Preliminary archaeoentomological analyses of permafrost-preserved cultural layers from the pre-contact Yup'ik Eskimo site of Nunalleq, Alaska: Implications, potential and methodological considerations

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At Nunalleq, a pre-contact Yup'ik Eskimo village site in Alaska (14th–17th century AD), abundant insect remains from highly organic substrates preserved within permafrost offer a unique opportunity to investigate past ecological and living conditions. This paper presents the preliminary results obtained from the analysis of two samples collected from floor layers in sod houses. The numerous and diverse insect remains highlight the exciting potential of archaeoentomology for reconstructing past ecological conditions, resource exploitation and the use of space at northern hunter–gatherer sites and have permitted the development of a strategy for the future collection of archaeoentomological data at permafrost-preserved sites in Alaska and elsewhere.

Keywords: Archaeoentomology, Pre-contact Alaska, Ectoparasites, Methods

Introduction

Archaeoentomology, the use of insect remains in archaeological interpretations, has been employed on many projects since its first use on British archaeological sites in the late 1960s (Coope and Osborne 1967). This approach, which uses the ecological requirements of taxa identified in fossil assemblages to reconstruct past ecological conditions (Kenward 1978; Elias 2010), has allowed for the assessment of past living conditions; the identification of activities (e.g. wool processing, delousing, resource exploitation, trade); and the evaluation of their impacts on local environments (e.g. Buckland *et al.* 1993; Bain 2001b; Smith 2012; King *et al.* 2014).

While urban and farm settlements are well-represented in the archaeoentomological record (e.g. Hall and Kenward 1990; Buckland *et al.* 1993; Kenward and Hall 1995; Bain 2001b; Smith 2012), little research has been undertaken on insect remains from northern hunter–gatherer occupation sites. The few studies conducted on Palaeo-Eskimo (Saqqaq and Dorset) and Neo-Eskimo (Inuit) sites in Greenland and north-eastern Canada have

nevertheless started to reveal the value of insect remains as indicators for animal and plant exploitation, hygienic practices and their impacts on local environments (Forbes *et al.* in press). In Alaska, numerous fossil beetle assemblages have been analysed and employed in reconstructing environmental and climate change over the last 5 million years (e.g. Elias and Matthews 2002; Matthews *et al.* 2003; Bigelow *et al.* 2014). However, few studies have targeted insect remains extracted from archaeological deposits (see Hoffecker *et al.* 2012 for an exception) and the potential of archaeoentomology to illuminate past pre-contact life-ways in Alaska remains largely unexplored.

This paper presents the results of preliminary archaeoentomological analyses conducted on samples taken from the floor layers of sod houses, occupied from *c.* 1300–1650 AD, at the pre-contact Yup'ik Eskimo site of Nunalleq (GDN-248), in Western Alaska. The site is located in the organic-rich wetland delta of the Kanektok and Arolik Rivers, part of a wider braided river system between the Yukon and Kuskokwim Rivers (Fig. 1). The organic nature of most of the artefacts and features at the site – where the former occupants employed wood and other organic materials in the fabrication
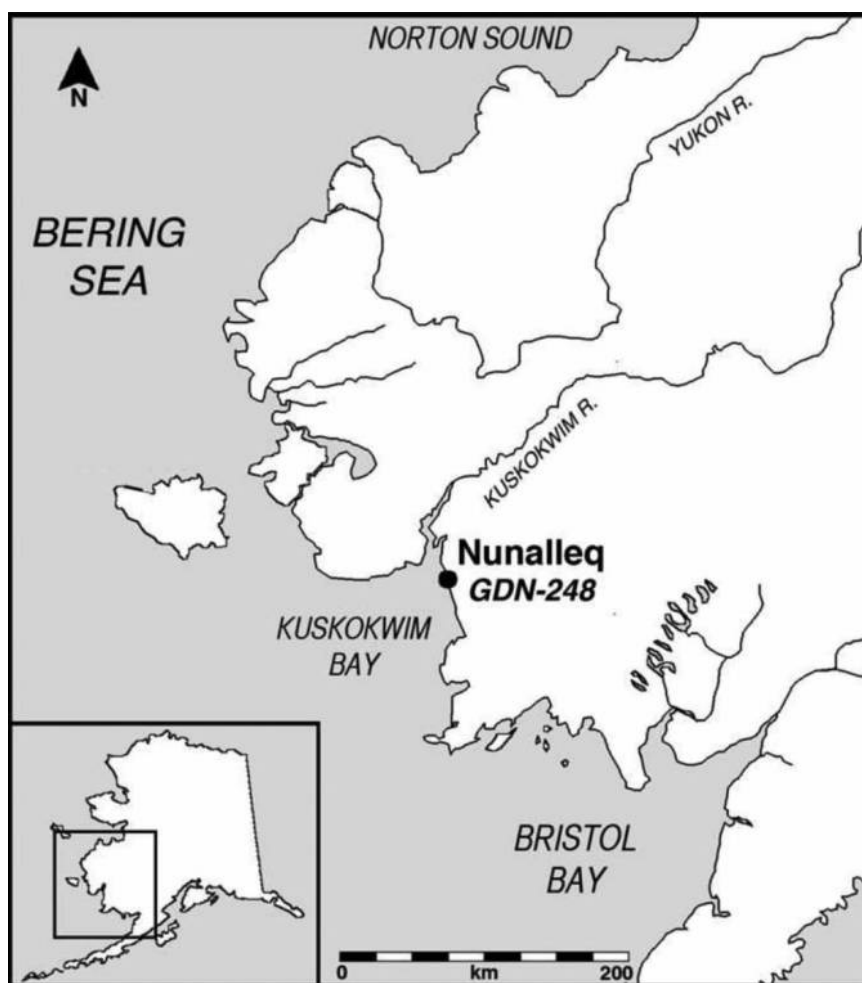
Figure 1   Map of western Alaska showing the location of Nunalleq (modified from Britton *et al*. 2013).

