

Original Research Article

## Impact on Density of *Paeonia emodi* along altitudinal gradient in Garhwal Himalaya, India

Prakash, Prem<sup>1</sup>, Joshi, Praveen<sup>1</sup> and Purohit, Vijay Kant<sup>2</sup>

<sup>1</sup>Department of Botany, Govt. M. B. P.G. College, Haldwani, Kumaun University Nainital, Uttarakhand

<sup>2</sup>High Altitude Plant Physiology Research Centre, H N B Garhwal Central University, Srinagar Garhwal, Uttarakhand

Corresponding Author: [drpp\\_bot@yahoo.co.in](mailto:drpp_bot@yahoo.co.in)

### ARTICLE INFO

Received: 21 July 2020 | Accepted: 15 August 2020 | Published Online: 30 September 2020

EOI: 10.11208/essence.20.11.SP2.132

Article is an Open Access Publication

This work is licensed under Attribution-Non Commercial 4.0 International

(<https://creativecommons.org/licenses/by/4.0/>)

©The Authors (2020): Publishing Rights @ MANU—ICMANU and ESSENCE—IJERC.

### ABSTRACT

In the present study we have described the impact of altitudinal gradient on the density of *Paeonia emodi* in the Garhwal Himalayan region. The study site was divided into three altitudinal gradients viz., between 1800 to 2000, 2200 to 2400 and 2600 to 2800 m asl. We observed that maximum density (3.80 individual/m<sup>2</sup>) and frequency (80 percentage) was found in lower altitude (1800-2200 m asl), medium (2.76 individual/m<sup>2</sup> and 76 percentage, respectively) at mid-altitude (2200-2400 m asl) and minimum (2.08 individual/m<sup>2</sup> and 60 percentage, respectively) at the maximum altitude between 2600 and 2800 m asl. Low population density of *P. emodi* along with increasing elevation is due to the unfavorable climatic conditions and lack of association with tree species like *Oak* and *Rhododendron*. This association provides the canopy cover and moist land as well as suitable habitat to many herbaceous species. The present investigation regarding species availability of target species can be used in understanding the distribution pattern and the relationship with altitudinal gradient of density would help in designing appropriate conservation and management policy to this important medicinal plant in terms of ethnobotanical view.

### KEYWORDS

Altitudinal gradient | Garhwal Himalayan Region | High altitude | *Paeonia emodi* |

Population density

### CITATION

Prakash, Prem, Joshi, Praveen and Purohit, Vijay Kant (2020): Impact on Density of *Paeonia emodi* along altitudinal gradient in Garhwal Himalaya, India. ESSENCE Int. J. Env. Rehab. Conserv. XI (SP2): 98 — 106. <https://eoi.citefactor.org/10.11208/essence.20.11.SP2.132>

## Introduction

The Indian Himalayan Region (IHR) with wide-ranging elevations, deep glacial and river valleys is centre of endemism for biodiversity, harboring endangered species and ecosystems, and sustaining the lives of millions peoples (Nandy *et al.*, 2006). A total of 1748 species of Medicinal and Aromatic Plant (MAPs) with various traditional and modern therapeutic uses (Samant *et al.*, 1998). Altitude and disturbance from human settlements in mountain area significantly influences the species richness and diversity and species cover in mountain region (Adnan and Hölscher, 2010; Namgail *et al.*, 2012). Ecologists have attempted to understand the variation in species density along altitudinal gradients in Himalayan ecosystem (Sharma *et al.*, 2009; Raina and Sharma, 2012; Malik and Nautiyal, 2016; Sharma and Kala, 2018). Hence, the Himalayan region can serve as an excellent system for the evaluation of medicinal plant density along an altitudinal gradient (Austrheim and Eriksson, 2001).

