Études Inuit Studies

Activity Areas or Conflict Episode? Interpreting the Spatial Patterning of Lice and Fleas at the Precontact Yup'ik Site of Nunalleq (Sixteenth to Seventeenth Centuries AD, Alaska)

frAires d'activités ou épisode de conflit ? Les phénomènes à l'origine de la distribution spatiale des poux et des puces à Nunalleq (XVIe-XVIIe siècles après J.C., Alaska)

Véronique Forbes, Jean-Bernard Huchet, Ellen McManus-Fry, Yan Axel Gómez Coutouly, Julie Masson-MacLean, Édouard Masson-MacLean, Paul M. Ledger, Kate Britton, Charlotta Hillerdal and Rick Knecht

Volume 43, Number 1-2, 2019

URI: https://id.erudit.org/iderudit/1071945ar
DOI: https://doi.org/10.7202/1071945ar

Publisher(s)

Centre interuniversitaire d'études et de recherches autochtones (CIÉRA)

ISSN

0701-1008 (print)
1708-5268 (digital)

Cite this article

Forbes, V., Huchet, J.-B., McManus-Fry, E., Gómez Coutouly, Y., Masson-MacLean, J., Masson-MacLean, É., Ledger, P. M., Britton, K., Hillerdal, C. & Knecht, R. (2019). Activity Areas or Conflict Episode? Interpreting the Spatial Patterning of Lice and Fleas at the Precontact Yup'ik Site of Nunalleq (Sixteenth to Seventeenth Centuries AD, Alaska). *Études Inuit Studies*, *43*(1-2), 197–221. https://doi.org/10.7202/1071945ar

Article abstract

Archaeoentomological research at the precontact site of Nunalleq (sixteenth and seventeenth centuries AD), Southwest Alaska, has identified hundreds of lice and fleas that infested both the human inhabitants of the site and their canine companions. As lice are host specific, staying attached to the host's hair or fur during the totality of their lifecycle, they are generally considered excellent indicators of activity areas. Fleas, however, are relatively less common in archaeological contexts and, since they are mobile and able to infest several different host species, their potential use in the spatial reconstruction of activities is more limited. At Nunalleq, the study of insects from the most recent archaeological contexts produced very different spatial distribution patterns for human lice, fleas, and dog lice. This article compares these archaeoentomological data with other datasets available for the site (carrion-feeding flies, human hair, fur, coprolites, projectile points, and pieces of clothing) with the aim of establishing the phenomena that produced the distinct spatial distributions observed.

Activity Areas or Conflict Episode? Interpreting the Spatial Patterning of Lice and Fleas at the Precontact Yup'ik Site of Nunalleq (Sixteenth to Seventeenth Centuries AD, Alaska)

Véronique Forbes[i], Jean-Bernard Huchet[ii], Ellen McManus-Fry[iii], Yan Axel Gómez Coutouly[iv], Julie Masson-MacLean[v], Édouard Masson-MacLean[vi], Paul M. Ledger[vii], Kate Britton[viii], Charlotta Hillerdal[ix], and Rick Knecht[x]

ABSTRACT

Archaeoentomological research at the precontact site of Nunalleq (sixteenth and seventeenth centuries AD), Southwest Alaska, has identified hundreds of lice and fleas that infested both the human inhabitants of the site and their canine companions. As lice are host specific, staying attached to the host's hair or fur during

i. Memorial University of Newfoundland, Department of Archaeology, St. John's, Newfoundland, Canada; UMR 5199 PACEA, Université de Bordeaux, Pessac, France; and Department of Archaeology, University of Aberdeen, Aberdeen, Scotland, United Kingdom. veorforbes@gmail.com

ii. UMR 5199 PACEA, Université de Bordeaux I, Pessac, France. jb.huchet@pacea.u-bordeaux1.fr

iii. Department of Archaeology, University of Aberdeen, Aberdeen, Scotland, United Kingdom.

iv. UMR 7055 Préhistoire et Technologie, Maison Archéologie & Ethnologie, Université Paris-Nanterre, Nanterre, France. yan.gomez@cnrs.fr

v. Department of Archaeology, University of Aberdeen, Aberdeen, Scotland, United Kingdom. julie.masson-maclean@abdn.ac.uk

vi. Department of Archaeology, University of Aberdeen, Aberdeen, Scotland, United Kingdom. edouard.masson-maclean@abdn.ac.uk

vii. Department of Archaeology, Memorial University of Newfoundland, St. John's, Newfoundland, Canada. pledger@mun.ca

viii. Department of Archaeology, University of Aberdeen, Aberdeen, Scotland, United Kingdom; and Department of Human Evolution, Max Planck Institute for Evolutionary Anthropology, Leipzig, Germany. k.britton@abdn.ac.uk

ix. Department of Archaeology, University of Aberdeen, Aberdeen, Scotland, United-Kingdom. c.hillerdal@abdn.ac.uk

x. Department of Archaeology, University of Aberdeen, Aberdeen, Scotland, United-Kingdom. r.knecht@abdn.ac.uk

ÉTUDES INUIT STUDIES 43 (1–2): 197–221

the totality of their lifecycle, they are generally considered excellent indicators of activity areas. Fleas, however, are relatively less common in archaeological contexts and, since they are mobile and able to infest several different host species, their potential use in the spatial reconstruction of activities is more limited. At Nunalleq, the study of insects from the most recent archaeological contexts produced very different spatial distribution patterns for human lice, fleas, and dog lice. This article compares these archaeoentomological data with other datasets available for the site (carrion-feeding flies, human hair, fur, coprolites, projectile points, and pieces of clothing) with the aim of establishing the phenomena that produced the distinct spatial distributions observed.

KEYWORDS
Ectoparasites, archaeoentomology, conflict, Yup'ik, Alaska

RÉSUMÉ

Aires d'activités ou épisode de conflit ? Les phénomènes à l'origine de la distribution spatiale des poux et des puces à Nunalleq (XVIe-XVIIe siècles après J.C., Alaska)

À Nunalleq, un site yup'ik précontact (XVIe et XVIIe siècles après J.C.) du sud-ouest de l'Alaska, des centaines de poux et de puces ayant infesté les habitants du site ainsi que leurs chiens ont pu être identifiés. Puisque les poux sont spécifiques à leur hôte, demeurant attachés aux poils ou à la fourrure de celui-ci pendant la totalité de leur cycle de vie, ils sont généralement considérés comme d'excellents indicateurs d'aires d'activités. Les puces sont relativement plus rares en contexte archéologique. Mobiles et capables d'infester plusieurs espèces-hôtes différentes, leur potentiel dans la reconstitution spatiale des activités semble, a priori, plus limité. Or, à Nunalleq, les résultats de l'étude des insectes provenant des contextes archéologiques les plus récents ont produit des schémas de distribution spatiale très différents entre les poux et les puces de l'Homme et également les poux du chien. Cet article compare ces données archéoentomologiques avec d'autres corpus de données disponibles à Nunalleq (mouches nécrophages, cheveux humains, fourrure, coprolithes, pointes lithiques, pièces vestimentaires) dans l'objectif de reconstituer les phénomènes à l'origine de ces distributions spatiales distinctes.

MOTS-CLÉS
Ectoparasites, archéoentomologie, conflit, Yup'ik, Alaska

******

Archaeoentomology uses the known ecology of insect species preserved in archaeological contexts to reconstruct past human–environmental interactions, practices, and behaviours. Although the approach remains underutilized outside of northern Europe, previous research has demonstrated the remarkable breadth of information that can be gleaned from the analysis of insect remains. For example, necrophagous (feeding on corpses or carrion) insects have been used to reconstruct Moche (Peru), Ancient Egyptian, Medieval (France), and Bronze Age (Levant) funerary practices

(Huchet 1996, 2010, 2013; Huchet and Greenberg 2010), and pests of stored products have revealed new information about trade and sanitary conditions in grain stores (Huchet 2017; King et al. 2014; Smith and Kenward 2011). In general terms, Coleoptera (beetles) subfossils can be used to reconstruct local ecological and climatic conditions (Dussault, Bell, and Grimes 2016; Elias 1997; Poher et al. 2017; Ponel et al. 2005), while also allowing the examination of past biodiversity change and the role humans played in the dispersal of species worldwide (Bain and King 2011; Panagiotakopulu 2014; Sadler 1991).