of buildings, tools and ceremonial objects – and its preservation in permafrost have allowed arthropod (insects, arachnids and crustaceans) fossils to be exceptionally well-preserved. Given that climate change and rising sea levels, combined with increasing storminess, are rapidly eroding the site, excavations at Nunalleq are as much a salvage operation as an opportunity to collect unique bioarchaeological datasets, making the establishment of an efficient and effective data collection strategy of primary importance. In this paper, we utilise the results of the preliminary analyses to explore the nature of arthropod remains preserved, the research questions that can be addressed and to build a strategy for the future collection of archaeoentomological data at Nunalleq.

Study Site and Methods
Nunalleq
Nunalleq is located on the coast of the Bering Sea (Fig. 1), close to the Yup'ik village of Quinhagak, set in a landscape characterised by low and flat tundra with abundant lakes, ponds and rivers and bordered by a sandy beach to the west. The area is characterised by a subarctic/maritime climate, with 13°C mean July (TMAX) and −10°C mean January

(TMIN) temperatures and a mean annual precipitation of 500 and 1000 mm (Hartman and Johnson 1978). At the Nunalleq site, cultural layers up to 75 cm thick are located *c*. 30 cm below the surface and rest upon clays and silts. Since 2009, the site has been excavated by a team led by archaeologists from the University of Aberdeen and Quinhagak's village corporation Qanirtuuq Inc., as part of a broader archaeological, scientific and community heritage project. The remains of at least four sod houses have been uncovered and ^{14}C dates suggest occupation between *c*. 1300–1650 cal. AD (Britton *et al*. 2013). Artefacts are abundant and include wooden tools and ornaments, lithics, pottery, as well as baskets, mats and cordage made of woven grass blades and roots. Human hair, fur and animal bones are also preserved (Britton *et al*. 2013).

Excavation and Sampling Methods
Excavation and associated data recording at Nunalleq followed a grid dividing the excavation areas into square units of 2 × 2 m. Initial excavations (2009–2012) were undertaken by unearthing archaeological layers within each square separately. Thus, the boundaries of each recorded unit were defined

laterally by the grid lines and vertically by the site stratigraphy, i.e. observed changes in the sediment composition and structure. However, when the extent of bioarchaeological remains became apparent the decision was made to convert to the single context recording system to facilitate the reconstruction of past activity, diet and living conditions at higher spatial and chronological resolutions.

Sporadic sampling of organic materials and floor layers to provide materials for dating and exploratory bioarchaeological analyses was undertaken in 2009–2010. In 2012, 2-l sediment samples, collected with clean tools and stored in heavy gauge plastic bags, were collected for biological macro-remains (both plants and insects) from all excavated floor layers. The following year, it was decided to collect one sample from each excavated context, and in the case of floor layers, to take one from each grid square (i.e. multiple samples from single contexts). Samples collected in 2012 and 2013 were stored in refrigerators immediately after their arrival at the University of Aberdeen, but those obtained in 2009 and 2010 were stored either in refrigerators or freezers, following air-drying in some cases. Two of these samples have been analysed and are discussed in this paper.

