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Impact of Biotic Interferences on Shankaracharya Forest Ecosystem

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Abstract
The present study is an attempt to document the impact of biotic interferences in Shankaracharya forest ecosystem, Kashmir (India). The cumulative effect of the biotic interferences was significantly seen in the reduction of the vegetation cover. The present study revealed that the prominent factor for the exploitation of the vegetation cover of the study area at herbaceous level is simple human interference. The increasing disturbance not only disturbs the plant species diversity, richness and evenness significantly but various plant species are near to get eliminated from impacted area by different kinds of interferences like tourism pressure, trespassing, vehicular disturbances, military activities etc. High number of species were recorded at undisturbed site than disturbed site.
Keywords: Shankaracharya forest; Ecosystem; Biotic interference; Vegetative cover; Disturbed and undisturbed site.

1. Introduction
Nature has endowed the planet earth with emenous diversity and diverse resources, forests as one among the major natural resource bestowed by nature as plenty number of biotic communities and forest resource occupies a unique position by playing an important role in the development of society by providing a wide range of goods and services and have diverse ecological roles . The vegetation is a fundamental component of ecosystems that reflects the effects of the total environment [1]. Plants grow collectively in a specific ecosystem and have a mutual relationship among themselves as well as within the local environment [2], which results in the formation of different vegetation types in different regions. Forests are important as they provide various ecosystem services such as species conservation, prevention of soil erosion and preservation of habitat for plants and animals [3, 4]. Tree species diversity is the determinant of total forest biodiversity as trees provide resources as well as habitats for almost all other forest species [5]. In forest ecosystems, tree species diversity varies greatly from place to place mainly due to variation in biogeography, habitat and disturbance [6]. Environmental variability in terms of climatic factors, social resources, grazing by herbivores and human interference are the critical factors which regulate the spatial and temporal patterns of the vegetation of an ecosystem [7]. However, the composition of vegetation is fluctuating and continuous modification takes place depending upon the temperature, moisture, sunlight and available nutrients [8].

The word disturbance is used in ecology to refer to a great variety of phenomena. Examples of disturbance include fires, storms, diseases, volcanic eruptions, earthquakes, contaminant spills, land clearing and dredging among many others [9] for an overview of sources and characteristics of disturbance. Impacts of disturbance on biodiversity have been studied in a great variety of ecosystems ranging from tundra communities [10] to coral reefs [11], a range of organisms extending from bacteria [12] to primates [13] and at multiple levels of organization including molecular pathways [14] and ecosystem functioning [15]. The types of disturbance involved include everything from single tree-falls [16] to ecological catastrophes [17]. From a historical perspective, disturbance has long been present in ecological theory. Early views focused on succession, which took communities from the colonization of barren space by pioneer species, to highly complex and diverse climax communities [18]. The importance of disturbance in this context is that it leads to secondary succession and sometimes prevents communities from reaching their climax state. The progressive realization of the roles of grazing and predation on delaying competitive exclusion led to the formulation of the intermediate disturbance hypothesis [19, 20].

Kashmir valley in our country harbors a rich repository of diverse of flora due to its varied topography and spatial heterogeneity [21]. The vast and varied natural resources of the earth are essential for the sustenance and wellbeing of mankind. Currently forest resources are under tremendous stresses due to human ecological assemblages and interferences with in ecosystem [22, 23]. The forests are threatened by uncontrolled degradation and conservation to other types of land uses, under the influence of increasing human needs, agricultural expansion, and environmentally harmful mismanagement, including unsustainable commercial logging, overgrazing and unregulated browsing, etc. The degradation of forests is chiefly due to various anthropogenic pressures [24]. Over recent decades levels of anthropogenic disturbance have been a major driver of biodiversity loss at local, regional

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and global scales. The vegetation has been affected directly and indirectly by man and his various activities in the forest ecosystems. Biotic factors are greatly responsible for changing the complexation of the forest vegetation in the recent past and even presently. Various biotic factors which disturbs the numerical diversity in forest ecosystem include; construction of roads, harvesting of timber, tourism pressure, collection of medicinal herbs, fodder collection, grazing and browsing activities , habitat destruction, over exploitation and pollution and species introduction. These biotic interferences have created an alarming situation for forest ecosystem which in turn affect overall environmental conditions of respective areas. In the recent past, increasing biotic pressures on forest ecosystem of Kashmir valley has altered their structure and function. Current forest ecosystem of valley are increasingly impacted by variety of biotic interferences such as deforestation, habitat loss, habitat fragmentation, fires, overexploitation of resources etc. [25, 26]. While being utilize the various services as well as foods from forest ecosystem, the fragile ecosystem becomes prime targets of various biotic interferences. Kashmir Himalayan forest ecosystems are very intricate and delicate for having varied landscape. Therefore, many problems are confronted with which have greatly affected the conservation and management of natural resources such as forests, water, soil and land [27]. Vegetation dynamics have been neglected by researchers because of their remoteness, inaccessibility, danger, and lack of local infrastructure. In recent times, the unsustainable anthropogenic activities are posing serious threat to the forest ecosystems of this Himalayan region. It is in this context the present study was carried out to understand the impact of biotic interferences on Shankaracharya forest ecosystem. Hopefully the present study on this forest ecosystem will provide a baseline for scientific understanding of the rich biodiversity to enable undertaking effective initiatives for the conservation and management of Shankaracharya forest ecosystem.