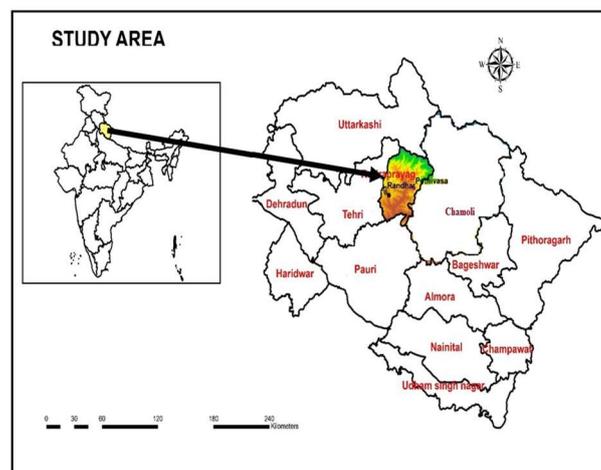
*Paeonia emodi* Wall. ex Royle (family Paeoniaceae), a perennial herb commonly known as ‘Chandra’ or ‘Dhanduru’ is distributed in IHR, between 1500-3000 m asl (Gaur, 1999; Rawat *et al.*, 2010). It generally grows in various forest habitats under moist conditions. The flowers are whitish, born from the axils of upper leaves, 6-10 cm in diameter, hermaphrodite and pollinated by insects. Fruits are oval shaped-pod with leathery in texture. Seeds are black, smooth, and shiny with hard seed coat. The flowering occurs between March-June and fruits appear at the beginning of monsoon (Joshi *et al.*, 2018). *P. emodi* has several applications in traditional medicinal health care systems;

the rhizomes and leaves are used to cure dropsy, epilepsy, headache, vomiting (Shinwari *et al.*, 2003; Hamayun, 2004). An infusion of the dried flowers is useful in treatment of diarrhea, whooping cough, hemorrhoids and intestinal pain (Ahmad and Sher, 2004). However, limited studies are available on medicinal plants densities among different habitats and with changing altitude, specifically in Garhwal region. Therefore, the objective of present study was to investigate the population density of ethnobotanically important species along with changing altitude in Garhwal Himalaya.

## Material and method

### Study area

Present study was conducted at Pothivasa region (30°30'0"N and 79°09'50"E) in Garhwal Himalaya, Uttarakhand, India (Fig 1).

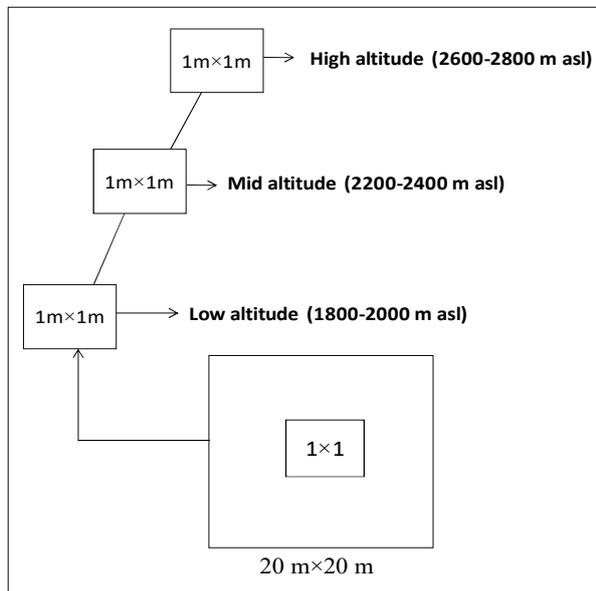


**Fig 1:** Location map showing study area

The study area is characterized by its typical temperate to near alpine climatic conditions. The dominant tree species in the area are *Quercus leucotrichophora*, *Rhododendron arboreum*, *Aesculus indica*, *Lyonia ovalifolia*, etc. Local community adjacent to the forest mostly depend on forest resources

for fodder, fuel wood, livestock grazing, timber and non-timber forest products.

