QUANTITATIVE ANALYSIS OF MOSSES IN THE TOPOGRAPHY OF KOLHAPUR DISTRICT, MAHARASHTRA, INDIA

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ABSTRACT

The present study deals with the quantitative analysis of mosses of Kolhapur District, Maharashtra. Regular and frequent visits during from January 2005 to December 2016 to different sites of Kolhapur District were made for topographic study of Moss species. 49 species of mosses belong to 25 genera are spread over 17 families of 8 orders are reported and studied here. Mosses such as *Pogonatum aloides, Funaria hygrometrica, Fissidens crenulatus, Barbula constricta, Bryum argentum, Stereophyllum ligulatum* etc. showed maximum frequency percentage.

Key Words: Abundance, Density, Frequency, Moss.

Introduction:

Alam (2015) compiled data of the Indian mosses revealed the occurrence of total 1578 species of mosses which belong to 21 orders, under 66 families and 328 genera. Out of these 897 species are retained their valid status, while 437 species are now considered as a synonym and status of 244 species is still unresolved *i.e.*, doubtful name while, 130 taxa have been reported as endemic to India.

However, the Western Ghats having *ca* 850-1000 species of which 682 are mosses, 280 species are of liverworts and 14 species are of hornworts (Gunawardene *et al.*, 2007). In Maharashtra the Bryo-floristic studies particularly mosses are very fragmentary. Bryologists like Dabhade (1998) described 87 species of mosses of Khandala and Mahabaleshwar; Hile (2001) described 17 species of mosses from Kasara Ghat. Chaudhary *et al.*, (2008) described 100 mosses from North Konkan of Maharashtra especially from Western Ghats of which 23 species are of liverworts, 18 species are of hornworts and 59 species mosses. Magdum et al., (2017) published checklist of 129 species of mosses belonging to 11 orders, 26 families and 59 genera were reported form Maharashtra.

The ecological study provides a background for understanding the basic relationships of the natural community and their surrounding environment. The diversity and distribution of living organism are controlled by abiotic and biotic factors. Therefore, the population of plants and animals in a given area can be determined by a balance between reproductive potential and the environmental resistance (Patil, 2014). In the ecosystem different communities of an organisms interacting with various biotic and abiotic factors. Therefore, quantification of an organism is very important. It documents ecological patterns of various habitats, as shown by diverse groups of plants and animals. It provides baseline data for future research into the dynamics and distribution of mosses and how they related to the environment factors. Studies on ecological (environment)

diversity and distributional aspects of mosses have not been made from Kolhapur district so far. Therefore, present investigation was undertaken to fill the gap in our knowledge about the diversity and quantitative analysis of mosses from Kolhapur District.

Material and Methods:

The present work gives an idea the important phyto-sociological attributes of community ecology such as frequency, abundance, density etc. These can be determined by quadrat method. The population of each species was counted by placing 1x1 foot size quadrate were randomly placed to quantify the moss species. Following phyto-sociological attributes were considered. The frequency, Abundance and Density of mosses were calculated by Skorepa and Vit method (1976) and Showman (1985,1986) respectively.

Frequency: It is the number of times a plant species is present in a given number of quadrats of a particular size. It was studied by sampling the study area at several places at random and recorded the name of species that occurred in each quadrat. It is calculated by the formula given below and is expressed in percentage (%) (Mishra, 1968 and Sharma, 2007).

$$\text{Frequency(F)} = \frac{\text{Number of quadrats in which the species occurred}}{\text{Total number of quadrats studied}} \text{ X } 100$$

Abundance: It is the study of a number of individuals of different species in the community per unit area. It is measured by following equation and expressed in individuals/m^2 (Mishra, 1968; Sharma, 2007).

$$\text{Abundance (A)} = \frac{\text{Total number of individuals of species in all quadrats}}{\text{Total number of quadrates in which the species occurred}}$$

Density: It is an expression of the numerical strength of a species where the total number of each species in all the quadrats is divided by the total number of quadrates studied. Density is calculated by using the following formula and is presented as plant/m^2 (Mishra, 1968; Sharma, 2007).

$$\textbf{Density (D)} = \frac{\text{Total number of individuals of a species in all quadrats}}{\text{Total number of quadrats studied}}$$

Result and Discussion:

Quantifying the mosses diversity and correlating with ecosystems can be estimate a standardize tool with which comparing both ecosystem and health of specific species. The exact diversity numbers and distribution are difficult to generate but knowing how environmental resources are distributed within a community can be more beneficial for analyzing species diversity. There are several ways to define the diversity of a moss species, that quantify the number of individuals in a given area while taking into accounts their degree of dissimilarity. During the present investigation quantification of 49 species of mosses were analyzed.

