Field Survey of *Nardostachys jatamansi* in Manedada, Gaurishankar Conservation Area, Ramechhap, Nepal

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Abstract

Nardostachys jatamansi is one of the most traded species in Nepal. The present study was conducted to know the availability of *Nardostachys jatamansi* in Manedada, Gaurishankar Conservation Area. Sampling was done by quadrat method at four different altitudinal belts with 50 m difference in between the range from 3800-3950 m asl. Altogether 12 quadrats of 5 m × 5 m were laid down. The number of individuals of *N. jatamansi* and other associated species were counted. The frequency, density, cover and Importance Value Index (IVI) of all the species were determined. Ten individuals of *N. jatamansi* were uprooted from each 5 m × 5 m quadrat randomly, dried for one month and weight was measured. Furthermore, rhizome samples from all the quadrats were collected and mixed for the quantification of essential oil. *N. jatamansi* was the most frequent species in the study area. The density of the species ranged from 64 to 84 per square m with the highest cover ranging from 37% to 41% in the study area. The study area was found rich for *N. jatamansi* with an IVI ranging from 140.9 to 151.8. The collective weight of 10 rhizomes varied significantly with the elevation. The density, cover and rhizome weight were highest at 3850 m asl. The average essential oil content in the rhizome sample was 0.9 %. The richness of *N. jatamansi* in study area might be due to the restriction on the collection of the species by the authorities of Gaurishankar Conservation Area.

Keywords: CITES, Essential oil, Jatamansi, Outcrop, Population, Rhizome

Introduction

Sustainable harvesting practices for wild species have been encouraged globally as an important area for the future prospects (CBD, 2006; UN, 2008). Many dimensions like ecological, biological, sociocultural, political and economic are considered to achieve sustainable use of non-timber forest products (NTFPs) (Hutton & Dickson, 2001; Ghimire et al., 2005). The problems that are being faced in sustainable harvest are: lack of knowledge on management practices and estimation of harvest levels for long term persistence (Ticktin, 2004).

Nardostachys jatamansi (D.Don) DC. (Syn. *Nardostachys grandiflora* DC., local name: Jatamansi) is one of the highly traded species belonging to the family Caprifoliaceae. It is a perennial herb growing in rocky slopes, rock outcrops, meadows, shrub land and forests of Himalayan region from 3200 to about 5000m asl in Nepal (Press et al., 2000; Ghimire et al., 2008). Herbarium deposition in National Herbarium and Plant Laboratories (KATH) and Tribhuvan University Central Herbarium (TUCH) shows that the *N. jatamansi* is distributed in 21 districts of Nepal, while the five-year management plan of Division Forest Office shows its distribution in 28 districts of Nepal (Ghimire & Dhakal, 2019).

N. jatamansi is prioritized by Government of Nepal for research and economic development (DPR, 2017). It is also a major species among 13 prioritized NTFP species by Government of Nepal for Agro-technology development (DPR, 2017). Recently, the various programs for its cultivation have been promoted in Nepal (DPR, 2019). It is one of the important commodities for supporting the livelihood of rural people of mountainous regions in Nepal.

N. jatamansi has been enlisted in Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) appendix II in 1997 as its population has been declining due to over exploitation, overharvesting of its rhizome for commercial trade throughout its range countries

(India, Nepal, Bhutan) (Mulliken, 2000). The Forest Regulations, 1995 has banned to export the species from Nepal which was amended in 2001 and allow the export of the species in processed form (Nepal Gazette, 2001). Since then, the semi-processed products (essential oil and marc) from rhizomes have been exporting to different countries. The average annual export of Jatamansi marc in the period (2013-2017) was about 253.8 tons (Ghimire & Dhakal, 2019). CITES Secretariat, Geneva as well as Control of International Trade of Endangered Wild Fauna and Flora (CITES) Act, 2017 of Nepal had again banned the trade of Jatamansi in 2017. In 2019 after the submission of Non-detrimental findings (NDF) of Jatamansi to CITES Secretariat, CITES Secretariat, Geneva had provided quota (382.7 tons dry weight of rhizome) as mentioned in the Non-detrimental findings for the export. Now Nepal can only export Jatamansi marc and oil equivalent to 382.7 tons of dry rhizome. NDF is a conclusion provided by a Scientific Authority that the export of specimens of a particular species will not impact negatively on the survival of that species in the wild. The non-detriment finding of each traded species should be prepared by Scientific Authority before an export or import permit granted for a specimen of an Appendix-I and II species (CITES). NDF is based on the best available scientific information. Population status is one of the key indicators of NDF. Status of the *N. jatamansi* population had been studied in few *N. jatamansi* resource districts of Nepal (Ghimire et al., 1999; Chhetri & Gautam, 2015; Shrestha & Shrestha, 2012).The main objective of the current study was to know the availability of *Nardostachys jatamansi* in Gaurishankar Conservation Area. This study has been conducted to support the preparation of NDF of *N. jatamansi*.

