Bark Factors Affecting the Distribution of Epiphytic Ferns Communities

Lalit M. Tewari[1*], Geeta Tewari[2] , Tapan Nailwal [3] and Y.P.S. Pangtey[4]
[1*,4]Department of Botany, [2]Departement of Chemistry, [3]Department of Biotechnology
D.S.B. Campus, Kumaun University, Nainital-263002 (Uttarakhand), India
*****Corresponding author E-mail: l_tewari@rediffmail.com

Abstract: Substratum plays an important role in the growth and behaviour of the plants. In present study 10 dominant phorophytes (host trees) were analyzed for their bark characteristics. All angiospermous bark except *Rhododendron arboreum* Smith were invariably hard and markedly rough textured while gymnospermous barks were also very hard and rough texture except *Cupressus torulosa* D. Don. All the tree barks studied found to have different range of acidity. The moisture content varied from 35.3 % (*Shorea robusta* Gartn. f.) to 120.7 % (*Cupressus torulosa* D. Don.). All the chemicals except calcium showed mixed pattern of range. Bark texture and moisture content in general are important for epiphytic ferns. The majority of epiphytic ferns were recorded from moist shady places suggesting that these ferns communities demand high humidity for their growth and survival. [Nature and Science. 2009;7(5):76-81]. (ISSN: 1545-0740).

Keywords: Substrate, epiphytic ferns, trees, bark.

1. Introduction

Although climate and geography play an important role in the distribution and composition of epiphytic communities, the texture and water relations of bark are also considered no less significant in the life of cryptogamic plants. The importance of substrate for the growth of cryptogamic vegetation has attracted considerable attention. According to Brodo (1973), the most tangible elements of a plant's environment are its substrate, the material on which the plant grows. The external texture of the substrate is also important in supporting the rhizome, in trapping the spore, capturing and retaining the moisture and chemical substances and also provides a platform for other organisms. The nature of bark and its importance in determining the composition and structure of epiphytic communities has been studied earlier by Barkman (1958), Iwatsuki (1960), Beals (1965), Smith (1982), Bates (1992),Tewari (1992), Gustafsson and Eriksson (1995), Klaus et al. (2005) and Hauck et al. (2006). Khullar (1981) also suggested that the bark of trees is a factor meriting considerable importance for the prevalence of epiphytic ferns. While Barkman (1958) extensively reviewed the literature on this subject, including such factors as bark relief, flaking or scaling, hardness, moisture holding capacity, presence of resin and tannin, salt concentration, pH and buffer capacity etc. Keeping this in view, an attempt has been made in the present study to explore the bark characteristics of dominant trees species of each dominant forest types and its possible relationship with epiphytic ferns.

2. Methodology

The bark samples of dominant trees from nine different forests : Sal forest (700-900m), Miscellaneous forest (900-1200m), Chir-pine forest (1200-1400m), Mixed chir-pine and banj-oak forest (1400-1700m), Banj-oak forest (1700-200m), Telonj-oak forest (2000-2300m), Cypress forest (2300-2500m), Deodar forest (2400-2611m) and Kharsu-oak forest (2500-2611m) were collected for chemical and physical analysis in the month of August, when the growth of epiphytic ferns was maximum. However, for pH and moisture contents, the bark samples were collected in mid June, August and September last, as premonsoon, monsoon and post monsoon samples. The various parameters studied were: the texture, colour, water or moisture holding capacity, moisture content and pH. The nutrient contents (organic C, N, Ca, P, K) of bark samples were also chemically analyzed.

For each parameter, three samples were taken. However, texture, colour, hardness and softness of bark were noted by visual observation during the field survey.

pH was measured by using pH meter and moisture content and moisture holding capacity were expressed as the ratio of water absorbed to dry weight of sample. Organic carbon content was determined by Walkely and Black method (1934). Calcium and exchangeable magnesium were determined by digestion and gravimetrical method given by Pipper (1944). For the determination of available phosphorus, spectropphotometre and for potassium, flame photometry method of Jackson (1958) was used. The physical and chemical properties of bark are presented in Table 1 and 2 respectively for dominant tree of each forest.

In all, 25 species of epiphytic ferns were collected and identified belonging to 15 genera and 6 families. The various species dealt in the present study include: *Araiostegia pseudocystopteris* (Kunze) Copel., *Arthromeris wallichiana (*Spreng.) Ching , *Asplenium ensiforme* Wall. Ex Hook. *et* Ching, *A. indicum* Sledge, *Drynaria mollis* Bedd., *D. propinqua (*Wall. Ex Mett.) J. Smith, *Lepisorus kashyapii* (Mehra) Mehra, *L. Nudus* (Hook.) Ching, *L. pseudonudus* Ching, *L. scolopendrium* (Buch. –Ham. Ex D. Don) Mehra *et* Bir, *L. tenuipes* Ching *et* Kullar, *Leucostegia immersa* Ching *et* Kullar, *Loxogramme involuta* (D.Don) Presl, *Microsorum membranaceum* (D.Don) Ching, *Oleandra wallichii* (Hook.) Presl, *Paradavallodes membranulosum* (Wall. Ex Hook.) Ching, *Phymatopteris oxyloba* (Wall. Ex Kunze) Pichi Sermolli, *Polypodiastrum argutum* (Wall. Ex Hook.) Ching, *Polypodiodes amoena* (Wall. Ex Mett.) Ching, *P. lachnopus* (Wall. Ex Hook.) Ching, *P. microrhizoma* (Clarke ex Baker) Ching, *Pyrrosia flocculosa* D. Don) Ching, *P. mannii* (Gies.) Ching, *P. stictica* (Kunze) Holtt. and *Vittaria flexuosa* Fe'e.