2. Study Area

The Shankaracharya hill is located between 34° 04' 35.56" and 34° 05' 25.08" N latitude and 74° 50' 03.16" and 74° 51' 08.63" E longitude, covering an area of approximately 138.35 ha. It represents one of the extension tail tips of the Zabarwan range in Srinagar and lies in south-east of Srinagar at a distance of about 4.5 km from clock tower, Lal chowk and 17.5 km from Dachigam National park. Average height of the hill is nearly 300 m i.e, from 1572 to 1880 m above mean sea level. It bears a prevailing northerly trend and shows a gradual increase in its height till it merges with the majestic snow-clad waterway mountains in the south east. It offers mountainous precipitous and actively eroding slopes and scraps topography, sometimes with differently dissected terrain. It is also punctuated by numerous Spurs, ravines and cliffs all along its area. The hill has a great religious value and is so named due to presence of a temple called Shankaracharya temple at its top. The temple is thought to be oldest shrine in Kashmir and an attraction for tourists all over the world.

For the present study, four sampling sites have been selected at different locations in the forest ecosystem.

Site A: is located at the foot (downhill) of the Shankaracharya forest hill station. This site is highly disturbed due to various activities like human encroachments and tourism. Hence this site is considered as disturbed site for this study. This site has very low vegetation cover and scanty trees were also present at this site.

Site B: This site is located at the middle area of Shankaracharya forest hill station. This site has been designated as undisturbed as it possesses a very high vegetation cover. Overall high diversity was found.

Site C: This site is located in upper area of the Shankaracharya forest ecosystem. This site has been designated as highly disturbed due to high trespassing which inturn is responsible for very low vegetation cover.

Site D: This site is located in inner side of Shankaracharya forest ecosystem. This site has been designated as undisturbed site. Almost no interferences was found. Diversity of species was good in number. *Vinca major* was abundantly found.

Fig-1. Map of study area

3. Material and Methods

During the present investigation, each site was divided into two parts disturbed and undisturbed site so as to compare the vegetation of both parts which provide a better understanding about the impact of biotic interferences on the vegetation.

Vegetation analysis was carried out on the monthly basis during June 2019 to January 2020, with gaps of few months due to turmoil conditions in valley. The vegetation and composition was recorded by quardrat method [28]. Herbs, shrubs and tree species were recorded by taking quardrates of size 1 x 1 sq.m, 5 x 5 sq.m and 10 x 10 sq.m respectively at various stations at each site depending upon the vegetal cover the site sustains. Herb and shrub cover were determined by the method proposed by Cain and Castro [29]. Vegetation survey of all sites were carried out and vegetation analysis in terms of frequency, density and abundance which was obtained by actual count method [28, 30] was followed in obtaining the Important value index (IVI) from the relative values of frequency, density and abundance of each species.. The vegetation analysis can be done by using following formulas:

3.1. Percentage Frequency

This is the dispersion of species within a community and was determined after Raunker [31]. Percentage frequency can be obtained by using following formula

$$Frequency\ \% = \frac{Number\ of\ quardrats\ in\ which\ species\ has\ occured}{Total\ number\ of\ quardrats\ studied} X100$$

3.2. Relative Frequency

Relative frequency can be obtained by using following formula:

$$\text{Relative frequency} = \frac{Frequency\ of\ one\ species}{Total\ frequency\ of\ all\ the\ species} X100$$

3.3. Density and Relative Density

Density and relative density can be determined by using following formulas;

$$\text{Density} = \frac{Total\ number\ of\ individuals\ of\ species}{Total\ number\ of\ quardrats\ studied}$$

$$\text{Relative density} = \frac{Density\ of\ one\ species}{Density\ of\ all\ species} X100$$

3.4. Abundance and Relative Abundance

Following formulas can be used to obtain abundance and relative abundance values;

$$Abundance = \frac{Total\ number\ of\ individuals\ of\ species}{Total\ number\ of\ quardrats\ in\ which\ species\ has\ occured}$$

$$\text{Relative abundance} = \frac{Abundance\ of\ one\ species}{Abundance\ of\ all\ species} X100$$

