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Phytosociology of *Sambucus wightiana* in Pahalgam of North-Western Himalaya

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Abstract
As the variation in plant communities and species diversity is linked to environmental gradients, plant species sharing similar environmental affinities occupy similar sites across the landscape. However, diversity along elevation in mountainous regions that are more vulnerable to climate change face more challenges than simple competition. Many of the species in these mountains need to shift their ranges to survive. *Sambucus wightiana* is one of the dominant sub shrub species in the mountain regions of north-western Himalaya, that has started expanding its range. Despite the considerable spread of *S. wightiana* in this region, there is no detailed and valid published study on the phytosociology of this species. The aim of this research is to identify the phytosociological associations of *S. wightiana* in Pahalgam region of the north-western Himalaya. The results of our study point towards the fact that *S. wightiana* form specific phytosociological associations, which could change due to anticipated climate change as most of these species may show idiosyncratic response to mountain warming.

Keywords: association, elevation, Pahalgam, range expansion, *S. wightiana*

Introduction
Understanding the formation of communities of living creatures has been a key focus of ecology since its inception. Extraction of the multiple processes involved in community assembly is not only intriguing, but it is also critical for anticipating how communities will adjust to future environmental scenarios. The conventional notion of assembly rules is based on the premise that plant species do not co-occur at random but are constrained by interspecific competition. Biotic interactions occur between plant species at the same trophic level in interactive communities. Several stabilising and equalizing processes have been proposed to allow species to coexist over time (Chesson, 2000) [9]. Many present and historical abiotic and biotic factors influence the species diversity and organisation of plant communities (Zobel, 1997; Ackerly, 2003; Agrawal *et al*., 2007) [1, 2, 48]. According to recent data, historical factors (Harrison and Grace, 2007; Zobel and Partel, 2008) [14, 47] and dispersal limitations (Zobel and Kalamees, 2005; Myers and Harms, 2009) [46, 26] may determine species diversity in a more significant way than previously believed. There is, however, a rapid expansion of plant populations from warm into cold biomes (Tamis *et al*., 2005) [38]. Range expansion is a key adaptive feature of plant species in response to climate change, habitat scarcity, and other limiting constraints (Walther *et al*., 2002; Parmesan and Yohe, 2003; Warren *et al*., 2001; Thomas *et al*., 2004; Lovejoy and Hannah, 2005; Brinkhuis, *et al*., 2006) [43, 28, 44, 40, 23, 6]. Mountains have traditionally functioned as species refugia during climate cycles (Loarie *et al*., 2009; Sandel *et al*., 2011; Tang *et al*., 2018) [22, 34, 39], assessing species elevational redistributions and the causes of these shifts can aid in forecasting the destiny of mountain biodiversity in the face of future climate change (Freeman *et al*., 2018; Rashid *et al*., 2021) [11, 31]. However, little consensus has been gained in recent decades on species elevational relocation in reaction to climate change, each on the global (Guo et al., 2018) [13] and nearby scales (Lenoir *et al*., 2008; Crimmins *et al*., 2011) [10, 21]. Several studies, for example, have found that plant species in the mountains have migrated upwards because of climate change during the previous century. (Lenoir *et al.*, 2008; Rumpf *et al.*, 2018) [21, 33]. Plant species in California, on the other hand, have shifted their heights downward (Crimmins *et al*., 2011) [10]. These disparate conclusions suggest that alpine species elevational shifts in reaction to climate change may vary depending on location. Furthermore, not all species can shift their range in the same way, which has an impact on ecological connections and may be disrupted when the diversity of plant species shifts (Lovejoy and Hannah, 2005) [23]. As a result, it is critical to collect baseline data on plant species associations that have just begun range expansion so that the reaction of these communities to projected climate change may be investigated in long-term ecological research. Here we collected data about plant diversity associated with a range expanding species with high genetic diversity (Sofi et al. 2021) [35] called *Sambucus wightiana*, along a mountainous region of Kashmir valley.