Archaeoentomological Methods

The two samples analysed for insect remains were collected from distinct house floor layers that were partially excavated at Nunalleq in 2010. Sample 10500 was collected from a building interpreted as a former *qasgiq* or men's house because of the predominance of wood scraps and artefacts linked to activities typically associated with males, while the other (10136) came from a structure of unknown function. Both were shipped from Alaska to the University of Aberdeen immediately after the field season and stored in a freezer: one while still damp and one after having been air-dried. Prior to analysis, the samples thawed in a refrigerator and were soaked in a *c.* 5% solution of sodium carbonate (Na_2CO_3) for a period of 24–48 hours. They were then wet-sieved through 300 μm meshes and processed using paraffin floatation (Kenward *et al.* 1980), conducted once for each sample. Resulting 'flots' were examined under a low-power (×10) binocular microscope. During this stage, all insect and other arthropod fragments were collected and placed in vials filled with 70% ethanol. Heavy residues were visually scanned to allow the collection of insect remains that did not float and the description of the samples' contents (Table 1).

Preliminary identification of arthropod remains to the taxonomic level of class and order was achieved through comparison with illustrations from websites and entomological publications (Peterson 1957;

Table 1 List and description of analysed archaeoentomological samples from Nunalleq

| Sample | Dating | Volume (ml) | Storage conditions | Description of the sediment | Macro-remains* | | | | Preservation state of insect remains |
					Charcoal	Seeds	Moss	Feathers	
10136	*c.* 1660 AD	400	Frozen while damp	Damp dark brown humose silt with 24% plant remains, 5% wood chips, 2% charcoal and <1% coarse sand.	F	F	D	O	Excellent, *c.* 10% Coleoptera slightly fragmented, *c.* 70% Phthiraptera twisted/distorted
10500	*c.* 1550 AD	800	Dried and frozen	Dry dark brown humose silt with 10% plant remains, 7% wood chips and <1% fish bones.	R	O	A/D	F	Good, *c.* 40–50% Coleoptera fragmented, *c.* 70% Phthiraptera twisted/distorted and fragmentary

*DAFOR: D, dominant; A, abundant; F, frequent; O, occasional; R, rare.

Arnett 1985; Borror and White 1991). Identifications of Coleoptera and Phthiraptera to more precise taxonomic levels were obtained by comparing fossil remains with reference specimens from the Canadian National Collection of Insects, Arachnids and Nematodes in Ottawa (CNC), with the assistance of coleopterists. Lice identifications were aided by consultation of publications by Price and Graham (1997) and Séguy (1944). The minimum number of individuals (MNI) for each insect taxon was calculated from the most abundant insect part.

Results

The full list of identified taxa recovered from the Nunalleq samples can be found in Table 2. The number of identified arthropods was particularly high (Fig. 2) and their preservation conditions were very good, although the less heavily sclerotised remains of lice were distorted and twisted. This is more likely to be an artefact of poor storage handling than of site taphonomy, as suggested by the remarkably high number of specimens that were recovered from such small volumes of processed sediment. Each sample yielded over 500 individuals, totalling 3703 arthropods (MNI) and this excludes an abundance of insect fragments that were observed but not quantified either because they could not be identified or were not deemed useful for archaeoentomological interpretation (i.e. remains of very mobile insects such as adult flies and wasps).

Over 300 mites (Acari) (Fig. 3A) were recovered from these samples. Mites inhabit all kinds of terrestrial and aquatic habitats, some are ectoparasitic on arthropods or vertebrates and others are associated with synanthropic situations such as food stores (Baker 2009; Kenward 2009).

Fairly small numbers of crustaceans, including two ephippia (egg sacs) of water fleas (Cladocera) (Fig. 3B) and one carapace of an ostracod (Ostracoda), were also retrieved. Most of the arthropods were insects including lice (Phthiraptera), beetles (Coleoptera), caddisflies (Trichoptera), true flies (Diptera) and fleas (Siphonaptera).