Materials and Methods

Study area

The study was conducted in west facing slope of Manedada of Chipleni Protected Forest, Gokulganga Rural Municipality-1, Ramechhap district, Central Nepal in October 2019. It lies in Gaurishankar Conservation Area (GCA), one of the protected areas of Nepal (Figure 1). GCA covers an area of 2,179 sq. km encompassing 2 Municipalities and 8 Rural Municipalities (RM) of three districts, Sindhupalchok, Dolakha and Ramechhap of Bagmati province of the country. GCA is rich in biodiversity which comprises of 16 major vegetation types of subtropical to alpine vegetation and harbors 565 plant species (NTNC, 2010).

Manedada is the trekking route of Jatapokhari and Panchpokhari. The Gokulganga RM ranges in the altitudinal gradient of 2000 to 4500 m asl which comprises the area of 198 sq. km, a population of 20,074, and major ethnic groups are Sherpa, Chhetri, Newar, and Kami (CBS, 2011). The area was found rich for medicinal and non-timber plants like *Aconitum spicatum* (Bikh), *Giradiana diversifolia* (Allo), *Cautleya spicata* (Gagleto), *Edgeworthia gardneri* (Argeli), *Artimisia vulgaris* (Titepati) etc.

Short questionnaire and interaction were carried out with local people and with key informants to know the status, trade and conservation attempts for high value medicinal plants with special focus on *N. jatamansi.*

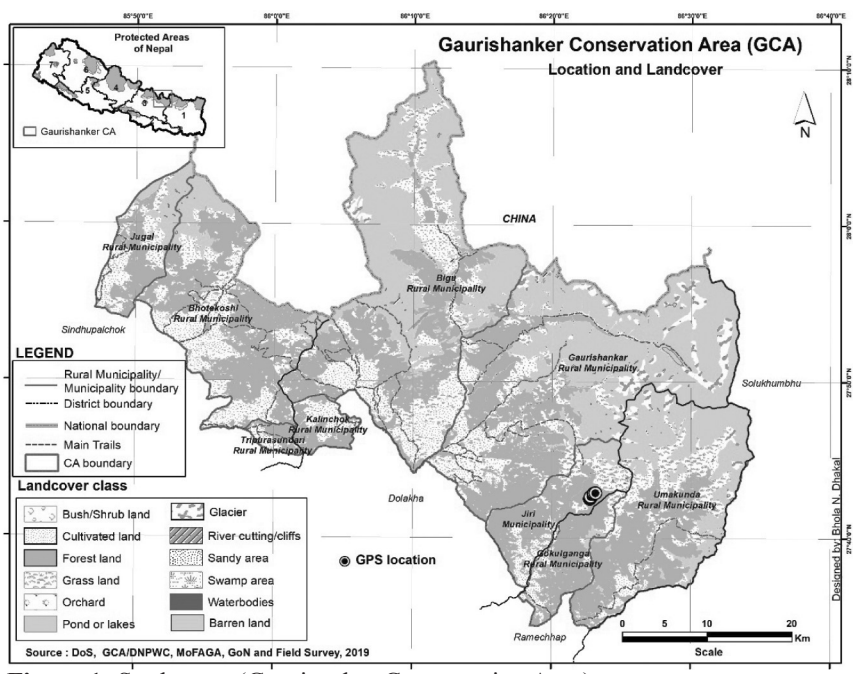

Figure 1: Study area (Gaurisankar Conservation Area)

