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Infestation Of Weed Vegetation *Parthenium hysterophorus* L. In Tehri Garhwal Himalaya, Uttarakhand, India

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Abstract: *Parthenium hysterophorus* L. is a weed of global significance causing severe economic, environmental, agricultural, biodiversity, livestock, and human health problems. It is a highly noxious, invasive plant species of sub-tropical America and quickly spreads almost in all climatic conditions of the world. The weed has been spread almost in every part of every state of India including Uttarakhand. *P. hysterophorus* was observed to spread from sub-tropical climatic conditions to the temperate region up to 2200 m asl in Tehri Garhwal, Uttarakhand. It has severely affected the habitats of native plant species. *P. hysterophorus* is an annual herb that starts to grow during March-April and remains till last of the November-December. The infestation of *Parthenium* has been maximum during the summer and abolished during the winter season. Regular field visits and surveys were made during the growing season (2018-19) from foothills to higher ridges of the study areas. The highest density value (729000 ind ha^{-1}) for *P. hysterophorus* was recorded at the Chauras site followed by Rishikesh (554000 ind ha^{-1}) and the Badshahithaul site (417000 ind ha^{-1}) whereas, the lowest density value for this weed was recorded at the Ranichauri site (61000 ind ha^{-1}). *P. hysterophorus* was determined to be the dominating plant species in most of the survey sites based on density, basal cover, and the Importance Value Index (IVI). However, the dominance of *P. hysterophorus* in most of the study sites is a signal of probable threat to the associated species. Plant species degradation caused by high anthropogenic pressure would provide appropriate circumstances for *Parthenium* weed to invade, presenting a major threat to the ecological balance of the region. The aim of present study to investigate infestation of *Parthenium* weed with altitudes wise in Tehri Garhwal, Uttarakhand, India.

Keywords: *Parthenium hysterophorus* L., Distribution, Infestation, Biodiversity, Tehri Garhwal

Introduction

Parthenium hysterophorus L. (Family Asteraceae) is an invasive alien plant considered the "World's Worst Weed" (Holm *et al.*, 1977). It is native to Central America and now has been spread to over 20 nations worldwide, spanning five continents and numerous islands (Picman *et al.*, 1984; Navie *et al.*, 1996). Recent findings suggest that weed has infested African nations and even eight Chinese provinces, spreading at an alarming pace from the tropical to the subtropical regions of the world (Dogra *et al.*, 2011).

The infestation level of *Parthenium* is severe in countries like Australia, South Africa, Ethiopia, India, Srilanka, and Pakistan. Nowadays, it is considered a weed of global and natural significance (Dhileepan, 2009). In India, it has entered with cereal grain imported from the USA before 1910 (Chandras and Vartak, 1970). Since then, it has become a prominent weed in practically almost every Indian state, specially Andhra Pradesh, Bihar, Haryana, Karnataka,

Madhya Pradesh, Tamil Nadu, and Uttar Pradesh, where there is a high prevalence of *Parthenium* infection (Sushilkumar, 2014; Manpreet Kaur *et al.*, 2014). The infestation level of *Parthenium* weed studied three different parameter which are low, medium, and high levels of infestation (Sushilkumar, 2014). Uttarakhand has achieved the medium infestation level among different Indian states (Lalita and Ashok Kumar, 2018).

Parthenium has invaded most of the crops and become a serious threat to agriculture production. It is a fast-growing annual herb with a deep taproot system and maybe eventually reaching a height up to 2 meters (Kaur *et al*., 2014). *P. hysterophorus* is originated because of the natural hybridization of *P. bipinnatifidum* and *P. confertum* (Nath, 1988). *Parthenium* can adapt to almost every agro-climatic condition and distribute itself to a variety of growing environmental conditions (Annupurna and Singh, 2003). It can produce more than 25,000 seeds per plant. The seeds are light in weight, mainly dispersed through water current, air, moving vehicle tires, machinery, livestock, fodder, grain, lesser animals, and human by their activities.