3.5. Important Value Index (IVI)

IVI = Relative frequency + Relative density + Relative abundance

In additional to this some other data and information was also collected from secondary sources. Data collected during the study period was carefully analyzed, compiled and interpreted

4. Results and Discussion

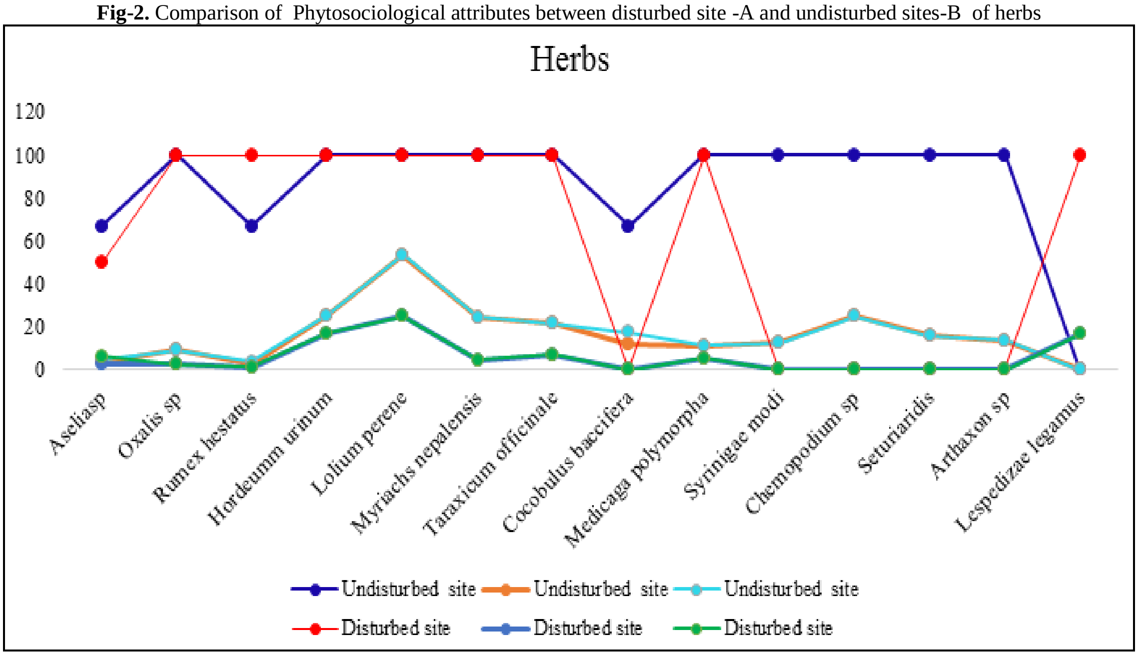
were herbs, 5 shrubs and 9 trees. The dominant families were Fabaceae and Poaceae each with 5 species, followed by Asteraceae with 4 species, Rosaceae with 4 species, Brassicaceae with 2 species, Oleaceae with 2 species, Polygonaceae with 2 species, Appiaceae with 1 species, Amaranthaceae with 1 species, Caryophllaceae with 1 species, Cuppreseaceae with 1 species, chemopodiaceae with 1 species, Celtraceae with 1 species, Hiptocastanaceae with 1 speciesDuring the present study, a total of 35 species were found belonging to the 18 families (Table 1). Out of 35, 21, Mavaceae with 1 species, Simurasoraceae with 1 species, Thymalaceae with 1 species, and Pinaceae with 1 species.

Table-1. Various species recorded during present study

S.NO.	Name of taxa	Family	Life form
1	Myriachs nepalensis	*Asteraceae*	Herb
2	Taraxum officinale	*Asteraceae*	Herb
3	Scandex pectin veneris	*Appiaceae*	Herb
4	Amaranthus virdis	*Amaranthaceae*	Herb
5	Aselia sp	*Asteraceae*	Herb
6	Conyza canadensis	*Asteraceae*	Herb
7	Sysimbrium loessile	*Brassicaceae*	Shrub
8	Not identified	*Brassicaceae*	Herb
9	Cocobulus baccifera	*Caryophyllaceae*	Herb
10	Cupressus toralusa	*Cupressaceae*	Tree
11	Chemopodium sp	*Chemopodiacea*	Herb
12	Celtis australis	*Celtraceae*	Tree
13	Lespediza elegamus	*Fabaceae*	Herb
14	Oxalis sp	*Fabaceae*	Herb
15	Medicaga polymorpha	*Fabaceae*	Herb
16	Rubina pseudoaccacia	*Fabaceae*	Tree
17	Spastium junecum	*Fabaceae*	Tree
18	Aesculus indica	*Hiptocastanceae*	Tree
19	Mavus alba	*Mavaceae*	Tree
20	Syringia emodi	*Oleaceae*	Herb
21	Ligustrium lucidims	*Oleaceae*	Tree
22	Hordeum murinum	*Poaceae*	Herb
23	Lolium perene	*Poaceae*	Herb
24	Avena sativa	*Poaceae*	Herb
25	Polygonium sp	*Polygonaceae*	Herb
26	Rumex hestatus	*Polygonaceae*	Herb
27	Seturiaridis	*Poaceae*	Herb
28	Arthsaxon sp	*Poaceae*	Herb
29	Cedrus deodara	*Pinaceae*	Tree
30	Rosa sp	*Rosaceae*	Shrub
31	Rubus ulmifolom	*Rosaceae*	Shrub
32	Geum sp	*Rosaceae*	Herb
33	Kerria japonica	*Rosaceae*	Shrub
34	Ailanthus altisimmia	*Simurasoraceae*	Tree
35	Vinca major	*Thymalaceae*	Shrub

