

Diversity of macrolichens in the Barluk Mountain National Nature Reserve in Xinjiang, China

Mamatali Reyhangul¹, Yong Haiying¹, Toksun Dolathan¹ and Tumur Anwar^{1,*}

¹Xinjiang University, Urumqi, 830046, China

Abstract. The Barluk Mountain National Nature Reserve of Xinjiang, China is known as a paradise of wildlife, that includes a great diversity of lichens attributed to its unique geology and geography that enhances the value for study and conservation. From 2021 to 2023, surveys were undertaken to determine the diversity of macrolichens in relation to altitude in all parts of the Nature Reserve. A total of 670 macrolichens were collected of which 106 taxa were identified as distinct and comprised of 102 species, 2 subspecies and 2 varieties within 31 lichen genera, *Cladonia* had the highest number of species with 21, followed by *Peltigera* (14 species). The greatest number of macro lichens was found between 1200 to 1800 m elevation. (69 species, 65.1% of the total number of species) followed by 900m to 1199m (56 species, 52.8% of the total). Foliose lichens comprised 67.9% of the total number of species, with 452 specimens, squamulose were 21.7%, with 152 specimens, and fruticose were 10.4%, with 66 specimens.

1 Introduction

In June 1992, the United Nations Conference on Environment and Development (UNCED) adopted the landmark Convention on Biological Diversity, recognizing the intrinsic value of biodiversity. Acknowledging that the conservation of biodiversity is a common concern for all humankind; and noted that it is important to anticipate, prevent and eliminate the factors that causes of biodiversity loss[1]. Thus, the conservation of biodiversity has become one of the major environmental issues that has attracted much attention in today's society. Nowadays, the protection of biodiversity is one of the hot issues of environmental protection and a global task all over the world. This has become an important part of sustainable development and ecological civilization construction in China. Nowadays, the protection of biodiversity is one of the hot issues of environmental protection and a global task all over the world[1]. This has become an important part of sustainable development and ecological civilization construction in China.

* Corresponding author: anwartumursk@xju.edu.cn

Lichens are composite organisms that are a symbiosis between algae and /or cyanobacteria that live among filaments of fungi. Lichen fungi are specialized fungi and may date from the Early Devonian (400 million years ago) [2,3]. It is estimated that, there are about 20,000 species of lichens in the world that occupy around 8% of the terrestrial surface of the earth is covered by lichen-dominated vegetation [4-6]. China is one of the lichen- rich countries, according to one estimate China may have 20,000 to 30,000 species of lichen [7], but at present only about 3,082 lichen species have been reported in China [7]. This is about 30% of the total likely number of macrofungi (about 10,000 species) in China.

Xinjiang (Xinjiang Uygur Autonomous region) is the largest province in China with an area of over 1.6 million km² (0.64 million square miles) and is located in northwestern China. Xinjiang borders eight countries: Russia, Kazakhstan, Kirghizstan, Tajikistan, Pakistan, Mongolia, India and Afghanistan. The research to date has revealed that, there are about 596 taxa composed of 580 species, 4 subspecies and 12 varieties known lichen species in Xinjiang, These encompass 160 genera, and about 2% of world species and about 20% of lichens in China [8]. However it is suspected that the actual number of lichen species is much higher than this but little research has been done in this remote province of China.

Barluk Mountain is located in Yumin County and Toli County, Tacheng Prefecture, Xinjiang, China. It is an independent mountain range, transiting between the Tianshan Mountains and the Altai Mountains. The region has a typical continental temperate semi desert climate. The average annual temperature is 6.2 °C, with an extreme maximum temperature of 38.6 °C and an extreme minimum temperature of -35.9 °C. The annual precipitation is 289.2mm. The Barluk Mountain National Nature Reserve of Xinjiang, China is known as a paradise of wildlife, the great diversity of lichens in this region is attributed to its unique geographical characteristics [9]. Research in the Barluk Mountain National Nature Reserve has mainly focused on higher plants [10-12]. To date, details of the overall Macro lichen flora of Barluk Mountain National Nature Reserve has not been completed.

In recent years, global changes and the continuous intensification of human activities, especially the destruction of natural ecosystems and over exploitation of lichens, the diversity of lichens has been severely reduced in all over the world [13]. Lichens grow extremely slowly in nature and take time to recover, Therefore, evaluating the current status of lichen biodiversity is of great importance for effectively protecting lichen resources. For this reason it is very important to study all parts of the Nature Reserve with respect to lichen diversity and ecological characteristics. The current survey aimed at providing an account of the distribution, and a checklist, of the macrolichen for the Barluk Mountain National Nature Reserve using data accumulated from 2018 to 2023.