### Sampling design and plot selection



**Fig 2:** Pictorial diagram of hytosociological sampling method

Vegetation sampling was carried out during the rainy season between July and September. The study site has been divided into three altitudinal gradient viz., between 1800 to 2000, 2200 to 2400 and 2600 to 2800 m asl for the study (Fig 2). A single line-transect was used along the altitudinal gradient (1800-2800 m asl) for assessing the status of *P. emodi* and associated herbs. Quadrature method (Misra, 1968) was used to study the plant density and distribution of species across the altitudinal gradient. For sampling, 1×1 m quadrates were randomly laid down at equal intervals with the distance of 200 m along transects. In each sampling quadrature, all plant species were identified and individuals of each species were enumerated. A voucher specimen of *P. emodi* was preserved by following the standard herbarium methods (Jain and Rao, 1977) and submitted in the herbaria of

Botanical Survey of India, Dehradun, Uttarakhand (BSI/NRC-Tech/Herb/Ident./2017-18/plant accession no.118052). Further, species were analyzed for various ecological parameters (frequency, density and abundance) following Curtis and McIntosh (1951). Importance value index (IVI) was calculated by the sum of relative values of frequency, density and abundance following earlier study Suyal *et al.* (2019).

### Results

During the distribution analysis of herbaceous species along the altitudinal gradient at low altitude (1800-2000 m asl), the dominant species was *Stellaria himalayensis* (IVI= 35.98) with co-dominant species such as *Paeonia emodi* (IVI= 35.83) and *Geranium wallichianum* (IVI=34.91). The maximum density was found for *Stellaria himalayensis* (3.84 individual/m<sup>2</sup>) and minimum for *Hedychium spicatum* (1.36 individual/m<sup>2</sup>). The density for *P. emodi* was reported 3.80 individual/m<sup>2</sup> and the frequency was 80% while the distribution pattern was found contagious (Table 1 and Fig 3).

Similarly, at the mid altitude between 2200 to 2400 m asl the dominant species was *G. wallichianum* with an IVI of 37.73. The co-dominant species were *P. emodi* (IVI=36.09), *Potentilla fulgance* (IVI=30.49) and *Viola pilosa* (IVI=29.72). The highest density was reported for *G. wallichianum* (2.92 individual/m<sup>2</sup>) and the lowest for *Paris poliphylla* (0.80 individual/m<sup>2</sup>). At this altitude, the density reported for *P. emodi* was 2.76 individual/m<sup>2</sup> and frequency was 76% while the contagious

distribution pattern was observed (Table 2 and Fig 3).

At the high altitude (2600-2800 m asl) the dominant species was found *V. pilosa* (IVI=46.18) with its co-dominant species namely; *Geum roylei* (44.10), *G. wallichianum* (41.21) and *P. emodi* (38.79). Among all the species, the highest density was recorded for *V. pilosa* (2.64 individual/m<sup>2</sup>) followed by *G. roylei* (2.52

individual/m<sup>2</sup>), *G. wallichianum* (2.24 individual/m<sup>2</sup>), *P. emodi* (2.08 individual/m<sup>2</sup>), *Legularia amplexicaulis* (1.96 individual/m<sup>2</sup>), *Arisaema tortusum* (1.68 individual/m<sup>2</sup>) and so on. The density observed for *P. emodi* was 2.08 individual/m<sup>2</sup> and frequency was 60% while the distribution pattern was found contagious at this altitude (Table 3 and Fig 3).

Species	F %	D	A	A/F	IVI
<i>Paeonia emodi</i>	80	3.80	4.75	0.06	35.83
<i>Paris poliphylla</i>	72	1.48	2.06	0.03	19.49
<i>Viola pilosa</i>	80	2.72	3.40	0.04	28.42
<i>Hedychium spicatum</i>	56	1.36	2.43	0.04	18.12
<i>Legularia amplexicaulis</i>	64	1.60	2.50	0.04	20.13
<i>Arisaema tortusum</i>	76	2.28	3.00	0.04	25.32
<i>Stellaria himalayensis</i>	84	3.84	4.57	0.05	35.98
<i>Geranium wallichianum</i>	84	3.68	4.38	0.05	34.91
<i>Geum roylei</i>	80	2.56	3.20	0.04	27.32
<i>Potentilla fulgance</i>	80	3.36	4.20	0.05	32.81
<i>Calanthe tricarinata</i>	64	1.80	2.81	0.04	21.67