In frozen, waterlogged or desiccated archaeological deposits—ideal conditions for the preservation of insect exoskeletons (Elias 2010)—lice are often abundant. The human louse (*Pediculus humanus* L.), the louse species most commonly encountered on archaeological sites, is generally considered an excellent indicator of activity areas (Forbes et al. 2017). The human flea (*Pulex irritans* L.) is rarer, but its presence on urban and proto-urban archaeological sites has been considered indicative of poor hygiene levels and high epidemic risk (Kenward 2009; Panagiotakopulu 2004b), while also revealing new information regarding the species' biogeographical history (Buckland and Sadler 1989; Yvinec, Ponel, and Beaucournu 2000). Several insects parasitizing domestic animals have been identified from archaeological contexts. Both the sheep-biting louse (*Bovicola ovis* Palma & Barker) and the sheep ked (*Melophagus ovinus* (L.)) are common on northern European sites, where they are often interpreted as indicative of wool processing activities (Buckland and Perry 1989). Dog lice of two different species (*Linognathus setosus* Von Olfers and *Trichodectes canis* (De Geer)) have been recovered from subpolar hunter-gatherer sites in North America (Dussault, Bain, and LeMoine 2014; Forbes, Britton, and Knecht 2015). On rural, proto-urban, and urban sites, another parasite of dogs, the dog flea (*Ctenocephalides canis* (Curtis)), has occasionally been found. Wild animal ectoparasites are comparatively rare, although duck fleas have been demonstrated as useful indicators for the harvesting of eiderdown, a resource otherwise virtually invisible in the archaeological record (Forbes 2015). For an exhaustive list of ectoparasites recorded from archaeological sites, see Forbes, Dussault, and Bain (2013) or Huchet (2016). The potential of studies of ectoparasites from archaeological contexts goes beyond the simple documentation of their presence at a particular place and time, as they can also provide indirect evidence for the presence of their host species. Careful consideration must, of course, be given to the biological cycle of ectoparasitic species, which calls for caution in such interpretations.

Lice (Phthiraptera) are known to spend their whole lifecycle attached to the hair, fur, or clothing of their host (Busvine 1976; Séguy 1944). Given that grooming, moulting, and the loss of feathers can all lead to the loss or death of lice (Mullen and Durden 2002), remains of these parasites can be expected to end up on the floors of buildings or rooms where the hosts were present (Kenward and Hall 1995). These insects, however, normally stay firmly attached to the host thanks to their clawed tarsi. Natural shedding and grooming may cause a few lice to become detached from the host, but they are unlikely to fall to the ground in large numbers. For this reason, the occurrence of high concentrations of lice on archaeological sites has most often been interpreted as deriving from refuse produced from activities such as delousing or wool or skin processing, which normally involve the physical removal of these parasites from animals or their skins (Buckland, Sadler, and Sveinbjarnadóttir 1992; Dussault, Bain, and LeMoine 2014; Forbes et al. 2017).

Fleas (Siphonaptera) are more mobile and less host specific than lice. Although some species spend the entirety of their adult life in the host's coat, most fleas only occasionally visit the host to feed (Mullen and Durden 2002). Since fleas are able to travel relatively long distances and can survive for relatively long periods of time away from their host, they are less useful than lice in the identification of activity areas. On the other hand, fleas are known vectors of serious infections, including bubonic plague. When found in archaeological contexts, they are sometimes considered to be indicative of poor hygienic conditions (Panagiotakopulu 2004b).

The interpretation of ectoparasite remains requires a thorough examination of the behaviour and ecology of the species identified, combined with a detailed understanding of the cultural context of the study. At Nunalleq, a precontact Yup'ik village in southwestern Alaska, over one thousand ectoparasites were preserved in house floors contemporary with a violent episode that caused the abandonment of the site. These terminal occupation layers are partially charred and were covered by the burnt roofs that collapsed following a deadly raid. Outside of the sod building, soils from around human remains, some of which were interpreted as the bodies of victims of this attack, also yielded large quantities of lice and fleas. The interpretation of ectoparasite remains from Nunalleq is therefore complicated by the fact that the conflict episode—having provoked the death of hosts infested with parasites—is likely to have influenced the spatial distribution of lice and fleas at the site.

This paper presents the results of the parasitological analysis of ten samples from house floors and humans remains contemporary with the attack on Nunalleq. The objective of this study is to interpret the taphonomic history and processes that influenced the spatial distribution of human and dog ectoparasites in these contexts. In order to achieve this, we begin by proposing a series of scenarios that could plausibly have led to the deposition of these human and dog ectoparasites in subpolar hunter-fisher-gatherer dwellings. We then test these hypotheses against the recorded spatial distribution patterns established for each of the three species identified, as well as for a selection of other datasets (selected artifacts and biological remains). By deploying an innovative method to critically assess the significance of the spatial patterning of ectoparasites on archaeological sites, this article provides guidelines for future archeoentomological analyses at Nunalleq and other domestic and conflict sites.

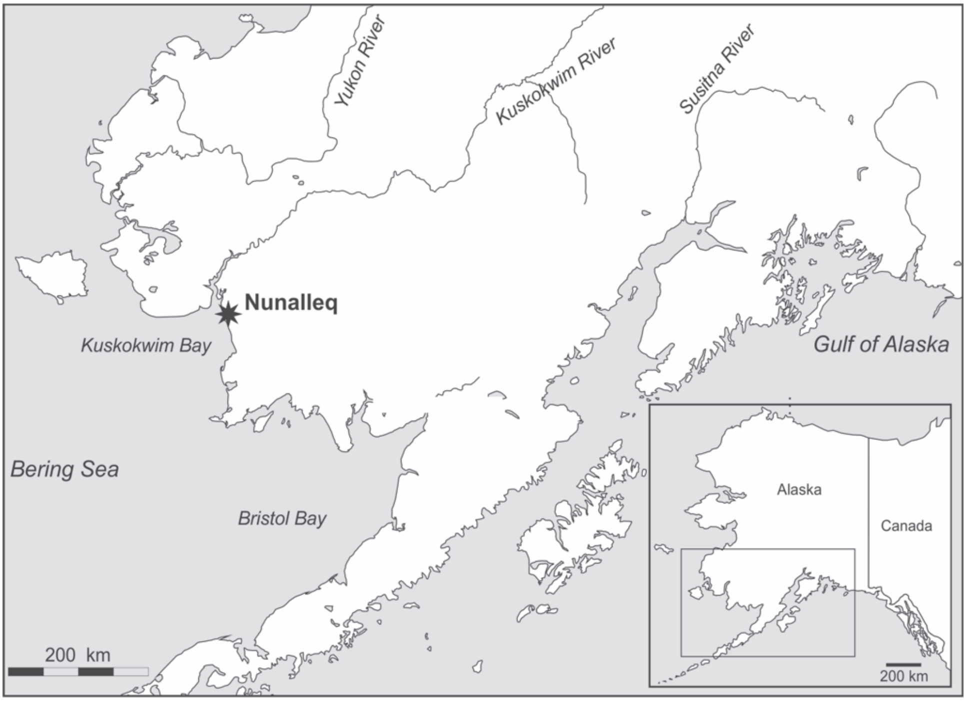

Figure 1. Map locating the Nunalleq archaeological site (Image by Paul Ledger).

Nunalleq: A Site of Precontact Indigenous Conflict

Nunalleq (GDN-248) is a precontact Yup'ik village located on the Alaskan coast of the Bering Sea (Figure 1) dated from the late sixteenth to the mid-seventeenth century (Ledger et al. 2018). The site was known to residents of the village of Quinhagak, located approximately five kilometres to the north, prior to the initiation of archaeological investigations (Fienup-Riordan, Rearden, and Knecht 2015).

Nunalleq has been the subject of eight excavation campaigns between 2009 and 2019. The site includes the remains of a village, including a dwelling made of sod and driftwood, comprising several rooms interconnected by a main passage (for more information about the architecture and phasing, see Knecht and Jones, this volume). As most of the site had most likely been eroded into the Bering Sea before the beginning of archaeological excavations, the original size of the village is unknown. The results of excavations revealed a dwelling that had undergone several phases of maintenance and renovation, as suggested by the different configuration of the walls and rooms during the different periods of occupation. Current evidence suggests the sod structure has been remodelled at least twice after its initial construction. Since excavations in 2015 recovered evidence for conflict at the site, the latter has been associated with the ancient village of Agaligmiut. According to the local oral tradition, Agaligmiut was destroyed during a period of conflict known as the Bow and Arrow Wars, which opposed different Yup'ik groups and other Indigenous neighbours (Fienup-Riordan and Rearden 2016; Gómez Coutouly, Knecht, and Masson-MacLean, this volume). This violent period appears to have ended in the late eighteenth century, shortly after the arrival of the first Russian explorers and missionaries in the Yukon–Kuskokwim Delta region (Fienup-Riordan and Rearden 2016).

The present study focuses exclusively on the last (most recent) phase of occupation of the dwelling (Phase II), and more precisely on the very end of this phase, which ended with the attack on the site (Event E). Bayesian modelling of radiocarbon data suggests the duration of Occupation Phase II is in the order of twenty-three years and that the attack likely occurred sometime between AD 1645 and 1675 (Ledger et al. 2018). During this phase, the sod dwelling consisted of at least six rooms (structures 1, 2, 3, 5, 11, and 12) and a long central passage (structure 6) oriented NE–SW. The latter seems to have led to one of the main entrances, as suggested by the change in the orientation of the boards at the eastern end of the passage (Figure 2). This passage may have played a defensive role during the Bow and Arrow Wars, potentially concealing movement of the building's occupants between the different structures or rooms (see Frink 2006). Current data does not allow the precise function of each room to be established; however, structure 1 is tentatively interpreted as an antechamber owing to the fact that it is open at one of the main entrances. Structure 4, in the north-centre of the excavation area, may also have been used as an entrance to the dwelling. The northeastern part of the excavation area was interpreted as an outdoor living space.