Two different orders of ectoparasitic insects were present at Nunalleq: Phthiraptera (lice) and

Table 2   List of invertebrate taxa identified from Nunalleq with calculated MNIs. Taxonomy follows Bouchard *et al.* (2011) for beetles and Arnett (1985) for other insect orders

	Sample number	
	10136	10500
CHELICERATA		
ARACHNIDA		
Acari indet.	259	39
CRUSTACEA		
BRANCHIOPODA		
Cladocera indet. (ephippia)		2
OSTRACODA		
Ostracoda indet.	1	
HEXAPODA		
INSECTA		
Phthiraptera		
Pediculidae		
Pediculus humanus L.	22	53
Trichodectidae		
Trichodectes canis (De Geer)	2	
Phthiraptera indet.		7
Coleoptera		
Carabidae		
Pterostichus sp.	2	
Pterostichus (*Cryobius* gr.) sp.	1	
Carabidae indet.	2	1
Dysticidae		
cf. *Hydroporus* sp.	1	
Staphylinidae		
Eucnecosum spp.	10	2
Olophrum spp.	4	1
cf. *Olophrum latum* Mäklin	1	
Omaliinae indet.		1
Aleocharinae indet.	12	3
Oxytelinae indet.	1	
Stenus spp.	6	
cf. *Euaesthetus laeviusculus* Mann.	2	
Staphylinidae indet.	8	2
Staphyloides indet.	1	
Latridiidae		
Latridius cf. *protensicollis* Mann.	1	3
Coleoptera indet.	4	1
Trichoptera		
Trichoptera indet. (larva)		6
Diptera		
Cyclorrhapha indet. (puparia)	137	3036
Chironomidae indet. (larva)	32	33
Siphonaptera		
Siphonaptera indet.	2	2
TOTAL MNI	511	3192

Siphonaptera (fleas). Apart from four unidentified heads of fleas, all other ectoparasites specimens are lice. The majority (85%) were identified as the human louse *Pediculus humanus* L. (Fig. 3C), which
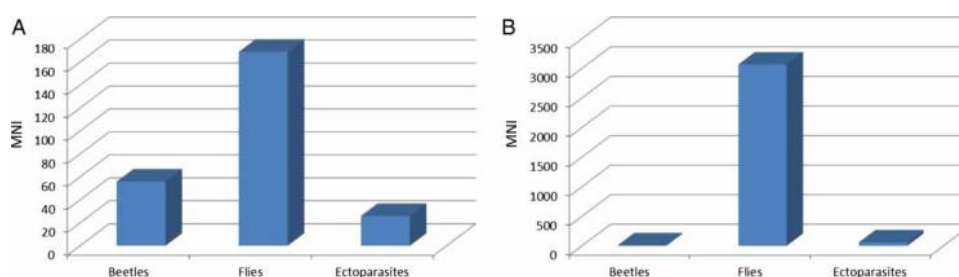

Figure 2   Histograms comparing the number (MNI values) of identified beetles, flies and ectoparasites recovered from sample 10136 (A) and sample 10500 (B).
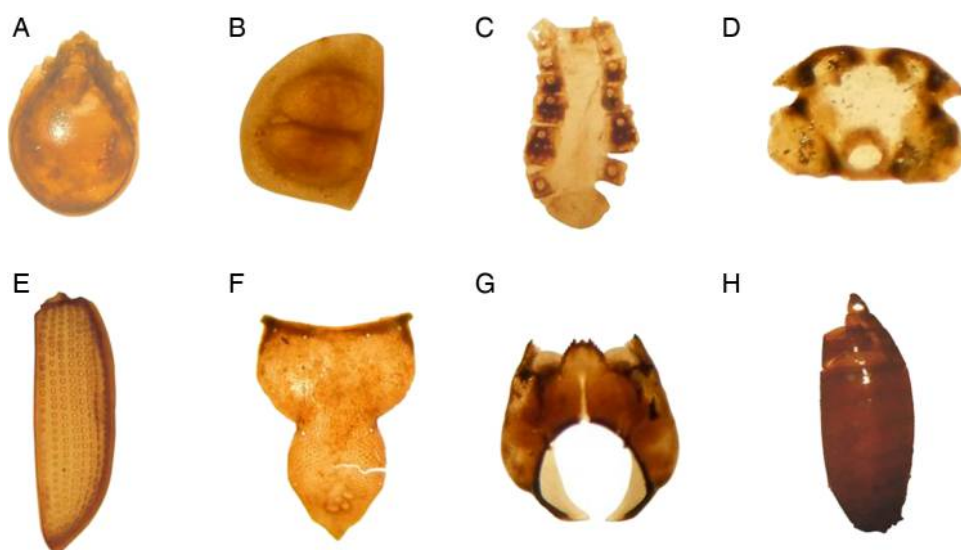
Figure 3   Photographs of arthropod remains recovered from Nunalleq: (A) abdomen and fused head and thorax of a mite (Acari), (B) ephippium of a water flea (Cladocera), (C) abdomen of a human louse (*Pediculus humanus*), (D) head of a dog-biting louse (*T. canis*), (E) right elytron of the beetle *Latridius* cf. *protensicollis*, (F) frontoclypeus of a caddis fly (Trichoptera) larva, (G) head capsule of a midge (Diptera: Chironomidae) larva and (H) puparium of a fly of the suborder Cyclorrhapha.