Sampling method

N. jatamansi rich area at the study site was identified by the interaction with local people. Known sites were sampled by quadrat methods following Zobel et al. (1987). *N. Jatamansi* was found from 3800 at the study site. Thus, four different altitudinal belts with difference of 50 m in the range at 3800-3950 m asl were selected for sampling (Figure 2). Due to physical constriction and discontinuous distribution of *N. Jatamansi*, three plots of 5 m × 5 m at purposive were made at each altitudinal belt. Then three small quadrats of 1 m × 1 m were laid down randomly in each plot. Individuals of *N. jatamansi* and other associated species in each small quadrat were counted. Percentage cover of each species in the quadrat was measured. Frequency (F), relative frequency (RF), density (D), relative density (RD), cover and relative cover (RC) were determined following Zobel et al. (1987). Individuals of *N. jatamansi* were not observed at 3950 m. Soil samples were collected from each plot and the pH of mixed soil sample was measured using pH meter. Ten individuals of *N. jatamansi* were uprooted from each 5 m × 5 m plots randomly, all the rhizomes were separated and packed in the news paper and brought into the laboratory. They were shade dried for one month and collective weight of 10 individuals was measured using a digital balance. Furthermore, more rhizome samples from all the quadrats were collected and mixed for the quantification of essential oil.

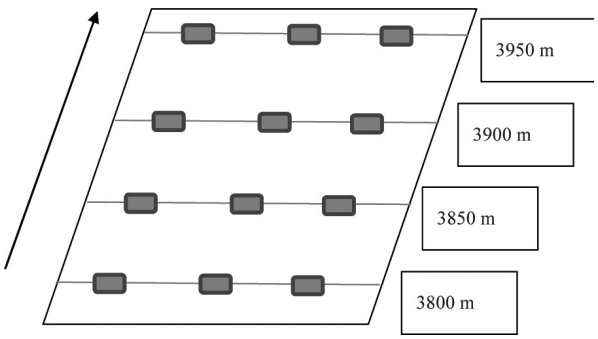

Figure 2: Schematic sampling design for plant survey of *Nardostachys jatamansi*.

Quantitative analysis

The density, frequency, and abundance of tree species, shrubs and herbs were determined with the following formula as per Zobel et al. (1987).

(a) Frequency (%) = Number of quadrats in which the species occurred × 100 / Total number of quadrats studied.

Relative frequency = Frequency of the species A / Total frequency of all species × 100

(b) Density / m^2= Total number of individuals of a species in all quadrats / Total number of quadrats studied

Relative density = Number of individuals of the species A measured / Total number of individuals of all the species × 100

(c) Cover: It was estimated by visual estimation method.

Relative cover = Cover of the species A / Total cover of all the species × 100

d) Importance Value Index: This index was calculated by summing the percentage values of the relative frequency, relative densities and relative cover.

Extraction and quantification of the Essential oil

Five hundred gram of fresh weight of rhizome was taken randomly from the study sites. It was dried in shade for one month. All the waste material were removed and again weighed. The essential oil content in the dried sample was extracted by hydro distillation method using the Clevenger apparatus which was repeated three times for the sample. The volume in ml of the oil was taken at room temperature.

Statistical analysis

One-way ANOVA was performed to test the significance difference of means for the weight of 10 rhizomes among the elevation belt, and Fisher's Least Significant Difference (LSD) post hoc comparisons were also performed using Statistical Package of Social Sciences (SPSS version 20.0.0).

Results and Discussion

The collective weight of 10 rhizomes varies significantly with the altitude ($P<0.001$) (Figure 3). The weight of rhizome was found higher at the altitude 3850 m asl. There was the presence of more

bushy shrubs like *Rhododendron anthopogon*, *R. lepidotum* at 3850 m asl which could have added more moisture and fertility to the soil. Moist and fertile soil might have led to the accumulation of more weight to the rhizomes of *N. jatamansi* which is also supported by Larson (2002). According to Larson (2002) abiotic factors may have a large impact on yield.

