



Impact of Habitat Variability on Phenotypic Attributes of *Hypericum perforatum* L. along Elevational Gradient in Kashmir Himalayas
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ABSTRACT

A number of environmental factors such as mean temperature, precipitation, soil characteristics, radiation intensity etc. changes with elevational gradient and thereby affect the morphological pattern of a plant species. Phenotypic attributes of a particular plant species varies along different altitudes in order to adapt and also to overcome these changeable and stressful conditions. The present analysis was undertaken to assess distribution pattern and impact of elevational gradient on morphology of an important medicinal and aromatic plant *Hypericum perforatum* L. growing in Kashmir Himalaya. *Hypericum perforatum* L. member of family Hypericaceae, is a perennial herb, distributed in Western Himalaya. The species exhibited distinct variability and a peculiar trend in morphological traits in response to different environmental conditions along an elevational gradient.

Keywords: Elevational; *Hypericum perforatum*; Hypericaceae; Distribution; Morphological traits; Kashmir; Himalaya

Introduction

The word *Hypericum* is derived from the Greek words “hyper” (above) and “eikon”(icon or image), as ancient Greeks and Romans placed the branches above images in their homes, believing that this plant had mystical power to protect them from evil spirits. The common name of the plant is St John’s wort means John’s day (June 24th) and ‘wort’ for plant. It bears golden yellow flowers which seem to be particularly abundant on 24th June, celebrated as the birthday of ‘St. John’ the Baptist. The currently accepted name of common St John’s wort is *Hypericum perforatum* L.

Hypericum perforatum L. (St. John’s wort) is one of the most important medicinal plants, which has been used as a medical herb for over 2000 years [1]. *H. perforatum* is a widespread Eurasian perennial plant species with remarkable variation in its morphology attributes, ploidy level and breeding system, which ranges from sex to apomixes. The genus *Hypericum* L. (St. John’s wort, Hypericaceae) consists of more than 450 species that occur in temperate as well as in tropical mountainous regions of the world. *H. perforatum* L. has potent and novel medicinal uses and has been used as Medicinal and Aromatic Plant (MAP) herbal medicine for the treatment of burns, skin injuries, neuralgia, fibrositis, sciatica and depression [2]. *H. perforatum* is a treasure of numerous compounds with biological activity such as hypericin, pseudohypericin, flavonoids, oligomeric procyanidines and hyperforin [3]. Generally the plant depicts great variability in distribution, reproductive behavior and other morphological traits with elevational gradient. *H. perforatum* also shows variability in distribution, reproductive behavior and phenotypic variability with increasing altitude. *H. perforatum* is treated by many authors as a common and grassland plant, occurring in pastures, meadows and rangelands, it may occur in the soil seed bank and establish after disturbance.

Hypericum perforatum is mostly found in upland temperate regions, but is occasionally also found in lowland areas

and sub-tropical environments. It is a weed of pastures, open woodlands, grasslands, forest plantations, roadsides, railways, river banks and waste areas. *H. perforatum* is fairly common in Kashmir on dry hilly slopes and waste places. *H. perforatum* requires a moderately warm and long growing season for completion of its life cycle [4,5]. At elevations of 4,000 feet and higher, St Johns wort stands are open and plants less vigorous than at lower altitude. *H. perforatum* is an herbaceous, erect, perennial herb, up to 1.5 m tall, but commonly 0.3-1 m tall, depending on genotype and site type. The plant is rhizomatous with an abbreviated taproot system, meaning that some roots bore deeply into the earth while some of the roots remain shallow. Taproots can penetrate as far as 2 ft into the soil. The roots that are shallow produce vegetative buds from which new crowns develop. The plant has numerous erect stems that appear to have a rust color (Figure 1). The stems are also woody and relatively smooth to the touch. One to several (up to 30) stems arise from a woody root crown. Stems are woody at the base, leafy and many-branched, mostly in the upper half. Leaves are 1.5-3 cm long and 1.5 to 5 mm wide. Leaves exhibit obvious translucent dots when held up to the light, giving them a 'perforated' appearance; hence the plants Latin name. The leaves are yellow green in color with transparent dots though out the tissue and occasionally with a few black dots on the lower surface. From May to September, this weed has an extensive flowering period. The specific arrangement of stamens in bundles, in the so-called stamen fascicles, is a characteristic feature for the whole genus *Hypericum* [6,7]. The flowers are from one to two centimeters in diameter and they develop in clusters (Figure 1). The fruit is a sticky, numerous-seeded, 3-celled capsule, 5 to 10 mm long. Seeds are about 1 mm long. It is a facultative apomict. *H. perforatum* pollen undergoes normal meiosis. There is evidence of both self-pollination and pollination by a variety of insects. Estimates and measurements of seed production for *Hypericum perforatum* are variable, but range from about 15,000 to 34,000 seeds per plant on average [5,8]. Variation in seed production may result from site factors, seasonal growth conditions, competition and/or herbivory.