A=Abundance; D= Density (individual/m<sup>2</sup>); F= Frequency (%); A/F= Ratio of abundance to frequency; IVI= Importance Value Index

**Table 1.** Population density of *P. emodi* and its associates between 1800 and 2000 m asl

Species	F %	D	A	A/F	IVI
<i>Paeonia emodi</i>	76	2.76	3.63	0.05	36.09
<i>Paris poliphylla</i>	56	0.80	1.43	0.03	16.38
<i>Viola pilosa</i>	72	2.08	2.89	0.04	29.72
<i>Hedychium spicatum</i>	56	1.00	1.79	0.03	18.55
<i>Legularia amplexicaulis</i>	68	1.72	2.53	0.04	26.21
<i>Arisaema tortusum</i>	68	1.76	2.59	0.04	26.60
<i>Geranium wallichianum</i>	72	2.92	4.06	0.06	37.73
<i>Geum roylei</i>	68	2.04	3.00	0.04	29.35
<i>Potentilla fulgance</i>	72	2.16	3.00	0.04	30.49
<i>Calanthe tricarinata</i>	52	1.20	2.31	0.04	20.72
<i>Anemone revolaris</i>	68	1.92	2.82	0.04	28.17

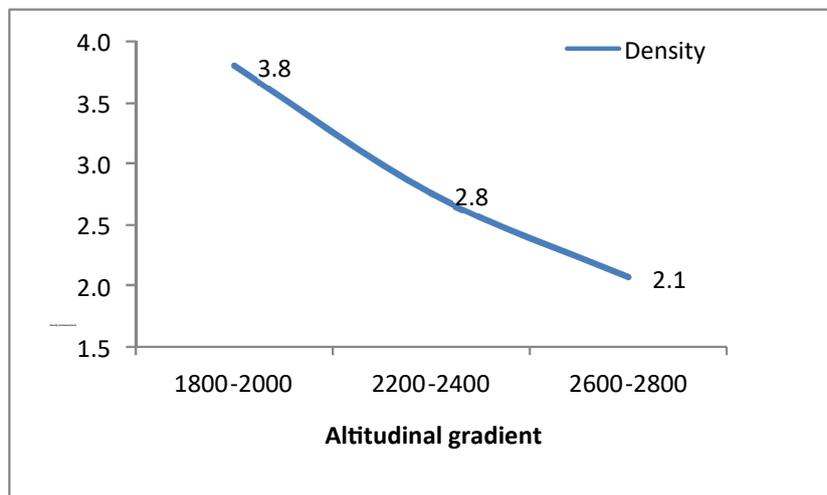
A=Abundance; D= Density (individual/m<sup>2</sup>); F= Frequency (%); A/F= Ratio of abundance to frequency; IVI= Importance Value Index

**Table 2.** Population density of *P. emodi* and its associates between 2200 and 2400 m asl

Species	F %	D	A	A/F	IVI
<i>Paeonia emodi</i>	60	2.08	3.47	0.06	38.79
<i>Paris poliphylla</i>	56	0.88	1.57	0.03	22.63
<i>Viola pilosa</i>	60	2.64	4.40	0.07	46.18
<i>Hedychium spicatum</i>	32	0.40	1.25	0.04	13.66
<i>Legularia amplexicaulis</i>	80	1.96	2.45	0.03	37.74
<i>Arisaema tortuosum</i>	60	1.68	2.80	0.05	33.52
<i>Geranium wallichianum</i>	56	2.24	4.00	0.07	41.21
<i>Geum roylei</i>	76	2.52	3.32	0.04	44.10
<i>Potentilla fulgance</i>	48	0.88	1.83	0.04	22.16

A=Abundance; D= Density (individual/m<sup>2</sup>); F= Frequency (%); A/F= Ratio of abundance to frequency; IVI= Importance Value Index

