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SPECIAL
FEATURE

Sampling research of a microscopic exploration of lichens, mosses, and flowers in Kujataa, Greenland

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ABSTRACT

The special feature presents a study through the Valley of a Thousand Flowers from Narsarsuaq, the Kujata area, a corner of the world with historical and natural value in Greenland. This valley became a protected area after being declared a World Heritage Site by UNESCO (United Nations Educational, Scientific and Cultural Organization). The microscopic image sampling focuses on lichens, mosses and flowers, which is the main vegetation of the Nordic area studied. It should be noted that this research represents the first scientific dissemination of these findings in a specialized journal. It also highlights the importance of the subarctic landscape of Kujataa, which combines agriculture, grazing, and hunting of marine mammals, which is one of the few places where it is legal to consume whales and seals.

Keywords: Lichens, Mosses, Flowers, Image sampling, Kujataa, Greenland

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Introduction

After a hike through the Valley of a Thousand Flowers from Narsarsuaq, the Kujata area, you can enjoy spectacular views of meanders, characterized by their pronounced sinuosity, and the huge valley formed by glacier retreat and subsequent sedimentation where you can also see the so-called nunataks or rock islands, emerging from the ice of the Kiattut Glacier.Unnoticed on the ground where we walk we can find some of the most amazing microscopic wonders. In this regard, microscopy is the best tool to capture incredible views of species invisible to the human eye. These species sometimes form microscopic ecosystems, which are the basis for this study to be published for the first time in a scientific journal.

Photograph 1
Landscape of a Nunatak (Rock Island), Greenland

It is worth mentioning the historical importance of the area, highlighting the Qassiarsuk village where, for centuries, Northern European Vikings lived together with the Inuit people. The area has ruins and reconstructions such as the first Christian church on the American continent, which belongs to the time when Erik the Red arrived in Greenland (year 985).

Moreover, it is also relevant to mention that the area of Kujataa was declared a World Heritage Site by UNESCO (2017), due to the sub-arctic agricultural landscape that represents key elements of the Norse and Inuit agricultural cultures. Although these are different cultures, both have many elements in common: they are agricultural, pastoral, and located at the climatic limits of viable farming. Likewise, they rely on a combination of agriculture, pastoralism and marine mammals hunting. This makes them one of the only legal places where whales, as well as seals and other marine mammals are commonly eaten.

Regarding the landscape, it represents the first introduction of agriculture in the Arctic. Meanwhile, its vegetation tends to be of small dimensions formed mainly by lichens, mosses, and small flowers. Most of these species were scientifically identified for this research. In this context, Greenland, with its arctic and subarctic climate, hosts a variety of mosses, flowers and lichens that have developed unique adaptations to survive in extreme conditions. Therefore, this article shows several existing species magnified through the microscope along with a description of some of the most notable species that can be found in the region, as detailed below. (Naturguide Grønland, 2022).

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Mosses

- **Polytrichum spp.:** This genus of moss, commonly called haircap moss or hair moss, is characterized by erect stems and lance-shaped leaves. They can absorb large amounts of water, allowing them to thrive in moist soil.
- **Sphagnum spp.:** This type of moss, also known as Peat Moss, is important for developing peatlands in Greenland.

This can retain water and nutrients, thus creating habitats for different species, and helping climate regulation.

The reproduction of most lichens, such as the Peat Moss Sphagnum Tarvemos Ipeggat or Kennet, occurs through the formation of spores in the many fruiting bodies. Generally, these organisms play an important role in Greenland's ecosystem by maintaining biodiversity and stabilizing the soil while adapting to extreme temperature variations and water availability.

Flowers

- **Salix herbacea (dwarf willow):** This flowering plant is one of the smallest in the world and its creeping growth allows it to resist Greenland's harsh weather conditions. This plant with small leaves and pale yellow petals, blooms at the beginning of summer.
- **Dryas integrifolia (mountain avens):** This perennial plant, has bright and plumpy leaves and white or yellow flowers that grow in clusters, it can be usually seen in the arctic tundra. It is important for soil stabilization and serves as the source of food for many herbivores.
- **Aappaluttunnguit Alpine/Trailing Azalea:** Also known as Loiseleuria procumbens, this plant grows in acidic soils and creates pillow-shaped spikes. The flowers may resemble a smaller version of the violet Stonebreak.