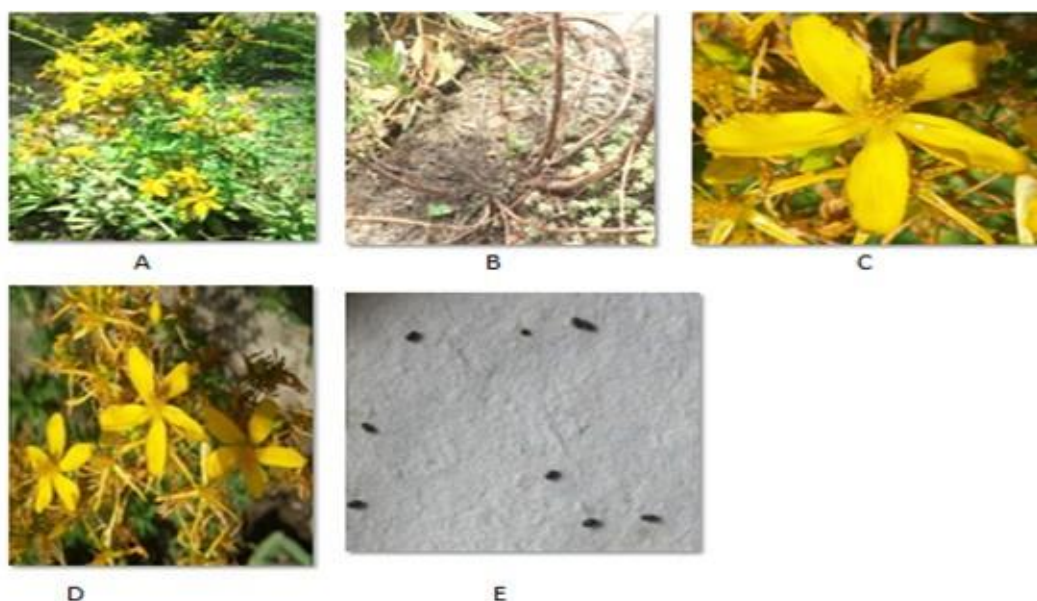


Figure 1: A–Whole plant, B–Habitat, C–Flower, D–Inflorescence, E–Seeds.

Material and Methods

The material for the present study was a medicinally important plant *Hypericum perforatum* L. During the present study various methods and approaches were carried out in the field, laboratory and in natural habitats to understand the phenotypic variability and reproductive strategies of the species. The data on various aspects of the phenotypic variability and seed germination were recorded during 2015 to 2019.

Survey, collection and documentation

An extensive exploration of different habitats of Kashmir Himalaya was carried out to identify specific areas across different geological conditions covering a wide range of habitats. To study the phenotypic variability of *Hypericum*

perforatum at different elevational gradients a total of four populations of St. John's wort (*Hypericum perforatum* L.) were selected for the present study from different areas of Kashmir valley from March to November. Geographical origins along with altitude, latitude and longitude of four St. John's wort populations are listed in table 1. All plants samples were collected at flowering stage.

The young seedlings, underground rhizomes, floral parts, fruits and seeds of *Hypericum perforatum* were collected in different seasons. The propagules and young seedlings of the species were also transplanted in the Kashmir University Botanical Garden (KUBG). The plants, fruits and seeds for various studies were collected from both natural habitats as well as from transplanted population.