feeds exclusively on the blood of humans (Kim *et al.* 1986). In addition, two heads of dog-biting louse *Trichodectes canis* (DeGeer) (Fig. 3D), which feeds on skin debris on domestic dogs and other canids (Durden 2002), were also present.

The coleopteran remains from Nunalleq span four families: the ground (Carabidae), predaceous diving (Dysticidae), rove (Staphylinidae) and minute brown scavenger (Latridiidae) beetles. Species in the ground beetle genus *Pterostichus* may be found in a wide range of habitats (Lindroth 1966), but members of the *Cryobius* subgenus are generally associated with cold, moderately moist environments (Arnett and Thomas 2001). All predacious diving beetles prey on other organisms in aquatic settings such as ponds and streams (Arnett 1985) and the single specimen from Nunalleq was tentatively identified as *Hydroporus* sp., associated with shallow water margins (Arnett and Thomas 2001). The samples produced several taxa of rove beetles, among which specimens of the genera *Eucnecosum*, *Olophrum*, *Euasthetus* and *Stenus,* spanning a wide range of habitats where organic matter is present. One of the specimens was tentatively identified as *Olophrum latum* Mäklin and two as *Euaesthetus laeviusculus* Mann. Both species are associated with swamps, bogs and fens (Campbell 1983; Koch 1989). The notoriously difficult subfamily Aleocharinae is also represented by 12 specimens. Latriidids (Fig. 3E) feed on moulds, fungi and spores in decaying vegetation and can be found in the open, in nests or inside buildings (Bousquet 1990). The four specimens recovered from Nunalleq were successfully matched with modern ones identified as *Latridius protensicollis* Mann. in the CNC, but as this family is rather poorly known taxonomically, it

is not possible to confirm this identification. Not all the beetles were definitively identified to species, but the recovery of several well-preserved genitalia indicates that it will be possible to do so in further stages of the analysis.

Six head capsules of caddisfly (Trichoptera) larvae (Fig. 3F) were present in sample 10500. As adults, they are ready-fliers, but their larvae live in aquatic environments (Arnett 1985; Elias 2010). Like caddisflies, the larvae of midges (Chirononimidae) (Fig. 3G) live in water, where they are largely sedentary (Walker 1987). By far the most abundant insects from Nunalleq were true flies (Diptera), totalising 3173 individuals. Many remains of adults and pupae of primitive flies from the suborders Nematocera and/or Brachycera were observed in the samples. However, apart from chironomid larval head capsules, only the puparia (hardened cases into which the pupae metamorphose into fully winged adult flies) from the suborder Cyclorrhapha (Fig. 3H) were counted as they preserve well in archaeological sediments and exhibit characteristics useful for identification (Skidmore 1996; Panagiotakopulu 2004). This group comprises species which, as larvae, occupy a diverse range of habitats, including decaying materials of plant and animal origin (Phipps 1983).

Discussion
Interpreting the Archaeoentomological Assemblage from Nunalleq
The arthropods identified from Nunalleq are highly diverse, yet, despite the fact that the samples were collected from cultural layers, nearly all these taxa are associated with natural, outdoor environments. In fact, this reflects a crucial difference between the

insect faunas present on northern sedentary settlements and seasonal hunter–gatherer sites. While synanthropic (dependent or favoured by human activity) beetles are dominant in samples collected directly from cultural layers (e.g. floors, middens, latrines) on urban and rural settlements (e.g. Hall and Kenward 1990; Kenward and Hall 1995; Smith 2012), they are virtually absent from hunter–gatherer sites. As at Nunalleq, the only synanthropic insect that is common in such contexts is the human louse *P. humanus* (e.g. Bresciani *et al.* 1983, 1989; Hansen *et al.* 1991; Dussault 2011)*,* which can be considered evidence for delousing practices (e.g. Buckland *et al.* 1998; Dussault 2011). One synanthropic beetle taxon has been identified from Inuit sites in Labrador, the brown minute fungus beetle *Latridius minutus* (grp.), but the dating of these deposits (17th–18th century AD) suggest that it was introduced to Inuit winter houses via contact with Europeans (Dussault and Bain 2010). Synanthropic beetles play a very important role in archaeoentomological reconstructions of past daily life. Economically important ones such as grain pests are often indicative of trading and agricultural activities (e.g. Smith and Kenward 2011; King *et al.* 2014), while decomposer beetles may reveal information about the ecological conditions and the types of materials present inside buildings (e.g. Smith 2012; Forbes and Milek 2013). The absence of synanthropic beetles on northern hunter–gatherer sites therefore poses new questions and challenges for archaeoentomologists used to dealing with these insects: why are they absent, and can other insects provide valuable and detailed information about human activity and living conditions?