Table 1 shows quantification of mosses from Kolhapur district. The phyto-sociological attributes like abundance, density, frequency and Importance Value Index were calculated. Similarly, tehsil wise Diversity

indices like Simpsons, Shannon and Similarly index of Kolhapur district were also been calculated (Table 2 & 3).

Table 1: Quantification of Mosses from Kolhapur District.

RE	Frequency (%)	Density(m^2)	Abundance
Ditrichum laxissimum (Mitt.) Kuntze	33.33	24.4	54.75
Pogonatum microstomum (R. Br. ex Schwägr.) Brid.	33.33	18.3	41
Brachymenium exile (Dozy & Molk.) Bosch & Sande Lac.	41.66	26.5	47.6
Brachymenium turgidum Broth. ex Dixon	41.66	24.3	43.6
Bryum capillare Hedw.	41.66	21.2	38
Bryum coronatum Schwägr.	41.66	17.2	30.8
Erpodium mangiferae Müll. Hal	41.66	24.3	43.6
Funaria nutan (Mitt.) Broth.	41.66	21.7	39
Macromitrium sulcatum (Hook.) Brid.	41.66	22.5	40.4
Physcomitrium cyathicarpum Mitt.	41.66	27.2	48.8
Physcomitrium eurystomum Sendtn.	41.66	23.5	42.2
Splachnobryum obtusum (Brid.) Müll. Hal	41.66	22.5	40.4
Bryosedgwickia aurea (Schwägr.) M. Fleisch.	50	27.2	40.66
Bryum uliginosum (Brid.) Bruch & Schimp.	50	21.7	32.5
Bryum wightii Mitt.	50	23.5	35.16
Bryum paradoxum Schwägr.	50	22.5	33.66
Campylopus flexuosus (Hedw.) Brid.	50	18.3	27.33
Diaphanodon procumbens (Müll. Hal.) Renauld & Cardot.	50	21.7	32.5
Ditrichum heteromallum (Hedw.) E.	50	22.4	33.5

Britton			
Entodon ovicarpus Dixon	50	34.2	51.16
Entodon plicatus Müll. Hal.	50	48.2	55.66
Fissidens zollingeri Mont.	50	21.2	31.66
Garckea flexuosa (Griff.) Margad. & Nork.	50	23.5	35.16
Gymnostomiella vernicosa (Hook. ex Harv.) M. Fleisch	50	27.2	40.66
Hymenostylium recurvirostrum (Hedw.) Dixon	50	18.3	27.33
Leucobryum bowringii Mitt.	50	21.7	32.5
Philonotis hastate (Duby) Wijk & Margad.	50	22.4	33.5
Philonotis mollis (Dozy & Molk.) Mitt.	50	24.4	36.5
Pterobryopsis acuminata (Hook.) M. Fleisch.	50	21.7	32.5
Stereophyllum setchiwanicum Broth.	50	29.7	59.33
Stereophyllum wightii (Mitt.) A. Jaeger	50	28.4	56.66
Fissidens macrosporoides Dixon & P. de la Varde	58.33	42.8	55
Hyophila rosea R.S. Williams	58.33	23.5	30.14
Entodon laetus (Griff.) A. Jaeger	66.66	24.4	27.37
Hymenostomum edentulum (Mitt.) Besch.	66.66	22.5	25.25
Anomobryum auratum (Mitt.) A. Jaeger	75	34.2	34.33
Bryum alpinum Huds. ex With.	75	36.4	36.33
Bryum recurvulum Mitt.	75	27.2	27.11
Campylopus latinervis (Mitt.) A. Jaeger	75	27.2	27.11
Fissidens bryoides Hedw.	75	27.2	27.11

Hyophila involuta (Hook.) A. Jaeger	75	27.2	27.11
Erpodium biseriatum (Austin) Austin	83.33	26.5	23.8
Philonotis revoluta Bosch & Sande Lac.	83.33	24.4	21.9
Stereophyllum ligulatum var. Sedgwickii Broth. & Dixon	83.33	32.2	38.6
Bryum argenteum Hedw.	91.66	42.8	35
Barbula constricta Mitt.	100	48.2	36.16
Fissidens crenulatus Mitt.	100	36.4	27.25
Funaria hygrometrica Hedw.	100	17.2	12.83
Pogonatum aloides (Hedw.) P. Beauv.	100	22.5	16.83