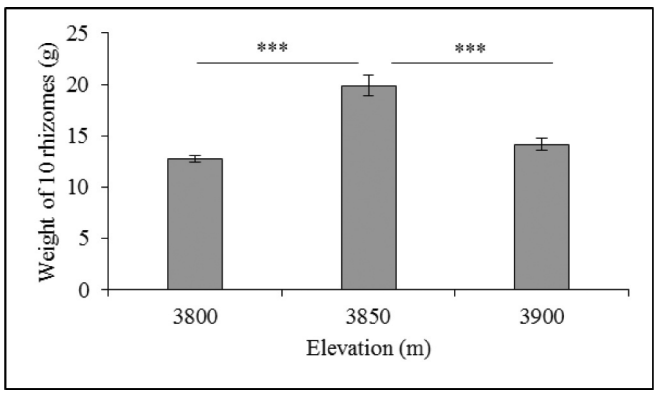

Figure 3: Weight of rhizome along various altitudinal belts. Values are means (n = 3) ± SD. Data were analyzed with one-way ANOVA and LSD post hoc comparisons; ***p < 0.001.

N. jatamansi was the most frequent species in the study area except at 3800 m asl. The density of the species ranged from 64 to 84 per m^2 with the highest cover ranging from 37% - 41% in the study area (Table 2). The highest density and the cover were reported from 3850 m asl (Table 2). The study area was found rich for *N. jatamansi* with an Importance Value index (IVI) ranging from 140.9 to 151. 8. Likewise, *Potentilla microphylla, Rhododendron lepidotum, Euphorbia stracheyi*, *R. setosum* were dominant species in the study area (Table 2). The highest value of *N. jatamansi* might be due the favorable slopes and grassland for it. Also, the restriction on the collection of the species by the authorities of GCA might be the reason for

Table 1: Status of *N. jatamansi* in each plot at various altitudinal belt.

Altitude (m asl)	Plot (5 m×5 m)	Density/m^2	Weight of 10 rhizomes (g)
3800	P1	5.7	12.7
	P2	131.7	12.4
	P3	106	13.1
3850	P4	25	20.9
	P5	111.3	18.9
	P6	116.7	19.8
3900	P7	29	13.6
	P8	56.7	14.1
	P9	107.7	14.8
3950	P10	0	0
	P11	0	0
	P12	0	0

Table 2: Summary of frequency, density and cover of the species in various altitudinal belt

S. N.	Name of species	3800 m asl			3850 m asl			3900 m asl		
		Frequency (%)	Density/ m^2	Cover (%)	Frequency (%)	Density/ m^2	Cover (%)	Frequency (%)	Density/ m^2	Cover (%)
1	*Nardostachys jatamansi* (D.Don) DC	88.89	81.11	37.69	100.00	84.33	41.12	100.00	64.44	37.06
2	*Rhododendron lepidotum* Wall. ex G. Don	66.67	1.33	20.66	44.44	0.56	6.59	44.44	0.44	7.76
3	*R. anothopogon* D.Don	11.11	0.11	1.33	0.00	0.00	0.00	0.00	0.00	0.00
4	*R. setosum* D.Don	33.33	0.33	3.80	33.33	0.56	7.05	66.67	0.78	11.42
5	*Euphorbia stracheyi* Boiss	55.56	0.78	1.27	11.11	0.22	0.44	11.11	0.11	0.48
6	*Aconitum spicatum* (Brühl) Stapf	22.22	0.44	0.41	0.00	0.00	0.00	0.00	0.00	0.00
7	*Anaphalis contorta* (D. Don) Hook. fil.	33.33	0.67	0.91	0.00	0.00	0.00	0.00	0.00	0.00
8	*Gentiana depressa* D.Don	0.00	0.00	0.00	0.00	0.00	0.00	33.33	1.22	1.81
9	*Potentilla microphylla* D.Don	100.00	3.56	7.29	100.00	2.44	7.07	66.67	0.89	2.05
10	*Rehum* sp.	0.00	0.00	0.00	33.33	0.33	6.95	0.00	0.00	0.00
11	*Circium* sp.	33.33	0.44	0.64	55.56	1.56	2.98	66.67	1.11	2.79
12	Grass (Common name - Chake)	100.00	4.56	25.98	100.00	4.00	27.78	100.00	5.44	36.62

