, and a holding flap cut to prevent water pressure from pushing out the trapping cup. A small drainage nick was cut at the rim of the latter to prevent catastrophic overflow at the expense of the possible loss of the smallest floating specimens. The results show that this was an interesting venture. In addition to trapping, collection was supplemented by searching and net dipping of pools.

Over the expedition period of one month three collections from each trap were possible. Although summary results of the Coleoptera from the traps have been published (Buckland *et al*. 1998; Buckland 2000; Buckland 2007), work on the Diptera was curtailed by the death of Peter Skidmore (cf. Skidmore 1997) and this material was lost. In addition, no arachnologist was available to deal with spiders and harvestmen. It was also only with the publication of the monograph on Greenland’s entomofauna (Böcher *et al*. 2015) that it became possible to readily identify the remaining material, largely Homoptera. Whilst storage in 75% ethanol has led to the partial decolorising of some specimens over 25 years, preservation remained sufficient to complete identification work and the results are presented in Table 1. Taxonomy follows Böcher *et al*. (2015).

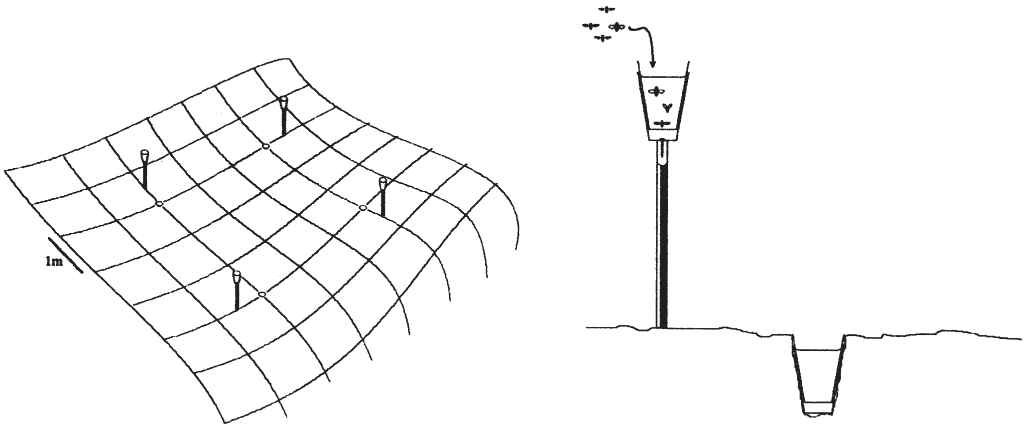

FIGURE 3. Layout of traps in each habitat.

Shannon and Simpson diversity indices, along with species richness, were calculated on raw and rarefied collection data using the PAST software (Hammer *et al.* 2001). The rarefied results allow for comparison between sites using diversity estimates based on the sample (= zone) with the lowest number of individuals.

Results

A total of 219 adult individuals were identified from 22 species, mainly from the Coleoptera and Homoptera. A further 140 nymph and larval stage individuals were identified from nine taxa, seven of which could be identified to species. A further 12 individuals of the Aphidoidea superfamily were also collected but not identified in more detail (Table 1).

Species richness varied between the sites, with Zone A producing the highest number of species (16) and Zone C the lowest (7). The number of identified individuals also varied considerably, again with Zone A producing the highest number of individuals (218) and Zone C the lowest (8). Rarefied results (and Simpson diversity index on the raw values) suggest that Zone C, the bog, could be expected to provide the highest species diversity (within the identified groups) if sampling was to be replicated over a number of seasons (Figure 4).

Discussion

New to Greenland was the small staphylinid *Mycetoporus nigrans* Mäklin, 1853. (det. P. Hammond; (Buckland *et al.* 1998)). It accounts for the highest number of individual Coleoptera trapped (11) and was found in all zones apart from D and F. Despite its apparently recent increase in frequency in the region – it has also been taken in pitfalls in Nuup Kangerlua / Godthaab Fjord to the northwest (Hansen *et al.* 2016) - and absence of records in any of the Quaternary fossil assemblages from Greenland (Panagiotakopulu 2021), its range of habitats and distribution elsewhere make it an unlikely recent introduction. Circumpolar in the Arctic and extending southwards into the alpine zones of both Europe and North America, Strand (1946) notes it in northern Norway from litter beneath *Salix* scrub, at margins of snow patches and under seaweed, whilst Campbell (1991) adds sites above the treeline and on the tundra in North America. Not recorded in Böcher (1988), he subsequently (Böcher 2015a) notes it as widespread in the Nuuk region. This may be a result of the paucity of similar studies, although its discovery may also reflect factors such as an increasing population, perhaps a result of warmer summers over the past few decades (Hanna *et al.* 2012). It is uncertain whether species of *Mycetoporus* are mycetophagous or predatory, perhaps on the immature stages of Mycetophilidae, fungus gnats,