Methods
Study area
Pahalgam is situated in the catchment area of Lidder which comprises the Kashmir valley's south-eastern region and is placed at 34.03° N and 75.33° E. The Lidder valley is located in the central Himalayas, between the Pir

Panjal range and the Zanskar range. It is one of the most popular and attractive hill resorts in Jammu and Kashmir. The road to Pahalgam passes through a deep forest with *Pinus wallichaina*, *Abies pindrow*, and *Cedrus deodara* as the major species.

Study species

Sambucus wightiana Wall. Ex Wight & Arn. is a shrubby herb (Fig. 1), that grows to a height of 1 to 1.5m. The leaves of *S.wightiana* are about 25 cm long and bear 5 to 9 leaflets. The leaflets have a lanceolate form with an acute to acuminate tip and are 5 to 18 cm long. Inflorescence is corymbose, pedunculate and about 10cm across. Flowers are small, actinomorphic and about 5 mm in diameter. Fruit is a drupe, globose in shape with a diameter of about 4 to 5mm and orange in colour that becomes black at maturity. The seed is 2.7 mm long and oblong in shape.

Fig 1: *Sambucus wightiana* plants in Pahalgam region of Kashmir

Field sampling and measurements

The mountainous region of Pahalgam was divided into 10 altitudinal bands from the lowest to highest possible sampling location. The GPS coordinates of the sites were recorded using a Garmin eTrex (Garmin International, Inc., Olathe, KS). At each elevational gradient 1 m × 1 m quadrats were laid. Standard taxonomic procedures were followed for the collection of plant specimens (Bridson and Forman, 1998) [5]. The collected specimens were dried and mounted on herbarium sheets using standard herbarium techniques. The collected specimens were correctly identified using the labelled herbarium specimens kept in the University of Kashmir Herbarium. The voucher specimens have all been placed at the KASH herbarium. The scientific names were cross checked with authentic taxonomic resources.

Results

A total of 79 plant species from 30 families were found during the study along the altitudinal belt of Pahalgam. Among the recorded plant species, there were 70 herbs, 6 graminoids, 2 shrubs and 1 subshrub (Table 1). The total numbers of plant species found in plots with and without *S. wightiana* were 59 and 69 respectively. Among 59 plants species associated with *S. wightiana*, 42 plant species were native and 17 were exotic (Table 1). On the other hand, in plots without *S. wightiana*, there were 49 native plant species and 20 exotic plant species.

Table: 1 Conspectus of the flora of Pahalgam.

S. No.	Name of the species	Family	Growth form	*S. wightiana*	
				With	Without
1	*Achillea millefolium* L.	Asteraceae	Herb	0	1
2	*Adiantum venustum* D. Don	Adiantaceae	Herb	1	1
3	*Androsace rotundifolia* Hardwicke	Primulaceae	Herb	0	1
4	*Anthemis cotula* L.	Asteraceae	Herb	1	1