In the majority of rooms, excavations identified three or four overlapping in situ occupation floors, each of which were sampled for environmental-archaeological analyses. Seven of the samples discussed in this paper came from the uppermost floor layers, which were sealed by collapsed and burnt roof sods and beams. In the northwestern part of the excavation area (structure 5), the floor layer was partially burnt and contained the remains of two juvenile dogs (*Canis familiaris*), one of which was retrieved directly under a carbonized wood beam (Figure 3). The latter presumably had fallen during the collapse of the roof, killing the dog. In the northwestern area, outside of the sod buildings, five human skeletons and an assemblage of cranial elements and other osteological remains representing at least twenty individuals were revealed. Interpretation of these contexts is still underway, but the human remains themselves were reburied in Quinhagak in 2015 a few days after they had been excavated and documented, following a protocol agreed with the Qanirtuuq Inc. board of directors. Preliminary interpretations suggest that at least two of the skeletons (SK1 and SK5) represent the remains of victims of the attack on Nunalleq.

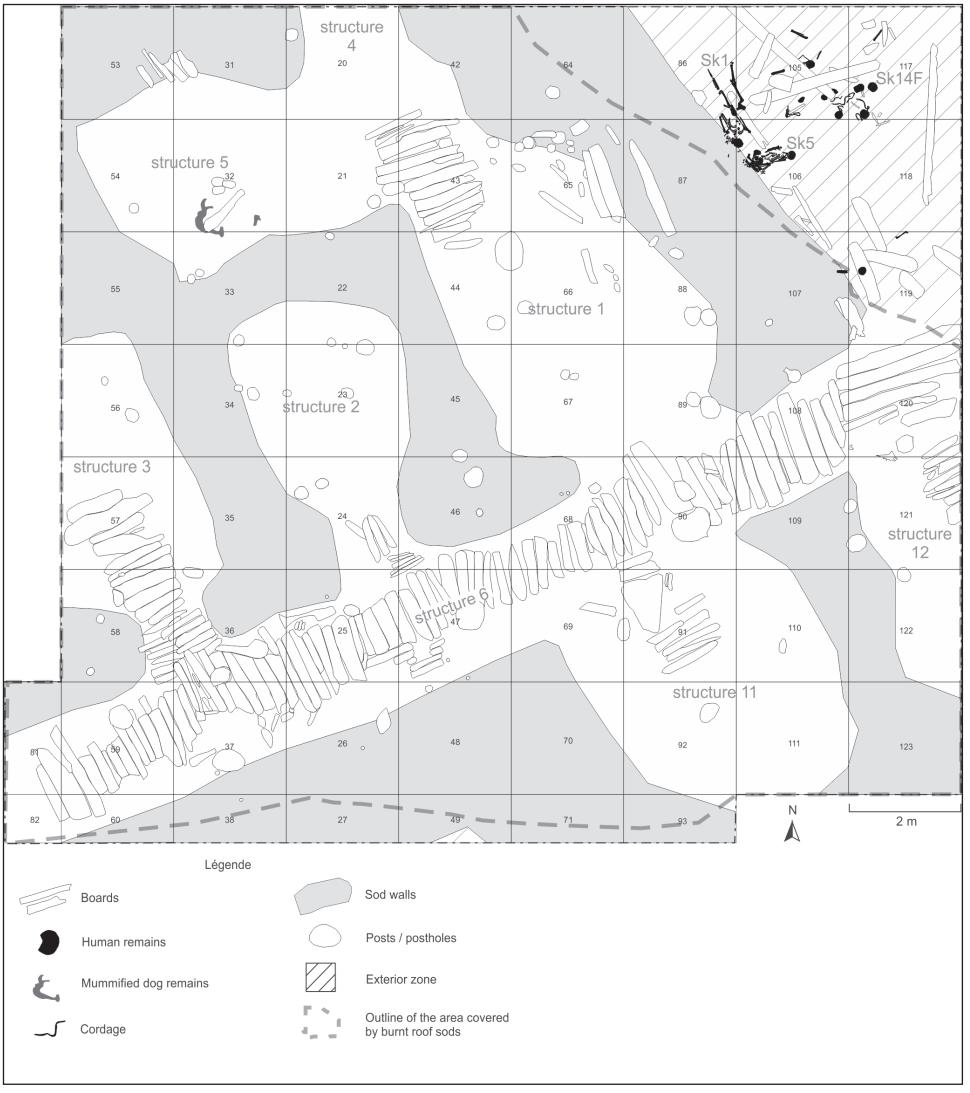

Figure 2. Plan of Nunalleq (Area A) illustrating the site as left after the attack that caused the site's abandonment (Phase II, Event E). Note that only part of the humans remains are illustrated in this image. (Image by Edouard Masson-MacLean and Véronique Forbes).

Figure 3. Photograph of a burnt wood beam and the remains of a dog puppy that likely died following the roof collapse during the attack on Nunalleq. (Photograph by Rick Knecht).

Methodological Framework

In order to investigate the processes by which ectoparasites became incorporated into floor layers and sediments associated with human skeletal remains at Nunalleq, we consulted a variety of published sources on the ecology of ectoparasitic insects (Busvine 1976; Marshall 1981; Mullen and Durden 2002) and Yup'ik and Inuit lifeways (J.H. Barker 1993; Dumond 1987; Fienup-Riordan 2007, 2017; Fienup-Riordan and Rearden 2012, 2016; Shaw 1998), as well as archaeoentomological studies (Buckland and Perry 1989; Erzinçlioğlu 2009; Dussault 2011; Dussault, Bain, and LeMoine 2014; Forbes et al. 2017; Huchet 1996; Skidmore 1995). These served as a basis for the formation of a series of hypotheses to explain the distribution of ectoparasites in the archaeological record. These scenarios then guided the selection of additional datasets to be incorporated into the analysis. Human hair offcuts and pieces of clothing were selected on the basis that both could harbour remains or traces of human lice and fleas. As dog skins are known to have been occasionally employed in clothing manufacture (McManus 2015), and traditional Yup'ik methods for processing skins involved the removal of the fur (Fienup-Riordan 2007), we also included fur samples in our dataset. Coprolites were also included, since they may indicate specific areas where dogs were allowed inside the dwelling. Given that one of the main objectives of the analyses was to verify whether the conflict episode influenced the spatial distribution of ectoparasites at Nunalleq, we also incorporated several types of data potentially connected to the attack. This includes the remains of necrophagous insects that could potentially have fed on the cadavers, as well as items of weaponry (arrow and spear end blades).

The archaeoentomological analysis of sediment surrounding the human skeletal remains allowed the identification of numerous immature stages of flies identified as belonging to the Calliphoridae family, commonly known as "blow flies." This family of flies, which is routinely employed in forensic investigations, includes numerous large-size species that lay their eggs on fresh cadavers, usually within minutes of an organism's death (Byrd and Castner 2010; Gennard 2007). Once the larvae attain maturity, they cease their activity and their cuticle (the outermost layer forming the exoskeleton) contracts and hardens to form a rigid envelop inside which metamorphosis into an adult fly takes place. This envelope—the puparium (plural: puparia)—is commonly found on archaeological sites where suitable preservation conditions occur (Panagiotakopulu 2004a). High concentrations of necrophagous fly puparia and ectoparasites, conjointly associated with human remains at Nunalleq, suggest that the corpses of the attack's victims were left to decompose in situ. Areas of the site where blow fly puparia occur in high quantities may therefore pinpoint locations where people died. The location of items of weaponry such as lithic end blades may in turn indicate areas of the sod dwelling where confrontation took place (Gómez Coutouly et al., this volume).

There could also be alternative explanations for the presence of ectoparasites in the Nunalleq floors. Lice and fleas (respectively, *qevlerliit* and *keggerpiit* in Yup'ik) are both mentioned in oral history and ethnographic accounts, where they are generally perceived as pests. Anthropologist Ann Fienup-Riordan (2017) describes various methods that have been deployed by past Yup'ik people to rid themselves of lice, which included the use of combs, the use of urine to wash the hair and body, shaving heads, and delousing by hand, which could sometimes involve swallowing or crushing lice between one's teeth or nails. Such practices seem to have been (at least occasionally) conducted in the entrance porch of houses. Other observations mentioned in oral accounts include the use of containers to collect lice removed with combs, lice eggs (nits, *ingqit* in Yup'ik) falling on the floor during delousing and sometimes hatching on soil or floors, as well as the practice of hanging coats outdoors in order to freeze the lice to help shake them off (Fineup-Riordan 2017). These are extremely useful accounts as they provide interesting clues to interpret the spatial distribution of lice on Yup'ik archaeological sites. Additionally, it is important to consider the possibility that the inhabitants of the site occasionally or regularly cleaned or maintained their living areas by shovelling out dirt, sweeping floors, or spreading ash or plant material onto them, all of which may have displaced or disturbed waste or refuse from domestic practices. High concentrations of ectoparasite remains may in such cases indicate areas where detritus associated with certain activities were disposed of, rather than the locations where the activities were taking place (e.g., see Dussault 2011 and Dussault, Bain, and LeMoine 2014).

