International Journal of Botany Studies
ISSN: 2455-541X, Impact Factor: RJIF 5.12
www.botanyjournals.com
Volume 2; Issue 4; July 2017; Page No. 28-31

Seasonal variation in lichen litter in different forest types of Kumaun Himalaya, India

Mahesh Kumar Arya, Balwant Kumar, Vijay Arya, Sonam

Department of Botany, Kumaun University, S.S.J. Campus Almora, Uttarakhand, India

Abstract
The study aims to assess lichen litter distribution and biomass in three altitudinal zones of Kumaun Himalaya. A total of 60 permanent quadrats having 2 m x 2 m size were randomly placed in the three different forest types i.e. *Q. leucotrichophora* mixed conifer forests, *Quercus leucotrichophora* broad leaved, and *Q. floribunda* broad leaved forest along the altitudinal gradient. Lichen litter samples from each sampled quadrat were collected on quarterly basis for assessment of their density, frequency and biomass. Maximum nine lichen species were found as litter fall at *Q. floribunda* forest (2200-2500 m asl) followed by eight from *Q. leucotrichophora* broad leaved forests (1700-2100 m asl). The overall density (Ind/ha) of fallen lichen in summer, rainy, winter, and spring season was found to be ranging from 27125-46625, 3500-23125, 8750-14125, and 6250-17500 respectively across the studied forests. Lichen litter biomass (g/ha) in summer, rainy, winter, and spring season ranged between 3450-4625, 238-1263, 963-1158, and 738-1025 respectively across the studied forests. Maximum lichen litter biomass was estimated in summer due to dryness of tree twigs and branches.

Keywords: lichen litter, density, biomass, forest types, Kumaun Himalaya

1. Introduction
High biomass of epiphytic lichens is a characteristic feature of many old-growth forest ecosystems in temperate and boreal areas (Esseen and Renhorn, 1998) [7]. In India, mostly Himalayan region is a rich centre of lichen diversity. This region holds a rich variety of ecological systems. Because of their vertical dimension, mountain creates gradient of temperature, precipitation and insulation. Macrolichens are substantial elements of the non-woody biomass in some forest ecosystems and contribute significantly to canopy nutrient capital and turnover (Boucher and Stone, 1992; Pike, 1978; Rhoades, 1995) [2, 15, 17]. Studies of the Northwest Pacific forests indicate that lichens are important component of food chain, and they play a significant role in forest nutrient cycling (Maser *et al*., 1985; Pike, 1978) [13, 16]. Besides ecosystem functioning and other uses lichens are important source of food for mammals like woodland caribou (Edwards and Ritcey, 1960; Rominger *et al.*, 1996; Terry *et al.*, 2000) [6, 18, 21] and flying squirrel (Maser *et al*., 1985; Zabel and Waters, 1997) [12, 23]; black-tailed deer, mule deer, musk deer goats, sheep, pikas and bats during winter when snow fall occur and reduce the availability of vascular forage plants (Conner, 1983; Hodgman and Bowyer, 1985; Kumar *et al.*, 2009; Stevenson and Rochelle, 1984; Waterhouse *et al.*, 1991) [3, 8, 11, 19, 22]. Some lichens are also ecologically important as food, shelter and nesting materials for a variety of birds (Mc Cune and Geiser 1997) [13].

In the remote hills of Kumaun and Garhwal Himalaya and other adjoining areas of Uttarakhand lichen litter collection is a livelihood activity of the local community. Milam, Askot, Jageshwar, Devidhura in Kumaun and Ghes-Balan, Mundoli, Malari, Rudranath, Madhmaheshwar etc. are common areas of Garhwal region where lichens are found abundantly (Kumar, 2012) [9]. Lichen collection and trade is a tradition practice of the stakeholders residing in these remote areas. Lichen taxa of these regions were studied by various authors but a few studies have focused on the lichen biomass and seasonally availability of lichens and regularly fallen lichen species (Kumar *et al.*, 2009; Rawat *et al.*, 2014) [11,16]. Standing crop of lichens may reach 1-3 tonnes ha^{-1} d.w. (Boucher and Stone, 1992) [2] while litter fall (fallen lichen) rates up to 320 kg ha^{-1} yr^{-1} were reported by Pike (1971) [14] and Stevenson (1986) [20]. *Quercus* twigs contributes maximum biomass as compared to other parts of the tree (Arya and Kumar, 2017; Kumar and Upreti, 2008) [1,10]. In the present investigation lichen litter biomass were assessed along the altitudinal gradients in three forests types situated in Kumaun Himalayan region.