Table 3: Importance Value Index (IVI) of the species in various altitudinal belt

S. N.	Name of species	3800 m asl				3850 m asl				3900 m asl			
		Relative Frequency	Relative density	Relative cover	IVI	Relative Frequency	Relative density	Relative cover	IVI	Relative Frequency	Relative density	Relative cover	IVI
1	*Nardostachys jatamansi* (D. Don) DC	16.33	86.90	37.69	140.92	20.93	89.72	41.12	151.76	20.45	86.57	37.06	144.09
2	*Rhododendron lepidotum* Wall. ex G. Don	12.24	1.43	20.66	34.33	9.30	0.59	6.59	16.49	9.09	0.60	7.76	17.44
3	*R. anothopogon* D. Don	2.04	0.12	1.33	3.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	*R. setosum* D. Don	6.12	0.36	3.80	10.28	6.98	0.59	7.05	14.62	13.64	1.04	11.42	26.10
5	*Euphorbia stracheyi* Boiss	10.20	0.83	1.27	12.31	2.33	0.24	0.44	3.01	2.27	0.15	0.48	2.91
6	*Aconitum spicatum* (Brühl) Stapf	4.08	0.48	0.41	4.97	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	*Anaphalis contorta* (D. Don) Hook. fil.	6.12	0.71	0.91	7.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	*Gentiana depressa* D. Don	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.82	1.64	1.81	10.27
9	*Potentilla microphylla* D.Don	18.37	3.81	7.29	29.47	20.93	2.60	7.07	30.60	13.64	1.19	2.05	16.89
10	*Rehum* sp.	0.00	0.00	0.00	0.00	6.98	0.35	6.95	14.28	0.00	0.00	0.00	0.00
11	*Circium* sp.	6.12	0.48	0.64	7.24	11.63	1.65	2.98	16.27	13.64	1.49	2.79	17.92
12	Grass (Common name - Chake)	18.37	4.88	25.98	49.23	20.93	4.26	27.78	52.97	20.45	7.31	36.62	64.39

its high IVI. It shows that the area is rich for high value medicinal plants like *N. jatamansi*, *Aconitum spicatum*, and aromatic *Rhododendron* species too.

The average pH of soil was found to be 6.6.

Essential oil percentage

The average essential oil of the rhizome sample was found to be 0.9 % (Table 4) which is lower than the essential oil extracted from the rhizome sample from Jumla (1.52%) and Humla (1.9%) collected in same month (Kadel, 2011). Similarly, the rhizome sample collected from Lauribina (3900m) in October yield 2% essential oil (Pradhan & Paudel, 2014). The variation in oil percentage could be drying periods and their quality as well as geographical location.

Though the *N. jatamansi* is not common in the study area, the occurrence of the plants in the known pocket area is adequate. West facing slope was found to be the most favorable for *N. grandiflora* in the study area. Larsen (2002) and Ghimire (1999) also reported *N. Jatamansi* at about 3800 m on west facing slope of Chaudabise Valley, Jumla and Ponger lake site, Manang with representative abundance. According to the local people, rhizome of *N. jatamansi* has not been harvested extensively since last ten years for trade. Hence, based on our survey and local perception, it can be said that the study site is the pocket area for *N. jatamansi*. Yet, if the collection of the *N. jatamansi* is opened for trade, only 10% rhizome harvesting should be allowed in five-year rotation period as the size of rocky outcrop populations would return to initial values within 5 years, only after 10% rhizome harvesting (Ghimire et al., 2008).

Conclusion

From the study we can conclude that the study site is rich for Jatamansi population due to undisturbed habitat. Essential oil content is comparatively lower than other places like Jumla, Humla, Rasuwa. This indicates the quality of rhizome at this site is not so better.

Table 4: Essential oil (%) of dry rhizome of *Nardostachys jatamansi*

Fresh wt. of Rhizome including debris (g)	Dry wt. of cleaned rhizome (g)	Decrease in weight (%)	Oil (%)
500	141.5	71.7	0.9

Author Contributions

First author was involved in concept development, research designing, literature review. All Authors collected the data. Statistical analysis was done by second author. First author, second author and fourth author analysed data, and prepared manuscript. First author and second author edited and reviewed the manuscript. Kalpana Sharma (Dhakal), as a corresponding author, is the guarantor for this article.