1. Frequency (%): Fig. 1 represents Species wise frequency (%) of Mosses from Kolhapur District which can be categorized into less frequent mosses, moderate mosses and more frequent mosses. Among these, the species, *viz. Erpodium biseriatum, Philonotis revoluta, Stereophyllum ligulatum, Bryum argenteum, Barbula constricta, Fissidens crenulatus, Funaria hygrometrica* and *Pogonatum aloides* were more frequent (83-100%) in study area. However, the species *viz., Ditrichum laxissimum, Pogonatum microstomum, Brachymenium exile, B. turgidum, Bryum capillare, Bryum coronatum, Erpodium mangiferae, Funaria nutans, Macromitrium sulcatum, Physcomitrium cyathicarpum, Physcomitrium eurystomum* and *Splachnobryum obtusum* were less frequent in the study area (33-42%). The mosses which had more frequent they may be considered as dominant species and uniformly distributed whereas the mosses which had less frequent, they may be considered as occasional species in the study area. Also, the high percentage of frequency for a species may be indicated a high adaptation to the environmental factors (Murty *et al*., 2011 and Patil, 2014). Frequency is used to determine the dominance and uniformity of a species in its distribution within an area (Sharma, 2007). In the study area, it was found that, the frequency of mosses was ranged from 33-100 %. Maximum frequency of mosses in study area may be due to more atmospheric humidity, low to moderate temperature and high to moderate soil moisture percentage.

2. Density (/m^2): Fig. 2 represents Species wise density (species/m^2) of Mosses from Kolhapur District which can be categorized into low density mosses, moderate density and high-density mosses in study area. During the present investigation the density of moss species was found ranged from 17-50 per m^2. The maximum density was observed for the moss species viz., *Anomobryum auratum, Barbula constricta, Bryum alpinum, Bryum argenteum, Entodon ovicarpus, Entodon plicatus, Fissidens crenulatus, Fissidens macrosporoides, Stereophyllum wightii, Stereophyllum setchiwanicum and Stereophyllum ligulatum.* Whereas minimum density was observed for the moss species *viz., Bryum capillare, Bryum coronatum, Bryum uliginosum, Campylopus*

flexuosus, Diaphanodon procumbens, Fissidens zollingeri, Funaria hygrometrica, Funaria nutans, Hymenostylium recurvirostrum, Leucobryum bowringii, Pogonatum microstomum and *Pterobryopsis acuminata* etc.

The density of an organism is depending on the distribution, proximity and range of settlements. It represents the numerical strength of a species in the community and greatly varies by continent, country and regions (Zobel *et al*.1976 and Patil, 2014). The high value of density for a moss species may be indicated a high adaptation to the different habitats whereas distribution of some species is restricted hence their density is minimum. Maximum density of mosses in study area may be due to more atmospheric humidity, low to moderate temperature and high to moderate soil moisture percentage.

3. Abundance (/m^2): Fig. 3 represents Species wise abundance (species/m^2) of Mosses from Kolhapur District which can be categorized into less abundant mosses, common and high abundant mosses in study area.

The abundance (A) of studied mosses was ranged from 12-60 per cm^2. The higher abundance was observed for the moss species, *viz. Brachymenium turgidum, Brachymenium exile, Bryosedgwickia aurea, Ditrichum laxissimum, Entodon ovicarpus, Entodon plicatus, Erpodium mangiferae, Fissidens macrosporoides, Gymnostomiella vernicosa, Macromitrium sulcatum, Physcomitrium cyathicarpum, Physcomitrium eurystomum, Pogonatum microstomum, Splachnobryum obtusum, Stereophyllum setchiwanicum and Stereophyllum wightii*. However, lower abundance was observed for the moss species *viz., Funaria hygrometrica, Pogonatum aloides, Philonotis revoluta, Erpodium biseriatum* and *Hymenostomum edentulum* etc.

Abundance may be used to categorize the analyzed plant community into their respective vegetation types such as abundant, common, frequent, occasional and rare. When high abundance is supplemented by little occurrence, it is considered as locally or sporadically abundance (Bartlet *et al.*, 2001 and Patil, 2014)

The maximum abundance for moss species in study area may be due to maximum atmospheric humidity, low to moderate temperature high to moderate soil moisture percentage and moderate light intensity. Above all observations on phyto-sociological attributes were agreed with investigation of earlier authors in various region of world (Murty *et al.*,2011; Narasimha and Lohitasyudu, 2012 and Patil, 2014).

4. Species Diversity Indices

4.1. Simpson Diversity Index (D):

Table 2 shows Simpson diversity index (D) of mosses from twelve tehsils of Kolhapur District. Amongst these low values of D was recorded for the tehsils Chandgad (0.21), Panhala (0.23), Shahuwadi (0.23) and Gaganbawada (0.26), which indicates higher diversity of mosses whereas higher value was recorded for the tehsils like Hatkanangale (0.77), and Shirol (0.73) which indicates lower diversity of mosses. With this index, 0 indicates infinite diversity and 1, no diversity. That is, the bigger the value of D, the lower the diversity (Patil, 2014).