Data collection

The samples and objects analyzed in the present paper were collected between 2013 and 2015 from deposits excavated within area A. Excavations proceeded by stratigraphic levels and followed single context recording procedures (P. Barker 1993), where excavation progresses in reverse chronological order, and each stratigraphic unit (named *context*) is fully exposed before being recorded and excavated. This method allowed for a better understanding of the sod and driftwood architecture at Nunalleq and systematic environmental sampling (cf. Branch et al. 2005).

Since 2013, the sampling protocol at Nunalleq involves the collection of two-litre sediment samples from all excavated contexts for environmental analyses (plant and insect macrofossils). In the case of undisturbed occupation floor layers, one such sample was recovered from each 2 x 2 metre square. Thanks to preservation in discontinuous permafrost, the floors layers and other contexts yielded a rich and varied array of organic remains, including fur, human hair offcuts, and coprolites, all of which were collected for biochemical and biomolecular analyses (e.g., Britton et al. 2013, 2018; McManus-Fry et al. 2018; Raghavan et al. 2014). These organic materials were sampled, given a unique identification number, localised in the 2 x 2 metre excavation grid, and their associated context and location within the grid were recorded.

Archaeoentomological analyses

All samples collected at Nunalleq from 2013 to 2015 were shipped to Aberdeen (Scotland, UK) to be analyzed. One litre of sediment was processed from each of the seven floor layer samples. In addition to those, three samples of sediment from around human skeletal remains were analyzed. Sample volumes in these instances varied from 450 to 800 ml. All ten samples were placed in a sodium carbonate solution (<5%) to facilitate their disaggregation, wet-screened at 300µm and submitted to paraffin floatation (Coope and Osborne 1967; Kenward, Hall, and Jones 1980). Only sample S-15492 was exempted from paraffin floatation due to its small volume (450 ml).

Residues from paraffin floatation were scanned with the naked eye to allow a detailed description of the samples' content (Table 1). The floating material from each sample was sorted under a low magnification (10X) binocular stereomicroscope to allow the extraction of insect remains and their storage in ethanol (70%). Lice (Phthiraptera) were identified through comparison with reference materials and with the aid of identifications keys (Kim et al. 1986; Price and Graham 1997; Séguy 1944). To facilitate the identification of fleas (Siphonaptera), terminal abdominal segments were mounted on temporary slides and compared with images and descriptions from the entomological literature (Brinck-Lindroth and Smit 2007; Holland 1985; Smit 1957).

Table 1. List and description of the analyzed samples.

Sample	Context	Grid square	Context interpretation	Volume (ml)	Sediment description	Approximate frequency of other macro-remains*	Preservation state of insect remains
S-14165	14065	67	Floor layer inside structure 1	1000	Decaying plant remains (52%), wood chips (40%), Fish bone (4%), charcoal (2%), twigs (1%), bird bones (1%)	Coleoptera: F, Diptera: F, Acari: A, Seeds: F/A, Moss: F, Feathers: O/R, Hair/fur: R	Excellent with c. 60% of lice and 40% of beetles more or less fragmentary
S-14168	14065	89	Floor layer inside structure 1	1000	Wood chips (45%), decaying plant remains (40%), charcoal (5%), sand (5%), stone (5%), fish bone (1%)	Coleoptera: F, Diptera: F, Acari: A, Seeds: A/F, Moss: F, Feathers: R/O, Hair/fur: R/O	Excellent with c. 75% of lice and 50% of beetles more or less fragmentary
S-1123	13014	23	Floor layer inside structure 2	1000	Decaying plant remains (80%), wood chips (10%), fish bones (3%), twigs (2%), mammal bones (2%), pottery sherds (1%), sand (1%), charcoal (<1%)	Coleoptera: F/A, Diptera: O/F, Acari: A, Seeds: A, Moss: D, Feathers: F, Hair/fur: F, Roots: O/F	Excellent with c. 50% of lice and 50% of beetles more or less fragmentary
S-1036	13013	56	Floor layer inside structure 3	1000	Decaying plant remains (43%), wood chips (20%), stones (5%), charcoal (5%), hair/fur (5%)	Coleoptera: F/A, Diptera: O/F, Acari: A, Seeds: F, Moss: A, Feathers: F, Hair/fur: A, Roots: O	Excellent with c. 25% of lice and 25% of beetles more or less fragmentary
S-1064	13035	20	Floor layer inside structure 4	1000	Decaying plant remains (65%), wood chips (25%), slate flakes (3%), fish bones (2%), mammal bones (1%), pottery sherds (1%), hair/fur (1%)	Coleoptera: F, Diptera: F, Acari: A, Seeds: O, Moss: A/D, Feathers: F, Hair/fur: F	Excellent with c. 25% of lice and 10% of beetles more or less fragmentary

Table 1. (Continued.)

Sample	Context	Grid square	Context interpretation	Volume (ml)	Sediment description	Approximate frequency of other macro-remains*	Preservation state of insect remains
S-14125	14035	32	Floor layer inside structure 5	1000	Decaying plant remains (53%), charcoal (30%), wood chips (5%), hair/fur (5%), burnt sod clumps (5%), stones (1%), fish bones (<1%)	Coleoptera: F, Diptera: F, Acari: A, Seeds: F/A, Moss: F, Feathers: R, Hair/fur: A	Excellent with c. 20% of lice and 30% of beetles more of less fragmentary
S-1191	13109	33	Floor layer inside structure 5	1000	Decaying plant remains (77%), wood chips (15%), charcoal (5%), stones (2%), fish bones (1%)	Coleoptera: F/A, Diptera: F, Acari: F/A, Seeds: O/F, Moss: F, Feathers: R, Hair/fur: O/R	Excellent with c. 60% of lice and 40% of beetles more of less fragmentary
S-14041	14031	86	Sediment in the thoracic cavity area of skeleton SK1	500	Moss (70%), Decaying plant remains (13%), roots (10%), wood (5%), charcoal (2%)	Coleoptera: F, Diptera: A, Acari: A, Seeds: O/R, Moss: F, Feathers: F	Excellent with <5% of lice 'folded' and some articulated or semi-articulated
S-15063	14031	106	Sediment in the thoracic cavity area of skeleton SK5	800	Moss (60%), roots (20%), decaying plant remains (20%)	Coleoptera: F/A, Diptera: A, Acari: F, Wood: O, Twigs: O, Seeds: O, Moss: A, Roots: A/D, Plumes/duvet: F/A	Excellent to very good, with c. 75% of lice more or less fragmentary
S-15492	15019	117	Sediment inside the cranium SK14F	450	Decaying plant remains (63%), mammal bones (15%), sand (10%), wood (10%), charcoal (2%)	Coleoptera: F, Diptera: A, Acari: F/A, Sand: O, Charcoal: F, Wood: F, Seeds: F, Moss: F/A, Roots: R, Hair/fur: R	Excellent but a few lice are fragmentary

*D=dominant, A=abondant, F=frequent, O=occasionnal, R=rare

Beetles and fly puparia were also collected during the sorting process under the microscope. Of these two insect orders, only puparia from the Calliphoridae family are reported here. These were identified using identifications keys (Erzinçlioğlu 1985, 1988; Hennig 1952; McAlpine et al. 1981) and through comparison with reference specimens. Samples from Nunalleq yielded puparia from numerous other Diptera families, but since the morphology of immature stages of flies is highly variable, and many families are understudied (McAlpine et al. 1981; Skidmore 1995), we did not attempt further identification. Since beetle remains from hunter-fisher-gatherer sites allow the exploration of distinct research themes (e.g., the reconstruction local ecological conditions and resource harvesting practices, see Forbes et al. 2017), they will be the object of subsequent papers.

A large proportion of the lice, fleas, and blow fly puparia were either disarticulated or fragmentary. Therefore, to allow quantitative analyses of our dataset, we calculated the minimum number of individuals (MNI) from the dominant anatomical part of each insect taxa recorded in each sample.