Lichens

- **Cladonia rangiferina (Gray reindeer):** This lichen represents an important component of Greenland's ecosystem because it serves as one of the main sources of food for reindeers. It also has a branched aspect with a grayish tone and is usually found on soils and rocks.
- **Usnea spp. (Beard lichens):** This lichen is known for its hanging aspect and dark green color. It grows on the branches of trees and shrubs. This plant is sensitive to air pollution, which makes it an indicator of environmental quality.
- **Elegant Sunburst Lichen Rusavskia:** This lichen has an orange-yellow crust, which grows typically along with various fruiting bodies in the form of scales (1-2 mm) of the same color. It is commonly distributed on rocks and stones throughout Greenland, especially near bird excrements. For example, it can be seen on old animal bones.

It is important to highlight that lichens have the capacity to spread in two ways: one is through the dispersion of fragments of the lichen itself, such as isidia and soredia; the other, through the dispersion of spores generated by the fungus, whether of sexual or asexual origin.

Methodology

A. Study Objective

- **Objective:** Conduct a detailed microscopic exploration of the lichen's structures, mosses, and flowers collected in Kujataa, Greenland, to identify morphological adaptations to the arctic environment.
- **Approach:** This is a systematic sampling exploratory research of the representative species, and a detailed morphological analysis using microscopic images.

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B. Research Area

- **Location:** Kujataa, Greenland. Despite its polar and subarctic climate, it is known for its unique combination of natural and cultural landscapes and biological diversity.
- **Ecological Context:** This research considers the diversity of weather conditions in the area, such as the temperature, humidity, and seasons, as well as geographical factors, considering altitude, and solar exposition which can influence the morphological characteristics of the species analyzed.

C. Selection and collection of samples through images

- **Selection criteria:** Identifying and selecting representative species of lichens, mosses, and flowers, focusing on those with a notable presence in the region and, at the same time, may show particular adaptations to the Arctic climate.
- **Sample size:** Collection of at least four samples per microscope images of each species to ensure representativeness.
- **Data Recording:** Each sample per image was conducted in its natural habitat while avoiding any type of contamination or alteration of its ecosystem. In addition, the precise location (GPS coordinates), date and time of collection, as well as the environmental conditions were recorded.

D. Microscopy Techniques Used

- **Optical Microscopy (OM):** Use of optical microscopy for general observation and imaging capture of cellular structures. Contrast techniques, such as phase contrast, will be used to enhance the visibility of specific structures.
- **Scanning Electron Microscopy (SEM):** Aimed to obtain high resolution images of the surface of the samples, which allow a detailed analysis of the morphological characteristics.
- **Transmission Electron Microscopy (TEM):** TEM was used to examine the subcellular structures of mosses and flowers.

E. Image Analysis

- **Image processing:** The images obtained will be processed using a specialized software (e.g., ImageJ) to conduct precise measurements of cellular and tissue structures.
- **Visual Documentation:** In order to determine the classification of each species, a book showcasing the biodiversity of Greenland was consulted, as well as the online search engine Global Biodiversity Information Facility (Naturguide Grønland, 2022; GBIF., n.d.).

F. Ethical and Conservation Considerations

- **Minimization of Impact:** The exploration and image capture were conducted ensuring that the natural ecosystem was not negatively affected, while following the ethical protocols in the handling and analysis of the species.

G. Research Limitations

- **Climate Conditions:** Adverse climate conditions may limit sample collection or affect sample quality.
- **Accessibility:** Logistical difficulties due to the geographic isolation of Kujataa may limit the number of samples collected.
- **Sample Size:** Limitations on the number of species analyzed due to time and resource constraints.