2. Material and method
2.1 Study area
The lichen litter biomass study was carried out in temperate areas of Kumaun Himalaya during the year 2014-15. The whole study area was categorized into three altitudinal zones: site I at Goluchina (1300-1600 m), site II at Binsar-Mahadev (1700-2100 m) of Almora district and site III at Kilbary forest (2200-2500 m) of Nainital district. Based on the vegetation types, the study sites were considered as *Q. leucotrichophora* mixed conifer forests (site I), *Quercus leucotrichophora* broad leaved (site II), and *Q. floribunda* broad leaved forest (site III). Geographically the studied forests lie between 29° 24′ 76″ to 29° 35′ 59″ N latitude and 79° 17′ 28″ to 79° 26′ 89″ E longitude. Presently lichen extraction is not done for any purpose in the study area. But more than two decades ago, the local inhabitants and outsiders used to extract lichens from the site III (i.e. Kilbary forest) for commercial purposes.

2.2 Sampling and lichen litter biomass estimation
Sampling was done as per method used by Kumar *et al.* (2009) [11]. A sum of 60 permanent quadrats (20 at each forest) having 2 m x 2 m size was randomly placed along the

altitudinal gradient in the studied forests. Quarterly observations were taken and thus four seasons viz. summer (April-June), rainy (July-September), winter (October-December) and spring (January-March) were considered for the study. In each observation lichen litter (fallen lichens) with and without twigs were collected carefully from each sampled quadrat. Curtis and McIntosh (1951) [5] method was applied to calculate density, frequency, abundance etc. The distribution pattern of fallen lichen species was calculated as the ratio of abundance to frequency in a community. Curtis and Cottam (1956) [4] suggested three pattern of distribution as regular (less than 0.025), contagious (0.025- 0.05) and random (more than 0.05). Fallen twigs on ground, bearing lichens were collected carefully and were placed in poly bags for further identification. The lichens were scratched of the twigs using a sharp knife. Fresh weight of the collected material (lichens & twigs) taken using an electronic balance which was oven dried at 60 ºC for 48 hours till constant weight. Seasonally collected lichen litter samples including lichens removed from fallen twigs were weighed. Collected samples were packed in hard card boards containing field notes viz. date of observation or collection, type of lichen, name of collector, quadrat number etc.

2.3 Identification of lichen taxa

Lichen litter specimens were identified morphologically, anatomically and chemically at Lichenology Laboratory of the CSIR-National Botanical Research Institute, Lucknow. The collected specimens were packed on hard card sheets inside a lichen herbarium packet (17 cm x 10 mm) with details of the locality and are preserved at Biodiversity Conservation Laboratory, Department of Botany, S.S.J. Campus Almora (Uttarakhand).

3. Result and Discussion

3.1 Distributional analysis of fallen lichen litter

A total of nine species of lichens such as *Canoparmelia ecaparata* (Mull. Arg) Elix & Hale; *C. texana* (Tuck) Elix & Hale; *Everniastrum cirrhatum* (Fr) Hale; *Heterodermia diademata* (Taylor) D.D. Awasthi; *Parmotrema tinctorum* (Nyl.) Hale; *P. praesorediosum* (Nyl.) Hale; *Ramalina sinensis* Jatta; *R. conduplicans* Vain; *Usnea orientalis* Mot were recorded as lichen litter from the study area. Out of which maximum 8 species each were found in summer and winter season at site II and in spring at site III followed by seven species each in summer at site III and in rainy at site II and III. Minimum three species of fallen lichens were found in spring season at site I and II. Mainly two lichen species viz. *P. praesorediosum* and *R. conduplicans* were dominant as lichen litters in all the seasons at all the respective sites. *R. sinensis* was found only in summer at site III. The overall fallen lichen density (Ind/ha) ranged between 27125-46625, 3500-23125, 8750-14125, and 6250-17500 in summer, rainy, winter, and spring season respectively across the studied forests (Table 1). Maximum density was observed for *P. praesorediosum* during all the season at site I. Site I is a community forest, well protected and dense in *Q. leucotrichophora* with mixed conifers. The manmade disturbances were also very less as compared to other study sites. The detailed parameters regarding distributional analysis has been given in the Table 2.