Spatial analyses

Spatial distribution maps were produced for each category of data, using excavation grid squares ($2m^2$) as base unit. In order to allow comparisons between the three species of ectoparasites identified, as well as blow fly puparia, we converted MNI values into numbers of individuals per litre of sediment analyzed (n/L). For human hair offcuts, fur clumps, and coprolites, the number of these elements listed per context (stratigraphic unit) per square was used. The category "lithic end blades" includes arrow and spear projectile points. We excluded preforms and fragments, on the basis that it was unlikely that such broken or incomplete implements would have been used as weapons. As for pieces of clothing, we counted the number of leather pieces with stitching marks, on the assumption that these would have originated from garment.

Results

In total 1,515 ectoparasites were identified in the ten analyzed samples (Table 2). This includes 1,108 human lice (Figure 4a), 171 dog-biting lice (Figure 4b), and 106 human fleas (Figure 4c). Human lice dominate this assemblage and are well distributed in all contexts, except for S-15492, which yielded only two specimens. The highest concentrations came from structures 1 to 4, and from sediments surrounding skeleton SK1 (Figure 5a). Although human fleas were also found in each of the samples from inside the sod structure (Figure 5b), they are in much smaller quantities. The only sample to have produced more than six human fleas is S-14041 (from SK1), from which 79 specimens (MNI) were counted in only 500 ml of sediment. No dog-biting lice were found in the samples associated with human remains. They are most numerous in structures 3 and 5 of the sod dwelling.

Table 2. List, number (n) and concentration (n/L) of ectoparasites identified from the ten analyzed samples.

	Structure 1				Structure 2		Structure 3		Structure 4		Structure 5				SK1		SK5		SK14F	
	S-14165		S-14168		S-1123		S-1036		S-1064		S-14125		S-1191		S-14041		S-15063		S-15492	
	n	n/L	n	n/L	n	n/L	n	n/L	n	n/L	n	n/L	n	n/L	n	n/L	n	n/L	n	n/L
PHTHIRAPTERA																				
Hoplopleuridae																				
Hoplopleuridae indet.	0	0	0	0	0	0	0	0	1	1	0	0	1	1	0	0	0	0	0	0
Pediculidae																				
Pediculus humanus L.	200	200	95	95	154	154	160	160	167	167	46	46	102	102	135	270	47	58.75	2	4.44
Trichodectidae																				
Trichodectes canis (De Geer)	21	21	14	14	8	8	40	40	14	14	44	44	30	30	0	0	0	0	0	0
Trichodectidae indet.	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phthiraptera indet.	14	14	18	18	17	17	24	24	12	12	8	8	23	23	0	0	0	0	0	0
SIPHONAPTERA																				
Pulicidae																				
Pulex irritans L.	3	3	5	5	1	1	3	3	5	5	6	6	1	1	79	158	3	3.75	0	0
Siphonaptera indet.	4	4	0	0	0	0	0	0	1	1	3	3	3	3	0	0	0	0	0	0
TOTAL	242	242	133	133	180	180	227	227	200	200	107	107	160	160	214	428	50	62.5	2	4.44

A total of 527 blow fly puparia—belonging to a single species, *Protophormia terraenovae* Robineau-Desvoidy (Figure 4d), commonly called the northern blow fly—were identified from samples associated with the human skeletal remains. This Nearctic species is particularly well adapted to cold conditions, as demonstrated by its circumpolar distribution (Erzinçlioğlu 2009). No blow fly puparia were encountered in any of the samples from the interior of the sod building.

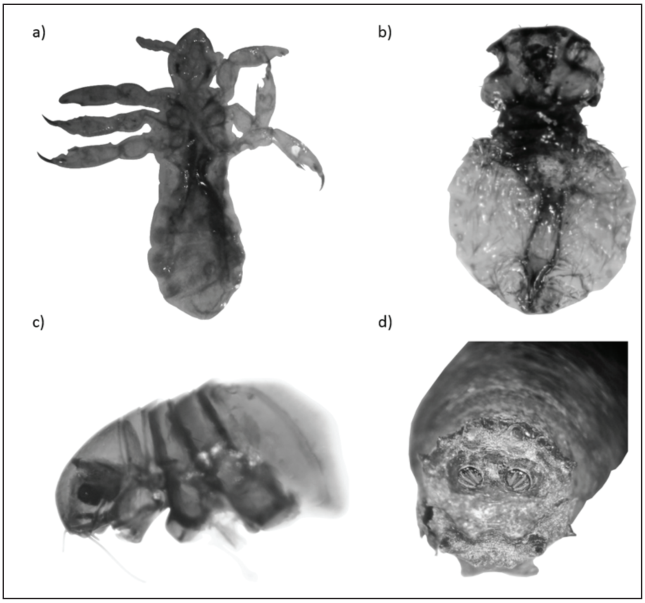

Figure 4. Photographs of some of the insect remains included in the spatial analyses: (a) human louse Pediculus humanus, complete and articulated; (b) dog-biting louse Trichodectes canis with the head, thorax, and abdomen articulated; (c) human flea Pulex irritans with the head, thorax, and first abdominal segment articulated; (d) posterior face of a Protophormia terraenovae puparium, showing the respiratory stigmata and the posterior papillae. (Image by Véronique Forbes).

A small number of human hair offcuts and fur clumps were sampled from archaeological layers contemporary with the attack (Table 3). Human hair samples are slightly more numerous in structures 2 and 5 (Figure 5e), while fur samples are more frequent in structures 1 and 2 (Figure 5f). No coprolites (Table 3) and only twelve lithic end blades were collected from contexts contemporary with the attack. The latter are distributed between each of the rooms, and a few were also recovered from outside the sod building. Pieces of clothing are even rarer in these contexts, with only two pieces identified, both from the outdoor area.

Discussion

Phenomena influencing the spatial patterning of human ectoparasites

The floors layers from four of the rooms investigated (structures 1 to 4), and sediment from around one of the human skeletons (SK1), yielded high quantities of human lice (Figure 5a). Based on our literature review, three phenomena could have caused such strong concentrations of human lice in archaeological deposits: delousing, hair cutting, or the death of the host. Given that the spatial patterning of human lice is not mirrored in any of the other datasets (which may have pointed towards a single cause), it is likely that different mechanisms led to their deposition in in these archaeological contexts.

For one of these contexts, skeleton SK1, it is likely that the death of the host is the cause of high concentrations of these parasites. In this particular case, human lice were not only associated with human skeletal remains, but also with high quantities of human fleas and northern blow fly puparia. Unlike the majority of Calliphoridae species, whose larvae leave the host's body to pupate away from the nutritional source, the species present at Nunalleq, *P. terraenovae*, typically pupates on, or within centimetres of a cadaver (Roux et al. 2006). It therefore seems likely that the co-occurrence of human lice and northern blow fly puparia marks the location where the host perished during, or shortly after, the attack on Nunalleq. Similar to lice, fleas will normally leave the body of a host shortly after the host's death (Smith 1986). Considering the dispersal capacities of the human flea and the fact that it is able to infest several different host species, a causal link between the death of the host and those of the fleas may seem improbable. Fleas are able to survive for a long time without nourishment (Krasnov et al. 2002). However, at low temperatures, their activity level decreases (Marshall 1981). At Nunalleq, average summer temperatures remained below 14.5°C during the site's occupation (Forbes et al. 2019). It is therefore likely that cold weather inhibited the dispersal of some of the fleas associated with SK1, preventing them from finding new hosts and leading to their death and preservation in situ. The lice and fleas found in samples associated with skeleton SK5, which included 47 human lice, 3 human fleas, and more than 300 northern blow fly puparia, likely perished in a similar manner.