TABLE 1. Insects and gastropod from GUS 1995. Locality (See Figure 2).

	A	**B**	**C**	**D**	**E**	**F**
Coleoptera						
Caraidae						
Patrobus septentrionis (Dejean, 1828)			1			
Dytiscidae						
Hydroporus morio Aubé, 1838					1	
Colymbetes dolabratus (Paykull, 1798)					4	
Gyrinidae						
Gyrinus opacus C. R. Sahlberg, 1817					1	
Gyrinus opacus Sahl. (larva)					1	
Staphylinidae						
Mycetoporus nigrans Mäklin, 1853	1	3	1		5	
Byrridae						
Simplocaria metallica (Sturm, 1807)		2			1	
Simplocaria elongata J. R. Sahlberg, 1903		1				
Simplocaria sp. (larva)		2				
Byrrhus fasciatus (Forster, 1870)	2	2	1			1
Coccinellidae						
Nephus redtenbacheri Mulsant 1846						3
Nephus redtenbacheri (larva)				1		
Coccinella transversoguttata Faldermann, 1835	4	1		1		
Coccinella transversoguttata Fald. (larva)						
Curculionidae						
Otiorhynchus arcticus (Fabricius, 1780)	1	1	1	1		1
Hemiptera						
Nabidae						
Nabis flavomarginatus Scholtz, 1847						9
Lygaeidae						
Nysius groenlandicus (Zetterstedt, 1840)						1
Nysius groenlandicus (Zett.) (nymphs)	2					
Miridae						
Chlamydatus pullus (Reuter, 1870)	12					
Cicadellidae						
Macrosteles laevis (Ribaut, 1927)			1			
Psammotettix lividellus (Zetterstedt, 1840)	81	4	1	11	4	30
Psammotettix lividellus (Zett.) (nymphs)	102	2	2	9	1	1
Psyllidae						
Cacopsylla groenlandica (Šule, 1913)				2		
Cacopsylla groenlandica (Šule) (nymphs)	1			5		

TABLE 1. *Continued.*

	A	**B**	**C**	**D**	**E**	**F**
Psylla betulaenanae Ossiannilsson, 1970	2			1		
Psylla betulaenanae Ossian. (nymphs)	1					
Ortheziidae						
Arctorthezia cataphracta (Olafsen, 1772)					1	
Aphidiidae						
Acyrtosiphon cf. *boreale* Hille Ris Lambers, 1952		2				
Aphidoidea indet.	1	3			3	4
Thysanoptera						
Thripidae						
Thrips vulgatissimus Haliday, 1836	1			1		1
Lepidoptera						
Gelechiidae						
Bryotropha similis (Stainton, 1854)						4
Indet. (larva)	1				1	
Mollusca						
Gastropoda						
Limnaeidae						
Ladislavella catascopium (Say, 1817)					1	

and its apparent increase in frequency may relate to complex changes in its microenvironment. If *M. nigrans* feeds on gnats, thrips (Thysanoptera) or mites (Acaridae), which were found in most traps, then rises in their populations due to a succession of warmer drier years could be responsible. If, on the other hand, it is a mould or fungus feeder then dry conditions could have accelerated the growth of dry loving moulds. These are pure speculations, and further work is needed to clarify this find. Very little work has been done in the area and it would be foolish to draw conclusions that suggest it is a recent immigrant with such sparse knowledge.

