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A preliminary study on bryoflora of Yazd province with Mediterranean desertic continental bioclimate and notes on bryological activities in Iran

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Abstract
Bryological activities in Iran started with the groundworks of Bornmüller, Buhse, Bruns, Knapp, Polak, and Strauss. These activities continued by Rechinger in the 1930s and Wendelbo in 1959. However, the most comprehensive work on bryoflora and vegetation in Iran started by Frey, Kürschner, and Probst in 1972. However, the studies about bryoflora and the bryodiversity of Hyrcanian forests and the Irano-Turanian floristic region are far from being complete. The Aim of our study is to provide the first list of bryophytes from Yazd province and emphasize the importance of documentation and recording taxa to obtain crucial data in Plant Sciences and Ecology. The collection sites are in Yazd province and located between Yazd City and Shirkuh mountain. Yazd province with its Mediterranean desertic continental bioclimate which results in low precipitation and extended summer drought, has had no bryological records. However, at the moment there is a list of mosses with 10 species. Moreover, as preliminary data, the dominance of acrocarpous moss families is obvious and only a family of pleurocarpous mosses is mentioned in the list.

Keywords: Yazd bryophytes, Shirkuh, acrocarpous, desertic bioclimate

Introduction

Bryophytes (Mosses, Liverworts, and Hornworts) are plants with a life cycle of alternation of generations consisting of haploid (Gametophyte) and diploid (Sporophyte) phases with domination of haploid phase. Bryophytes are distinguished among tracheophytes by their branched gametophytes and unbranched sporophytes [1, 2]. These organisms are widely accepted as a monophyletic group of organisms which form a sister group to vascular plants [3]. The significant role of bryophytes in preventing soil erosion, water retention, nutrient cycling, nutrient pools, water budgets, etc. are highly important in ecosystem functioning [4, 5]. However, bryophytes are mostly overlooked by botanists due to their small size and are unfairly recognized as primitive land plants in comparison with vascular plants in anatomical, physiological, etc. traits [5, 6]. Undoubtedly, one of the most important features of land plants is to maintain their existence and to survive in water depletion and desiccation circumstances due to sustain metabolic activities. It is suggested that desiccation tolerance in early land plants occurred poikilohydric due to unistratous structures and simple architecture. Thus, the same strategy happens in bryophytes nowadays. Poikilohydry means that the water content of the plant is directly in equilibration with water content of the environment. In contrast, the term endohydric refers to a strategy for resistance in terrestrial environments in plants with traits such as thick cuticle, stomates, conducting tissues, and roots [1, 7]. Life syndromes (Functional traits) that are co-evolved by parallel evolution under similar environmental conditions including rock habitats, wetlands, forests, and even deserts are important morphological and anatomical traits to ensure a successful dispersal, etc. in bryophytes. Furthermore, different life forms (incl. Turfs, pendants, tails, and etc.) and life strategies (e.g., fugitives, annual shuttle species, etc.) are important factors regarding functional traits that evolved independently in different and unrelated taxa [8-10]. Moreover, there is a life form that forms solitary plants (Gregarious) specialized for arid ecosystems and it can be related to competition between individuals in harsh environments [11]. Bryofloristical studies in Iran had a long tradition in Europe, but concentrated primarily on large field excursions and collecting activities. Pioneers in this way were Bornmüller, Buhse, Bruns, Knapp, Polak, and Strauss laying the groundwork, followed by collections of Rechinger and Wendelbo in the 1930s and 1959 respectively [12]. StrØmer (1963) published the data of collection activities which were done by Wendelbo in 1959. Moreover, Frey (1974) published an article about all liverworts of Iran. Between 1972 and 1977 Frey, Kürschner, and Probst made several journeys to Iran for geobotanical research. Furthermore, they were able to make intensive collection activities of bryophytes [13]. Therefore, The first comprehensive work on floristic and vegetation of bryophytes in Iran was done by Frey, Kürschner, and Probst in the 70s and resulted in numerous publications about bryoflora and vegetation of bryophytes [14]. There are noteworthy data about epiphytic moss flora and moss vegetation of the Hyrcanian lowland and montane forests which are based on collection activities of Probst, Frey, and Frey / Kürschner. Epiphytic bryoflora of tree species such as ***Carpinus orientalis*** Mill., ***Acer velutinum*** Boiss. , ***Fagus orientalis*** Lipsky, ***Parrotia persica*** (DC.) C.A.Mey., and ***Quercus castaneifolia*** C.A.Mey. in lowland and montane forests were studied. These studies demonstrated that the physiognomy of epiphytic vegetation is formed by four species which can be different in east toward west lowland and montane forests (e.g., The dominant species in the west are ***Palamocladium euchloron*** (Bruch ex Müll.Hal.) Wijk & Margad., ***Thamnobryum alopecurum*** (Hedw.) Ganguleeand, species from ***Cirriphyllum*** Grout, and ***Neckera*** Hedw. groups) [15]. Furthermore, phytosociological studies on epiphytic bryophytes in the