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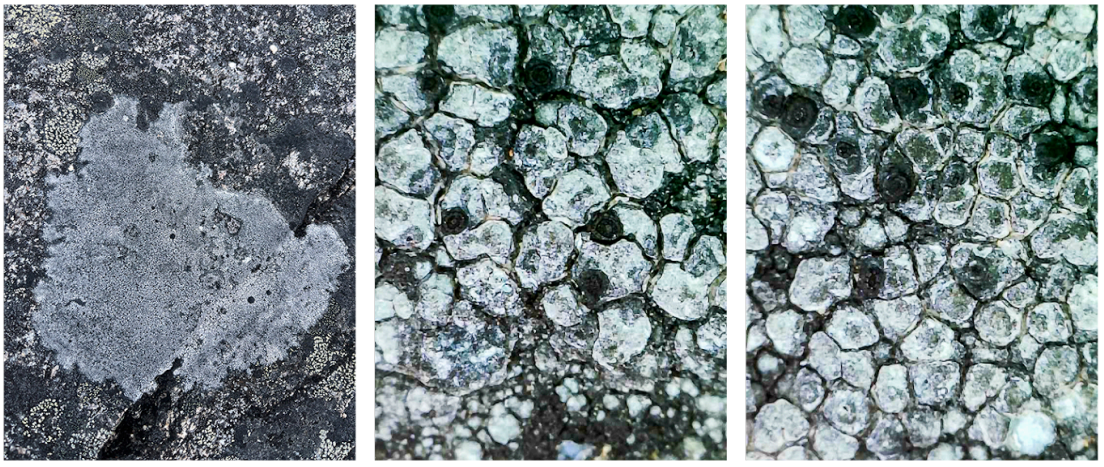
Results

The expedition conducted in Kujataa, Greenland, allowed to conduct an image sampling research, which has revealed a surprising biodiversity of lichens, mosses, and flowers adapted to the extreme conditions of the Arctic and that only grows in this part of the world.

Through the microscopic analysis, it was possible to identify unique structures and morphological adaptations that have provided these species the ability to survive in this inhospitable environment. Detailed images of the collected samples are presented below, highlighting the species captured through the applied microscopy techniques (OM, SEM, and TEM).

Photograph 2
Aspilidea myrinii (Fr.) Hafellner



Note: Species not recorded in Greenland

Photograph 3
Alectoriaceae

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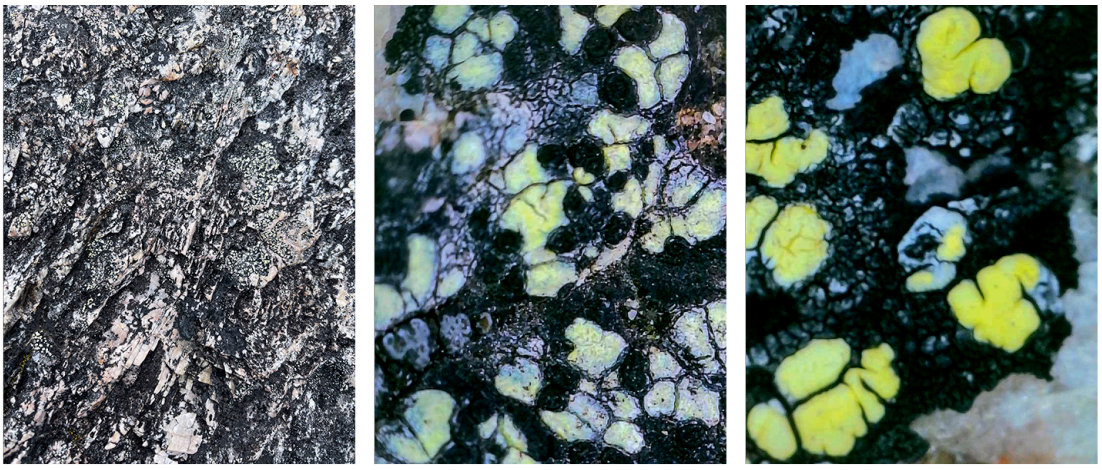
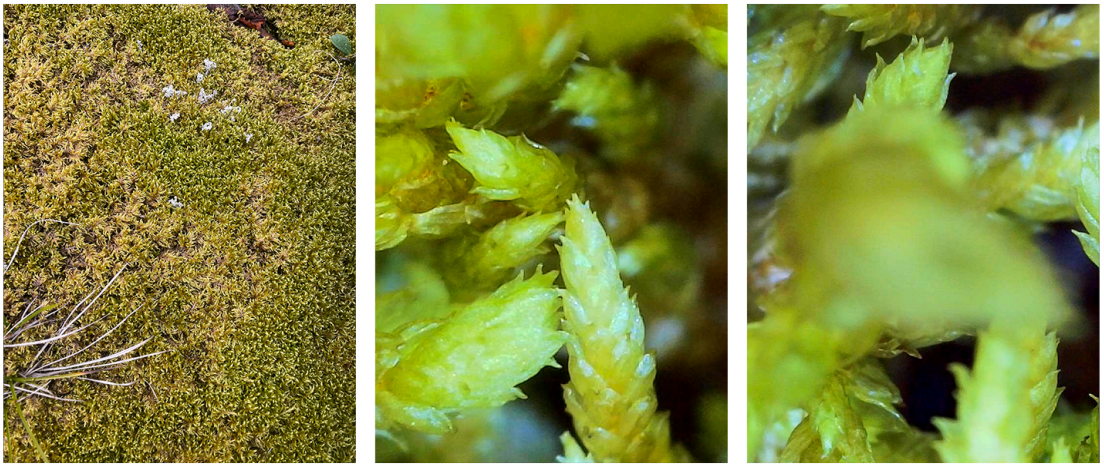
Photograph 4
Catolechia flavovirescens Flo



