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Searching for myxomycetes in Antarctica: the experience of conducting research in one of the most extreme environments on Earth

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Abstract: Antarctica constitutes one of the most inhospitable terrestrial environments for life, where low temperatures, persistent winds, scarcity of liquid water, and reduced nutrient availability act as strong environmental filters. Even so, myxomycetes are restricted to specific microhabitats capable of maintaining temporarily favorable conditions for plasmodial development and sporophore formation. This study presents a field-based perspective on the search for myxomycetes in scientific camps established at Elephant Point and Cape Shirreff, Livingston Island, describing the logistical, environmental, and methodological challenges involved in researching these organisms in polar ecosystems. The observations show that meteorological conditions determine not only the routine of expeditions but also the availability of suitable microhabitats and the duration of windows favorable to biological activity. Intense wind action accelerates substrate desiccation, while small differences in exposure, moisture, and protection create a mosaic of microenvironments that condition the occurrence of myxomycetes. Despite targeted sampling efforts, the detection of sporophores proved to be quite rare, indicating that the currently known low richness results both from strong environmental filtering and from the inherent limitations of observing ephemeral structures. This paper also reviews the history of research on Antarctic myxomycetes, highlighting that all available records derive from opportunistic collections carried out during studies focused on other biological groups. Taken together, these observations reinforce that the known diversity represents only a minimal fraction of the community actually present, underscoring the need for dedicated surveys and greater integration between field observations and laboratory approaches in order to expand our understanding of the ecology and distribution of Antarctic myxomycetes.

Keywords: Amoebozoa, nivicolous, protists, South Pole

There are environments where life manifests itself almost imperceptibly, and Antarctica represents one of the most extreme examples of this condition. At first glance, the continent may appear to be a biologically simple system; however, this perception changes profoundly when the environment is examined at the scale of microhabitats. The terrestrial landscape reveals a much more structured ecological organization than expected, in which inconspicuous organisms play fundamental roles in decomposition and organic matter cycling. Nevertheless, this biota is confined to an extremely small fraction of the continent. Most of Antarctica remains permanently covered by ice, and virtually all terrestrial life is restricted to small ice-free coastal areas, where the combination of low temperatures, persistent winds, extremely limited availability of liquid water, and nutrient scarcity acts as a rigorous environmental filter. Rather than merely limiting biological richness, this set of factors determines which organisms are able to establish populations and complete their life cycles, making the observed diversity the outcome of intense ecological selection.