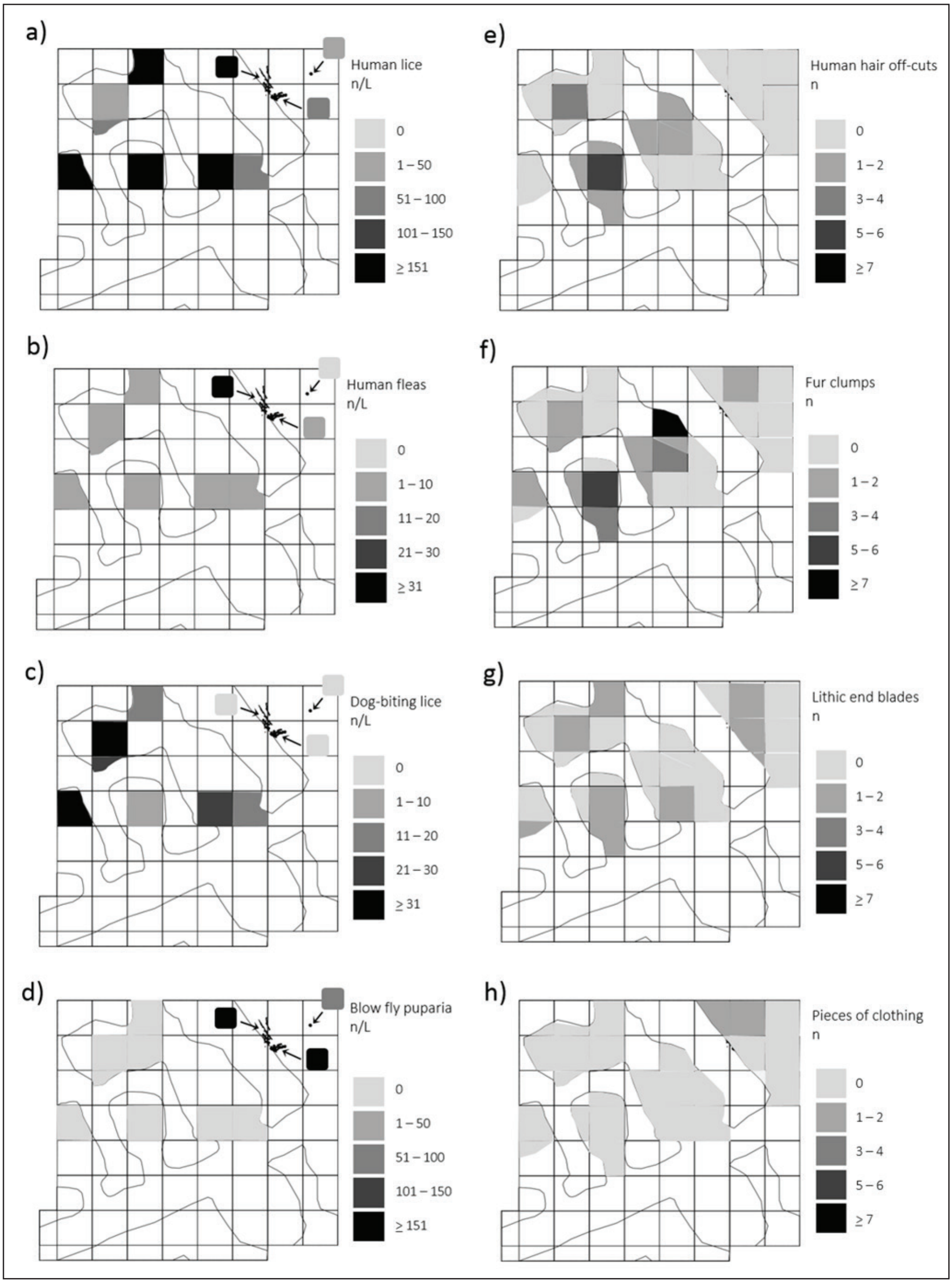

Figure 5. Spatial distribution maps for ectoparasites and other corpus of data from archaeological contexts contemporary with the attack on Nunalleq: (a) human lice; (b) human fleas; (c) dog-biting lice; (d) blow fly puparia; (e) human hair offcuts; (f) fur clumps; (g) lithic end blades, and (h) pieces of clothing. (Image by Véronique Forbes).

Table 3. Details regarding additional data included in the spatial analyses.

Structure or location	Contexts	Grid squares	Blow fly puparia (n/L)	Human hair (n samples)	Fur (n samples)	Coprolites (n)	Lithic end blades (n)	Pieces of clothing (n)
1	14065	44	N/A	1	1	0	0	0
		45	N/A	0	1	0	0	0
		66	N/A	2	3	0	0	0
		67	0	0	0	0	1	0
		88	N/A	0	0	0	0	0
		89	0	0	0	0	0	0
	14084	65	N/A	2	7	0	0	0
		66	N/A	2	1	0	0	0
2	13014	22	N/A	1	0	0	0	0
		23	0	5	6	0	1	0
		24	N/A	2	3	0	1	0
		34	N/A	2	1	0	0	0
3	13013	56	0	0	1	0	0	0
		57	N/A	0	0	0	2	0
4	13035	20	0	0	0	0	2	0
		21	N/A	0	4	0	0	0
5	13109	33	0	0	1	0	0	0
	14035	31	N/A	0	0	0	0	0
		32	0	4	2	0	1	0
		53	N/A	0	0	0	0	0
		54	N/A	0	0	0	0	0
Exterior	14031	86	366	0	0	0	0	1
		105	N/A	0	0	0	0	1
		106	393.75	0	0	0	0	0
	15019	105	N/A	0	1	0	2	0
		106	N/A	0	0	0	1	0
		107	N/A	0	0	0	1	0
		117	64.44	0	0	0	0	0
		118	N/A	0	0	0	0	0
		119	N/A	0	0	0	0	0

The total absence of blow fly puparia and human remains in samples from floor layers suggests that the conflict episode did not play a significant role in the distribution of human lice and fleas inside the sod structure. The rarity of projectile end blades in these contexts could potentially be interpreted as indicating that the confrontation did not occur specifically in these rooms, and that perhaps the events of the conflict occurred outside the structure (although see Gómez Coutouly, Knecht, and Masson-MacLean, this volume). It is therefore probable that delousing or hair cutting (whether intended to get rid of parasites or not) produced the strong concentrations of human lice inside the building. Since samples from structures 1 and 2 produced human hair offcuts, it is likely that some of the human lice deposition in these rooms is related to grooming. However, since no samples of human hair were identified in structures 3 and 4, other mechanisms may also have played a role. Delousing, or the disposal of delousing refuse, may have occurred in these rooms. Structures 1 and 4 are both potential entryways into the building and they may have been used for the disposal of delousing waste (cf. Dussault 2011). This idea is supported by Yup'ik oral accounts that mention delousing having taken place in the entrance porch of houses (Fienup-Riordan 2017).

Phenomena influencing the spatial patterning of dog ectoparasites

Structures 3 and 5 of the sod building yielded the highest concentrations of dog-biting lice. These ectoparasites also occurred, although in lesser numbers, in structure 1. We suggest three possible explanations for these distributions: (1) these rooms were used (at least occasionally or in part) as dog kennels, (2) processing of dog skins or the disposal of associated refuse occurred, or (3) they mark the location where the host(s) died. In the case of structure 5, it seems obvious that the death of the host caused the death of the dog-biting lice, since dog cadavers were discovered in the room (Figure 3). The absence of Calliphoridae puparia in this context suggests that the dogs were instantly covered by the sod roofs that collapsed on them, preventing *P. terraenovae* from accessing and laying eggs on the cadavers. This data is reminiscent of the analysis of entomological subfossils from a Norse farm in Greenland, where the remains of a goat, presumably killed during the collapse of the turf building and mummified under the rubble, did not produce any puparia from necrophagous flies (Panagiotakopulu, Skidmore, and Buckland 2007). The fact that the dogs died in structure 5 demonstrates that they were permitted inside the sod structure. Dog-sucking lice (*L. setosus*) in the floors of Inuit houses in Greenland have also been posited as evidence of dogs sheltering inside dwellings (Dussault, Bain, and LeMoine 2014).

It is likely that the dog lice from structures 1 and 3 originated from the rooms being used as dog shelter. Nevertheless, Yup'ik and Inuit groups processed dog skins to make elements of their clothing (Issenman 2011; McManus 2015). Therefore, the processing of dog skins in this manner may also have led to lice deposition in these rooms. The preparation of skins would have involved them soaking in urine or saltwater (Fienup-Riordan 2007) to promote the detachment of the ectoparasites alongside the fur (e.g., see Buckland and Perry [1989] for ectoparasites from wool processing). We considered coprolites and fur in our analysis in the hope that they would help distinguish which of these phenomena—dog-skin processing or the use of specific rooms as kennels—is the most likely factor influencing the distribution of dog lice at Nunalleq. Unfortunately, no coprolites were identified from the targeted contexts (Table 3). In comparison, some of the lowest (oldest) floor layers at the site, which were excavated in 2017, produced numerous coprolites. These levels were the best preserved, since their depth allowed them to remain frozen. The slightly poorer preservation conditions of the uppermost occupation layers may not have allowed the identification of coprolites during excavation. Structures 1 and 3 produced few clusters of fur, making it unlikely that these lice represent refuse from dog-skin processing. Since dogs were clearly admitted inside structure 5, the most plausible explanation is that they were also allowed in structures 1 and 3.

Conclusion

Archaeological remains of ectoparasites are generally considered excellent indicators of activity areas. However, different phenomena may cause the incorporation of such insect remains into the archaeological record. These may relate to specific types of activities having taken place in areas of sites where those parasites occur, or alternatively, ectoparasites may derive from a dead host's body. To allow accurate interpretations of insect remains from contexts contemporary with the attack on Nunalleq, we compared the spatial distribution of ectoparasites with that of other datasets, including blow fly puparia, human hair offcuts, fur clumps, coprolites, end blades, and pieces of clothing. The results of this study suggest that the Bow and Arrow Wars conflict episode influenced the spatial distribution of ectoparasites at Nunalleq. Human lice and fleas preserved around human skeletons found at the site, along with dog lice collected from the floor of structure 5 (close to the remains of at least two animals), appear to have died following their hosts' death. However, most of the human lice from inside the dwelling likely derived from delousing, while the presence of dog-biting lice in most of the rooms investigated suggests dogs were (at least occasionally) sheltered inside.

