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Short communication

# Lichens growing on human bone remains: A case study from continental Patagonia (Deseado Massif, Santa Cruz, Argentina)

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ABSTRACT

Lichens are organisms capable of colonizing almost every type of materials, provided they are stable and have sufficient exposure to light. The growing of lichens on bone surface is rare, due to the speed to which this substrate is weathered and destroyed. For the most part, documented cases occur in extreme environments, such as the Arctic and Antarctic, where bone elements remain unaltered for long periods, although they have also been found in other latitudes. The aim of this paper is to describe the taxonomic diversity of the lichens growing on a set of human bones recovered at a looted Late Holocene aboriginal cairn burial (*chenque*) in southern continental Patagonia (Piedra Museo archaeological locality, Deseado Massif, Santa Cruz, Argentina). In the analyzed bone assemblage (NISP = 56), a total of 63 lichen thalli were recorded. They were assigned to seven different species, except one case that could only be determined at the genus level. This is the first well-described record of lichen flora growing on human bone remains for South America, having important implications for both archaeological and forensic sciences.


## 1. Introduction

Lichens are organisms that, because of their ability to photosynthesize and adapt to survive in extreme environments, grow on a variety of surfaces, like rocks, bark, leaves, manufactured materials and even animal remains like the shells of turtles and molluscs, skins, and bones (Brightman and Seaward, 1977; Seaward, 2008). Among the aforementioned materials, bones are not the most common substrates for the growth of lichens, since they constitute relatively soft and unstable surfaces that undergo deterioration (e.g. weathering, erosion by abrasion) at a relatively rapid rate. However, lichens are organisms capable of colonizing almost any type of materials, provided they are stable and have sufficient exposure to light. According to Olech (1996), the growing of lichens on bones is related to the microclimatic conditions and the retention of nutrients in the pores of the bone substrate. Thus, examples of species that can be found on bones have been recorded mainly in extreme environments, such as the Arctic and Antarctic. Lichens that live in such environments have a low dependence on the substrate, and this characteristic allows them to colonize a bone substrate using similar strategies as the ones used when colonizing rocks (Jacobsen and Kappen, 1988; Nývlt et al., 2016; Pereira de Albuquerque et al., 2018).

Our study area corresponds to the Deseado Massif (northern Santa Cruz, Argentina, Fig. 1); it presents a cold and dry climate, characterized by a mean annual temperature range between 3 and 12 °C, less than 200 mm annual precipitations and strong west winds (Paruelo et al., 2005). One of the research lines within the archaeological project that we are carrying out in the area is to study the potential of lichens for reconstructing the post depositional histories of surface archaeological materials found in open air contexts. Along this line of inquiry, we have previously recorded and analyzed lichens growing on small size chipped stone artifacts (usually less than 10 cm long) manufactured on siliceous rocks, petrified wood, and rhyolite (García et al., 2015; Magnin et al., 2015, Magnin et al., 2017). The aim of this paper is to describe the taxonomic diversity of the lichens growing on a

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**Fig. 1.** Location of Deseado Massif, represented by a red dot in the map at the northeast of Santa Cruz Province, Argentina.

human bone assemblage recovered at a looted Late Holocene aboriginal cairn burial (*chenque*) located at the Piedra Museo archaeological locality, in the northeast sector of the Deseado Massif. The assemblage consists of 56 heavily weathered bone specimens (comprising both anatomically identifiable and unidentifiable elements and fragments), all belonging to a single human individual. The burial, known as chenque "El Sargento", corresponds to the hunter-gatherers who inhabited Patagonia in Late Holocene times. The *chenques* are a kind of funerary structures that consist of a variable number of stone blocks of different size and shape placed directly on one or more corpses, forming low-height piles that can take a generally elliptical shape of variable dimensions (Barrientos et al. 2007; Magnin, 2010). As for its chronology, a bone sample (left patella) was radiocarbon dated at 727 ± 48 $^{14}$C years BP (Miotti, 2006), i.e. 717–555 cal BP (2 sigmas; SHCal13.14c calibration dataset on Calib 7.04). The reason why it was possible for lichens to colonize this bone assemblage is that the funerary structure was opened and disturbed by modern looters, who left the bones exposed to the action of subaerial agents for a yet undetermined period of time, likely of the order of several decades considering the growing of lichens on highly weathered bone surfaces.

## 2. Methodology

Each bone specimen was carefully inspected in order to detect, record and identify lichens. The taxonomic determination of the lichens was made trying to avoid damaging the underlying bone, which is mostly fragile due to advanced weathering. The techniques used for detection included the naked-eye observation of the bones surface, as well as the use of low-power magnifying devices like binocular glasses and stereoscopic microscope. The taxonomic identification was performed by means of histological sections obtained by free-hand cut, and the use of the K and C reagents. The identification was carried out using the taxonomic keys by Elix and Nash (1992), McCune (2012), and De la Rosa et al. (2012). A small number of specimens were grouped together by shared morphological features like the shape and colour of the thalus, although it was not possible to assign them to any formal taxonomic category.

## 3. Results

A total number of 63 lichen thalli were observed, 48 of which (76%) could be taxonomically determined (Fig. 2). They were assigned to seven different species, except one case that could only be determined at the genus level and another at the family level. In addition, five other specimens remained unidentified because they lacked reproductive structures and could not be related to any known taxon (Table 1).

The most frequent species was *Psiloparmelia distincta*, which accounts for the 30.2% of the sample. Between the radial-growing species, the individual with the largest diameter was a *P. distincta* with 6.28 cm.