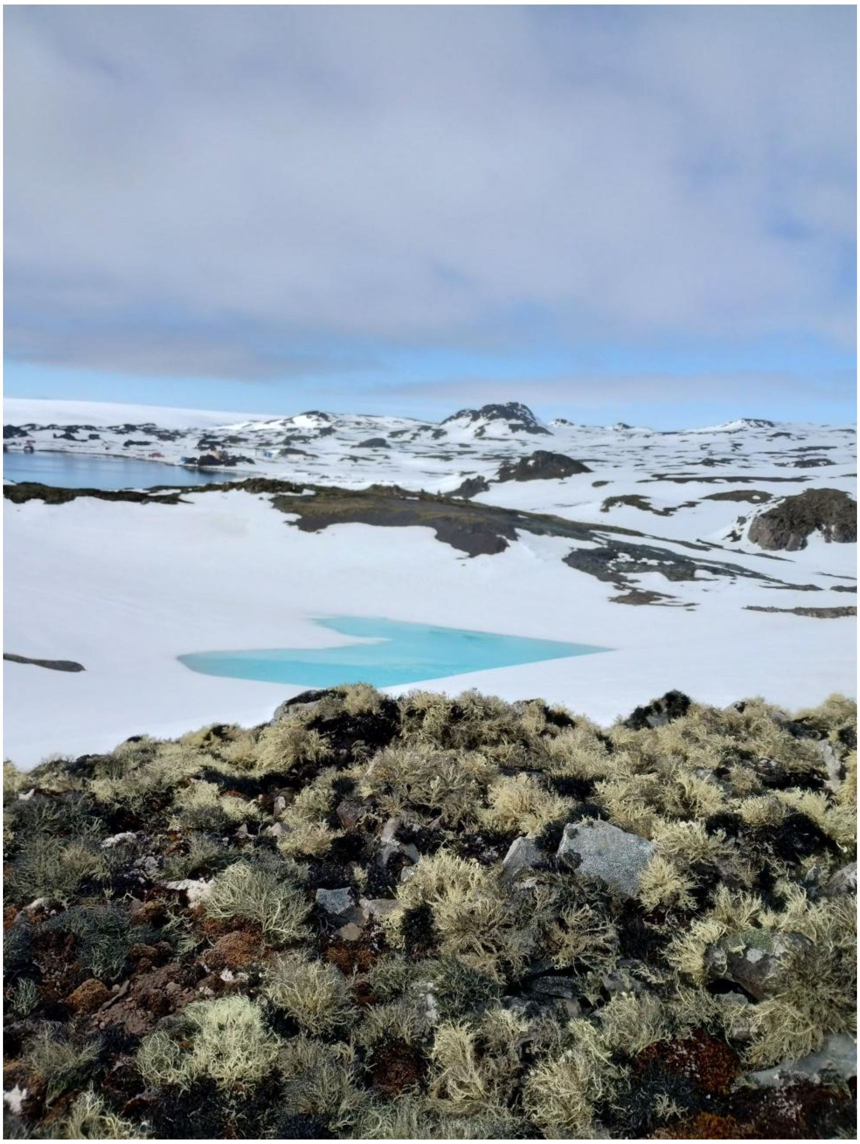

Figure 1. View of a section of the Fildes Peninsula, King George Island, where lichens of the genus *Usnea* dominate the landscape amid the vast expanses of ice and rock. Photo: November 2023.

Field experience in this setting was essential for understanding this ecological scale. All observations presented here were made during field expeditions conducted as part of the TERRANTAR Project, coordinated by the Universidade Federal de Viçosa under the Brazilian Antarctic Program

(PROANTAR). Living and working in isolated camps in Antarctica provides direct insight into an environment where meteorological conditions not only influence expedition logistics but completely dictate the day-to-day dynamics of scientific activities. At both Elephant Point and Cape Shirreff, located on Livingston Island, fieldwork was carried out under continuous exposure to strong winds, abrupt weather changes, and marked thermal instability.

The camp itself served simultaneously as shelter and constraint: tents permanently strained by the wind, daily routines adjusted to prevailing weather conditions, and access to study sites limited to brief windows of favorable conditions. Even when sampling sites could be reached, field collections were restricted to very short observation periods. Rapid changes in weather frequently interrupted field activities, limited movement, and often forced the entire team to remain confined inside the tents or return to camp earlier than planned, substantially reducing the time effectively available for sampling.