Allelopathic chemicals found in *Parthenium* can reduce moisture and nutrients in the agricultural field and inhibit germination and growth of adjacent crops and other plants species and reduce biodiversity by the displacement of the native as well as exotic plants species (Shabir and Bajwa, 2006; Gnanavel, 2013). These studies showed that chemicals released by *Parthenium* weed inhibit the growth and development of wheat, sorghum, and other crop species, and the effect of *Parthenium* in the agricultural field in a different part of the world has been reported (Javid *et al.*, 2011; Gnanavel, 2013; Zuberi *et al.*, 2014; Khan *et al.*, 2014). *Parthenium* weed threatens biodiversity by competing with indigenous crop plant species for resources (nutrients, moisture, sunlight, and even space). *Parthenium* weed completely dominated grazing land in Australia and reduced stacking rate by up to 80% and loss of beef production up to AU$ 22.0 million per year (Chippendale and Panneta, 1994).

Thus, *Parthenium* weed is found to affect human and animal health also. In humans, weed causes asthma, allergic, rhinitis, bronchitis, dermatitis, and hay fever were coming in contact with *Parthenium* leaves and inhalation of pollen grains and toxins present in weed has been reported to cause effects in milk and meat production in the livestock (Gnanavel, 2013).

Parthenium reduces 40% of several crops in Australia it is found a major threat to perennial grassland in the central states of Queensland (Kholsa and Sobti, 1997; Navie *et al.*, 1998; 2004).The use of herbicides for the control of *Parthenium* is prohibited globally due to high cost and adverse effects, in severe situations weed can be controlled by application of 2, 4, D, or Atrazine (Holman, 1981).

The soil seed bank is the major factor in the spreading of *Parthenium.* Soil can preserve its seeds for a long time for seed dormancy, seed longevity and the capability of weed to grow in favorable environmental conditions. An investigation reported the dormancy of seeds in soil was tenacious to be high seeds in Queensland and seed bank persistency reached 65-87% (Navie *et al.*, 2004).

Parthenium is a serious problem in many rain-fed ecosystems and non-cropped situations, as well as in agricultural pastures and woodland ecosystems, However, weed is now infesting numerous forest's land and endangering biodiversity. The availability of the weed of palatable grass herbivores and national parks across the world, it's also a concern (Sushil Kumar, 2014).

Keeping in view the relevance of this invasive noxious weed in terms of suppressing native flora

in the area. A comprehensive study was carried out to calculate the infestation and distribution of *P. hysterophorus* in the Tehri Garhwal Himalayas, Uttarakhand.

Materials and methods

The present study was undertaken in the Garhwal Himalayas region situated between Latitude 30˚26`15" N and between longitude 78˚18`45" to 80˚8`0" E (Atkinson, 1884). The survey elevation ranges from 370 – 2200 m asl. Physiographically, the area consists of hill slopes and valleys of Tehri Garhwal district of Uttarakhand state with sub-montane and montane forests. A total of five sites, differing in altitudes with general characteristics and species compositions, were selected for the present investigation in the district of Tehri Garhwal, Uttarakhand (Fig. 1). These sites are (i) Rishikesh (ii) Chauras, (iii) Nagni, (iv) Badshahithaul and (v) Ranichauri (Dandachali) . The general characteristics with anthropogenic activities are of the study sites are presented in Table 1.

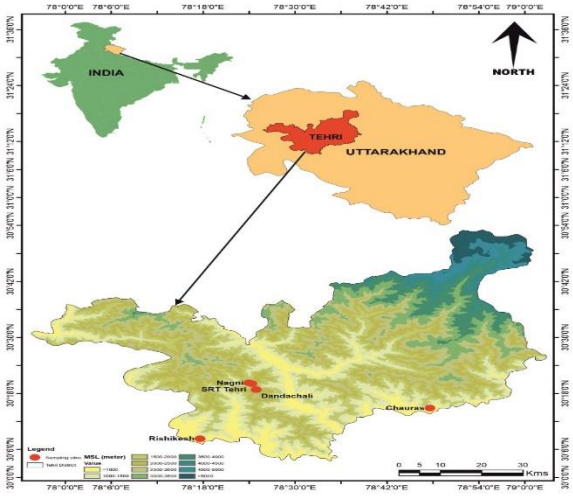

Fig. 1: Map showing survey sites in the study area.