5	*Arctium lappa* L.	Asteraceae	Herb	0	1
6	*Artemisia vestita* Wall. ex DC.	Asteraceae	Herb	0	1
7	*Barbarea intermedia* Boreau.	Brassicaceae	Herb	1	0
8	*Bellis perennis* L.	Asteraceae	Herb	1	1
9	*Bothriochloa ischaemum* (L.) Keng	Poaceae	Graminoid	0	1
10	*Brassica tournefortii* Gouan.	Brassicaceae	Herb	1	1
11	*Caltha alba* (Cambess) Hook.	Ranunculaceae	Herb	0	1
12	*Capsella bursa-pastoris* Medic.	Brassicaceae	Herb	1	1
13	*Cardamine hirsuta* L.	Brassicaceae	Herb	0	1
14	*Cardamine impatiens* L.	Brassicaceae	Herb	0	1
15	*Centaurea iberica* Trev. ex Spreng.	Asteraceae	Herb	1	0
16	*Cerastium cerastioides* (L.) Britton	Caryophyllaceae	Herb	1	1
17	*Cirsium arvense* Scop.	Asteraceae	Herb	1	1
18	*Cirsium falconeri* (Hook.f.) Petr.	Asteraceae	Herb	1	1
19	*Cirsium vulgare* (Savi.) Ten.	Asteraceae	Herb	1	1
20	*Clinopodium vulgare* L.	Lamiaceae	Herb	1	1
21	*Corydalis rutifolia* (Sm.) DC.	Papaveraceae	Herb	1	1
22	*Crepis sancta* (L.) Bornm.	Asteraceae	Herb	1	0
23	*Cynodon dactylon* Pers.	Poaceae	Graminoid	1	1
24	*Dryopteris blanfordii* (Ching) Fraser	Dryopteridaceae	Herb	1	1
25	*Fragaria nubicola* Lindel. ex. Lacaita	Rosaceae	Herb	1	1
26	*Gagea elegans* Wall.ex.D.Don	Liliaceae	Herb	1	0
27	*Galingsoga parviflora* Cav.	Asteraceae	Herb	1	0
28	*Galium aparine* L.	Rubiaceae	Herb	1	1
29	*Galium triflorum* Michx.	Rubiaceae	Herb	1	1
30	*Geranium pratense* L.	Geraniaceae	Herb	1	1
31	*Geum elatum Wall.* ex G.Don	Rosaceae	Herb	1	1
32	*Impatiens balfourii* Hook. F	Balsaminaceae	Herb	1	1
33	*Impatiens bracycentra* Kar. & Kir.	Balsaminaceae	Herb	1	1
34	*Indigofera heterantha* Brandis	Fabaceae	Shrub	1	0
35	*Lamium album* L.	Lamiaceae	Herb	1	1
36	*Malva neglecta* Wall.	Malvaceae	Herb	1	1
37	*Marrubium vulgare* L.	Lamiaceae	Herb	0	1
38	*Medicago polymorpha* L.	Fabaceae	Herb	0	1
39	*Medicago sativa* L.	Fabaceae	Herb	1	1
40	*Mentha longifolia* L.	Lamiaceae	Herb	1	1
41	*Myosotis arvensis* (L.) Hill	Boraginaceae	Herb	1	1
42	*Myosotis palustris* (L.) Nath.	Boraginaceae	Herb	1	1
43	*Nepeta erecta* (Boyle ex Benth.) Berth	Lamiaceae	Herb	0	1
44	*Oenothera rosea* Ait.	Onagraceae	Herb	1	0
45	*Oxalis corniculata* L.	Oxalidaceae	Herb	1	1
46	*Paeonia emodi* Wall. ex Royle	Paeoniaceae	Herb	1	1
47	*Picris hieracioides* Sibth. & Sm.	Asteraceae	Herb	1	0
48	*Plantago lanceolata* L.	Plantaginaceae	Herb	1	1
49	*Plantago major* L.	Plantaginaceae	Herb	1	1
50	*Poa alpina* L.	Poaceae	Graminoid	1	1
51	*Poa annua* L.	Poaceae	Graminoid	1	1
52	*Poa bulbosa* L.	Poaceae	Graminoid	1	1
53	*Polygonum amplexicaule* D.Don	Polygonaceae	Herb	1	1
54	*Polygonum amphibium* L.	Polygonaceae	Herb	1	1
55	*Polygonum aviculare* L.	Polygonaceae	Herb	0	1
56	*Ranunculus laetus* Wall. ex D. Don	Ranunculaceae	Herb	1	1
57	*Rumex dentatus* L.	Polygonaceae	Herb	1	1
58	*Rumex nepalensis* Spreng.	Polygonaceae	Herb	1	1
59	*Rumex obtusifolius* L.	Polygonaceae	Herb	1	1
60	*Sambucus wightiana* Wight &Arn.	Adoxaceae	Subshrub	1	0
61	*Scandix pecten-veneris* L.	Apiaceae	Herb	0	1
62	*Sibbaldia cuneata* Schouw exKunze	Rosaceae	Herb	0	1
63	*Stellaria media* (L.) Vill	Caryophyllaceae	Herb	0	1
64	*Stipa sibirica* (Linn.) Lam.	Poaceae	Graminoid	1	1
65	*Taraxacum officinale* Weber	Asteraceae	Herb	1	1