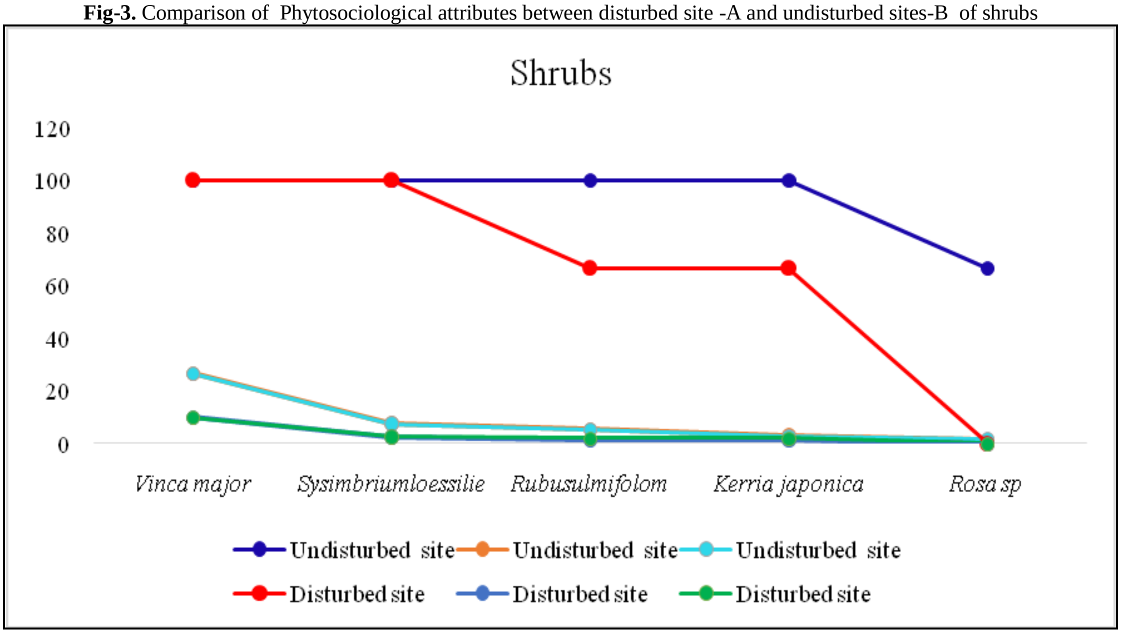
In the first set of vegetation analysis frequency, density and abundance was compared between the undisturbed and disturbed sites, so as to determine the intensity of impact of biotic interferences. Data presented in (fig. 2) shows Site C had the highest biotic interferences as depicted by the vegetation analysis of herbaceous vegetation, followed by Site A, B and D in a descending order.

Fig-2. Comparison of Phytosociological attributes between disturbed site -A and undisturbed sites-B of herbs