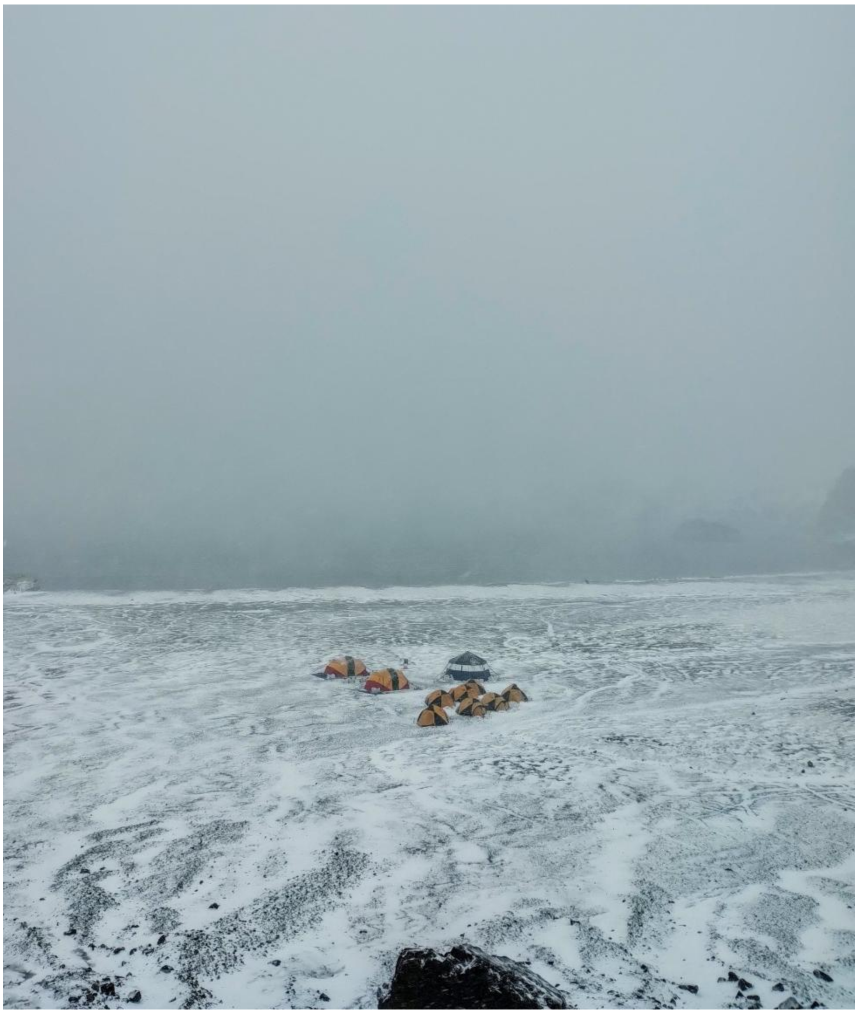

Figure 2. Scientific camp at Elephant Point, Livingston Island. Photo: February 2025.

At Elephant Point, during the austral summer of February 2025, a snowstorm lasting more than 40 hours made any fieldwork impossible. The accumulation of nearly one meter of snow made it difficult even to enter or leave the individual tents, requiring continuous snow removal, including throughout the night, to prevent the structures from becoming completely buried. On virtually every night, wind gusts ranging from 80 to 100 km/h struck the camp, making concern inevitable not only for the safety of the research team but also for the integrity of the scientific equipment and the samples stored in the improvised field laboratory.

Figure 3. (A) Researcher removing snow accumulated on his tent following a snowstorm. (B) Researchers conducting fieldwork. Photo: Elephant Point, Livingston Island, February 2025.

Sample processing also required constant adaptation. The samples were prepared in an improvised laboratory set up inside one of the tents, where they had to be carefully dried and packaged to withstand approximately 30 days in the field before being safely transferred to the research vessel.

The prolonged isolation, combined with the absence of comfort and the need for continuous adaptation to environmental conditions, profoundly transformed my perception of both the landscape and the practice of field research itself. By slowing the pace of observation and imposing direct engagement with the limits of the environment, it became easier to recognize the presence of inconspicuous forms of life that often go unnoticed during conventional observations.

It is within this context that myxomycetes emerge as one of the most inconspicuous components of the Antarctic terrestrial biota. Their occurrence is associated with highly specific microhabitats beneath rocks and within bryophyte mats, particularly mosses with a high water-retention capacity, as well as areas containing accumulated decomposing organic matter, especially among tufts of *Colobanthus quitensis* and *Deschampsia antarctica*, the only two native flowering plants in Antarctica. These systems function as environmental mosaics on a millimeter scale, where subtle differences in moisture, protection from wind, substrate availability, and thermal stability determine whether conditions are suitable for the development of myxomycete reproductive structures.

Figure 4. (A) Individual tents and (B) the laboratory tent following a snowstorm. Photo: Elephant Point, Livingston Island, February 2025.

The importance of this environmental heterogeneity is also evident in Antarctic fauna, whose animals systematically seek more sheltered areas during periods of intense winds. At the microscopic scale, the same principle appears to determine which microhabitats remain sufficiently moist to support myxomycete development. Strong winds not only hinder field activities but also accelerate moisture loss from surface substrates, reducing the duration of conditions favorable for plasmodial development and sporophore formation. Consequently, slight differences in wind exposure may determine whether a given microhabitat is capable—or incapable—of supporting the life cycle of these organisms.