Table 1: General characteristics of the study sites.

Study sites	Latitude	Longitude	Altitude (m asl)	Habitat characteristics	Anthropogenic activities
Rishikesh	30˚07`25.426"N	78˚16`47.730"E	370	Forest and road sides	Construction activities and industrialization
Chauras	30˚13`25.027"N	78˚48`07.873"E	560	Grassland and way sides	Construction of Dam and roads
Nagani	30˚18`39.208"N	78˚20`40.016"E	1000	Forest edges and road sides	Forest fire and grazing
Badshahithaul	30˚23`02.837"N	78˚25`25.633"E	1750	Forest edges, road side and agricultural field margins	Forest fire, grazing, collection of fodder and fuelwood
Ranichauri (Dandachali)	30˚13`25.027"N	78˚48`07.873"E	2200	Forest edges, road side and agricultural field margins	Forest fire, grazing, collection of fodder and fuelwood

The field surveys were conducted on the major road networks which were due to its core infestation of the weed in crop areas and waste lands. In every five locations, one field/area was randomly selected for data collection. Distribution and infestation were determined as

the presence and absence of *Parthenium* weed in the residential areas, along roadsides, agricultural fields, grazing lands, forest land, etc.

The quadrat method was used to assess the species composition at all selected sites during 2018-2019. Herbs were measured and counted in 20 quadrats of 1 m × 1 m size at each study site, The frequency, density, and abundance values for herbs and shrub layers were calculated following by following Curtis and Mcintosh (1950).

The basal area was estimated by clipping the herbaceous species with the help of scissors, at few centimeters just above the ground and the diameter of the stem emerging out of ground is measured with the of calipers or scale. Usually, 100 stems of the species were selected for the measurement of diameter, and then the average diameter for the individual species was calculated by using the formula: Basal area = 3.14 X Average diameter X Average diameter X 0.25 (Tiwari, 2005). Importance Value Index (IVI) was calculated by summing relative density, relative frequency, and relative dominance as proposed by Curtis and Mcintosh (1950) and Phillips (1959). Species richness was the total number of species in a particular study site.

Shannon-Wiener Diversity Index ($\overline{H}$) was calculated as per Shannon and Weaver (1963), employing the following formula:

$$\overline{H} = -\sum_{i=1}^{s}\left(\frac{N_i}{N}\right)\log_2\left(\frac{N_i}{N}\right)$$

Where, $\overline{H}$ = Shannon-Wiener Diversity Index; N_i = Importance Value Index of a species; N = Total Importance Value Index of all the species.

Results and Discussion

P. hysterophorus is an annual herb and starts to grow during March-April at foot-hills while it started to grow in May-June or after first rain at high altitude region of Tehri Garhwal and remains till last of the November-December. The infestation of *Parthenium* has been maximum during the summer and abolished during the winter season. The highest density value (729000 ind ha^{-1}) for *P. hysterophorus* was recorded at the Chauras site (Fig. 2) followed by the Rishikesh site *i.e.*, 554000 ind ha^{-1} whereas the lowest density value for *P. hysterophorus* was recorded at the Ranichauri site (61000 ind⊕ha^{-1}) followed by Nagani (246000 ind ha^{-1}). Thus, it is evident from the present investigation the density and infestation of *Parthenium* are higher at a lower elevation such as Chauras and Rishikesh in comparison to higher elevations (Table 2-6). There is a great variation in the range of total basal cover (TBC) at Rishikesh 30777.78cm^2 ha^{-1}, Chauras 43133.47 cm^2 ha^{-1},Nagni 14052.01cm^2 ha^{-1}, Badshahithaul 49856.73 cm^2 ha^{-1}, and Ranichauri 2624.36 cm^2 ha^{-1}plant species at five different sites (Fig.3).

Fig. 2 (A – H): Infestation of *Parthenium hysterophorus* at different study sites.