south coasts of the Caspian and Black Seas reveal the existence of two different associations which are **Palamocladio euchloronis – Leucodontemum immersi** Kürschner, Kirmaci & Parolly (Restricted to remaining lowland forests of the Pontic province) **Pseudoleskeello nervosae-Leucodontetum immersi** Kürschner, Kirmaci & Parolly (Restricted to Montane forests of the Pontic province) [16]. Most areas of SW Asia belong to arid zones, however, the areas of the south coasts of the Caspian and Black Seas are humid areas. The Euro-Siberian region occurs with the province of Euxin-Caucasian-Hyrcanian in the SW Asia [12]. Iran with a 1,648,000 km^2 surface area has one of the most diverse flora in SW Asia and a number of floristic regions occur in Iran (e.g., Irano-Turanian region) [14, 17, 18] Irano-Turanian region is one of the 35 different floristic regions of the world. However, Although, This floristic region connects the western and eastern floras of the Holarctic Kingdom, the studies about the Irano-Turanian region are far from being complete [18]. GBC (Global Bioclimatic Classification) in Iran showed 3 macrobioclimates, 10 bioclimates and 3 different bioclimatic variants. Three different macrobioclimates of Iran are Temperate, Mediterranean, and Tropical. The macrobioclimate of Most of the areas in the Northern, Western, eastern highlands, and central plateau is defined as the Mediterranean. Mediterranean desertic-continental (Mdc) is one of ten different bioclimates in Iran which covers most of the central desertic areas of the central Iranian plateau and is recognized for its very low annual precipitation and extended summer drought [17]. Yazd province of Iran is located in the Irano-Turanian floristic region with Mediterranean desertic continental bioclimate. Yazd city in c. 337 days per year is without rainfall. The driest month is July and the wettest month is April (c. 29 mm rainfall) (https://weatherandclimate.com/iran/yazd). There are a number of isolated mountainous areas in central areas of Iran e.g., Yazd-Kerman massif including Shirkuh (4050 m a.s.l.) in Yazd province. These isolated mountainous areas are located between lowlands and plain desertic and semi-desertic areas. The Mountains of Yazd-Kerman massif are floristically interconnected and contain some of species-rich genera of the Irano-Turanian region such as ***Astragalus***, ***Acantholimon,*** and ***Nepeta.*** The aim of our study is to provide a preliminary checklist of Yazd province mosses based on collection activities and to start exploring about byoflora of Yazd province and Irano-Turanian region and its isolated mountainous areas more than before [19, 20]

Material and Methods

There are three main locations of collection activities in Yazd province which are listed below:

1- Manshad village (31.510989 N, 54.224325 E) is located in the southeastern locations of Shirkuh and the southwestern part of Yazd city.
2- Deh Bala village (31.637296 N, 54.136718 E) is located in the western areas of Yazd City and eastern locations of Shirkuh mountain.
3- Taft city (31.73173 N, 54.165507 E) is located in the northeastern areas of Shrikuh and western locations of Yazd city.

All collection localities are placed between Yazd city and Shirkuh Mts. which can be a good insight into the bryoflora of Yazd province (Figure 1).

The exemplars, identified by using the most recent checklist, identification keys with illustrations 'Liverworts, Mosses, and Hornworts of southwest Asia' published by Kürschner and Frey (2020) [21]. At the moment, this book is the main reference for studying bryoflora of SW Asia and is available for students of biology, researchers, and all of the people who are interested in bryology. The book is a result of working on the bryophytes of SW Asia for several years by Kürschner and Frey. The several publications including the main reference for our identifications are highly invaluable for all biologists especially plant biologists. Moreover, Taxonomy and nomenclature of taxa are based on Kürschner & Frey (2020).

All the specimens collected from the mentioned localities and identified are preserved at the Central Herbarium of Tehran University (TUH).