Note: Species not recorded in Greenland

Photograph 5
Cladonia Stellaris

Photograph 6
Aulacomnium Schwägr.



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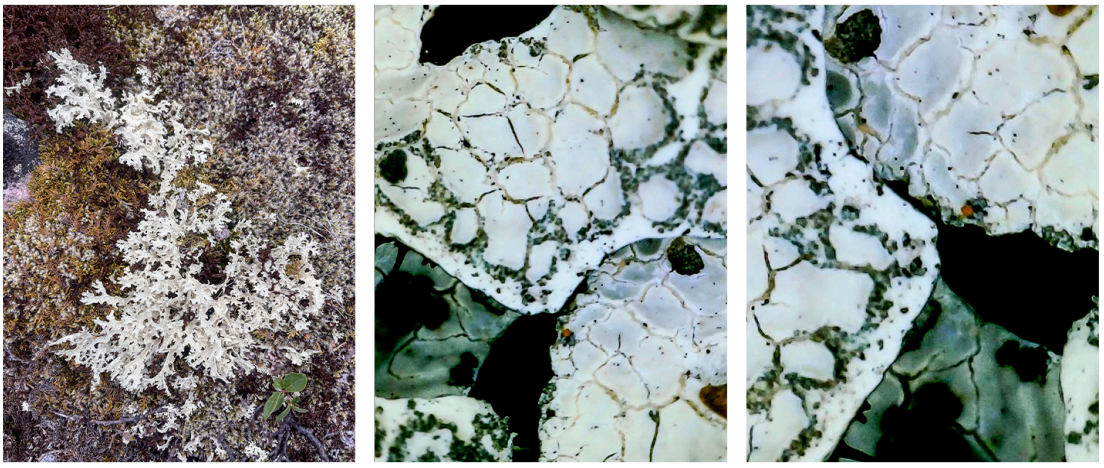
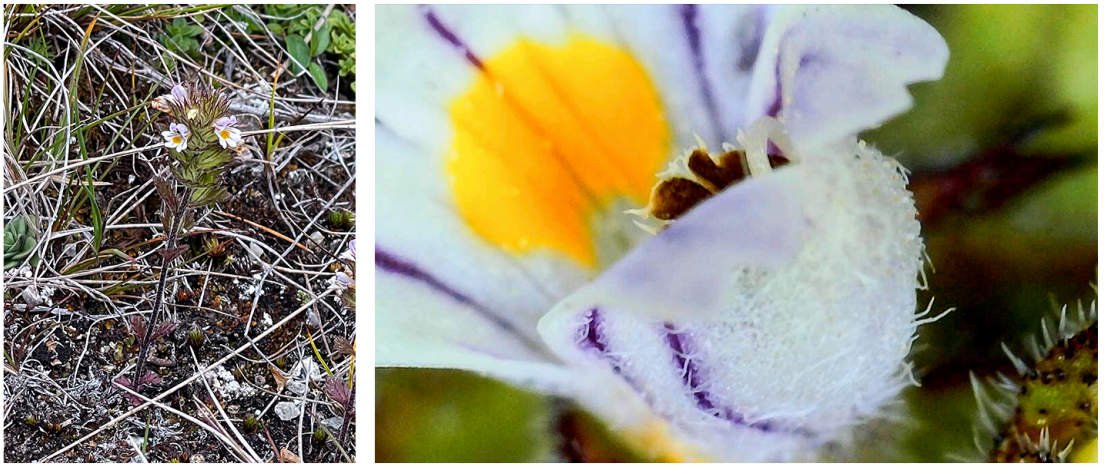
Photograph 7
Physcia tribacia (Ach.) Nyl