2 Materials and Methods

The study sites were located at The Barluk Mountain Nature Reserve (82°26'~ 83° 13' E, 45°42'~ 46°03' N), the surface is 115037.3 hm², China . The climate in this area is a classical continental climate [9]. The lichen survey of Barluk Mountain Nature Reserve was conducted between June to August in 2022 and in 2023 at an altitude between 1150 m and 2700 m. All species were recorded and specimens of the less easily identified lichens were collected. A site location reading was taken at each sampling place using a Garmin GPS. The lichens were examined using a Nikon Eclipse E200 stereo-microscope. Hand-cut sections using a razor blade were mounted and observed in water and iodine. The internal structures were studied with a Zeiss Axioskop 2 plus light microscope and photographed using a Nikon Digital Camera D50. The chemical constituents of the collected lichens were

identified by colour spot tests and thin-layer chromatography using solvent system C [14-17]. Voucher specimens are deposited in the Lichen Herbarium of College of Life Science and Technology, Xinjiang University, China.

3 Results and Discussion

3.1 Macrolichen species composition

The 670 specimens were collected from Barluk Mountain Nature Reserve included 106 taxa composed of 102 species, 2 subspecies and 2 varieties of the 31 lichen genera, *Cladonia* has the highest number of species with 20, followed by *Peltigera* (14 species) .

The number of species and % of the total number of species respectively of the six commonest genera were *Cladonia* (20 spp. & 19.6%), *Peltigera* (14 spp. & 13.7%), *Physcia* (9 spp. & 8.82%), *Xanthoparmelia* (8 spp. & 7.84%), *Physconia* (6 spp. & 5.9 %) and *Melanelia* (6 spp. & 5.9 %) (Table 1).

Table 1. The marolichens of Barluk Mountain Nature Reserve, Xinjiang, China

Genus name	Num. of species	%	Genus name	Num.of species	%
<i>Anaptychia</i> Körb.	2	1.96	<i>Melanohalea</i> O. Blanco, A. Crespo, Divakar, Essl., D. Hawksw. & Lumbsch	1	0.98
<i>Arctoparmelia</i> Hale	1	0.98	<i>Myelochroa</i> (Asahina) Elix & Hale	1	0.98
<i>Bryoria</i> Brodo & D. Hawksw.	1	0.98	<i>Nephroma</i> Ach.	1	0.98
<i>Cetraria</i> Ach.	1	0.98	<i>Normandina</i> Nyl.	1	0.98
<i>Cladonia</i> P. Browne	20	19.60	<i>Parmelia</i> Ach.	1	0.98
<i>Collema</i> F.H. Wigg.	3	2.94	<i>Peltigera</i> Willd.	14	13.73
<i>Dermatocarpon</i> Eschw.	4	3.92	<i>Phaeophyscia</i> Moberg	5	4.90
<i>Enchylium</i> (Ach.) Gray	1	0.98	<i>Physcia</i> (Schreb.) Michx.	9	8.82
<i>Evernia</i> Ach.	1	0.98	<i>Physconia</i> Poelt	6	5.88
<i>Flavocetraria</i> Kärnefelt & A. Thell	1	0.98	<i>Pseudevernia</i> Zopf.	1	0.98
<i>Flavoparmelia</i> Hale	1	0.98	<i>Ramalina</i> Ach.	2	1.96
<i>Flavopunctelia</i> (Krog) Hale	1	0.98	<i>Siphula</i> Fr.	1	0.98
<i>Fuscopannaria</i> P.M. Jørg.	1	0.98	<i>Umbilicaria</i> Hoffm.	3	2.94
<i>Heterodermia</i> Trevis.	1	0.98	<i>Usnea</i> Adans.	1	0.98
<i>Leptogium</i> (Ach.) Gray	2	1.96	<i>Xanthoparmelia</i> (Vain.) Hale	8	7.84

<i>Melanelia</i> Essl.	6	5.88		
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Morphologically, foliose lichens were 67.9% of the total number of species, with 452 specimens, squamulose were 21.7%, with 152 specimens, and fruticose were 10.4%, with 66 specimens.