Figure 1. Locations of Yazd City and shirkuh. All collection localities are in between Yazd city and Shirkuh (The map modified after https://www.worldometers.info/maps/iran-map/)

Results

The first list of mosses from Yazd province is provided. At the moment 10 species of Bryophyta (mosses) are listed. The list contains acrocarpous and pleurocarpous mosses. However, the dominance of acrocarpous families is obvious. The only pleurocarpous moss familiy is Cratoneuraceae and acrocarpous mosses are distributed in Bryaceae, Encalyptaceae, Funariaceae, Grimmiceae, Mniaceae, and Pottiaceae families.

Bryaceae

Bryum argenteum Hedw.

Yazd: Taft, 31.73173 N 54.165507 E, 1624 m, on rock, *28. April. 2024, S. Mohaghegh B2003 (TUH).*

Cratoneuraceae

Palustriella falcata (Brid.) Hedenäs

Yazd: Manshad village, 31.510989 N 54.224325 E, 2407 m, In bank by stream, *8. May. 2024 S. Mohaghegh B2002 (TUH).*

Encalyptaceae

Encalypta sp.

Yazd: Taft, 31.73173 N 54.165507 E, 1624 m, on rock, *18. April. 2024, S. Mohaghegh B2005 (TUH).*

Funariaceae

Funaria hygrometrica Hedw.

Yazd: Taft, 31.73173 N 54.165507 E, 1624 m, on rock, *28. April. 2024, S. Mohaghegh B2004 (TUH).*

Grimmiaceae

Grimmia plagiopodia Hedw.

Yazd: Tezerjan, 31°34'N 54°27'E, 2300 m, on stone, *17. May. 2012, S.A. Ismailzadeh (IRAN 0463 B)* [22].

Mniaceae

Pohlia cf. *nutans* (Hedw.) Lindb.

Yazd: Manshad village, 31.510989 N 54.224325 E, 2407 m, In bank by stream, *8. May. 2024 S. Mohaghegh B1138 (TUH).*

Pohlia sp.

Yazd: Manshad village, 31.510989 N 54.224325 E, 2407 m, In bank by stream, *8. May. 2024 S. Mohaghegh B1142 (TUH).*

Pottiaceae

Gymnostomum calcareum Nees & Hornsch.

Yazd: Taft, Deh Bala, 31.637296 N 54.136718 E, 2301 m, on rock, *10. May. 2024 S. Mohaghegh B1140 (TUH).*

Hydrogonium bolleanum (Müll.Hal.) A.Jaeger [*Barbula bolleana* (Müll.Hal.) Broth.]

Yazd: Taft, 31.73173 N 54.165507 E, 1624 m, In bank by stream, *27. March. 2024 S. Mohaghegh B1141(TUH).*

Syntrichia caninervis Mitt.

Yazd: Taft, 31.73173 N 54.165507 E, 1624 m, on rock, *28. April. 2024, S. Mohaghegh B2001 (TUH).*

Discussion

Documentation, identification, and recording of specimens have always been a crucial step in Plant Sciences and Ecology. Therefore, obtaining data and information about the flora of a country is a primary tool [23]. However, most of the data about the bryoflora of Iran is restricted to humid areas, and data from the Irano-Turanian region and arid and semi-arid areas of Iran are far from being complete. Furthermore, there is a lack of knowledge about bryoflora in central and southern areas of Iran (e.g., Esfahan, Hormozgan, Khuzestan, Yazd, etc.) [14, 24]. In 2004, Akhani and Kürschner [14] published the checklist of Iranian bryoflora and mentioned that there are some provinces without any record of bryophytes e.g., Yazd province. However, in 2014, Shirzadian et al. [22] published a new record to Iran from Yazd province (i.e., *Grimmia plagiopodia*). Therefore, at the moment 9 new records for Yazd province are added and the number of species in this area increased to 10.

Conclusion

Despite harsh environments, low precipitation, and extended summer drought in semi-arid and arid areas in central and southern parts of Iran, however, there are habitats for bryophytes e.g., rock habitats and places near springs, rivers, waterfalls, etc. [23]. Therefore, Yazd province with its desertic continental bioclimate harbors bryoflora which is demonstrated by the preliminary checklist. Undoubtedly, we provided results of a preliminary study on the bryodiversity of Yazd province, and intensive collection activities must be done for further near-complete results.

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