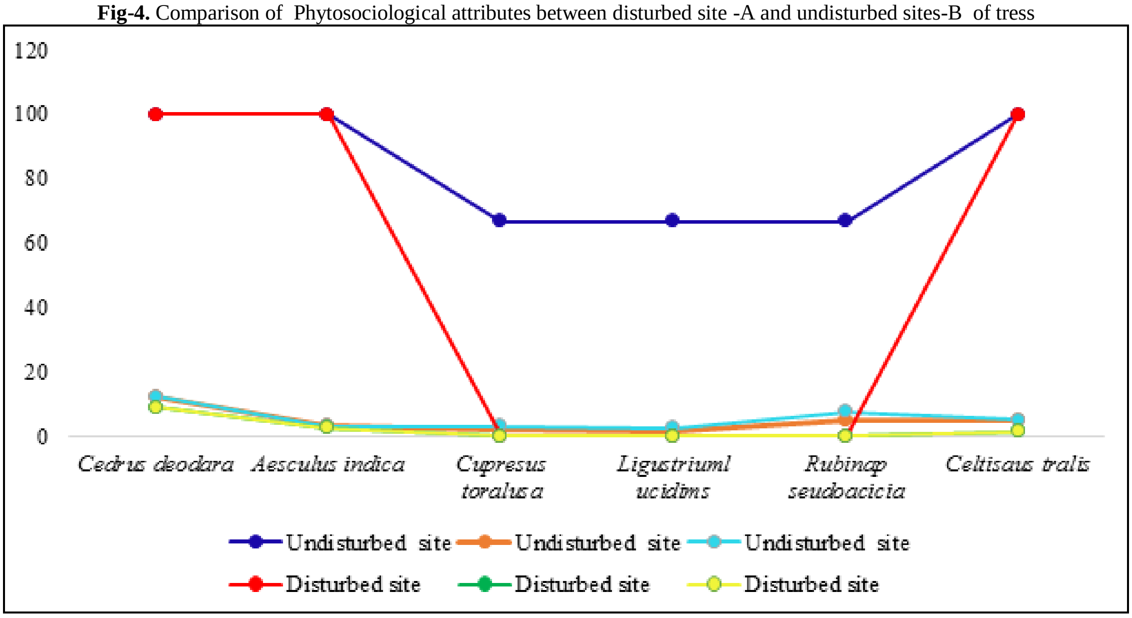
During the present study, herebaceous vegetation was compared between undisturbed site (Site B) and disturbed site (Site A) as depicted in fig 2. It isevident that the herebaceous vegetation showed significant decline at Site A (disturbed site) with respect to frequency%, density and abundance. Almost frequency% was same between two sites and minimum frequency valued (0%) was shown by 5 species such as *Cocobulus baccifera, Syriniga emodi, Chemopodium sp, Seturia ridis* and *Arthaxon sp* at disturbed site. Numerical density which is an important parameter in vegetation analysis were found markedly disturbed at disturbed site (A) as compared to undisturbed site (B). The maximum density at disturbed site was observed by *Lolium perene* in comparison to undisturbed site maximum density was recorded by *Lolium perene*. Many species depicted lowest (0) density at disturbed site such as *Syriniga emodi, Chemopodium sp.* etc. Similarly abundance of species was found to be low in disturbed site as compared to undisturbed site. Lowest abundance value (0) was shown by 5 species and High value of abundance was depicted by *Lolium perene* at disturbed site, in comparison to undisturbed site lowest value (0) was recorded by *Lespediza elegamus* and High value was found by *Lolium perene.*

Fig-3. Comparison of Phytosociological attributes between disturbed site -A and undisturbed sites-B of shrubs



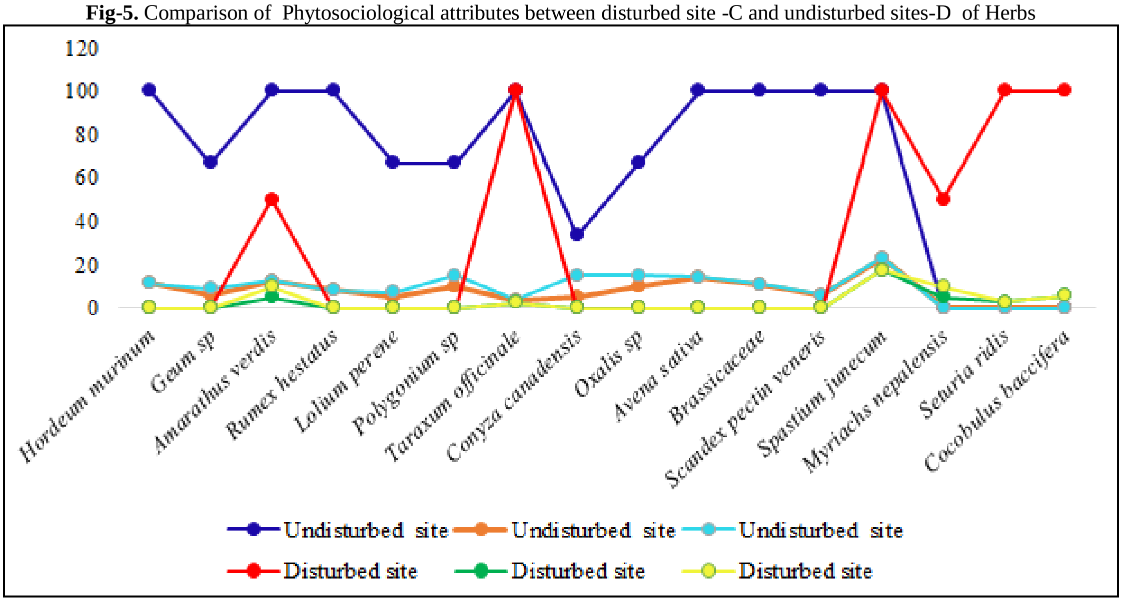
Vegetation analysis was compared between undisturbed site (B) and disturbed site (A) as shown in fig 3. During the study period, it was found that 5 species were present in undisturbed site (B) and in contrast to disturbed site (A) only 4 species were found. At disturbed site 2 species depicted 100% frequency and minimum frequency% (0) was showed by *Rosa sp.* in comparison to undisturbed site, 4 species revealed 100% frequency and minimum frequency% value (66.6) was found by *Rosa sp.* Maximum density at disturbed site was observed by *Vinca major* (10) and minimum density (0) was found by *Rosa sp.* In contrast to undisturbed site, maximum density was shown by *Vinca major* (26.66) and minimum density (1.33) was depicted by *Rosa sp.* Variations of values of abundance was observed between disturbed site and undisturbed site. High abundance value was observed by *Vinca major* (10) and lower value (0) of abundance was propounded by *Rosa sp.* in comparison to undisturbed site, maximum abundance value was shown by *Vinca major* (26.66) and minimum value (2) was depicted by *Rosa sp.*