Population No	Location	Altitude(m)	Latitude	Longitude	Habitat
1	Kangan, Ganderbal	1835	34° 14'N	74° 47'E	Open slopes and pastures
2	Phalgam, Anantang	2350	34° 02'84"N	75° 20' 50"E	Open slopes and disturbed sites
3	Drang, Tangmarg	2235	34°2'870"N	74°25'4.57"E	Sunny open slope with rock cervices
4	*KUBG	1595	34°7'57.17"N	74°50'15.19"E	Open field and on the roadside

Table 1: Salient features of the selected sites.

Species morphology and phenotypic variability

Field trips were organized at the selected sites fortnightly keeping the standard procedures into consideration. All the morphological traits, habitat, associated species and the sample collections were done at the maturity (flowering stage) of the plant. Herbarium specimens were prepared following standard herbarium procedures and the plant species were identified by consulting relevant literature and herbarium studies at Kashmir University Herbarium. Photographs were taken with Samsung camera of the resolution of 16 pxl. To study the botany traits (microscopic and macroscopic characteristics) of St. John's wort plant, 10 plant samples of each population in each region were randomly collected. The morphological traits that were assessed for phenotypic variability included: Plant height, number of leaves per plant, mean leaf length per plant, mean leaf breadth per plant, rhizome length, root length and inflorescence length etc. (Table 2). Microscopic characteristics included dark and light glands density on the leaves (the bottom, middle and top leaves) and dark and light glands density on the leaves surface area. The macroscopic and microscopic characteristics including dark glands density on the leaves were measured at the collection sites. The other microscopic traits were examined at the laboratory. Simple statistics (*i.e.* mean, maximum, minimum and standard deviation) were used in order to compare all morphological traits.

S.NO.	Phenotypic character	Population	Range of variation	Mean \pm SD
1	Plant height (cm)	Drang, Tangmarg	25-40	32.5 \pm 4.57
		Kangan, Ganderbal	19-37	27.16 \pm 6.31
		Phalgam, Anantang	18-30	24.50 \pm 4.42
		KUBG	23-52	36.63 \pm 9.07
2	No. of leaves per plant	Drang, Tangmarg	97-130	110.16 \pm 11.85
		Kangan, Ganderbal	87-120	107.33 \pm 11.42
		Phalgam, Anantang	98-131	116 \pm 10.31
		KUBG	89-149	132.33 \pm 20.92
3	Root length	Drang, Tangmarg	8-12	10.58 \pm 2.70
		Kangan, Ganderbal	7.9-12	10.40 \pm 1.62
		Phalgam, Anantang	7.9-13	10.33 \pm 1.83
		KUBG	7-16	10.05 \pm 3.09
4	Inflorescence length (cm)	Drang, Tangmarg	79-150	123.66 \pm 25.32
		Kangan, Ganderbal	100-121	93.22 \pm 10.31
		Phalgam, Anantang	79-102	92.16 \pm 10.41
		KUBG	87-118	97.66 \pm 10.07

5	Leaf length per plant (cm)	Drang, Tangmarg	1-1.7	1.23 ± 0.02
		Kangan, Ganderbal	1.5-2.0	1.43 ± 0.01
		Phalgam, Anantang	1.2-1.3	1.12 ± 0.01
		KUBG	1.6-2.4	1.59 ± 0.09
6	Stem diameter	Drang, Tangmarg	5-8	8.23 ± 1.0
		Kangan, Ganderbal	6-9	8.41 ± 1.01
		Phalgam, Anantang	4-9	8.11 ± 1.01
		KUBG	5-11	8.89 ± 1.23
7	Dark gland density on leaves	Drang, Tangmarg	31-70	50.00 ± 13.28
		Kangan, Ganderbal	42-83	52.32 ± 13.30
		Phalgam, Anantang	37-98	52.76 ± 13.27
		KUBG	26-69	49.67 ± 12.32
8	Light gland density on leaves	Drang, Tangmarg	108-416	226.5 ± 97.87
		Kangan, Ganderbal	200-395	201.7 ± 69.66
		Phalgam, Anantang	200-350	200.31 ± 77.23
		KUBG	100-200	157.75 ± 39.67

Table 2: Phenotypic variability of *Hypericum perforatum* across different sites.