Synanthropic beetle species most commonly encountered on urban and rural archaeological sites likely originated from natural contexts such as nests and tree hollows in temperate regions before they moved to the food stores and buildings created by humans and dispersed throughout the world as a result of global trade and human migrations (Kenward and Allison 1994; King *et al.* 2014). These tend to become more strongly restricted to indoor environments in northern latitudes, because buildings may be seen as 'islands' of exploitable habitats for insects that could not withstand outdoor temperatures (Kenward and Allison 1994). In such contexts, the presence of synanthropic species is dependent on their capacity to invade buildings, while their long-term survival depends on the permanence of suitable habitats and the frequency of invasions (Kenward and Allison 1994; Kenward 1997). Archaeoentomological research has shown that agriculture, human migrations and trade played an important role in the configuration of insect faunas around the globe (Sadler and Skidmore 1995; Bain and King 2011; King *et al.* 2014). For example, fossil records

dating from the Viking Age (9–11th centuries AD) suggest that at least 25% of the Coleoptera species listed by Larsson (1959) as synanthropic in Iceland were first introduced to the country on the ships of the first Norse colonists (Sadler 1991). The successful establishment and persistence of these introduced insects was no doubt enabled by the continuous availability of suitable habitats in the turf houses, animal buildings and middens present on Icelandic farmsteads (Sadler 1991; Sadler and Skidmore 1995). In contrast, the relative isolation and transitory nature of northern hunter–gatherer sites such as Nunalleq would appear to have precluded the development of substantial synanthropic faunas. Indeed, contact between the site's occupants and other cultures would have been limited or non-existent prior to the arrival of Russian and Euro-American missionaries and explorers from 1818 AD, apart from encounters with other Eskimo bands and their Dena'ina/Athapaskan neighbours (Vanstone 1984).

The dwellings at Nunalleq may not have supported the development of synanthropic insect faunas, but they are likely to have provided habitats that differed from those available in the natural environment. Indeed, previous archaeoentomological studies have recovered higher densities of beetles associated with organic waste on Palaeo-Eskimo and Inuit occupation sites than in the natural surroundings (see Forbes *et al.* in press). These mostly included rove beetles (Staphylinidae), which thrive as predators and scavengers in all kinds of decaying matter and are therefore likely to have been favoured by the occurrence of food waste and decaying sods on hunter–gatherer settlements. Since *c*. 80% of the beetles recovered from Nunalleq are also staphylinids, it appears likely that the site also provided ideal habitats for these insects. Insects other than beetles have been recovered from hunter–gatherer sites, most notably flies (e.g. Böcher and Fredskild 1993; Skidmore 1996; Hoffecker *et al.* 2012) and mites (Haarløv 1967). Since flies normally pupate in their primary breeding context and have narrow temperature, light, humidity and dietary requirements, they can be extremely useful in reconstructing local ecological conditions (Panagiotakopulu 2004). Those from the Palaeo-Eskimo site of Qeqertasussuk in Greenland included species feeding on meat and marrow, indicating the presence of food or butchery remains in the sampled archaeological layers (Skidmore 1996). The abundant fly puparia at Nunalleq (3038 in sample 10500) offer exciting potential, since their successful identification to species could allow very detailed reconstructions of the ecological conditions that occurred, and the activities that took place, inside and around the sod buildings.