Elytra of the byrrhid *Simplocaria elongata* J. R. Sahlberg, 1903 were first noted as distinct from *S. metallica* (Sturm, 1807) in material from Norse midden deposits from sites in the Western Settlement in Ameralla by the late Russell Coope (pers. comm. 1982) but identification was only confirmed by a modern specimen collected near Kilaarsarlik in 1984. Described from northern Russia by J. Sahlberg, the species is Holarctic in distribution with records from Varanger in Norway, the Kanin Peninsula and northern Siberia (Lemdahl 1997). In North America, the species was previously recorded under the synonym *S. remota* Brown, 1940 (Böcher 1988) and has recently been found in Little Ice Age archaeological deposits in Alaska (Forbes *et al*. 2020), where it is presumably still extant. The Kilaarsarlik specimen was observed feeding on encrusting mosses and lichens on a stone. Böcher (1995) also notes a tentative fossil identification of *S. elongata* from deposits at Kap Kobenhavn, Greenland, dated to between 2.6 to 1.8 million years old, suggesting the species may have colonised the island multiple times.

Very few terrestrial Coleoptera were observed in general, and additional searching failed to bring back many specimens – only eleven individuals were taken over the four weeks. This was also noted when observing the traps. Bird droppings around some of the traps in Zone F may partially explain low catch rates. It is possible that the ravens preferred Coleoptera, a colleague having told PIB that there were “black beetles” in the