It is hoped that the method deployed here to establish the significance of ectoparasites' spatial distribution will serve as a guide for further interpretations of ectoparasites remains from Nunalleq. The ten analyzed samples represent only a tiny fraction of the samples collected from the site since 2013. Thanks to the precision of the chronological framework for the site and to our extensive sampling program, it should eventually be possible to interrogate the various datasets available to reconstruct in a very detailed manner how the generations who lived at Nunalleq used their domestic space. Here, we attempted to take into account all possible activities, events, and phenomena that could account for the deposition of human and dog ectoparasites in subpolar forager occupation sites. Beyond guiding future interpretations of such data, we hoped that our paper further demonstrates the potential of archaeoentomology in the study of Arctic and Subarctic lifeways.

Acknowledgements

This project was funded through the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement no. 703322, as well as through a grant from the Arts and Humanities Research Council of the UK (AH/K006029/1). The authors wish to thank Warren Jones and Qanirtuuq Inc. for their logistical support in the field, as well as the inhabitants of Quinhagak for warm hospitality over several summers. Thanks are also due to all the students, staff, and volunteers who participated in excavations at Nunalleq from 2013 to 2015. This study, including the use of images, has been undertaken with the permission of Qanirtuuq Inc. and the village of Quinhagak.

References

Bain, A.L., and G. King. 2011. "Asylum For Wayward Immigrants: Historic Ports and Colonial Settlements in Northeast North America." *Journal of the North Atlantic* Special vol. 1: 109–24. doi: 10.3721/037.002.s110.

Barker, J.H. 1993. *Always Getting Ready / Upterrlainnarluta: Yup'ik Eskimo Subsistence in Southwest Alaska*. Seattle: University of Washington Press.

Barker, P. 1993. *Techniques of Archaeological Excavation*. 3rd ed. London: B.T. Batsford Ltd.

Branch, N., M. Canti, P. Clark, and C. Turney. 2005. *Environmental Archaeology: Theoretical and Practical Approaches*. London: Hodder Education.

Britton, K., R. Knecht, O. Nehlich, C. Hillerdal, R.S. Davis, and M.P. Richards. 2013. "Maritime Adaptations and Dietary Variation in Prehistoric Western Alaska: Stable Isotope Analysis of Permafrost-Preserved Human Hair." *American Journal of Physical Anthropology* 151: 448–61.

Britton, K., Ellen McManus-Fry, E., Nehlich, O., Richards, M., Ledger, P. M., and R. Knecht. 2018. "Stable Carbon, Nitrogen and Sulphur Isotope Analysis of Permafrost-Preserved Human Hair from Rescue Excavations (2009, 2010) at the

Precontact Site of Nunalleq, Alaska." *Journal of Archaeological Science: Reports* 17: 964–72.

Brinck-Lindroth, G., and F.G.A.M Smit. 2007. *The Fleas (Siphonaptera) of Fennoscandia and Denmark*. Fauna Entomologica Scandinavica, vol. 41. Leiden: Brill.

Buckland, P.C., and D.W. Perry. 1989. "Ectoparasites of Sheep from Stóraborg, Iceland and Their Interpretation." *Hikuin* 15: 37–46.

Buckland, P.C., and J.P. Sadler. 1989. "A Biogeography of the Human Flea, *Pulex irritans* L. (Siphonaptera: Pulicidae)." *Journal of Biogeography* 16, no. 2: 115–20.

Buckland, P.C., J.P. Sadler, and G. Sveinbjarnadóttir. 1992. "Palaeoecological Investigations at Reykholt, Western Iceland." In *Norse and Later Settlement and Subsistence in the North Atlantic*, edited by C.D. Morris and D.J. Rackham, 149–67. Glasgow: University of Glasgow.

Busvine, J.R. 1976. *Insects, Hygiene and History*. London: Athlone Press, University of London.

Byrd, J.H., and J.L. Castner, eds. 2010. *Forensic Entomology: The Utility of Arthropods in Legal Investigations*, 2nd ed. Boca Raton, FL: CRC Press.

Coope, G.R., and P.J. Osborne. 1967. "Report on the Coleopterous Fauna of the Roman Well at Barnsley Park, Gloucestershire." *Transactions of the Bristol and Gloucestershire Archaeological Society* 86: 84–87.

Dumond, D.E. 1987. *The Eskimos and Aleuts*, rev. ed. London: Thames and Hudson.

Dussault, F. 2011. "Hygiène et considérations hygiéniques des inughuits du nord-ouest du Groenland: Étude archéoentomologique des Sites d'Iita, Cap Grinnell et Qaqaitsut au Groenland." MA thesis, Université Laval.

Dussault, F., A. Bain, and G. LeMoine. 2014. "Early Thule Winter Houses: An Archaeoentomological Analysis." *Arctic Anthropology* 51, no. 1: 101–17.

Dussault, F., T. Bell, and V. Grimes. 2016. "Archaeoentomological Perspectives on Dorset Occupations in Newfoundland: A Case Study from the Site of Phillip's Garden (EeBi-1)." *Arctic* 69, no. S1: 1–15.

Elias, S.A. 1997. "The Mutual Climatic Range Method of Palaeoclimate Reconstruction Based on Insect Fossils: New Applications and Interhemispheric Comparisons." *Quaternary Science Reviews* 16, no. 10: 1217–25.

———. 2010. *Advances in Quaternary Entomology*. Amsterdam: Elsevier.

Erzinçlioğlu, Y.Z. 1985. "Immature Stages of British *Calliphora* and *Cynomya*, with a Re-evaluation of the Taxonomic Characters of Larval Calliphoridae (Diptera)." *Journal of Natural History* 19, no. 1: 69–96.

———. 1988. "The Larvae of the Species of *Phormia* and *Boreellus*: Northern, Cold-Adapted Blowflies (Diptera: Calliphoridae)." *Journal of Natural History* 22, no. 1: 11–16.

———. 2009. "Fly Puparia Associated with the Condover Mammoths." *Geological Journal* 44:447–79.

Fienup-Riordan, A. 2007. *Yuungnaqpiallerput / The Way We Genuinely Live: Masterworks of Yup'ik Science and Survival*. Seattle: University of Washington Press.

———. 2017. "*Ciiissit*: Les insectes dans la tradition orale yup'ik." *Recherches Amérindiennes au Québec* 47, no. 2–3: 79–93.

Fienup-Riordan, A., and A. Rearden. 2012. *Ellavut: Our Yup'ik World and Weather*. Seattle: University of Washington Press.

———. 2016. *Anguyiim Nalliini/Time of Warring: The History of Bow-and-Arrow Warfare in Southwest Alaska*. Fairbanks: University of Alaska Press.

Fienup-Riordan, A., A. Rearden, and M. Knecht. 2015. "Irr'inarqellriit / Amazing Things: Quinhagak Elders Reflect on Their Past." *Alaska Journal of Anthropology* 13, no 2: 37–70.

Forbes, V. 2015. "Duck Fleas as Evidence for Eiderdown Production on Archaeological Sites." *Journal of Archaeological Science* 61: 105–11.

Forbes, V., K. Britton, and R. Knecht. 2015. "Preliminary Archaeoentomological Analyses of Permafrost-Preserved Cultural Layers from the pre-contact Yup'ik Eskimo Site of Nunalleq, Alaska: Implications, Potential And Methodological Considerations." *Environmental Archaeology* 20, no. 2: 158–67.

Forbes, V., F. Dussault, and A. Bain. 2013. "Contributions of Ectoparasite Studies in Archaeology with Two Examples from the North Atlantic Region." *International Journal of Paleopathology* 3: 158–64.

Forbes, V., F. Dussault, O. Lalonde, and A. Bain. 2017. "Coléoptères, poux et puces subfossiles provenant d'habitats de chasseurs-cueilleurs: L'apport des recherches archéoentomologiques dans le nord circumpolaire." *Recherches amérindiennes au Québec* 47, no. 2–3: 11–21.

Forbes, V., P.M. Ledger, D. Cretu, and S. Elias. 2019. "A Sub-Centennial, Little Ice Age Climate Reconstruction Using Beetle Subfossil Data from Nunalleq, Southwestern Alaska." *Quaternary International*, corrected proof available online July 8, 2019. https://doi.org/10.1016/j.quaint.2019.07.011.

Frink, L. 2006. "Social Identity and the Yup'ik Eskimo Village Tunnel System in Precolonial and Colonial Western Coastal Alaska." *Archeological Papers of the American Anthropological Association* 16, no. 1: 109–25.

Gennard, D.E. 2007. *Forensic Entomology: An Introduction*. Chichester, UK: John Wiley & Sons.

Gómez Coutouly, Y.A., R. Knecht, and E. Masson-MacLean. 2019. "Les pointes de projectile polies du site de Nunalleq (village d'*Agaligmiut*), sud-ouest de l'Alaska: Une nouvelle approche des *Bow-and-Arrow Wars* chez les Yupiit." Études Inuit Studies 43, no. 1–2, this volume.