**Table 3.** Population density of *P. emodi* and its associates between 2600 and 2800 m asl



**Fig 3:** Population density of *P. emodi* under different altitudinal gradient

**Discussion**

The vegetation of any place is the outcome interaction of many factors such as mesotopographic gradients (i.e. slope, aspects and elevation), soil nutrients, species composition and biotic interferences (Le Brocque and Buckney, 2003; Mandal and Joshi, 2014). Moreover, these factors influence the species richness and dispersion behavior of plant species (Eilu and Obua, 2005; Kharkwal *et al.*, 2005). Diversity of life-forms usually decreases with increasing altitude and only one or two life forms remain at extreme altitudes (Pavón *et al.*, 2000). The

low altitudinal sites was relatively dense populated probably because of human interference in these areas facilitates the introducing and establishment of non-native species (Raina and Sharma, 2012; Rawal and Pangtey, 1994). Since the availability of any species in the forest is determined by elevation and habitat types (Sharma and Kala, 2018; Thakur *et al.*, 2016). In the present study it has been revealed that *P. emodi* is distributed in temperate to subalpine regions, ranging in altitudinal gradient between 1800 to 800 m asl across Garhwal Himalayan range inhabiting moist shady and slope habitat. The

habitat of low altitude between 1800 to 2400m was suitable for the growth of *P. emodi* as compared to high altitudes because low altitudes and moderate slopes constitute suitable growth conditions for many herbaceous species suggested by Sharma *et al.* (2009) and Gairola *et al.* (2011). However, Malik and Nautiyal (2016) suggested that the growth activity increases with increase in temperature and moisture. It was found that lower altitudes having the high population density of *P. emodi* in the studied area is due to the presence of other herbaceous species. This is in line with the observations of Siddique (1991) and Gurevitch (1992) that severe climatic conditions operative at higher altitudes have a negative impact on the overall growth of a plant. Similar findings by Nazir *et al.* (2017) observed a great degree of phenotypic variability and on an average, this species found with low population density with increasing altitude gradient in Kashmir Himalaya.

Our study revealed that density of *P. emodi* was found 3.80 individual/m<sup>2</sup> at low altitude which declined up to 2.08 individual/m<sup>2</sup> with increasing altitudes (Fig 3). It was nominal as compared to earlier assessed by Rawat *et al.* (2016) and they observed highest density (8.75±5.52 individual/m<sup>2</sup>) at low altitude (1800 to 2400 m asl) from Badrinath forest division (FD) in Chamoli district. Similar study was done by Rawat *et al.* (2010) reported comparatively low density for *P. emodi* (2.40-1.60 individual/m<sup>2</sup>) at higher elevation between 2500 and 2800 m asl from Kumaun Himalaya and concluded that the species has tendency to spread over a wide space in a given area but is unable to exhibit thick stocking due to the over harvesting,

trampling and highly market demand. Vegetation analysis of *P. emodi* was conducted by Pandeya (2016) and Negi *et al.* (2018) revealed the low densities (1.15–0.85 individual/m<sup>2</sup> and 1.42–0.82 individual/m<sup>2</sup>) under Kumaun Himalaya and Western Himalaya respectively. However, very less density (0.05-0.18 individual/m<sup>2</sup>) for *P. emodi* was recorded by Bhat *et al.* (2013) from Garhwal Himalaya due to the excessive anthropogenic activities. Low population density of *P. emodi* along with increasing elevation in the studied site indicates poor availability due to the unfavorable climatic conditions and lack of association with tree species like *Oak* and *Rhododendron* which provides the canopy covers and moisture land as well as suitable habitats to many herbaceous species. The present study reveals that density of *P. emodi* varies along the altitude; it decreases gradually from lower altitude (1800-2000 m) to high altitude (2600-2800 m).

### Conclusion

This present study revealed that the quantitative information of a species plays a fundamental role in designing conservation and management plans as well as in understanding the ecological behavior of the species. In this study the target species is restricted to some specific habitats with declining density with the increasing altitudinal gradients. This indicated that elevation has different impact on species density in the study area. The present data regarding species availability of target species can be utilized in understanding the distribution pattern and the relationship of different altitudinal gradient with density. This type of study would help in designing

appropriate conservation and management plans to conserve economically important species. In view of this, more detailed research on ecological analysis is needed to develop sustainable utilization and greater attention to maintain the population structure in the natural habitats.