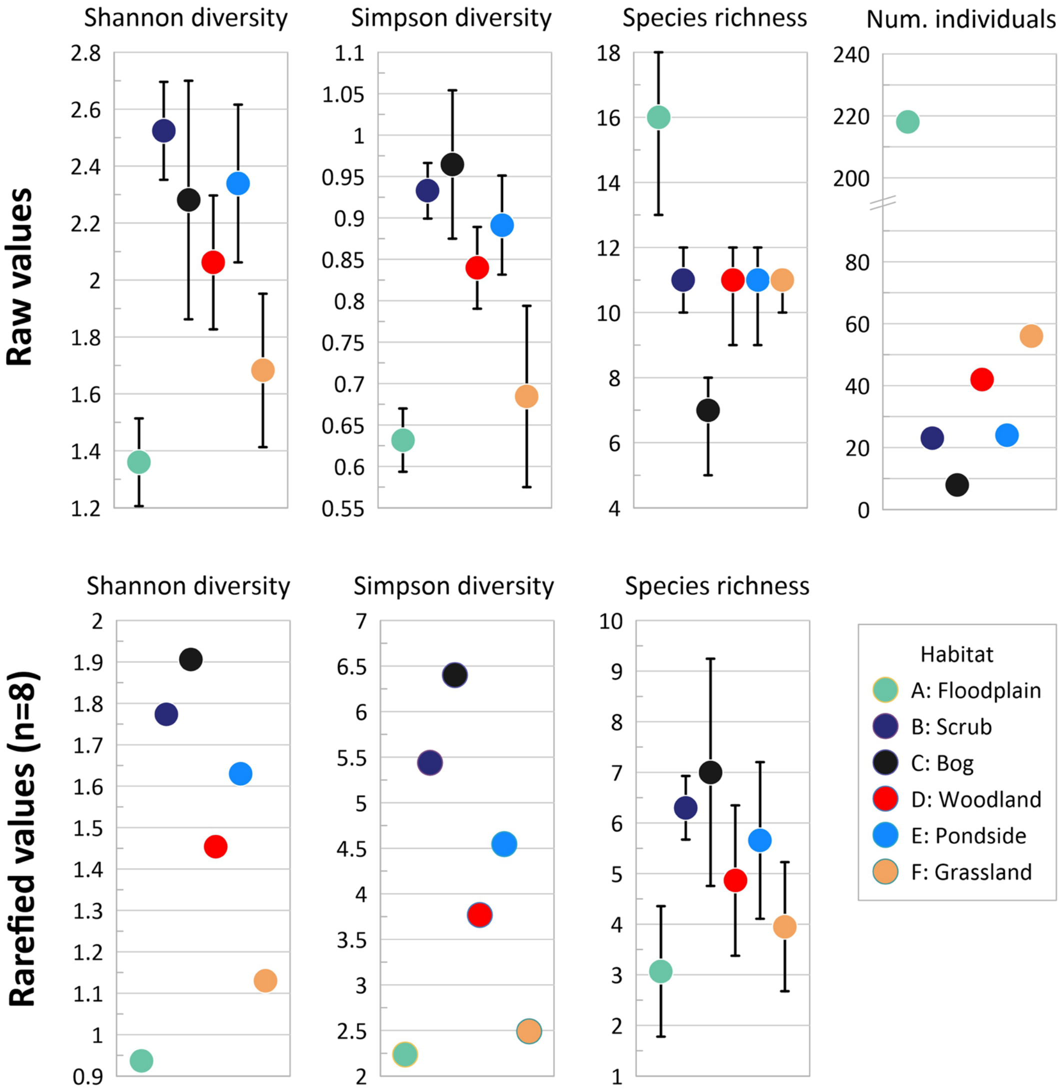

FIGURE 4. Diversity indices and species richness estimates calculated both from raw counts and rarefied to 8 individuals (smallest sample). Error bars show 95% unbiased (centred) Bootstrap limits calculated on 9999 replicates for the raw results and rarefied richness only. Calculations undertaken in PAST v4.10 (Hammer *et al.* 2001).

traps before they were emptied, and there is no reason to doubt this. Ravens in the area appeared curious about human activity and frequently visited the archaeological excavation out of working hours. However, the exposed nature of Zone F (Figure 2) may not have been ideal for catching insects. Reindeer (Caribou) were observed to be curious about the traps but were not destructive. Co-workers on the archaeological site, with several years' experience of Greenlandic summers, commented that even the presence of mosquitoes and black fly was low compared with previous years, and it is possible that the black fly season was delayed by weather conditions in this and the previous year. The lack of surface active Coleoptera contrasts with results from a decade earlier at Kilaasarlik (Sandnæs) at the head of the Ameralla to the north, where casual collecting noted both carabids and staphylinids active on warm silt and rock surfaces and byrrhids feeding on mosses and lichens in the ruins of Norse farms (Buckland, P. C., unpubl., but see Böcher (1988) for records). In contrast, aquatic insects were abundant in all but the most eutrophic (i.e. caribou dung polluted) ponds. The whirligig beetle *Gyrinus opacus*, C. R. Sahlberg, 1819, represented by a single larval individual in the pitfalls, occurred in large numbers on the surface of pools. Both dytiscids, *Colymbetes dolabratus* (Paykull, 1798) and the small *Hydroporus morio* Aubé, 1838, were easily collected by dipping vegetated ponds but only a single mature larva of the former appeared in a pitfall trap, presumably leaving the water to find a suitable pupation site.

Lepidoptera were largely impossible to identify after a week's emersion in pitfalls, and larger species of moth were unusually prevalent dominating almost all trap assemblages. The exceptions were zone C (bog moss and grass) (Figure 2), where arachnids were dominant, and zone E (pond side) where Diptera were exceptionally abundant. Much of the willow scrub was in poor condition, looking either dry or eaten, if in recovery, but with some sparse new growth. It may be that earlier in the year the species suffered a plague of caterpillars which would explain the number of moths in the traps. The run of two consecutive dry years would make conditions ideal for such an occurrence since this would have stressed the vegetation and made it more susceptible to successful lepidopterous attack, a point made by Johannes Iversen (1934) concerning an outbreak of *Eurois* (= *Agrotis*) *occulta* (Linnaeus, 1758), a species to which many of decayed off-white moths in the traps probably belonged, nearly a century ago. One small species of moth, *Bryophora similis* (Stainton, 1854) was identified from a trap in area F (Ole Karsholt, pers. comm.); the species is common and ubiquitous in SW Greenland.

Although the quantity of insects caught was low, there are some interesting additional results which add to distributional data. Previous modern records of the small ladybird *Nephus redtenbacheri* (Mulsant, 1846) are restricted to much further south, around Narsaq and Qoqortoq (Böcher 1988), although there are Norse fossil records from the site at Niaqussat near the head of Ameralla (McGovern *et al*. 1983). The species was used as an example of the use of insects as indicators of climatic change by Buckland *et. al.* (1996), but those arguments perhaps now have to be rethought. It was argued that these records belong to the warmer period previous to the Little Ice Age, and that it could not have survived through to the present day. Whether it actually *did* survive the Little Ice Age *in situ* or has recolonised the area subsequently is a subject for debate. More extensive sampling of fossil environments could help to establish its presence/absence at various points through time.