The invasion of plant communities by hardy exotics and warned that invasive species pose a serious threat to biodiversity (Heywood, 1989; Cronk et al., 1995; Luken and Thieret, 1997 and Schmitz *et al.*, 1997). *P. hysterophorus* is a noxious invasive weed species that have created devastation to the natural habitat around the

world by replacing native species, in their species-rich areas with single species monoculture (Mack and D` Antonio 1998) and reducing the diversity of native (Meiners *et al*., 2001).

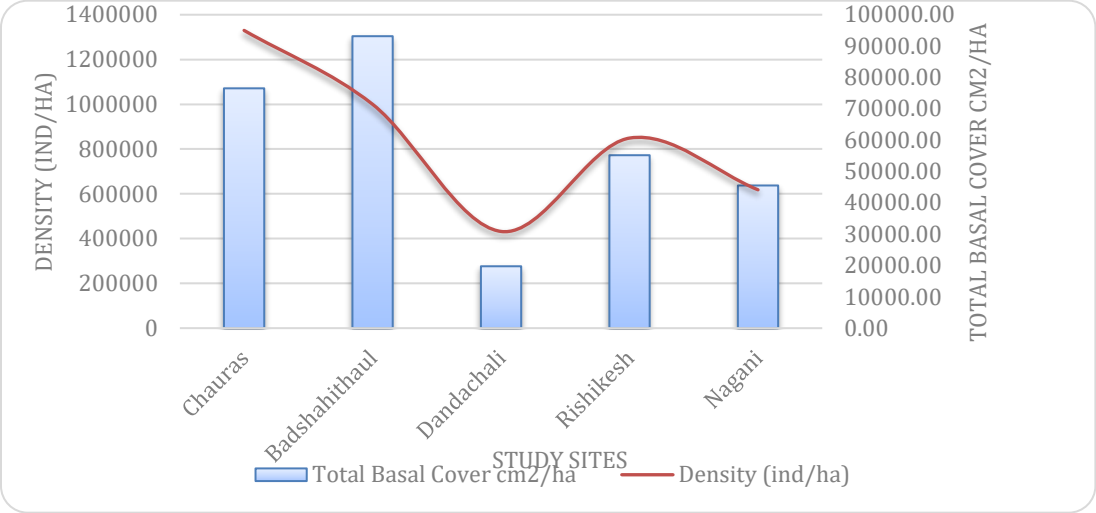

Fig. 3. Density values and Total Basal Cover of the vegetation in the study area.

P. hysterophorus has also been found in the Kargil area of Jammu and Kashmir, as well as Port Blair in the Andaman and Nicobar Islands, demonstrating the weed's exceptional capacity to invade new environments (Yadhuraju *et al*., 2005).The study about the infestation of *Parthenium* weed in a different region of India was reported by Sushil Kumar and Varshney (2010), Sushil Kumar, (2012), Dogra *et al*. (2011) from Himachal Pradesh and Dolai*et al*., (2013) from West Bengal in the Indian continent. Similar findings have also been reported for *P. hysterophorus*by Fite *et al*.(2017), K. Dhileepan (2017), Zareen *et al*. (2018), Maszura *et al*. (2018), and Wubneh (2019) from various parts of the world.

Analysis of the Importance Value Index (IVI) of a species can be used to recognize the pattern of association of dominant species in a community (Parthasarathy and Karthikeyan, 1997). The high IVI of a species indicated its dominance and ecological success, its good power of regeneration, and greater ecological amplitude. Among the plant species, *P. hysterophorus*was found dominant species at most of the sites (Table 2-6). At Ranichauri high altitude site, where *Eupatorium adenophorum* was observed most dominant (53.98) followed by *Gnaphalium sylvacticum* (36.79) and *P. hysterophorus* (34.39) was the third dominant plant.

Based on density, basal cover, and Importance Value Index (IVI), *P. hysterophorus* was found to be the most dominant plant species in most of the sites, whereas the dominance of *P .hysterophorus* in most of the sites is an indication of possible threat to the associated species.