Fig-4. Comparison of Phytosociological attributes between disturbed site -A and undisturbed sites-B of tress



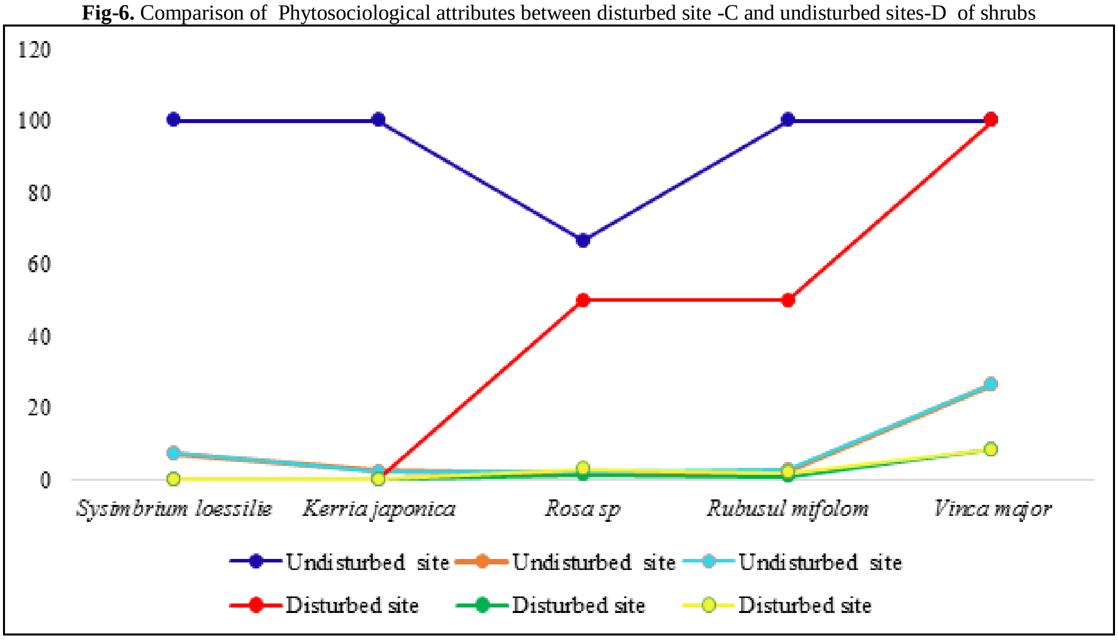
Tresses was compared between disturbed site (A) and undisturbed site (B) as depicted in fig 4. Only 3 species were present at disturbed site, and all the 3 species depicted 100% frequency%. In contrast to undisturbed site, 6 species were found, among which 3 species depicted 100% frequency% like *Cedrus deodara*, *Aesculus Indica* and *Celtis australis* and 3 species shows 66.6% such as *Cupresus toralusa*, *Ligustrium lucidims* and *Rubina pseudoacicia*. Numerical density was compared between disturbed site (A) and undisturbed site (B). The maximum density (9) at disturbed site was shown by *Cedrus deodara* in comparison to undisturbed site, maximum density (12.3) was shown by *Cedrus deodara* and lowest (1.66) by *Ligustrium lucidims.* Abundance value was determined by comparing values between disturbed and undisturbed site. Maximum abundance value (9) was found by Cedrus deodara and minimum value (0) was shown by *Cupresus toralusa*, *Ligustrium lucidims*, *Rubina pseudoacicia* at disturbed site and in contrast to undisturbed site, maximum abundance value was depicted (12.33) by *Cedrus deodara* and minimum value (3) was found by *Aesculus Indica* and *Cupresus toralusa.*