Note: Species not recorded in Greenland

Photograph 8
Thymus praecox Opiz

Photograph 9
Alpine Eyebright



Note: Species not recorded in Greenland

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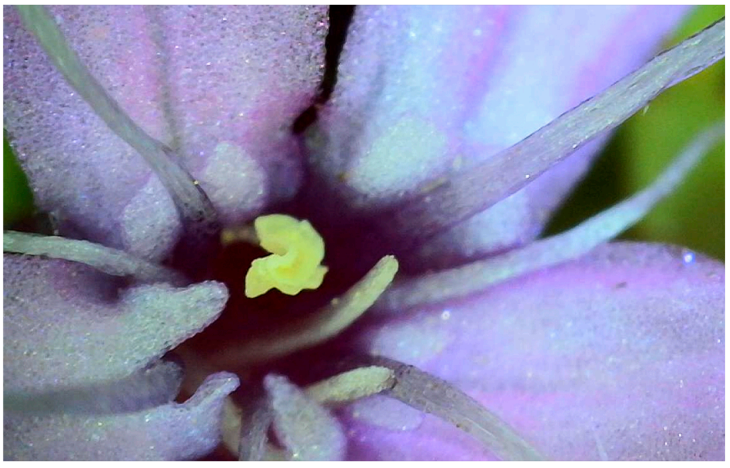
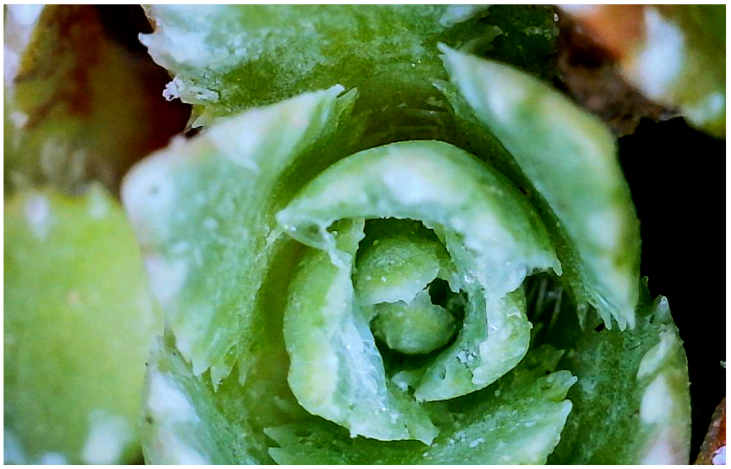
Photograph 10
Alchemilla alpina L.


Photograph 11
Niviarsiaq

Photograph 12
Saxifraga paniculata

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Photograph 13
Colobanthus quitensis


Photograph 14
Polycauliona candelaria



Photograph 15
Rusavskia Elegans



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Photograph 16
Physcia Adscendens

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Conclusions

In brief, this research has provided unique images of plant species as a result of their morphological adaptations, which have had to develop to subsist in the cold, subarctic climate of Kujataa, Greenland.

Thanks to the use of advanced microscopy techniques, the structural diversity of lichens, mosses and flowers has been documented, showing for the first time their important cellular and tissue characteristics that reflect their adaptations to extreme cold and limited nutrient availability, as well as a remarkable capacity for resilience and plasticity in such a challenging ecosystem.

The obtained findings highlight the relevance of micromorphology as a tool to further understand the adaptive strategies of plants in polar regions.

Likewise, it is concluded that the aspects observed through the images presented in this article are signs of defense mechanisms against desiccation, protection against UV radiation, optimization of water and nutrient uptake in poor soil conditions.

Finally, this research contributes to the global knowledge about biodiversity in Greenland, a little explored region that is also currently experiencing climate changes, which may have an impact on its usual ecosystems.

Indeed, the image sampling obtained not only provides a compilation of its biodiversity of great value for science per se, but also be used as an early record to raise awareness among humanity about the preservation of these fragile habitats.

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