The very existence of these organisms depends on the coincidence of environmental conditions that rarely occur simultaneously. Although billions of spores are potentially dispersed worldwide by atmospheric currents, only a minute fraction reaches microhabitats capable of supporting their initial establishment. Once established, however, populations likely persist for long periods in resistant stages, such as microcysts, sclerotia, and spores, surviving extended intervals of unfavorable conditions until new pulses of moisture allow the resumption of their life cycle. Thus, the distribution of myxomycetes in Antarctica appears to be determined less by dispersal capacity than by the intensity of environmental filtering, which constrains both the establishment and persistence of populations.

Moreover, the possibility that some Antarctic morphospecies represent cryptic lineages adapted to polar conditions—a hypothesis that remains to be tested through molecular studies—suggests that the diversity of Antarctic myxomycetes may be even more underestimated than currently recognized.

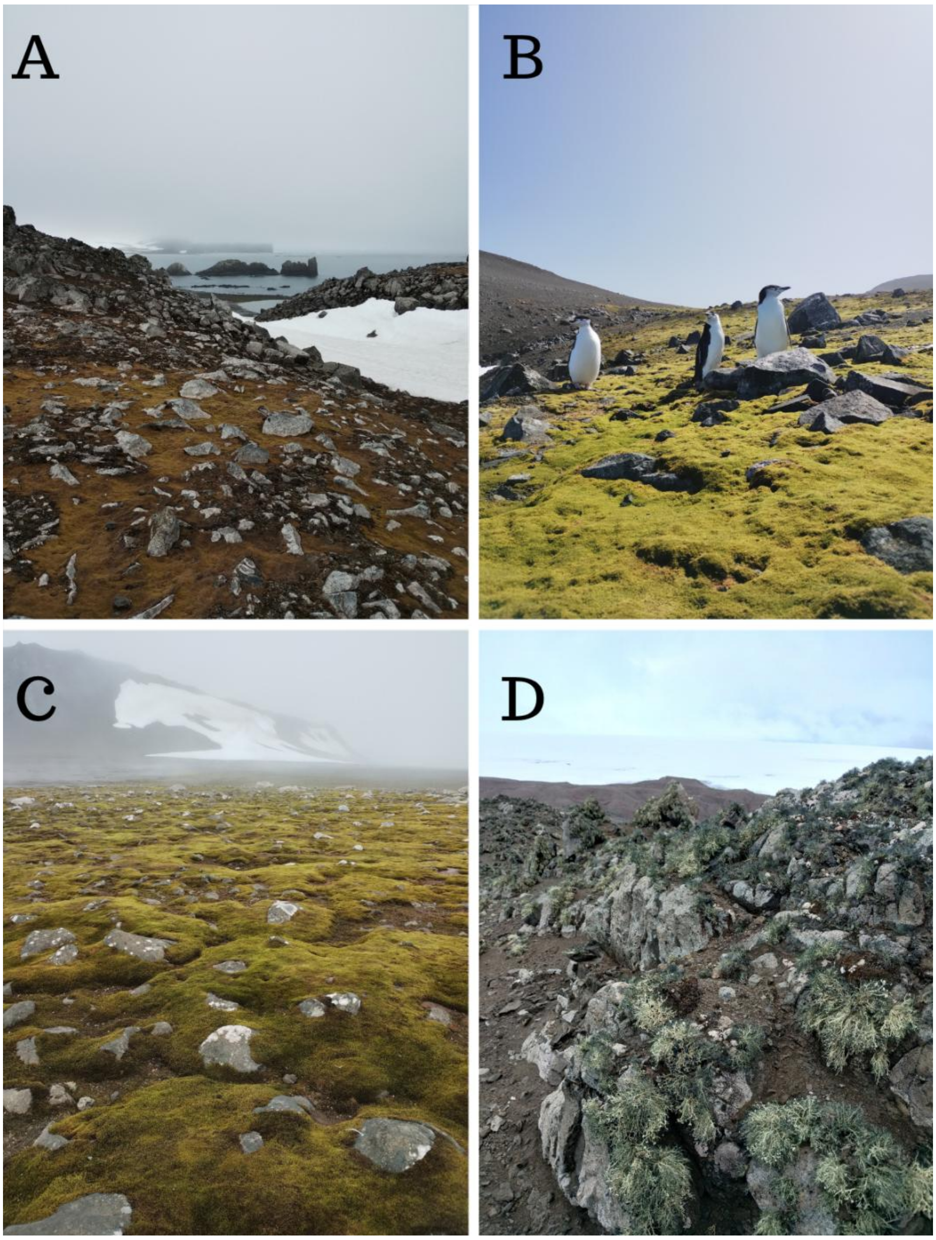

Figure 5. (A–B) Western side of Cape Shirreff, Livingston Island, fully exposed to the prevailing westerly winds and facing the notorious Drake Passage. (C–D) Eastern side of Cape Shirreff, Livingston Island, in an area sheltered from the prevailing winds. Photos: Cape Shirreff, Livingston Island, January 2026.

Knowledge of Antarctic myxomycetes began in the 1960s with the description of *Diderma antarcticolum* E. Horak, based on material collected during broad botanical expeditions in which myxomycetes were not the primary focus (Horak 1966). During the following decades, particularly throughout the 1970s and 1980s, studies by Ing and Smith (1983) and Arambarri and Spinedi (1989), based on collections from Cierva Point and Paradise Bay, expanded the known inventory. During this period, *Didymium dubium* Rostaf., *Lamproderma arcyrioides* (Sommerf.) Rostaf., *Stemonitopsis subcaespitosa* (Peck) Nann.-Bremek., and *Diderma niveum* (Rostaf.) E. Sheld. were added to the regional species list, consolidating the view that the group was indeed present but remained severely undersampled.

Figure 6. Patch of *Deschampsia antarctica* sheltered from the wind among volcanic rock fragments. Photo: Keller Peninsula, King George Island, December 2023.