The true bug *Nabis flavomarginatus* Scholtz, 1847 was a slightly surprising discovery (although one should perhaps never be surprised in an area that has been examined by so few researchers). It was only caught in the traps of the relatively dry grassland of Zone F (Figure 2). Böcher (2015b) notes that this predatory bug is largely restricted to former Norse hayfields and considered it to have been accidentally introduced by the settlers, finding a home in the managed hayfields on their farms. It is common in the sheep farm areas of southwest Greenland and has been found fossil in samples from the Norse site at Niqussat in Ameralla (McGovern *et al*. 1983). It now seems to be living on exposed grass slopes in the area close to the farm site. Largely flightless, although with the occasional macropterous individual, its survival to the present day suggests that some species may have the ability to persist in conditions which might be regarded as quite different from their usual habitat.

The most abundant species by far was the leafhopper *Psammotettix lividellus* (Zetterstedt, 1840), which feeds on grasses, and was present in all zones. Its dominance on the floodplain (Zone A) as both adult and nymphs suggest this is its primary habitat, with the grassy hillside (Zone F) possibly being an environment preferred by the adults. The species has been noted fossil in a number of Norse Greenland sites, including GUS (Buckland & Buckland 2006), and has been caught in pitfall traps in Greenland both north (Texas A&M University Insect Collection, 2021), and south (Panagiotakopulu & Buchan 2015) of the current site. Böcher (1971) notes that the mirid bug *Chlamydatus pullus* (Reuter, 1870) is occasionally predatory on other small insects but it is largely a polyphagous phytophage and its apparent restriction to the low birch and sedge scrub on the floodplain (Zone A) suggests that other factors than the availability of host plants may limit its distribution.

Conclusions

Synanthropy, the dependence of a species on man-made environments, is often a function of the species' distance from its 'natural' environment. Human constructions create niches which are so ecologically similar to naturally occurring ones that some insects can live there permanently north of their 'natural' limits. In the context of Norse farms on North Atlantic islands, temperature plays an important role, in that the houses and byres must have been significantly warmer than the outside, especially during the winter months. Members of families such as the Cryptophagidae and Latridiidae may occur in natural environments in the warmer temperate zone and Tropics but are largely synanthropic in the Arctic and subarctic; examples of both families appear in assemblages from the abandoned Norse farms around the head of Ameralik Fjord (cf. Sadler 1987). The above discussion of *N. flavomarginatus* gives us a slightly different example, and some terminological difficulties (which Kenward (1997) has tried to address in terms of subclassifications of synanthropy). It is believed that the species did not naturally occur in Greenland prior to Norse settlement, but then survived as a synanthrope in the environment created by the activities of the farmers (Böcher 2015b). Whether it should still be called a synanthrope whilst living in the 'artificial' post-clearance, and post occupation landscape is debatable. The landscape is of human creation, but no longer maintained. The species also serves to illustrate the persistence of human impact on the landscape in Arctic environments, and as a reminder that any changes made today may affect insect biodiversity for hundreds of years.

A similar problem occurs in the discussion of species, in particular *Xylodromus concinnus* (Marsham, 1802) and *Quedius mesomelinus* (Marsham, 1802), which appear both in Norse farms and 19th century Inuit turf houses. It is unknown whether the beetles survived in the time between these habitats or were reintroduced later (Böcher 1988). It is also relevant to discuss here, as a final note, the concept of *ecotones,* the zones of overlap between environments (cf. 'transitions' in Hansen *et al.* 2016). As can be seen in Figure 2, ecotones have not expressly been included in the survey, and we have only attempted to sample specific vegetational regimes and not the transitional areas in between (although their definition is often a question of scale, and quite difficult to decide). Given more time the investigation would have included some, since there can often be more species found there, a mixture of individuals from all the surrounding zones. This phenomenon is known as the *edge-effect* in ecology and is well documented in studies of species abundances (Odum 1971, 157; more recently, see van Klink *et al.* 2016). Whilst more difficult to quantify, edge-effects will have long-term chronological components on archaeological timescales, influenced by a complex entanglement of climate change and anthropological influences on the environment. Further studies linking long-term past and present changes in biodiversity are essential for understanding present biodiversity patterns and future implications of climate change and human impact (Dietl 2019, Hochkirch 2017, Pilotto *et al.* 2022).

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