66	*Thalictrum minus* L.	Ranunculaceae	Herb	0	1
67	*Thymus linearis* Benth	Lamiaceae	Herb	0	1
68	*Trifolium pratense* L.	Fabaceae	Herb	1	1
69	*Trifolium repens* L.	Fabaceae	Herb	1	1
70	*Tussilago farfara* L.	Asteraceae	Herb	1	1
71	*Urtica dioica* L.	Urticaceae	Herb	1	1
72	*Valeriana jatamansi* Jones	Valerianaceae	Herb	0	1
73	*Verbascum thapsus* L.	Scrophulariaceae	Herb	1	1
74	*Veronica laxa* Benth.	Scrophulariaceae	Herb	0	1
75	*Veronica persica* Poir.	Scrophulariaceae	Herb	0	1
76	*Viburnum grandiflorum* Wall. ex DC	Caprifoliaceae	Shrub	1	1
77	*Viola biflora* L.	Violaceae	Herb	1	1
78	*Viola odorata* L.	Violaceae	Herb	1	1
79	*Xanthium spinosum* L.	Asteraceae	Herb	1	0

The number of plant species that were exclusively found in association with *S. wightiana* and without *S. wightiana* plots were 10 and 20 respectively (Fig. 2). In the plots with *S. wightiana*, the maximum number of species were 28 that were found at an elevation of 2093 m asl, followed by an elevation of 2119 m asl where 24 plant species were found, and 20 species were found at 2025 m asl. In case of plots without *S. wightiana* the maximum number of species that were collected at elevation of 2093m asl, 2119m asl and 2025m asl were 28, 28 and 24 respectively.

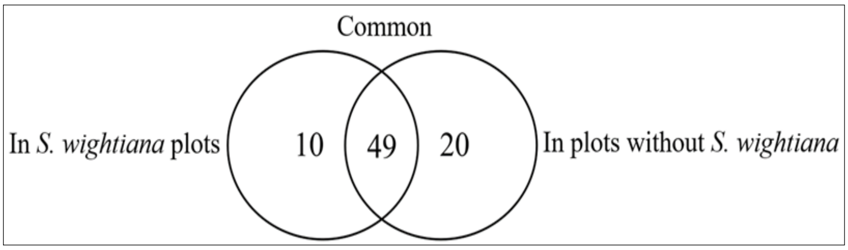

Fig 2: Number of plant species plots with and without *S. wightiana*

Both in the plots of *S. wightiana* and without it, Asteraceae was the largest family represented, however the relative contribution of families was different among sites. In *S. wightiana* sites Asteraceae was represented by 12 plant species followed by Poaceae (5), Polygonaceae (5), and Fabaceae (4), while as in the plots devoid of *S. wightiana* Asteraceae was represented by 10 members followed by Lamiaceae (6), Poaceae (6), and Ploygonaceae (6).