Hennig, W. 1952. *Die larvenformen der dipteren*. Berlin: Akademie-Verlag.

Holland, G.P. 1985. "The Fleas of Canada, Alaska and Greenland (Siphonaptera)." *Memoirs of the Entomological Society of Canada* 130: 1–631.

Huchet, J.-B. 1996. "L'archéoentomologie funéraire: Une approche originale dans l'interprétation des sépultures." *Bulletins et Mémoires de la Société d'anthropologie de Paris, Nouvelle Série* 8, no. 3–4: 299–311.

———. 2010. "Archaeoentomological Study of the Insect Remains Found within the Mummy of *Namenkhet Amun* (San Lazzaro Armenian Monastery, Venice/Italy)." *Advances in Egyptology* 1: 59–80.

———. 2013. "L'archéo-entomologie: Les insectes nécrophages associés aux soldats de Carspach." In *A l'est, du nouveau ! Archéologie de la Grande Guerre en Alsace et en Lorraine*, 111–12. Musée de Strasbourg, collection Archéologie.

———. 2016. "L'animal-amphitryon: Archéologie de l'ectoparasitisme." *Anthropozoologica* 50, no. 1: 55–65.

———. 2017. "Le coléoptère, la graine et l'archéologue: Approche archéoentomologique des principaux ravageurs des denrées stockées." In *Plantes, produits végétaux et ravageurs. Actes des Xe Rencontres d'Archéobotanique, Les Eyzies-de-Tayac, 24-27 septembre 2014, Aquitania* (supl. 36), edited by M.-F. Diestch-Sellami, C. Hallavant, L. Bouby, and B. Pradat, 17–42. Bordeaux: Aquitania.

Huchet, J.-B., and B. Greenberg. 2010. "Flies, Mochicas and Burial Practices: A Case Study from Huaca de la Luna, Peru." *Journal of Archaeological Science* 37, no. 11: 2846–56.

Issenman, B.K. 2011. *Sinews of Survival: The Living Legacy of Inuit Clothing*. Vancouver: UBC Press.

Kenward, H. 2009. *Northern Regional Review of Environmental Archaeology*: *Invertebrates in Archaeology in the North of England*. Research Department Report Series (12/2009), Portsmouth, English Heritage.

Kenward, H.K., and A.R. Hall. 1995. *Biological Evidence from 16-22 Coppergate*. Archaeology of York, 14/7. York, Council for British Archaeology for York Archaeological Trust.

Kenward, H. K., A.R. Hall, and A.K.G. Jones. 1980. "A Tested Set of Techniques for the Extraction of Plant and Animal Macrofossils from Waterlogged Archaeological Deposits." *Science and Archaeology* 22: 3–15.

Kim, K.C., H.D. Pratt, and C.J. Stojanovich. 1986. *The Sucking Lice of North America: An Illustrated Manual for Identification*. University Park: Pennsylvania State University Press.

King, G.A., H. Kenward, E. Schmidt, and D. Smith. 2014. "Six-Legged Hitchhikers: An Archaeobiogeographical Account of the Early Dispersal of Grain Beetles." *Journal of the North Atlantic* 23: 1–18.

Knecht, R, and W. Jones. 2019. "'The Old Village': Yup'ik Pre-Contact Archaeology and Community-Based Research at the Nunalleq Site, Quinhagak, Alaska." *Études Inuit Studies* 43, no. 1–2, this volume.

Krasnov, B. R., I.S. Khokhlova, L.J. Fielden, and N.I. Burdelova. 2002. "Time of Survival under Starvation in Two Flea Species (Siphonaptera: Pulicidae) at Different Air Temperatures and Relative Humidities. *Journal of Vector Ecology* 27:70–81.

Ledger, P.M., V. Forbes, E. Masson-MacLean, C. Hillerdal, W.D. Hamilton, E. McManus-Fry, A. Jorge, K. Britton, and R. Knecht. 2018. "Three Generations under One Roof?: Bayesian Modelling of Radiocarbon Data from Nunalleq, Yukon–Kuskokwim Delta, Alaska. *American Antiquity* 83, no. 3: 505–24.

Marshall, A.G. 1981. *The Ecology of Ectoparasitic Insects*. London: Academic Press.

McAlpine, J.F., B.V. Peterson, G.E. Shewell, H.J. Teskey, J.R. Vockeroth, and D.M. Wood. 1981. *Manual of Nearctic Diptera, vol. 1*. Agriculture Canada Monograph 28. Ottawa: Minister of Supply and Services Canada.

McManus, E.T. 2015. "Pre-Contact Ecology, Subsistence and Diet, on the Yukon-Kuskokwim Delta: An Integrated Ecosystem Approach to Pre-Contact Arctic Lifeways Using Zooarchaeological Analysis and Stable Isotope Techniques." PhD diss., University of Aberdeen.

McManus-Fry, E., R. Knecht, K. Dobney, M.P. Richards, and K. Britton. 2018. "Dog–Human Dietary Relationships in Yup'ik Western Alaska: The Stable Isotope and

Zooarchaeological Evidence from Pre-Contact Nunalleq. *Journal of Archaeological Science: Reports* 17: 964–72.
Mullen, G., and L. Durden. 2002. *Medical and Veterinary Entomology.* San Diego, CA: Academic Press.
Panagiotakopulu, E. 2004a. "Dipterous Remains and Archaeological Interpretation." *Journal of Archaeological Science* 31: 1675–84.
Panagiotakopulu, E. 2004b. "Pharaonic Egypt and the Origins of Plague." *Journal of Biogeography* 31: 269–75.
Panagiotakopulu, E. 2014. "Hitchhiking across the North Atlantic: Insect Immigrants, Origins, Introductions and Extinctions." *Quaternary International* 341: 59–68.
Panagiotakopulu, E., P. Skidmore, and P. Buckland. 2007. "Fossil Insect Evidence for the End of the Western Settlement in Norse Greenland." *Naturwissenschaften* 94: 300–06.
Poher, Y., P. Ponel, F. Médail, V. Andrieu-Ponel, and F. Guiter. 2017. "Holocene Environmental History of a Small Mediterranean Island in response to Sea-Level Changes, Climate and Human Impact." *Palaeogeography, Palaeoclimatology, Palaeoecology* 465 (Part A): 247–63.
Ponel, P., R. Coope, P. Antoine, N. Limondin-Lozouet, C. Leroyer, A.-V. Munaut, J.-C. Pastre, and F. Guiter. 2005. "Lateglacial Palaeoenvironments and Palaeoclimates from Conty and Houdancourt, Northern France, Reconstructed from Beetle Remains." *Quaternary Science Reviews* 24, no. 23: 2449–65.
Price, M.A., and O.H. Graham. 1997. *Chewing and Sucking Lice as Parasites of Mammals and Birds.* Technical Bulletin No. 1849, Washington, DC: US Department of Agriculture.
Raghavan, M., M. DeGiorgio, A. Albrechtsen, I. Moltke, P. Skoglund, T.S. Korneliussen, B. Grønnow, et al. 2014. "The Genetic Prehistory of the New World Arctic." *Science* 345, no. 6200. doi: 10.1126/science.1255832.
Roux, O., C. Gers, N. Telmon, and L. Legal. 2006. "Circular Dispersal of Larvae in the Necrophagous Diptera *Protophormia terraenovae* (Diptera: Calliphoridae)." *Annales de la Société Entomologique de France* 41, no. 1: 51–56.
Sadler, J.P. 1991. "Beetles, Boats and Biogeography." *Acta Archaeologia* 61: 199–211.
Séguy, E. 1944. *Insectes ectoparasites (Mallophaga, Anopleures, Siphonaptera)*. Faune de France 43, Paris: Lechevalier.
Shaw, R.D. 1998. "An Archaeology of the Central Yupik: A Regional Overview for the Yukon–Kuskokwin Delta, Northern Bristol Bay, and Nunivak Island." *Arctic Anthropology* 35, no. 1: 234–46.
Skidmore, P. 1995. "A Dipterological Perspective on the Holocene History of the North Atlantic." PhD diss., University of Sheffield.
Smit, F.G.A.M. 1957. "Siphonaptera." *Handbooks for the Identification of British Insects*, vol. 1, part 16. London: Royal Entomological Society.
Smith, K.G.V. 1986. *A Manual of Forensic Entomology.* London: British Museum.
Smith, D.N., and H.K. Kenward. 2011. "Roman Grain Pests in Britain: Implications for Grain Supply and Agricultural Production. *Britannia* 42: 243–62.
Yvinec, J.H., P. Ponel, and J.-C. Beaucournu. 2000. "Premier apports archéoentomologiques de l'étude des puces: Aspects historiques et anthropologiques (Siphonaptera)." *Bulletin de la Société Entomologique de France* 105, no. 4: 419–25.