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References

CBD. (2006). VIII/15. *Framework for Monitoring Implementation of the Achievement of the 2010 Target and Integration of Targets into the Thematic Programmes of Work*. Conference of the parties to the Convention on Biological Diversity Eighth meeting Curitiba, Brazil.

Chhetri, R., & Gautam, R. K. (2015). *Conservation of three threatened medicinal plant species and their habitats in Langtang National Park (Nepal) for livelihood improvement.* A Research Report Submitted to Rufford Small Grant for Nature Conservation, U.K.

DPR. (2017). Kheti Prawidhi Anusandhan Karyaka lagi Prathamikataprapta Jadibutiharu. *Banaspatishrot Samacharpatra, 21*(1), 2.

DPR. (2019). *Operating Procedure on Subsidy for Medicinal Plants Development*. Department of Plant Resources, Nepal.

Ghimire, M. D., & Dhakal, K. S. (2019). *Non - detrimental findings for Nardostachys grandiflora DC. from Nepal.* Department of Plant Resources, Nepal.

Ghimire, S. K., Sah, J. P., Shrestha, K. K., & Bajracharya, D. (1999). Ecological study of some high altitude medicinal and aromatic plants in the Gyasumdo valley, Manang, Nepal. *Ecoprint* 6 (1), 17-25.

Ghimire, S. K., Gimenez, O., Pradel, R., McKey, D., & Aumeeruddy-Thomas, Y. (2008). Demographic variation and population viability in a threatened Himalayan medicinal and aromatic herb *Nardostachys grandiflora*: matrix modelling of harvesting effects in two contrasting habitats. *Journal of Applied Ecology, 45*(1), 41-51.

Ghimire, S. K., McKey, D., & Aumeeruddy-Thomas, Y., (2005). Conservation of Himalayan medicinal plants: Harvesting patterns and ecology to two threatened species, *Nardostachys grandiflora* DC. and *Neopricrorhiza scrophoulariflora* (Pennell) Hong. *Biological Conservation,124,* 463-475.

GoN (1995)**.** *Forest Regulation 1995*. Nepal Law Commission, Nepal.

https://cites.org › eng › resources › quotas.CITES

Hutton, J., & Dickson, B., (2001). Conservation out of exploitation: a silk purse from a sow's ear? In J. D. Reynolds, G. M. Mace, K. H. Redford, J. G. Robinson, (Eds.), *Conservation of Exploited Species* (pp. 440-461). Cambridge University Press.

Kadel, K. L. (2011). *Quality Assessment of Essential Oil from Rhizomes of Nardostachys grandiflora DC. from Humla and Jumla, western Nepal.* (Unpublished Master dissertation), Tribhuvan University, Nepal.

Larson, H. O. (2002). Commercial medicinal plant extraction in the hills of Nepal: Local management system and ecological sustainability. *Environmental Management*, *29*(1), 88-101.

Mulliken, T. A. (2000) Implementing CITES for Himalayan medicinal plants *Nardostachys grandiflora* and *Picrorhiza kurroa*. *Traffic Bulletin*, *18*, 63-72.

Nepal Gazette. (2001). *Forest Regulation* vol. 3, Section 51 No. 36, Ministry of Forests and Soil Conservation, dated December 31, 2001.

NTNC (2010). *Gaurishankar Conservation Area Project*. National Trust for Nature Conservation, Nepal.

Pradhan, R., & Paudel, K. (2014). Seasonal variation of the essential oil of *Nardostachys grandiflora* DC., *Bul. Dept. Pl. Res. 36*, 76-78.

Press, J. R., Shrestha, K. K., & Sutton, D. A. (2000). *Annotated Checklist of the Flowering Plants of Nepal*. The Natural History Museum, UK.

Shrestha, N., & Shrestha, K. K. (2012). Vulnerability assessment of high-valued medicinal plants in Langtang National Park, central Nepal. *Biodiversity, 13*(1), 24-36.

Ticktin, T. (2004). The ecological implications of harvesting non-timber forest products. *Journal of Applied Ecology*, *41*, 11-21.

UN. (2008). *Fact Sheet*, Goal 7: Ensure Environmental Sustainability United Nations.

Zobel, D. B., Jha, P. K., Behan, M. J., & Yadav, U. K. R. (1987). *A Practical Manual for Ecology*. Ratna Pustak Distributor, Nepal.