Discussion

As the temperature warms, there is more evidence of species redistribution. However, our knowledge of the interspecies interaction range changes and isotherm shifts is still restricted (Lenoir *et al*., 2020) [20]. Even at moderate levels of warming, field observations show that extinction risks for wild species vary across geographic areas and taxonomic classes (e.g. Urban, 2015; Román-Palacios and Wiens, 2020) [41, 32]. This geographical variation in impacts influences the sensitivity of global biodiversity to climate change. Elevation gradients are a significant tool for exploring climate-vegetation relationships (Korner, 2007) [19], the present study clearly shows the species richness pattern across elevational gradient in Pahalgam area of north-western Himalaya. The pattern of life-forms obviously varies along an elevational gradient. The findings revealed that elevation is the most important factor impacting biodiversity as well as vegetation form. Factors determining the number of functional types were assumed to be substantially different from those regulating the variety of species within a functional type. (Cody, 1991; Huston 1994) [16]. However, the relative richness of distinct life-form categories changed throughout the elevational gradient. The community's life-form composition is an expression of its component species' adaptability to environmental conditions, and it adds to the community's design (Jamir *et al.*, 2006) [17].

In the current study, a high percentage of phanerophytes in almost all of the study sites, were the attributes of humid bioclimate, and their high prevalence along the elevationall gradient reflected an important role of canopy in improving the climate, influencing the regeneration, herbaceous plant establishment, biodiversity preservation, and ecosystem functioning. The co-dominance of cryptophytes at higher elevations represented the highest performance of these living forms. Cryptophytes have subterranean perennating organs such as rhizomes, bulbs, and so on that provide energy during adverse situations. As a result, at higher elevations in the Pahalgam region, cryptophytes become the next dominating life form. Annuals prevail at lower elevations, which could be explained in part by soil disturbance, which offers an excellent habitat for ruderals. Temperatures generally decrease by 0.5 - 0.6 ^{o}C for every 100 m rise in altitude. As a result, temperatures and growing season lengths are suitable at lower altitudes in the research area, but soil moisture is not easily accessible, which may be

accountable for well-developed annual plants. Annual plant count decreased with increasing elevation and dropped dramatically in the sub-nival zone. Furthermore, the increased proportion of chamaephytes and hemicryptophytes in the lower altitudes might be linked to the influence of anthropogenic activities, since the lower altitude sites have been subjected to anthropogenic stress. Chamaephytes and therophytes, according to Qadir and Shetvy (1986) [29], are considered sign of an adverse environment. Furthermore, the competing ability of chamaephytes influences the performance of other allied species. As a result, the predominance of chamaephytes is found in areas subjected to environmental disturbance. Thus, the biotic spectra at upper and lower altitudes along the transect indicates the diverse biological spectra which have emerged in response to the climatic conditions existing in the area.
Although it is often assumed that plant species richness declines with altitude (Stevens, 1992; Odland and Birks, 1999; Korner, 2000) [18, 27, 36]; however, many authors have demonstrated the occurrence of a mid-elevation peak in species richness (Rahbek, 1995; Grytnes and Vetaas, 2002) [30, 12], resulting in a humped correlation. This peak has been observed in alpine areas around the tree line (Bruun *et al*., 2006) [8], where both stress and competitive pressure are moderate and habitat variability is abundant. The relation between altitude and species richness may also depend on the scale of the study (Whittaker *et al*., 2001) [45], especially when significant local variables fluctuate greatly over short ranges. However, a few key plant species, such as dominating shrub species, can alter species composition over altitudinal gradients. (Walker *et al*., 2006) [42].Among the most prevalent reactions of species to climate change are geographic range changes, expansions, and contractions (Molinos *et al*., 2016) [25]. Species with vast geographic ranges are thought to be less susceptible since they may explore suitable habitat in areas of their range. (Lucas *et al.*, 2019) [26].
The present study clearly shows association of few species with *S. wightiana* and absence of other species in plots of *S. wightiana*. Nontrophic interactions between plant species that increase the average individual survival of at least one of the taxa involved are termed positive interactions. According to studies that examined the relative importance of positive and negative relationships in plant communities across climatic variables, the relative value of facilitation increases with environmental severity (Bruno *et al.*, 2003; Bashirzadeh et al., 2022) [7, 4]. Given that hard circumstances can make it difficult for plants to acquire resources, any improvement in these conditions brought about by the presence of a neighbour would favour growth to the extent that it outweighed the adverse, competitive outcome of growing in close associations.

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