The most recent review available (Velloso et al. 2023) shows that this pattern persisted over the following decades. From the 1990s through the early 2000s, additional records continued to be incorporated into the Antarctic inventory, but always opportunistically, as by-products of broader ecological surveys. In nearly every case, myxomycetes were recorded incidentally during studies of mosses and liverworts, saprobic fungi, or general terrestrial biodiversity inventories. Later records, including *Trichia varia* (Pers. ex J.F. Gmel.) Pers. from Nelson Island (Putzke 2003), *Dianema nivale* (Meyl.) G. Lister (Velloso et al. 2020), *Diderma effusum* (Schwein.) Morgan recovered from moist chamber cultures prepared with mosses from Livingston Island (Stephenson 2025), and observations associated with mosses of the genera *Bryum*, *Chorisodontium*, *Polytrichastrum*, *Sanionia*, and *Warnstorfia* (Velloso et al. 2021), further reinforce this methodological pattern. Collectively, these records raise the total number of species currently recognized for Antarctica to at least ten.

The absence of inventories specifically dedicated to myxomycetes represents an important structural limitation: current knowledge is not the result of targeted sampling but rather of the incidental overlap between the occurrence of these organisms and the sampling of other taxa, particularly bryophytes. This introduces a substantial detection bias, especially considering the strong dependence of myxomycetes on highly specific microhabitats.

This methodological limitation initially led us to hypothesize that the low species richness currently known from Antarctica primarily reflected the absence of surveys specifically targeting myxomycetes. However, our field experience revealed a more complex scenario. After consecutive days of sampling at Elephant Point and Cape Shirreff, traversing extensive moss beds, inspecting hundreds of rocks, examining decomposing plant debris, and searching a wide variety of potentially suitable microhabitats, the scarcity of sporophores remained striking. On several sampling days, hours of intensive searching resulted in the observation of only one or a few sporophores, highlighting the considerable sampling effort required to document their occurrence. In contrast, macrofungi such as species of *Galerina*, *Omphalina*, *Arrhenia*, and *Rickenella* were encountered relatively frequently in the same areas, indicating that the low detectability observed cannot be explained solely by the difficulty of locating such minute organisms, but also reflects ecological characteristics intrinsic to myxomycetes in the Antarctic environment.