Table 2: Density, IVI and Diversity related parameters of plants at Rishikesh site.

Species	Frequency %	Density (ind ha^{-1})	TBC (cm^2 ha^{-1})	IVI	Shannon-Wiener Diversity Index
Achyranthus aspera	50	33000	3945.50	14.3847	-0.301
Ageratum conyzoides	50	54000	4234.03	16.7945	-0.394
Argimone maxicana	40	19000	1325.98	8.80287	-0.212
Artemecia cappilaris	50	18000	1279.16	10.0225	-0.204
Bidens pilosa	30	26000	1887.09	8.73536	-0.260
Celosia argentea	50	6000	445.14	7.92716	-0.092
Conyza canadensis	50	12000	190.96	8.25431	-0.154
Cynoglossum sp.	60	7000	282.30	9.22222	-0.104
Desmodium sp.	70	4000	180.00	10.1823	-0.068
Eupatorium adenophorum	50	50000	3348.90	15.4443	-0.379
Euphorbia hirta	70	35000	419.66	13.5395	-0.312
Parthenium hysterophorus	50	554000	30777.78	95.2888	0.712
Sida rhombifolia	30	5000	541.34	5.19071	-0.080
Sonchus oleraceus	40	16000	5617.95	13.1102	-0.189
Xanthium strumarium	40	10000	696.89	7.22755	-0.135
	730	849000	55172.68	244.127	-2.173

Table 3: Density, IVI, and Diversity related parameters of plants at Chauras site.

Species	Frequency %	Density (ind ha^{-1})	TBC (cm^2 ha^{-1})	IVI	Shannon-Wiener Diversity Index
Anisomeles indica	30	25000	1620.00	7.89	-0.234
Argemone maxicana	40	15000	856.83	7.44	-0.165
Artemisia capillaris	60	146000	9531.01	31.22	-0.528
Bidens pilosa	40	53000	1102.82	10.62	-0.366
Boerhavia diffusa	50	26000	906.05	9.63	-0.240
Cannabis sativa	40	68000	2820.10	13.99	-0.415
Conyza canadensis	60	61000	2190.63	15.24	-0.393
Corchorus aestuanus	60	17000	4654.60	15.15	-0.180
Cuscuta reflexa	50	33000	748.59	9.95	-0.279
Parthenium hysterophorus	40	729000	43133.47	116.37	1.175
Rumex hastatus	70	36000	605.00	12.59	-0.294
Saussurea heteromalla	50	27000	1024.12	9.86	-0.246
Sida cordifolia	70	35000	367.94	12.20	-0.289
Stellaria media	30	19000	3306.95	9.65	-0.195
Tridax procumbens	50	23000	1695.74	10.44	-0.221
Triumfetta rhomboidea	30	17000	1958.40	7.73	-0.180
	770	1330000	76522.25	300.00	-3.049

Table 4: Density, IVI, and Diversity related parameters of plants at Nagani site.

Species	Frequency %	Density (ind ha^{-1})	TBC (cm^2 ha^{-1})	IVI	Shannon-Wiener Diversity Index
Achyranthes aspera	40	23000	1360.86	8.70252	-0.221
Ageratum conyzoides	60	33000	2154.26	13.0886	-0.279
Ajuga bracteosa	60	19000	682.32	10.1125	-0.195
Alternanthera sessilis	40	13000	270.50	6.52575	-0.149
Bidens pilosa	40	35000	1451.52	9.72324	-0.289
Capsella bursa	50	23000	521.74	8.90465	-0.221
Chenopodium album	70	8000	134.44	9.86811	-0.104
Clinopodium umbrosum	50	16000	606.88	8.4896	-0.173
Cyperus rotundus	50	45000	3317.76	14.2126	-0.335
Echinochloa colona	70	5000	52.56	9.53554	-0.073
Eupatorium adenophorum	50	37000	1289.37	10.9604	-0.299
Galinsoga parviflora	50	18000	1166.4	9.37115	-0.187
Gomphrena celosiodes	50	11000	1914.55	9.82253	-0.132
Origanum vulgare	50	3000	821.40	7.79248	-0.049
Oxalis corniculata	50	21000	2419.20	11.2339	-0.208
Parthenium hysterophorus	50	246000	14052.01	43.353	-0.472
Persicaria nepalensis	50	6000	388.80	7.45272	-0.084
Polygonium barbatum	30	21000	3655.05	10.2515	-0.208
Rumex hustatus	60	33000	9035.40	22.081	-0.279
Xanthium strumarium	30	2000	230.40	4.34757	-0.035
	1000	618000	45525.48	235.829	-3.992