It is a degree of diversity and often used to measuring the diversity of a habitat. The number of mosses present there in, as well as the abundance of each moss are considered.

4.2. Simpson's Reciprocal Index (1/D):

Table 2 shows Simpson's **Reciprocal** index (1/D) of mosses from twelve tehsils. Among this higher value of 1/D was recorded for the tehsils Chandgad (4.76), Panhala (4.34), Shahuwadi (4.34) and Gaganbawada (3.84) which indicates higher diversity of mosses whereas low value was recorded for the tehsils like Hatkanangale (1.29), and Shirol (1.29) which indicates lower diversity of mosses. with this index, 0 indicates infinite diversity and 1, diversity. That is, the lower the value of 1/D, the lower the diversity (Patil, 2014).

Table 2: Tehsils wise Simpson's Diversity Indices: Simpson diversity index (D) and Simpson's Reciprocal index (1/D) of Mosses.

Tehsils/Simpson Index	Simpson D	Simpson1/D
Chandgad	0.21	4.76
Panhala	0.23	4.34
Shahuwadi	0.23	4.34
Gaganbawada	0.26	3.84
Radhanagari	0.33	3.03
Ajara	0.37	2.70
Bhudargad	0.48	2.08
Gadhinglaj	0.48	2.08
Kagal	0.65	1.53
Karveer	0.68	1.47
Hatkanangale	0.77	1.29
Shirol	0.77	1.29

4.3: Shannon Diversity Index (H): Table 3 shows Tehsils wise Shannon Diversity Index (H) of Mosses from Kolhapur district. The Shannon diversity index of mosses from twelve tehsils of Kolhapur district was ranging from 0-2. Amongst these the higher values of Shannon diversity index was observed for the tehsils like Chandgad (1.708), Panhala (1.681) Shahuwadi (1.681) and Gaganbawada (1.672) whereas low value was found for the tehsils like Hatkanangale (0.699) and Shirol (0.699). It is widely used index for comparing diversity between habitats.

The Shannon diversity index values (H) can range of 0 to ~4.6 using the natural log (ln). A value near 0 it would indicate that every species in the sample is the same. A value near 4.5 it would indicate a high uncertainty, meaning that members of each species are evenly distributed between all the species (Clarke and Warwick, 2001).

The highest value of Shannon diversity index (H) is due to maximum number of mosses in the tehsils like Chandgad, Ajara, Radhanagari, Panhala *etc*. whereas low value due to few numbers of mosses in the tehsils like Shirol, Hatkanangale, Kagal etc. Tehsil wise Shannon diversity index of 54 pteridophytes from Satara district were studied by Patil (2014). Thus, all observations are on same directions as of present work.

Table 3: Tehsils wise Shannon Diversity Index (H)of Mosses

Index	Shahuwadi	Gaganbawada	Panhala	Radhanagari	Ajara	Chandgad	Gadhinglaj	Bhudargad	Kagal	Karveer	Hatkanangale	Shirol
Shannon H' Log Base 10.	1.68	1.67	1.68	1.62	1.66	1.70	1.30	1.23	1.17	1.11	0.69	0.69
Shannon Hmax Log Base 10.	1.68	1.67	1.68	1.62	1.66	1.70	1.30	1.23	1.17	1.11	0.69	0.69

4.4: Similarity Index: Fig. 4 shows Similarity index of mosses from twelve tehsils of Kolhapur district. The dendrogram was generated by Bary-Curtis cluster analysis. In this dendrogram all the tehsils fall under three major clades. Clade 1 was formed by the tehsils, *viz.* Hatkanangale and Shirol. Clade 2 is divided into two subclades. Subclade 1 included the tehsils, *viz.*, Karveer (Karv), Kagal (Kag) and Bhudargad (Bhud) while the subclade 2 contained a single tehsil Gadhinglaj (Gad). Clade 3 is divided into two subclades. Subclade 1 includes single tehsil Radhanagari (Radha) while subclade includes the tehsils like Chandgad (Chand), Gaganbawada (Gagan), Ajara, Panhala (Panh) and Shahuwadi (Shahu). The maximum dissimilarity was observed between the tehsils situated in Western Ghats and Eastern region tehsils. Because Western Ghats regions receives maximum precipitation (4500 mm) per annum while eastern region receives very less precipitation (600 mm) per annum.