Figure 7. Potential microhabitats for myxomycetes in different Antarctic environments. (A) Whale mandible on the beach. (B) Moss mats in an exposed area. (C) Moss mats sheltered by rock outcrops. (D) Whale vertebra colonized by algae. Photos: (A) Cape Shirreff; (C–D) Elephant Point, both on Livingston Island. Photos: (A) Cape Shirreff, Livingston Island, February, 2026; (B) -(D) Elephant Point, Livingston Island, February 2025.

These results suggest that the currently known low species richness cannot be attributed exclusively to historically limited sampling effort, but also reflects an ecological constraint imposed by polar ecosystems. Just as field activity is restricted to short windows of meteorological stability, sporophore formation is likely dependent on equally brief intervals during which temperature, liquid water availability, and substrate moisture become simultaneously favorable. This further reduces the probability that these structures coincide temporally with sampling campaigns.

This difficulty is amplified by the biological characteristics of myxomycetes themselves. Their reproductive structures are extremely small, fragile, and ephemeral, often less than one millimeter in height, and remain available for collection only for very short periods. In Antarctica, where expeditions are limited to a few days of favorable conditions, the likelihood of encountering these structures precisely during sporulation becomes naturally very low.

Nevertheless, this apparent rarity must be interpreted with caution. Because the vegetative phase of myxomycetes is microscopic and remains hidden within soil and substrate matrices, a significant portion of the community may remain undetectable during field observations. In most cases, their presence only becomes evident through laboratory induction using moist chamber techniques, in which apparently sterile substrates produce plasmodia and sporophores after weeks or months of incubation. This strong dependence on laboratory methods demonstrates that directly observed diversity in the field represents only a small fraction of the community actually present in Antarctic microhabitats, reinforcing the hypothesis that their true distribution across the continent is substantially underestimated. The interaction between global spore dispersal, high dormancy capacity, and strong environmental constraints on active establishment forms the ecological framework that explains their low detectability.

From a biogeographical perspective, the observed pattern is one of discontinuous distribution between Antarctica and sub-Antarctic islands, with no clear evidence of community structuring or consistent endemism. This scenario reflects less the intrinsic ecology of the group and more historical and methodological limitations in sampling. Our most recent results indicate that distinct communities are primarily shaped by the combination of geographic isolation and the intensity of environmental filtering, producing species turnover among different islands. Thus, the set of approximately ten species currently recognized should be interpreted as a minimal observed subset, rather than a representation of the true diversity.

Field observations across different expeditions on Livingston Island and King George Island support this interpretation. Systematic exploration of microhabitats in areas such as Elephant Point and Cape Shirreff demonstrates that the detection of myxomycetes depends on an extremely detailed reading of the environment, including moss texture and density, substrate decomposition stage, and local patterns of moisture retention. In highly oligotrophic and climatically extreme systems, these conditions are not only heterogeneous but also highly episodic, further reducing the likelihood of direct observation.

The terrestrial areas available to these organisms are also in constant transformation. At Elephant Point, recently exposed moraines resulting from glacial retreat were observed to already be colonized by small patches of mosses and other pioneer organisms. This rapid colonization highlights the dynamic nature of Antarctic terrestrial microhabitats and gradually increases the availability of potentially suitable environments for myxomycete establishment, although still under severe climatic constraints.

In addition, there is a near-complete absence of natural woody substrates, which are traditionally used by many myxomycete species in temperate and tropical ecosystems. In Antarctica, moss mats cease to be merely a component of the vegetation and instead become the principal ecological substrate available, providing water retention, protection against wind-driven desiccation, and suitable surfaces for development and sporulation. Their frequent association with mosses suggests that bryophytes play a major role in the ecology of Antarctic myxomycetes.

In summary, myxomycetes in Antarctica represent a biological system whose understanding remains profoundly constrained by methodological limitations and the fragmented nature of their detection. The absence of targeted studies on the group, combined with exclusive reliance on opportunistic collections, means that current knowledge is necessarily incomplete. However, available evidence indicates that the observed low richness does not simply reflect limitations in spore dispersal, but primarily the strong environmental filtering exerted by polar ecosystems, where only a small fraction of propagules encounters conditions suitable for establishing viable populations. In this context, Antarctica not only restricts the occurrence of these organisms but also imposes significant barriers to their detection, making them one of the most underestimated components of polar cryptogamic biota.

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