Results

Studies of morphology and reproductive biology of plants help in understanding the nature of the species adaptation, phenotypic variability with altitude habitat, systematics and reproductive success. Characterization of the morphology of the species provides valuable information about the phenotypic variability and habitat and the effect of altitude on it. Present investigation revealed that *Hypericum perforatum* grows mostly in open grassy slopes along with shrub-beries, in disturbed soil along the roadside and on the rocky slopes where enough soil cover is available. It grows along a varied range of altitude from 1000-4000 m above sea level. In Kangan it grows along the sloppy area within the shrubs of *Medicago* and *Indigofera* sp. In Drang the plant was growing well in the rocky areas where abundant soil is available. In Pahalgam it has its occurrence along roadside and disturbed open slopes within shrubberies. The four populations that were used in the present study are Pahalgam, Drang, Kangan and KUBG Srinagar. *H. perforatum* consist of freely branching shrubby herbs that typically range from 18 to 40 cm in height. The stems and branches are densely covered by oblong, smooth-margined leaves that range from 1 to 2 cm long and 0.3-1.0 cm wide. The leaves are interrupted by minute translucent spots that are evident when held up to the light. The upper portions of mature plants can produce several dozen five-petaled yellow flowers that are typically 1.0-2.0 cm wide and the whole inflorescence stretches between 79-121 cm. The edges of the petals are usually covered with black dots. Crushed flowers produce a blood-red pigment. By late summer, the flowers produce capsules that contain dozens of tiny, dark-brown seeds. It thrives in poor soils and is commonly found in meadows, fields, waste areas, roadsides and abandoned land.

Discussion

The plant exhibits a significant variability in its phenotypic traits under different environmental conditions. The data collected from the sites is simplified in terms of range of variation, mean and standard deviation as shown in the table 2.

Hypericum perforatum (St. John's wort) populations were evaluated in respect of dark and light glands density on the leaves. The population at Pahalgam had the greatest dark glands density on the leaves *i.e.* 52.76 ± 13.27 cms and the least dark glands density on the leaves were seen in KUBG population with 49.67 ± 12.32 cms. It can also be seen from the data that more is the mean plant height; more is the number of leaves per plant because of the increased number of branching *e.g.*, average plant height at Drang is 32.5 ± 4.57 cms with mean number of leaves more *i.e.* 110.16 ± 11.85 compared to Kangan having mean plant height 27.16 ± 6.31 cms and 107.33 ± 11.42 cms mean no of leaves per plant. It can also inferred from the data that with increasing altitude mean root length increases with highest at Drang with 10.58 ± 2.70 cms to lowest at KUBG with 10.05 ± 3.09 cms. Inflorescence length had profound effect of altitude as the population of Drang was found to have highest inflorescence length with 123.66 ± 25.32 cms and the population at Kangan had least inflorescence length of 93.22 ± 10.31 cms. Similar variability was found to occur in case of leaf length in the *Hypericum perforatum*. Both of these parameters are vital for the existence and propagation of the plant species considering the extreme environmental conditions into consideration.

Conclusion

Hypericum perforatum (St. John's wort) grown at different elevational range exhibited differences in plant architecture, biochemistry and reproduction. These changes resulted from the combined effects of seasonal dynamics and the elevational gradients of environmental factors. It has been studied that *H. perforatum* L. depicts morphological characteristics in different altitudes such as plant height decreased at high altitudes due to reduction of stem internodes number and also decrease of leaf chlorophyll content [9]. Similar results were found in the present study. Our results indicated that leaves and flowers number, leaves dimensions and dark and light glands density on the leaves increased with rising stem height, flowering branches number and secondary branches number. Based on results of our study it showed that every environmental condition (location) had an enormous effect on the growth and development, plant reproduction, height, leaves, flowers and inflorescence dimensions, etc. of *H. perforatum* L.

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Conflict of interest

The authors declared that they have no conflict of interest.

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