The diversity indices may help in assessing the diversity of all the habitats (Patil, 2014). The maximum diversity indices were observed for the tehsils, *viz.*, Chandgad, Gaganbawada, Ajara, Panhala, Radhanagari and Shahuwadi. This maximum diversity may be due to environmental conditions suitable for the growth of mosses like high humidity, Low temperature and high soil moisture *etc.*

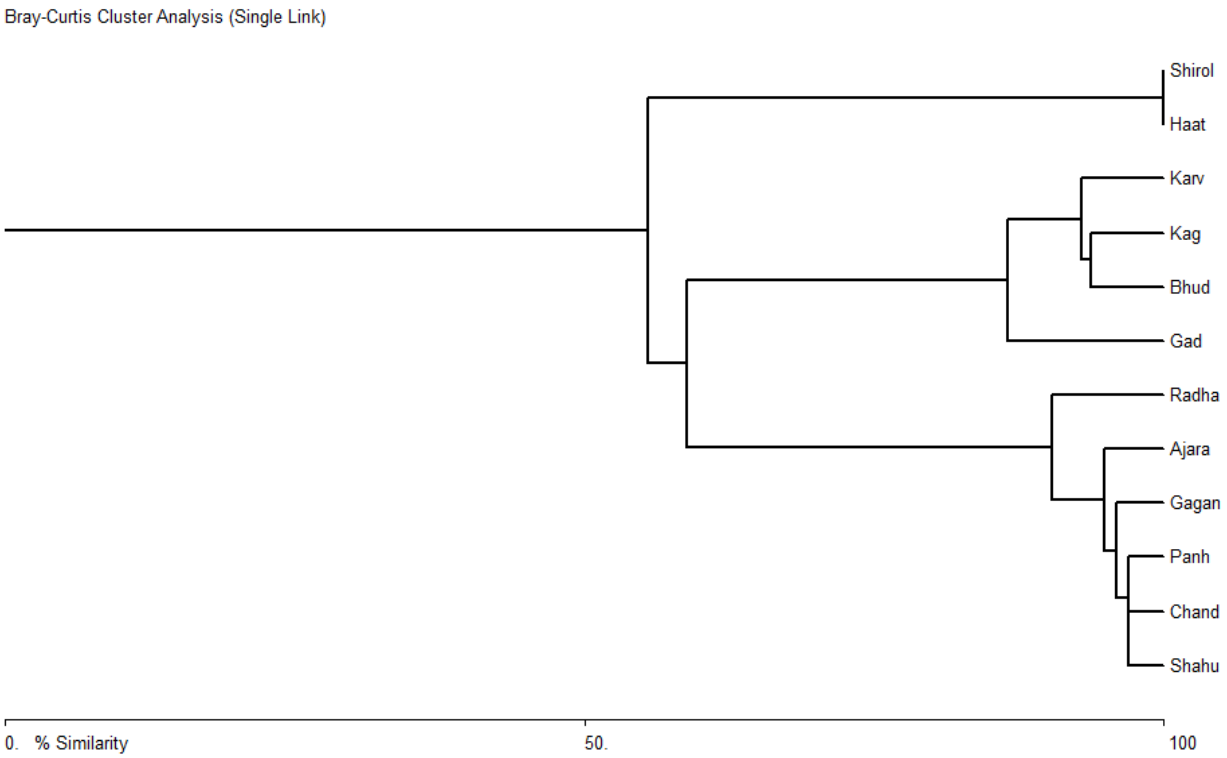

Fig. 4: Tehsil wise Similarity Index of Mosses

Conclusion: Mosses are very important constituents of many hill ecosystems in spite of their small size and relatively low biomass. Terrestrial mosses are important for soil fixation, mineral recycling, humus accumulation and moisture retention which later on play a major role in establishment of different communities. Mosses are responsible for maximum carbon gain of any forest cover and after death add organic matter to the substratum. The present study is supportive to understand the phyto-sociological attributes of 49 species of mosses such as Density, Frequency, Abundance. The luxuriant growth of mosses in terms of frequency and abundance is influenced largely by the nature of parent rock or substratum, habitat and is further influenced by microclimate and niche. Again, during rainy season mosses are highly distinctive due to rich moisture and relative humidity. These investigations of moss species are helpful in giving an idea about diversity of each species and also interaction between each species. The present study provides a baseline data for their preservation and making us aware about their usefulness which is necessary for future studies in bryophytes of Maharashtra.