## 4. Discussion and conclusions

The case reported in this paper is the first detailed study of lichens growing on human bones in South America, where there are very few mentions—in the archaeological literature—about this type of finding (e.g. Barrientos et al., 2014), as it is also the case for other regions around the world (Fernandez-Jalvo and Andrews, 2016; Thackeray, 2016). The paucity of information about lichens growing on human bones in contexts other than forensics, is likely related to the fact that they tend to remain for just a relatively short period of time on the land surface after having been unearthed by some natural or anthropic process, since they are soon destroyed by mechanisms such as weathering or erosion by abrasion (Junod and Pokines, 2013).

The rich mineral content of bones probably acts as a key factor favouring the proliferation of some species, but also limiting the presence of others (Pereira de Albuquerque et al., 2018). The species identified in the present case are primarily saxicolous, most

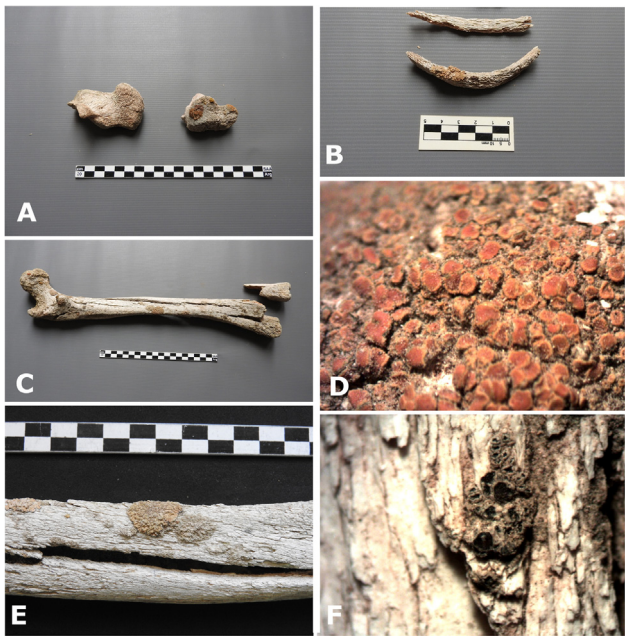


**Fig. 2.** lichens growing on bones A. calcaneus; B. ribs; C. humerus; lichen species D. crustose Teloschistaceae E. *Psiloparmelia distincta* F. *Myriolecis torrida.*

**Table 1**
Species of lichens found, frequency, percentage frequency (%) and biotype (c = crustose, f = foliose).

| | Frequency | % | Biotype |
|---|---|---|---|
| *Psiloparmelia distincta* | 19 | 30.2 | f |
| Undetermined sp. | 12 | 19.0 | c |
| crustose Teloschistaceae | 5 | 7.9 | c |
| *Xanthoria elegans* | 5 | 7.9 | f |
| *Acarospora* sp. | 4 | 6.3 | c |
| *Candelariella aurella* | 4 | 6.3 | c |
| *Myriolecis dispersa* | 4 | 6.3 | c |
| *Myriolecis hagenii* | 4 | 6.3 | c |
| *Myriolecis torrida* | 2 | 3.2 | c |
| Undetermined sp. 2 | 1 | 1.6 | c |
| Undetermined sp. 3 | 1 | 1.6 | c |
| Undetermined sp. 4 | 1 | 1.6 | c |
| Undetermined sp. 5 | 1 | 1.6 | c |

of them present a crustose morphology, while only two species present a foliose one (Brightman and Seaward, 1977; De la Rosa et al., 2012; García et al., 2015). The species found on bone have also been found on rock in the province of Santa Cruz or in bordering provinces (Calvelo and Liberatore, 2002; De la Rosa et al., 2012). According to Pereira de Albuquerque et al. (2018), these species are pioneer species in non-vegetated sites.

Between the identified species, the most frequent is *P. distincta*, which is saxicolous and has not been previously reported as growing on this particular substrate (Elix and Nash, 1992). On the other hand, the groups *Caloplaca s.l.* and to *Lecanora s.l*, have been observed in seal and whale bones (Jacobsen and Kappen, 1988; Nývlt et al., 2016; Pereira de Albuquerque et al., 2018). The species *Myriolecis dispersa, M. torrida, M. hagenii* and *Xanthoria elegans* have also been registered growing on bone, but it was not specified the species those bones belonged to (Brightman and Seaward, 1977; De la Rosa et al., 2012). No similarities were found between the species found on whale bone and those found in our study, although the pattern of the dominant group being crustose and a few folioses remained (Kim et al., 2006; Pereira de Albuquerque et al., 2018).

According to Hawksworth and Wiltshire (2011) the genus *Caloplaca* s.l. and *Lecanora* s.l. have potential in forensic use; since they are common in bones. If their growth speed was known, it could be possible to estimate the time when the surface was available for colonization in a particular environment. However, there are no detailed studies to look at growth rates on bone in order to provide an accurate estimate of the time of exposure of human remains. Although in the case of *X. elegans* there are studies on its growth, which could be considered for carrying out lichenometric studies (Beschel, 1954). But as it was studied by McCarthy, 1997, it should also be taken into account that microclimate conditions are the ones that modify growth, making it impossible to extrapolate the growth of individuals from different environments.

Such studies would have important implications for both archaeological and forensic sciences. This work is part of a research of greater scope, aimed at establishing the time of permanence of human and animals bones on the surface in central-southern Patagonia, for which the evidence of weathering and presence of lichens is relevant.

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## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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