Undoubtedly, some of the arthropods identified at Nunalleq did not originate from the site but were

either incorporated into the archaeological record as background fauna (*sensu* Kenward 1975) or as a result of their transport in resources collected from the local environment. Remains of aquatic taxa such as water fleas, chironomids and caddisflies are likely to have been transported with sods, water or aquatic vegetation into buildings (e.g. Buckland *et al*. 2012; Forbes and Milek 2013). The hygrophilous rove beetles *O. latum* and *E. laeviusculus* may have been carried with similar resources, or else indicate that marshes were present in the vicinity of the site *c*. 400 years ago, similar to the present-day. Some of the fleas and lice from Nunalleq may have originally infested animals or animal products that were brought to the site by the former human occupants. Apart from human lice, one other ectoparasite was successfully identified to species: the dog-biting lice *T. canis.* The two heads recovered are the only known archaeological records of this species to date, but other fossil records of dog parasites include specimens of the sucking louse *Linognathus setosus* Von Oflers, identified from Neo-Eskimo sites in northeast Greenland (Dussault 2011).

The interpretive value of insect fossils from archaeological sites often goes beyond supporting archaeobotanical and zooarchaeological evidence for the exploitation of particular plant and animal resource by revealing details as to how or where these resources were processed or stored. A good example comes from Uivak in Labrador, where Bain (2000, 2001a) recovered bark beetles (family Scolytidae) associated with freshly cut or fallen wood, suggesting this resource may have been harvested, rather than gathered, by the site occupants. On Palaeo- and Neo-Eskimo sites in Greenland, archaeological records of bird ectoparasites have been interpreted not only as evidence for the presence of bird carcasses (Böcher and Fredskild 1993), but also the plucking of birds prior to their consumption (Dussault 2011), while remains of bird fleas on Icelandic sites appear to have originated from collected eiderdown (Forbes *et al*. 2013). Mammals, birds and fish are all likely to have been employed by the occupants of Nunalleq in the fabrication of parkas, boots and various pieces of clothing, all of which require processed skins. Traditional methods known to have been employed by Alaskan Eskimos for such purposes include the use of fermented urine as a cleansing agent and the 'ageing' of skins to rid them of hair (Fienup-Riordan 2007) and these are likely to have produced accumulations of wild animal ectoparasites on house floors or outdoor living surfaces. The unidentified fleas and lice recovered from the site may have derived from such practices.

Ethnographic records of Yup'ik life-ways (e.g. Oswalt 1967; Barker 1993; Fienup-Riordan 2007; Fienup-Riordan and Rearden 2012) describe the gendered division of living spaces in winter villages and seasonal camps. Men and boys normally dwelt in buildings called *qasgiq* (plural *qasgi*), which also acted as political and ceremonial centres, while women and very young children lived in extended family houses called *eneat* (plural *enet*). In the *qasgiq*, men would have worked on repairing hunting and fishing tools, slept and taken their meals as well as 'fire baths' to clean themselves in heat and smoke. Women were responsible for the distribution, storage and processing of the gathered, fished and hunted resources, as well as the preparation of meals and confection of clothing. Archaeological research in southwest Alaska suggests the gendered division of spaces and activities was also a feature of pre-contact Yup'ik life (e.g. Lutz 1973; Shaw 1998; Frink *et al*. 2002). This has implications for archaeoentomology, since if animal resource processing and food preparation were undertaken in different buildings than those where men bathed and slept, these are likely to have produced different entomological signatures. Bathing in *qasgiq* may, for example, have caused the removal and death of large numbers of human lice that fell onto floors; while cooking, storage and animal carcass preparation, if it took place in the *eneat*, would have introduced more carrion-associated fly and beetle species and wild animal ectoparasites. Interestingly, the two samples analysed from the site produced remarkably different assemblages. The one that came from a probable *qasgit* was dominated by fly puparia and contained higher numbers of human lice than the other, which produced more mites and beetles remains.

Methodological Implications

The gendered division of living spaces and activity on Alaskan Eskimo sites has been discussed by archaeologists (e.g. Lutz 1973; Shaw 1998; Frink 2007) and occasionally investigated using environmental archaeology approaches (e.g. Bouchet *et al*. 1999; Knudson *et al*. 2004), though never using archaeoentomological methods. One of the most promising applications of archaeoentomology at Nunalleq thus lies in its use in examining the spatial organisation of activities. In light of the preliminary findings presented here, it is suggested that ectoparasites (both lice and fleas), fly puparia and beetles would prove the most valuable in the attainment of this objective, since they may permit the identification of traces of certain activities and resources. The remaining arthropods that were identified from Nunalleq are likely to be of more limited value. When recovered from buildings, water fleas, caddis fly and midge larvae are indicative of the transport and use of resources from marine and aquatic environments, but there is (arguably) little more they can reveal regarding past living conditions and activity.