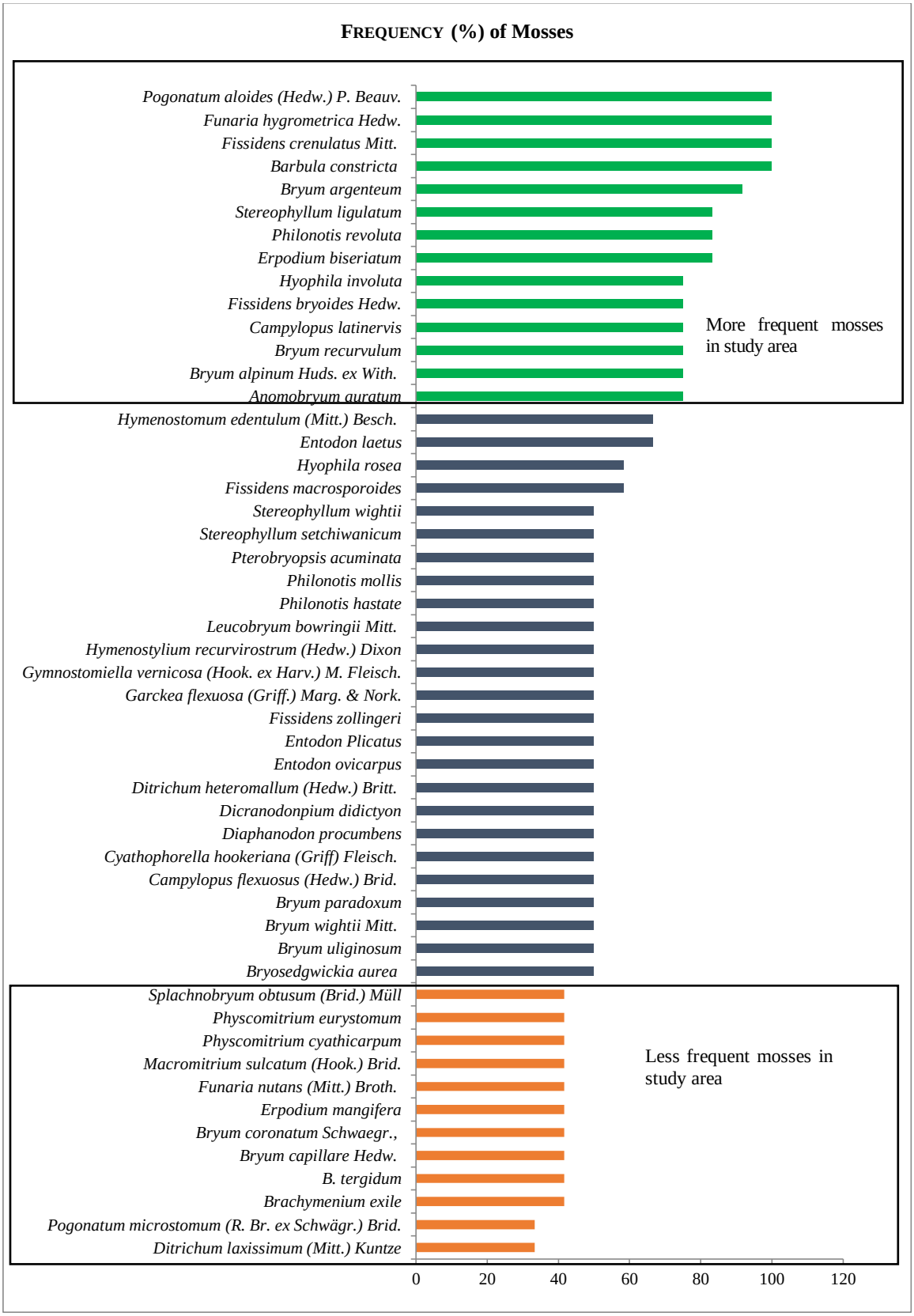

Fig. 1: Species wise frequency (%) of Mosses from Kolhapur District

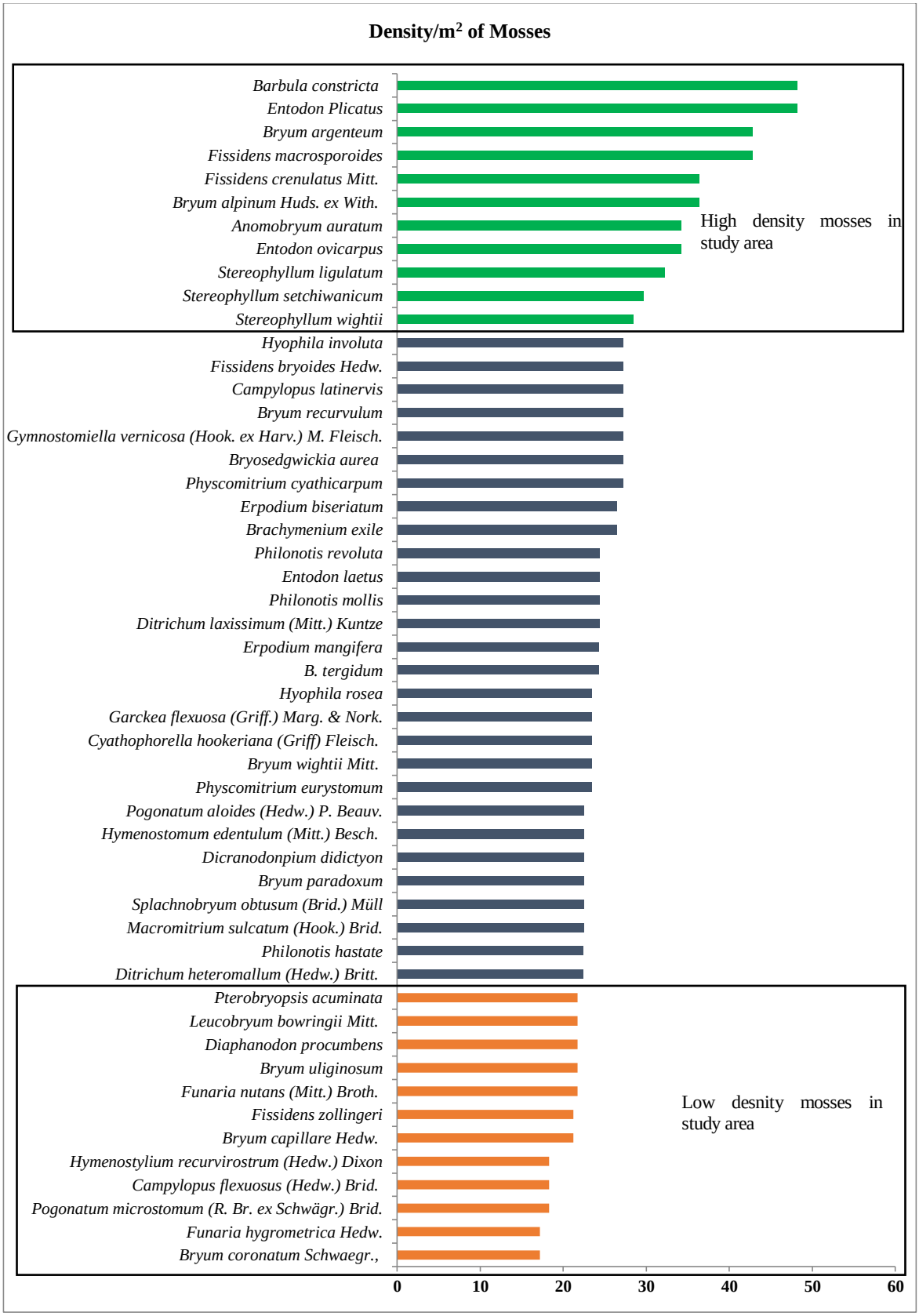

Fig. 2: Species wise density (/m^2) of Mosses from Kolhapur District

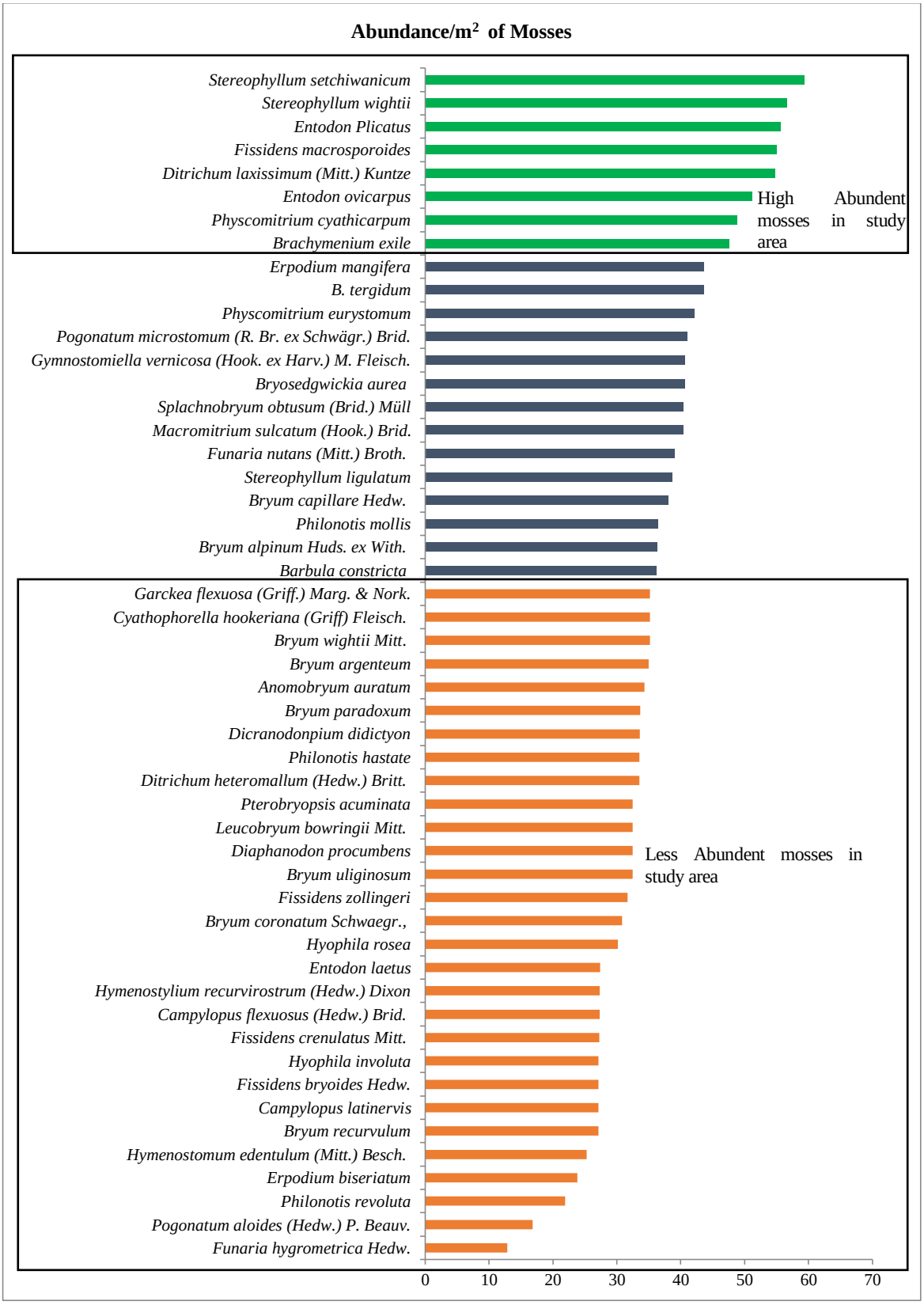

Fig. 3: Species wise Abundance (/m^2) of Mosses from Kolhapur district

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References:

Alam, A. (2015). *Moss Flora of India. An Updated Summary of Taxa*, Munich, GRIN Verlag. Pp.196 https://www.grin.com/document/294363

Bartlett, J.E., Kotrlik, J.W., and Higgins, C.C. (2001). Inform. *Tech. Learn. and Perfor. Jour.* **19 (1):** 23-29.