3.2 Fallen lichen litter biomass

Lichen litter biomass (g ha^{-1}) in summer, rainy, winter, and spring season was estimated to be ranging from 3450-4625, 238-1263, 963-1158, and 738-1025 respectively across the studied forests (Table 1). Maximum lichen litter biomass was estimated in summer due to dryness of tree twigs and branches. More lichen litter biomass was estimated at site I in comparison to other studied sites as the site I is *Q. leucotrichiphora* mixed conifer forest. Coniferous forest floor exhibits more lichen biomass than the other forests (Rawat *et al.*, 2014) [16].

Table 1: Fallen lichen litter density and biomass across various seasons in the study sites

Season	Density (Ind./ha)			Biomass (g/ha)		
	Site I	Site II	Site III	Site I	Site II	Site III
Summer	46625	29375	27125	4625	3450	3613
Rainy	23125	3500	11750	1450	238	1263
Winter	14125	8750	13750	1050	1188	963
Spring	11750	6250	17500	738	500	1025

3.3 Regularly fallen lichen species

A single lichen species *Ramalina conduplicans* was found as regularly fallen species in summer season at site II. However most of the species (3-8 species) were found in contagious distribution in all the seasons across the various study sites. 1-2 species were found in random distribution (Fig. 1).

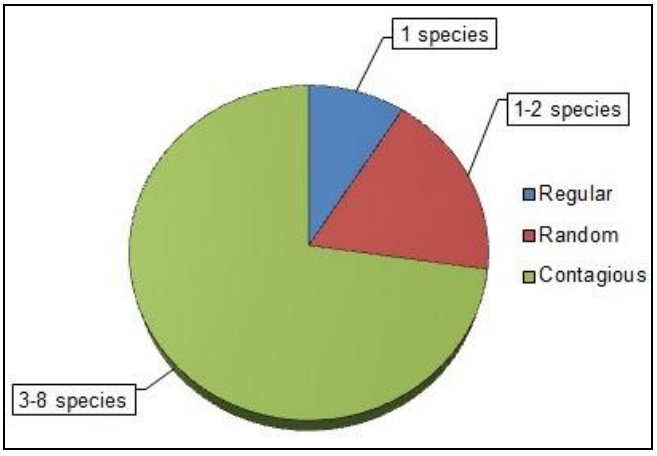

Fig 1: Distribution pattern of fallen lichen species

Table 2: Distributional analysis of lichen litter in different seasons in the study area