Fig-5. Comparison of Phytosociological attributes between disturbed site -C and undisturbed sites-D of Herbs



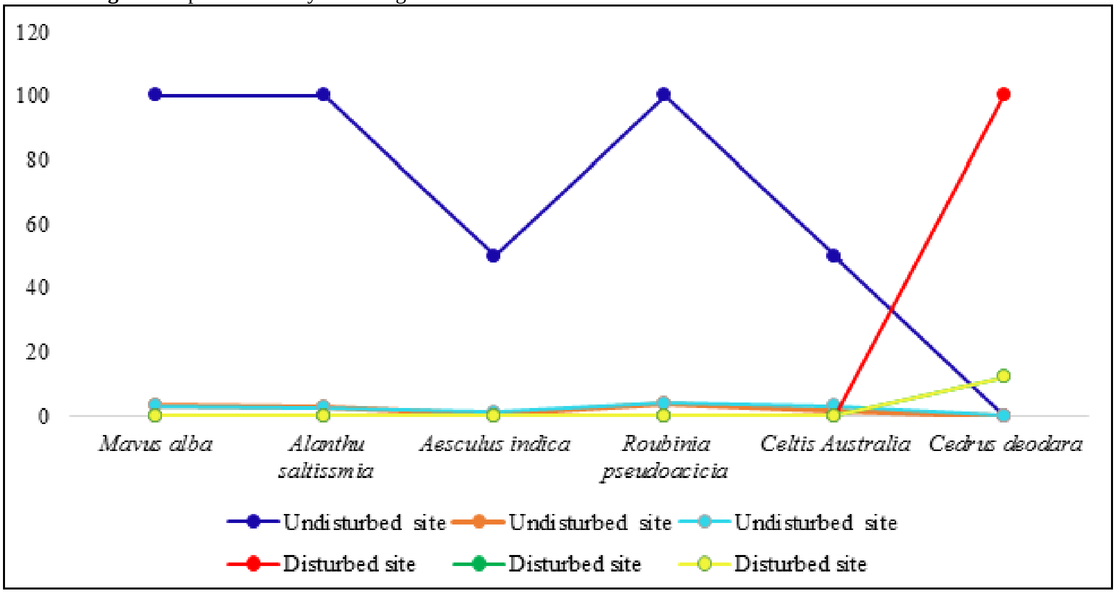
During the study period, herebaceous vegetation cover was compared between disturbed site (C) and undisturbed site (D) as depicted in fig 5. It was found that the herebaceous cover had showed drastic decline at Site C (disturbed) with respect to frequency%, density and abundance. The minimum frequency% (0) was shown by 10 species such as *Geum sp*, *Rumex hestatus* etc.at disturbed site, in contrast to undisturbed site, the minimum frequency% (0) was observed by 3 species such as *Myriachs nepalensis, Seturia ridis and Cocobulus baccifera.* Density which is an important parameter in vegetation analysis was compared between disturbed (C) and undisturbed (D) site. The maximum density at disturbed site was observed by *Spastium junecum*, in contrast to undisturbed site was recorded by *Spastium junecum* followed by *Avena sativa* and so on. The minimum abundance value (0) at disturbed site was depicted by almost 10 species such as *Oxalis sp*, *Avena sativa* etc. and maximum value was found by *Spastium junecum.* In comparison to undisturbed site, the minimum value (0) was observed by 3 species such as *Myriachs nepalensis*, *Seturia ridis* and *Cocobulus baccifera.*

Fig-6. Comparison of Phytosociological attributes between disturbed site -C and undisturbed sites-D of shrubs



Vegetation analysis was performed and data was compared between disturbed (C) and undisturbed (D) site as shown in fig 6. The minimum frequency% (0) at disturbed site was shown by 2 species such as *Sysimbrium loessilie* and *Kerria japonica,* maximum frequency%(100) value was found by Vinca major, in contrast to undisturbed site, 4 species depicted 100% frequency and minimum value (66.6) was observed by *Rosa sp.*Density which is an other parameter in vegetation analysis was conducted and compared between disturbed (C) and undisturbed (D) site. The maximum density (8.5) at disturbed site was recorded by *Vinca major* and minimum density (0) was shown by 2 species such as *Sysimbrium loessilie* and *Kerria japonica,* in contrast to undisturbed site minimum density was found by *Rosa sp* and maximum density was shown by Vinca major (26.6). Similarly abundance was also compared between disturbed (C) and undisturbed (D) site. The maximum abundance was found by *Vinca major* and minimum abundance (0) was found by 2 species, in contrast to undisturbed site minimum abundance was observed by *Kerria japonica.*

Fig-7. Comparison of Phytosociological attributes between disturbed site -C and undisturbed sites-D of trees