Chaudhary, B.L., Sharma, T.P., and Bhagora, F.S. (2008). *Bryophyte Flora of North Konkan, Maharashtra (India).* Himanshu Publications, Udaipur and New Delhi. Pp. 326.

Clarke, K.R., and R.M. Warwick (2001). *Mar. Ecol. Prog. Ser.,* 216: 265-278.

Gunawardene, N.R., Daniels, A.E.D., Gunatilleke, I.A.V.N; Gunatilleke, C.V.S., Karunakaran, P.V., Geetha Nayak, K., Prasad, S., Puyravaud, P., Ramesh, B.R., Subramanian, K.A., Vasanthy, G. (2007). *Curr. Sci.*,**93 (11):** 1567-1572.

Hile, V.K. (2011). *Indian J. Applied and Pure Bio.* **26**(2): 223-228.

Magdum, S.M., Patil, S.M., Lavate, R.A. and Dongare, M.M. (2017). *Bioscience Discovery,* **8** (1):73-81.

Mishra, R. (1968). *Ecology Work Book*. Oxford and IBH Publishing Company, Calcutta.

Murty, P.P., Rao, D.S., Dora, S.V.V.S. and Narasinha Rao N.G.M. (2011). *Curr.Bot.,***2(7):** 01-04.

Narasimha Rao, G.M. and Lohitasyudu, K. (2012). *IJBAS.***19(5):**730-736.

Patil, S.M. (2014). *Systematic studies on the Pteridophytes of Satara District (Maharashtra).* Ph. D. thesis submitted to Shivaji University, Kolhapur.

Sharma, P.D. (2003). Ecology and Environment. 7th Edition, Rastogi Publication, Meerut.

Showman, R.E. 1985. Gavin Area, Air quality Biomonitoring studies. American Electric Power Service Corporation. Columbus, Ohio. (Cambridge University Press).

Zobel, D.B., McKee, A. and Hawk, G.M. (1976). *Ecological. Monographs.* **46:** 135-156.