### Acknowledgement

The authors are thankful to the Department of Botany, M.B.G.P.G. College, Haldwani, Nainital Uttarakhand, India for providing facilities to undertake this work. We thanks to the field staff of HAPPRC, H.N.B. Garhwal University Srinagar Garhwal Uttarakhand, India cooperated during the study.

### Conflict of interest

Authors have no conflict of interest.

### References

- Adnan, M., Hölscher, D., Medicinal plant abundance in degraded and reforested sites in Northwest Pakistan. *Mountain Research and Development* 30, 25–32, 2010.
- Ahmad, M., Sher, H., Medicinally important wild plants of Chitral, medicinally important wild plants in view of ethnobotanical study of district Chitral. *PMID* 67, 432–440, 2004.
- Austrheim, G., Eriksson, O., Plant species diversity and grazing in the Scandinavian mountains-patterns and processes at different spatial scales. *Ecography* 24, 683–695, 2001.
- Bhat, J.A., Kumar, M., Bussmann, R.W., Ecological status and traditional knowledge of medicinal plants in Kedarnath Wildlife Sanctuary of Garhwal Himalaya, India. *Journal of Ethnobiology and Ethnomedicine* 9, 1, 2013.
- Curtis, J.T., McIntosh, R.P., An upland forest continuum in the prairie-forest border region of Wisconsin. *Ecology* 32, 476–496, 1951.
- Eilu, G., Obua, J., Tree condition and natural regeneration in disturbed sites of Bwindi Impenetrable Forest National Park, southwestern Uganda. *Tropical Ecology* 46, 99–112, 2005.
- Gairola, S., Sharma, C.M., Ghildiyal, S.K., Suyal, S., Tree species composition and diversity along an altitudinal gradient in moist tropical montane valley slopes of the Garhwal Himalaya, India. *Forest Science and Technology* 7, 91–102, 2011.
- Gaur, R.D., Flora of the District Garhwal, North West Himalaya. *Transmedia*, 1999.
- Gurevitch, J., Sources of variation in leaf shape among two populations of *Achillea lanulosa*. *Genetics* 130, 385–394, 1992.
- Hamayun, M., Studies on ethnobotany, conservation and plant diversity of Utror and Gabral valleys district Swat, Pakistan (PhD Thesis). Quaid-i-Azam University Islamabad, Pakistan, 2004.
- Jain, S.K., Rao, R.R., Handbook of Field and Herbarium Methods, Today and Tomorrow's Printers and Publishers. New Delhi, India, 1997.
- Joshi, P., Prakash, P., Purohit, V.K., Joshi, K., Bioprospecting of *Paeonia emodi* for livelihood enhancement in Western Himalaya, India. *ENVIS Bulletin Himalayan Ecology* 26, 67–70, 2018.