The species diversity can be defined by the combination of two factors i.e., the number of species present to as species richness and the distribution of individuals among species, to as evenness or equitability. The number of species present is referred to as species richness. Shannon-Wiener's index ($\bar{H}$) of diversity is one of the most popular measures of general diversity. In the present study, the maximum Shannon-Wiener's index ($\bar{H}$) value was reported at the Chauras site (1.175) followed by the Badshahithaul site (0.099) and the minimum diversity value was recorded at the Ranichauri site (-0.405), which indicates the stress of *Parthenium* is very high at lower altitude and decreasing towards higher altitude regions. The highest plant diversity was recorded for the Badshahithaul site (4.352) followed by for Chauras site (3.049) while the lowest diversity indices (3.044)were recorded for the Ranichauri site (Fig. 4).The species diversity of herbaceous plants varies greatly from place to place mainly due to variation in biogeography, habitat, intensity of disturbance and anthropological interruption in a particular region (Hubbell *et al.*,1999; Sagar *et al.*, 2003).

Table 5: Density, IVI, and Diversity related parameters of plants at Badshahithaul site.

Species	Frequency %	Density (ind ha^{-1})	TBC (cm^2 ha^{-1})	IVI	Shannon-Wiener Diversity Index
Achyranthus aspera	70	27000	323.74	12.64	-0.266
Amaranthus viridis	50	31000	1722.22	11.80	-0.290
Artimesea rouxburghiana	50	30000	2009.34	12.01	-0.284
Bidens pilosa	40	45000	3140.48	13.35	-0.359
Conyza canadensis	50	52000	3695.35	16.02	-0.387
Cynodon dactylon	60	38000	1532.46	13.66	-0.327
Datura stamonium	30	30000	3248.03	10.60	-0.284
Eupatorium adenophorum	50	143000	11212.34	33.19	-0.531
Galinsoga parviflora	50	27000	2003.12	11.70	-0.266
Malvestrum coromandelianum	70	32000	1440.00	14.33	-0.296
Parthenium hysterophorus	50	417000	49856.73	102.07	0.099
Poa fendleriana	40	25000	1742.22	9.85	-0.254
Rumex hastatus	40	21000	7373.56	15.49	-0.227
Setariaviridis	50	37000	588.79	11.18	-0.322
Urtia dioica	30	45000	3266.12	12.12	-0.359
	730	1000000	93154.52	300.00	-4.352

Table 6: Density, IVI and Diversity related parameters of plants at Ranichauri site.

Species	Frequency %	Density (ind ha^{-1})	TBC (cm^2 ha^{-1})	IVI	Shannon-Wiener Diversity Index
Anaphalis busua	30	50000	2560.00	31.52	-0.366
Cynoglossum glochidiatum	60	7000	46.45	15.81	-0.099
Cyperus rotundus	30	18000	451.58	13.43	-0.195
Echinops cornigerus	50	18000	1232.10	22.04	-0.195
Eriphonumcomosum	20	47000	3045.60	30.96	-0.354
Eupatorium adenophorum	30	147000	2561.07	53.98	-0.530
Gnaphalium sylvaticum	40	30000	4056.00	36.79	-0.272
Leucas lanata	30	14000	740.89	13.97	-0.164
Origanum vulgare	20	10000	512.00	9.56	-0.129
Parthenium hysterophorus	30	61000	2624.36	34.39	-0.405
Primula dentatus	50	9000	517.75	16.33	-0.119
Verbascum thapsus	40	21000	1391.21	21.21	-0.216
	430	432000	19739.01	300.00	-3.044

The invasive species has been well established in all ecological zone and habitats, the homogenization of weed species diminishing the population of many valuable native plant species and wildlife in Chamoli and Pauri Garhwal Himalaya (Bisht *et al.*, 2012) The high propagule pressure and dispersal rates are the two most significant features that help an invasive species to establish itself. *P. hysterophorus* meets both the requirements (Eschtruth and Battles, 2009).