3.2 Lichen distributed by species

The most abundantly distributed and the most frequently collected species in Barluk Mountain Nature Reserve was *Peltigera canina* (15.2%) followed by *Peltigera elisabethae* (11.9%) and *Physcia caesia* (7.01%) which were all foliose lichens. Among fruticose lichens, *Cladonia squamosa* (4.17%) was the most abundant followed by *Cladonia subsquamosa* (3.28%). There are 12 species of macros lichens in the reserve, namely *Peltigera canina* (102), *Peltigera elisabethae* (80), *Physcia caesia* (47), *Cladonia squamosa* (28), *Cladonia subsquamosa* (22), *Peltigera praetextata* (18), *Cladonia humilis* (16), *Cladonia gracilis* (15), *Cladonia scabriuscula* (13), *Peltigera horizontalis* (10), *Peltigera neopolydactyla* (9) and *Physcia dubia* (9), which accounting for 52.24% of the total macrolichen flora, with the remaining 94 species accounting for 47.76%.

3.3 Lichen distributed by elevation

The number of macrolichens on the different substrata in the Barluk Mountain National Nature reserve increased with the altitude from 900 m to 1800 m, but began to decline above 1800 m. The greatest number of macro lichens was found between 1200 to 1800 (69 species, 65.1% of the total number of species) followed by 900 m to 1199 m (56 species, 52.8% of the total number of species) (Figure 1) .

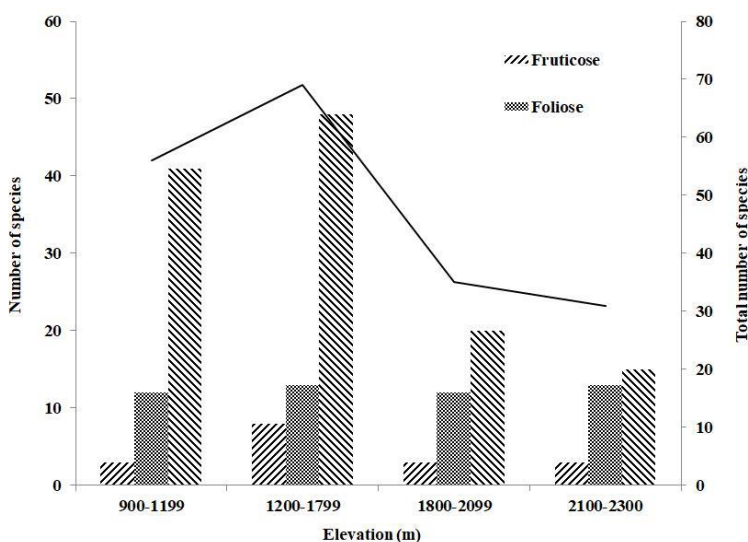


Fig.1. Macro lichens distribution along altitude in Barluk Mountain National Nature reserve

4 Conclusion

Lichens are a diverse, ecologically significant, yet understudied group of organisms. The abundance of epiphytic cyanobacterial macro lichens has been observed to indicate long

forest continuity in temperate and boreal forests of Europe and north America [18-19], their presence could thus be used as one important factor when evaluating the conservation value of old forests. Recently, lichens are useful indicators of air quality, ecological integrity and continuity [20], and the impacts of climate change on biodiversity [21-22]. However, the lack of available regional baseline species data is a barrier to monitoring changes. As a result, lichens are frequently excluded from conservation management planning [23].

In Xinjiang Province of China, there are 36 nature reserves. Detailed lichen inventories have been compiled at 6 of them, there are other nature reserves that have no published information about their lichen biota. As a result of collecting and identifying 670 specimens through 47 sampling sites in Barluk Mountain National Nature Reserve of Xinjiang, China from 2021 to 2023, 106 taxa composed of 102 species, 2 subspecies and 2 varieties of macrolichens in 31 genera, 11 families, and 6 orders were identified. In this survey of Barluk Mountain National Nature Reserve nine previously unreported species were found *Physconia rossica* Urban., *Cladonia kurokawae* Ahti & Stenroose, *Xanthoparmelia pulvinaris* (Gyeln.) Ahti & D. Hawksw., *Enchylium polycarpon* (Hoffm.) Otálora, P.M. Jørg. & Wedin, *Leptogium hirsutum* Sierk, *Peltigera monticola* Vitik., *Fuscopannaria cheiroloba* (Müll. Arg.) P.M. Jørg, *Dermatocarpon arnoldianum* Degel. and *Umbilicaria aprina* Nyl.. Twelve species of macrolichens accounted for 52.24% of the total macrolichen flora distribution in this studied sites, with most of them being distributed in the forest ecosystem between elevation 1200 m to 1799 m.

Our initial investigation of macrolichens in this region of China was aimed at identifying the number of macrolichen species and their distribution in this nature reserve. The presently reported survey provides basic data for future research, forest management and conservation of lichens species diversity on Barluk Mountain National Nature Reserve, most importantly on the impact of long term environmental changes resulting global climate warming.

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