- Kharkwal, G., Mehrotra, P., Rawat, Y.S., Pangtey, Y.P.S., Phytodiversity and growth form in relation to altitudinal gradient in the Central Himalayan (Kumaun) region of India. *Current Science* 873–878, 2005.
- Le Brocque, A.F., Buckney, R.T., Species richness–environment relationships within coastal sclerophyll and mesophyll vegetation in Ku-ring-gai Chase National Park, New South Wales, Australia. *Austral Ecology* 28, 404–412, 2003.
- Malik, Z.A., Nautiyal, M.C., Species richness and diversity along the altitudinal gradient in Tungnath, the Himalayan benchmark site of HIMADRI. *Tropical Plant Research* 3, 396–407, 2016.
- Mandal, G., Joshi, S.P., Analysis of vegetation dynamics and phytodiversity from three dry deciduous forests of Doon Valley, Western Himalaya, India. *Journal of Asia-Pacific Biodiversity* 7, 292–304, 2014.
- Misra, R., Ecology workbook. Oxford & IBH Publ, 1968.
- Namgail, T., Rawat, G.S., Mishra, C., van Wieren, S.E., Prins, H.H., Biomass and diversity of dry alpine plant communities along altitudinal gradients in the Himalayas. *Journal of plant research* 125, 93–101, 2012.
- Nandy, S.N., Dhyani, P.P., Samal, P.K., Resource information database of the Indian Himalaya. Citeseer, 2006.
- Nazir, S., Yaqoob, U., Nawchoo, I.A., Effect of Altitude and habitat characteristics on growth and reproductive allocation in *Paeonia emodi* Wall. ex Royle. *Res. Rev. J. Bot.* 6, 5–12, 2017.
- Negi, V.S., Maikhuri, R.K., Maletha, A., Phondani, P.C., Ethnobotanical Knowledge and Population Density of Threatened Medicinal Plants of Nanda Devi Biosphere Reserve, Western Himalaya, India. *Iranian Journal of Science and Technology, Transactions A: Science* 43, 63–73, 2018.
- Pandeya, H., Vegetation analysis along an altitudinal gradient in forests of Western Ramganga watershed in Kumaun Himalaya, 2016.
- Pavón, N.P., Hernández-Trejo, H., Rico-Gray, V., Distribution of plant life forms along an altitudinal gradient in the semi-arid valley of Zapotitlán, Mexico. *Journal of Vegetation Science* 11, 39–42, 2000.
- Raina, A.K., Sharma, N., Species composition and diversity of tree species along an altitudinal gradient in Sewa catchment of north-western Himalayas, Jammu and Kashmir, India. *Environment Conservation Journal* 13, 173–179, 2012.
- Rawal, R.S., Pangtey, Y.P.S., High Altitude Forest in a Part of Kumaun in Central Himalaya: Analysis along Altitudinal Gradient. *Proceedings-Indian National Science Academy Part B* 60, 557–564, 1994.
- Rawat, B., Gairola, S., Bhatt, A., Habitat characteristics and ecological status of *Paeonia emodi* Wallich ex Royle: A high value medicinal plant of West

- Himalaya. Medicinal Plants- International Journal of Phytomedicines and Related Industries 2, 139–143, 2010.
- Rawat, G., Adhikari, B., Kumar, U., Tiwari, L., Chandola, S., Raut, N., Medicinal plants of Garhwal region, Uttarakhand: Baselines on the status and distribution. Priyanka Graphic Printers, Dehradun, 2016.
- Samant, S.S., Dhar, U., Palni, L.M.S., Medicinal plants of Indian Himalaya– Diversity, Distribution. Diversity, potential values 1998.
- Sharma, C.M., Suyal, S., Gairola, S., Ghildiyal, S.K., Species richness and diversity along an altitudinal gradient in moist temperate forest of Garhwal Himalaya. Journal of American Science 5, 119–128, 2009.
- Sharma, N., Kala, C.P., Patterns in distribution, population density and uses of medicinal plants along the altitudinal gradient in Dhauladhar mountain range of Indian Himalayas. Current Science 114, 2323, 2018.
- Shinwari, Z.K., Khan, A.A., Nakaike, T., Kyōkai, N.S.H., Medicinal and other useful plants of District Swat, Pakistan. Al-Aziz Communications, Peshawar 4, 78–83, 2003.
- Siddique, M.A.A., Germplasm Assessment of rare and threatened medicinal plants of Kashmir Himalayas (PhD Thesis). Ph. D. Thesis, University of Kashmir, Srinagar, (J&K) India 1991.
- Suyal, R., Bhatt, D., Rawal, R.S., Tewari, L.M., 2019. Status of Two Threatened Astavarga Herbs, *Polygonatum cirrhifolium* and *Malaxis muscifera*, in West Himalaya: Conservation Implications. Proceedings of the National Academy of Sciences, India Section B: Biological Sciences 1–10.
- Thakur, K., Puri, S., Verma, J., 2016. Assessment of Species Diversity Along Different Altitudinal Gradients In Bandli Wildlife Sanctuary District Mandi, Himachal Pradesh.