Herebaceous vegetation cover was determined and data was compared between disturbed (C) and undisturbed (D) site as depicted in fig 7. The minimum frequency% (0) was shown by 5 species like *Mavus alba* etc. Highest frequency %(100%) was observed by *Cedrus deodara*, in comparison to undisturbed site, minimum frequency%(0) was shown by Cedrus deodara and maximum (100%) was found by 3 species such as *Mavus alba, Alanthus altissmia and Rubina pseudoacicia.* Numerical density was compared between disturbed and undisturbed site. The maximum density at disturbed site was observed by Cedrus deodara, in contrast to undisturbed site was recorded by *Alanthus altissmia.*Abundance value was also compared between disturbed and undisturbed site. The maximum abundance at disturbed site was shown by *Cedrus deodara*, in comparison to undisturbed site was observed by *Rubina pseudoacicia.*

5. Discussion

So the above results revealed that although Shankaracharya forest ecosystem which has been designated as a reserved forest of Kashmir valley is not free from biotic interferences. The results had also showed that various kinds of biotic interferences were observed in Shankaracharya forest ecosystem that were responsible for degradation and decline in vegetation cover. The increasing interferences disturbs the plant species diversity, richness and evenness significantly. The biotic factors are also responsible for spatial distribution of vegetation [32]. It has also been shown that various plant species are near to become extinct due to various types of biotic interferences like trespassing, disturbance due to security forces, tourism pressure, Hindu pilgrimage etc. From vegetation analysis, minimum number of species were found in disturbed sites, the low species richness at disturbed sites may be attributed to environmental stresses in disturbed sites [33]. Impact of disturbance on species depends upon it's tolerance towards that disturbance, Sagar, *et al.* [34] had found similar results, in comparison to undisturbed sites, maximum number and distribution of species were found.

Biotic disturbances are making site poor in nutrients and eroding top soil making regeneration pattern inadequate, [35]. Tourism is often considered to be intrinsically sustainable as it attracts tourists. There is no need for extensive infrastructural development as tourists are usually genuinely interested in the local culture and traditions. Tourism can fulfill its role as the "industry of peace" [36] But contrary to above concept of ecotourism (sustainable tourism), it has been observed that in Shankaracharya forest ecosystem that tourism is also playing its role in degradation of the forest ecosystem results in loss of biodiversity. Further tourist influx has greatly increased during recent past due to return of normalcy in valley, overall adversely affects natural forest ecosystem. Growing demands for the increasing population have created various disturbances in the existing forests resulting in the deterioration and loss of biodiversity, Bhat, *et al.* [27] foundsimilar results.

Unrestricted and open accessibility may cause enhanced utilization of the forest resources and this may eventually lead to species poor state [37] Military activities also play its role in degrading the forest ecosystem. The army personnel also use the forest resources in different ways and in turn generates solid and liquid wastes which are housed to deteriorate the environment of the area and also become a source of diseases. The pressure of vehicles used along with their harmful effects and different types of food items used by tourists (chips packet, plastic bottles and other items) littering on ground, thereby creates interferences with natural environment which in turn can alter environmental conditions [38]. Human disturbances results in change in vegetation cover and affect forest dynamics and plant diversity at local and regional scales. Pandey and Shukla [39], revealed Similar results.

Forest disturbance can alter environmental conditions by changing light availability and soil conditions [39]. Recurrent human intervention for the collection of fuel wood, litter, trampling etc. can substantially alter species habitat [40]. Trespassing was observed as one of the major biotic interference in the Shankaracharya forest ecosystem which not only damages vegetal cover but also leads to compaction and denaturation on soil (shown in site C). As a result of trespassing, there becomes a great rise of soil erosion during rainy season. Thus from present investigation, it is evident that biotic interferences are found to be increased day to day. Under these circumstances, it is important to study the major forest resources of the region, not only to protect the environment but also to provide the basic needs of the people residing near by Bhat, *et al.* [27]. Therefore, the area needs complete protection from all types of biotic interferences so, that original vegetation can occur again.

6. Conclusion

The observations from present investigation conclude that forest ecosystem of Shankaracharya is victim of varied biotic stresses. Biotic interferences had significantly degrade the vegetation cover in the forest area. The numerical density, diversity and richness of various plant species have decreased due to rigorous biotic interventions. The results had also revealed that various species are near to become extinct due to various trespassing by tourists, pilgrimage and security forces. The cumulative biotic interferences have made entire ecology of Shankaracharya forest vulnerable to various threats. While being preserved forest of Srinagar city, the Shankaracharya hill station is also famous for Hindi religious point of view which is found measure source of threat to fragile forest ecology of the hill station. The present study had also conclude that the species of plants on upper area are highly disturbed than middle and lower area. At the foothill various human encroachments were also noted which may become threat to forest ecology in near future.

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