Fallen lichen taxa	Density (Ind/ha)			Frequency (%)			Abundance			A/F		
	Site I	Site II	Site III	Site I	Site II	Site III	Site I	Site II	Site III	Site I	Site II	Site III
Summer season												
Canoparmelia ecaparata	1125	1375	-	25	20	–	1.8	2.8	–	0.072	0.14	-
C. texana	875	4750	875	20	55	15	1.8	3.5	2.3	0.09	0.063	0.153
Everniastrum cirrhatum	500	500	4625	5	10	55	4	2	3.4	0.8	0.2	0.061
Heterodermia diademata	–	5750	625	–	60	15	–	3.9	1.7	-	0.065	0.113
Parmotrema. tinctorum	–	6250	7125	–	30	50	–	8.3	5.7	-	0.276	0.114
P. praesorediosum	38000	4375	-	85	55	–	17.9	3.2	–	0.210	0.058	-
Ramalina sinensis	–	–	1750	–	–	45	–	–	1.6	-	-	0.035
R. conduplicans	6125	5750	10000	70	50	75	3.5	4.6	5.3	0.05	0.012	0.070
Usnea orientalis	–	625	2125	–	15	50	–	1.7	1.7	-	0.113	0.034
Rainy season												
C. texana	375	500	250	10	20	10	1.5	1	1	0.15	0.05	0.1
E. cirrhatum	–	125	3250	–	5	40	–	1	3.2	-	0.2	0.08
H. diademata	1875	625	625	25	20	25	3	1.3	1	0.12	0.065	0.12
P.. tinctorum	–	125	2875	–	5	15	–	1	7.7	-	0.2	0.513
P. praesorediosum	19500	375	1875	65	15	25	12	1	3	0.184	0.066	0.12
R. conduplicans	1375	1625	2625	15	40	30	3.7	1.6	3.5	0.246	0.04	0.116
U. orientalis	–	125	250	–	5	10	–	1	1	-	0.2	0.1
Winter season												
C. ecaparata	–	500	500	–	15	10	–	1.3	2	-	0.086	0.2
C. texana	375	625	–	5	5	–	3	5	–	0.6	1.0	-
E. cirrhatum	–	125	1125	–	5	20	–	1	2.3	-	0.2	0.115
H. diademata	1750	625	–	20	15	–	3.5	1.7	–	0.175	0.113	-
P. tinctorum	125	625	500	5	20	10	1	1.3	2	0.2	0.065	0.2
P. praesorediosum	10625	3625	1500	55	30	15	7.7	4.8	4	0.14	0.16	0.266
R. conduplicans	1250	2500	8250	30	30	50	1.7	3.3	6.6	0.056	0.11	0.132
U. orientalis	–	125	1875	–	5	40	–	1	1.9	-	0.2	0.047
Spring season												
C. ecaparata	–	–	125	–	–	5	–	–	1	-	-	0.2
C. texana	–	375	500	–	5	15	–	3	1.3	-	0.6	0.086
E. cirrhatum	–	–	1625	–	–	25	–	–	2.6	-	-	0.104
H. diademata	1000	–	250	20	–	5	2	–	2	0.1	-	0.4
P. tinctorum	–	–	3125	–	–	35	–	–	3.6	-	-	0.102
P. praesorediosum	10375	4875	1375	55	30	20	7.5	6.5	2.8	0.136	0.216	0.325
R. conduplicans	375	1000	5125	10	10	55	1.5	4	3.7	0.15	0.4	0.067
U. orientalis	–	–	5375	–	–	15	–	–	14.3	-	-	0.953

4. Conclusion

Lichens play a significant role not only in nutrient cycling but also they contribute in the economy of stakeholders residing in the lichen rich areas of Kumaun Himalaya. Therefore lichens must be conserved. Extraction of lichen host like tree bark, branches and twigs should be controlled. Vegetation type of a particular forest also plays important role in biomass production as the lichen litter biomass was more at site I due to mixed coniferous forest. Therefore forest management could play a key role in improving lichen biomass and densities. In pine dominated areas (eg. site II), forest fire is a major problem during summer, it should be controlled and monitored. Besides extraction of pine resin, lopping, grazing are the major causes for loss of diversity and biomass in the middle altitude forest at site II (Binsar-Mahadev). Lopping of trees affects twig lichens as lichens prefer to grow on smooth twigs. Poor occurrence of shrubs, herbs and seedlings in all the studied forest sites are also important reason for less lichen litter biomass. Lichen litter along with other forest litter moves down to the valleys due to steepness of the mountains and could not play their role in forest ecosystem. It is a major problem to entire forest ecosystem in all the forests situated at steep slope having only old trees, where regeneration is poor and occurrence of forest floor litter, cryptogams and herbs is less.

5. Acknowledgement

The authors are thankful to the Head of the Department for providing necessary laboratory facilities.