Given that mites inhabit a wider range of ecological habitats, they could potentially contribute useful information on cultural environments (see Baker 2009); however, identification and access to relevant taxonomical and ecological information is renowned to be difficult and time consuming (Kenward 2009).

In most palaeoecological and archaeological approaches to the fossil record, it is customary to count at least as many specimens as a predicted number needed to obtain a representative sample (see Table 3) (Birks and Birks 1980; Pearsall 2010; Reitz and Shackley 2012) and this threshold is sometimes determined by methodological tests on fossil assemblages or modern biotic communities (e.g. Lytle and Wahl 2005; Lee 2012). In archaeoentomology, because processed samples are likely to have been sorted according to insect remains' size and shape, the whole flot needs to be examined once the fossil picking has begun (Kenward 1974). Therefore, specialists need to predict how much sediment must be processed in order to produce representative assemblages. The complex nature of archaeoentomological assemblages (see Kenward 1975, 1978) makes it very difficult to gauge this. In early archaeoentomological work, Kenward (1978) proposed that a minimum number of 100 individual insects (beetles and true bugs) per sample was desirable, but there has been scarcely any investigation of the influence of sediment sample and assemblage sizes on the accuracy and precision of archaeoentomological reconstructions since then. Numerous studies conducted on British sites have shown how heterogeneous the archaeoentomological record can be, both in terms of density and composition (e.g. Hall and Kenward 1990; Kenward and Hall 1995; Smith 2012). Characteristic assemblages can be defined for particular site/phase/feature combinations, but where duplicate subsamples have been analysed, results suggested there can be considerable variations even at the context level (Kenward 2009). Assumptions and limitations inherent to chosen sampling strategies are not always stated, but most archaeoentomologists favour the collection of standard-sized samples to facilitate inter-site comparisons. These normally vary between 2 and 5 l (e.g. Bain 2001b; Panagiotakopulu *et al.* 2007), or 1 and 5 kg (e.g. Kenward 2009).

Rather than favouring higher counts from single samples (and hence larger sample volumes), it may be preferable to devote more time and energy to increasing the temporal and spatial resolution of sampling, as well as the number of assemblages analysed (cf. Kenward 2009). A subsample from each context excavated at Nunalleq should therefore be analysed to enable meaningful comparisons of past living conditions and activities through time and space. As duplicates were collected from living surfaces and floor layers, it will also be possible to assess inter-context variations. The volumes examined were smaller than those normally analysed in archaeoentomology, but the MNIs recovered largely exceed the 100-mark proposed as required to make useful interpretations if ectoparasites and fly puparia are counted alongside beetles (Kenward 1978). One-litre subsamples should therefore provide ample data. Preservation conditions of insect remains were generally very good and this was no doubt enabled by the permafrost and the predominance of organic matter at the site. However, because of the way these samples were handled and stored, distortion and fragmentation of certain remains were observed. Although the effects of drying and freezing on the preservation of insect remains has never been systematically tested, these results suggests it would be better, in the future, to store the samples, still damp, in refrigerators.

Conclusion

This paper presented the results of the first analysis of insect fossils recovered from *in situ* archaeological floors layers from Eskimo sod houses in Alaska. The diversity and sheer numbers of arthropods recovered from the two samples analysed from Nunalleq highlight the strong potential of archaeoentomological analyses at the site. The abundant human lice, animal ectoparasites and fly puparia recovered suggest further work will help reconstruct activity areas and the use of space at the site, while aquatic taxa such as larval caddis flies and midges indicate the collection of resources from aquatic environments. In view of the research objectives and of the richness of these samples, it is suggested that further analyses should focus on remains of ectoparasites, fly puparia and beetles and that small samples collected from

Table 3 Comparison between the assumed numbers of fossil needed to obtain representative samples in various sub-disciples of palaeoecology/environmental archaeology

Sub-disciplines	Counts per sample	References
Palynology	300–500	Birks and Birks (1980)
	≥700	Cappers and Neef (2012)
Archaeobotany (plant macrofossils)	500	Hastorf (1999)
Fossil chironomid analyses	50–100	Walker (1987)
Palaeoentomology/archaeoentomology (beetle and true bug MNIs)	≥100	Kenward (1978)

each excavated contexts should provide ample data for examining how cultural environments and everyday practices at the site varied in time and space. Further analyses at Nunalleq will allow a detailed characterisation of insect faunas present in Eskimo homes, thus establishing a baseline for archaeoentomological analysis in the context of Western Alaskan prehistory.

Acknowledgements

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