By human activities, most alien plants species are moved out of their natural habitat and get established in other`s native areas and persist where they are cultivated or efflorescence in many habitats like disturbed land, uncultivated land, etc. These invasive species overcome many barriers to establishment and are tenacious and consolidated in the biota of the new region (Richardson and Van Wilgen, 2004). Nowadays *P. hysterophorus* has been successfully established from tropical to subtropical regions of the world (Kohli *et al.*, 2006). Thus, the invasion of *P. hysterophorus* is relative more in Tehri Garhwal (Uttarakhand) of India, it may be due to an increase in transportation, infrastructural development sectors, development of all-weather roads, etc. The weed has reached almost every village and city. The present investigation showed that the infestation of *Parthenium* was recorded in subtropical to temperate regions in Tehri Garhwal Himalaya, Uttarakhand. The infestation of the weed decreased with increasing altitude and the presence of weed was not recorded above 2200 m asl.

The abundance and frequency of *P. hysterophorus* were significantly more between foothills and surrounding areas. The infestation level is high from 370 to 1750 m asl and gradually decreases toward higher elevation. Therefore, this study will be very helpful in the management and conservation of the local plant biodiversity of this region.

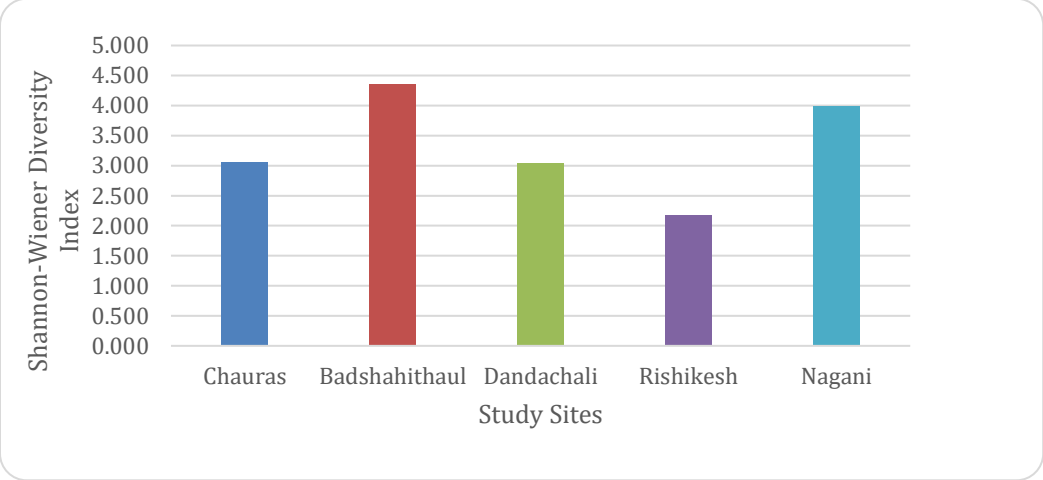

Fig. 4. Shannon-Wiener's index ($\bar{H}$) of diversity at different sites in the study area.

Recommendations:

P. hysterophorus is alien weed which is spreading almost every part of world including India. Its high level of infestation is hazardous for biodiversity of plant and animal and human health too. In Uttarakhand, the infestation of weed has increased due to more anthropogenic

actives from low to high altitudes areas. Due to so many harmful impact of *Parthenium*, its control is important. People awareness programs and integrated weed management should be applied for the management of this noxious weed. The classical biocontrol agent *Zygogramma bicolorata* should also be reared and released on *P. hysterophorus*, which is significantly controlling the weed. The biocontrol programs are cost effective and environmentally safe.

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