6. References

1. Arya V, Kumar B. Variation in epiphytic lichen biomass occurring on *Quercus semicarpifolia* Smith, sapling at two high altitude forests of Central Himalaya, India. Indian Forester. 2017; 143 (6):537-540.
2. Boucher VL, Stone DF. Epiphytic lichen biomass. In the fungal community: its organization and role in the ecosystem 2nd ed. By G.C. Carrol and D.T. Wicklow. Marcel Dekker, New York. 1992, 582-599.
3. Conner DA. Life in a rock pile. Natural History. 1983; 6:51-57.
4. Curtis JT, Cottam G. The use of distance measure in phytosociological sampling. Ecology. 1956; 37:151-160.

5. Curtis JT, McIntosh RP. An upland forest continuum in prairie forest border region of Wisconsin. Ecology. 1956; 32:76-96.
6. Edwards RY, Ritcey RW. Foods of caribou in Wells Gray Park, British Columbia. Canadian Field Naturalist. 1960; 74:3-7.
7. Esseen PA, Renhorn KE. Mass loss of epiphytic lichen litter in a boreal forest, 1998.
8. Hodgman TP, Bowyer RT. Winter use of arboreal lichens, Ascomycetes, by white-tailed deer, Odocoileus virginianus, in Maine. Can. Field-Nat. 1985; 99:313-316.
9. Kumar B. Exploitation and depletion of lichens in high altitude regions district Chamoli, Garhwal Himalaya. In ecology and culture of Uttarakhand. Edited by B.L. Sah. Durga Maa Prakashan, Haldwani. 2012, 78-83.
10. Kumar B, Upreti DK. An account of lichens on fallen twigs of three *Quercus* species in Chopta forest of Garhwal Himalayas, India, Annals of Forestry. 2008; 15(1): 92-98.
11. Kumar B, Upreti DK, Singh SP, Tiwari A. Seasonal pattern of lichen fall from trees in an evergreen *Quercus semecarpifolia* forest of Garhwal Himalaya, India. Nature and Science. 2009; 7(3):8-12.
12. Maser Z, Maser C, Trappe JM. Food habits of the northern flying squirrels (*Glaucomys sabrinus*) in Oregon. Canadian Journal of Zoology. 1985; 63:1085-88.
13. McCune B, Greiser L. Macrolichens of Pacific Northwest. Oregon State University Press, Corvallis, U.S.A, 1997.
14. Pike LH. The role of epiphytic lichens and mosses in production and nutrient cycling of an oak forest. Ph.D. dissertation thesis submitted to the University of Oregon, 1971.
15. Pike LH. The importance of epiphytic lichens in mineral cycling. The Bryologist. 1978; 81(2):247-57.
16. Rawat S, Upreti DK, Singh RP. Macrolichen biomass in Nanda Devi Biosphere Reserve, Chamoli District, Uttarakhand, India. Geophytology. 2014; 44(2):155-167.
17. Rhoades FM. Nonvascular epiphytes in forest canopies: worldwide distribution abundance and ecological roles. In forest canopies. Edited by M.D. Lowman and N.M. Nadkarni. Academic Press Inc., San Dieog, Calif. 1995, 353-408.
18. Rominger EM, Robbins CT, Evans M. Winter foraging ecology of woodland caribou in northeastern Washington. Journal of Wildlife Management. 1996; 60:719-728.
19. Stevenson SK, Rochelle JA. Lichen litter fall-its availability and utilization by black tailed deer. In Fish and Wildlife Relationships in Old-growth Forests (W. R.Meehan, T. R.Merrell & T. A. Hanley, eds): American Institute of Fishery Research Biologists, 1984.
20. Stevenson SK. Litter fall rate as a limitation on the availability of forage lichens in second-growth forests. Silvifauna research, Prince George, British Columbia, 1986.
21. Terry EL, McLellan BN, Watts G. Winter habitat ecology of mountain caribou in relation forest management. J. Appl. Ecol. 2000; 37:589-602.
22. Waterhouse MJ, Armleder HM, Dawson RJ. Forage litterfall in Douglas-fir forests in the central interior of British Columbia. Victoria: British Columbia Ministry of Forests, 1991.
23. Zabel CJ, Waters JR. Food preference of captive northern flying squirrels from the Lassen National Forest in northeastern California. Northwest Sci. 1997; 71:103-107.