3. Results and discussion

In present study, ten dominant phorophytes (host trees) were analysed for their bark characteristics viz. *Shorea robusta* Gartn. f., *Boehmeria rugulosa* Wedd., *Toona ciliata* Roem., *Pinus roxburghii* Sarg., *Quercus incana* Roxb., *Q. floribunda* Rehder, *Q. semecarpifolia* Smith, *Rhododendron arboreum* Smith, *Cupressus torulosa* D. Don and *Cedrus deodara* Loud.

3.1. Physical nature of bark

In the present study, the bark of an agiospermous tree i.e. oak was mainly dark reddish brown to light grey or blackish in colour and very rough in texture. Regarding the hardness, all the trees had hard natured barks. On the other hand, gymnospermous tree barks varied in colour. In *Pinus roxburghii* Sarg., the bark colour varied from grey to pinkish-brown, smooth and hard in nature, while the colour of *Cedrus deodara* Loud. bark was brown to reddish, rough and hard in nature. Contrary to this, *Cupressus torulosa* D. Don bark had remarkably different features i.e. the colour of the bark was pale of dark brown-reddish and soft in nature exfoliating in fibrous strips. In general, gymnospermous trees had soft textured barks compared to angiospermous tree barks (Table 1).

3.2. Moisture content

The moisture content of the bark depends upon bark texture (Smith 1982). The moisture content was recorded maximum during monsoon period (August) in all the trees barks studied and it varied from 35.3% (*Shorea robusta* Gartn. f.) to 120.7% (*Cupressus torulosa* D. Don). Among gymnospermous bark, moisture content was maximum (120.7%) in *Cupressus torulosa* D. Don and minimum (80.2%) in *Cedrus deodara* Loud. during August. In angiospermous bark, it was maximum (70.2%) in *Quercus floribunda* Rehder and minimum (36.3%) in *Shorea Robusta* Gartn. f. during August (Table 1).

3.3. Moisture holding capacity

Gilbert (1970) concluded that water supply was independent for substrate. Billing and Dew (1938) did found that hemlock bark both a lower water absorption capacity and higher water loss than did tulip poplar bark and they also showed that the absorptive capacity of bark changed with height, exposure and epiphytic cover. In general, water-holding capacity of barks varied from 38.2% (*Shorea robusta* Gartn. f.) to 126.2% (*Rhododendron arboreum* Smith) in all trees studied. It also indicated that the gymnospermous trees had greater moisture holding capacity compared to angiospermic trees. Exceptionally maximum moisture holding capacity was recorded in *Rhododendron arboreum* Smith bark. Among gymnospermous tree barks, water-holding capacity was maximum in *Cupressus torulosa* D. Don (125%) and minimum in *Pinus roxburghii* Sarg. (85.2%), while other angiospermous tree barks had comparatively low moisture holding capacity i.e. *Quercus floribunda* Rehder had 72.2% (maximum), while *Shorea robusta* Gartn. f. 38.2%(minimum) moisture holding capacity. The low moisture holding capacity in latter case was probably due to rough texture and hardness and since the moisture holding capacity of bark depends upon the density, porosity, texture and internal structure of bark (Table 1).

3.4. pH

A number of workers had determined the pH of bark in many trees species and emphasized that the differences in epiphytic community was due to the difference in moisture content and pH of the various barks. The pH of the bark and the epiphytic communities are closely related to bark texture and humid condition. In general, all bark types studied were acidic in nature and it was maximum during monsoon period (August) in each case and varied between 6.6 to 4.8. Tewari (1992) also recorded maximum pH during monsoon for tree barks.

The pH of gymnospermous tree barks was comparatively more acidic than angiospermous. In gymnospermous tree bark, it was less acidic in *Cupressus torulosa* D. Don (5.9) and more acidic in *Quercus incana* Roxb. (6.6) and more acidic in *Shorea robusta* Gartn.f. (5.1) during monsoonal period. In all three barks studied, pH fluctuated in a narrow range. However, it was maximum during monsoonal period (Table 1).

Table 1. Bark characteristics, moisture content (MC), pH and moisture holding capacity (MHC) of dominant tree species

Sl. No.	Name of host tree	Bark characteristics	Months						
			June		August		September		MHC (%)
			MC (%)	pH	MC (%)	pH	MC (%)	pH	
1	*Shorea robusta* Gartn.f.	Dark reddish-brown or grey, long deep and wide vertical fissures, 1.8-3.1 cm thick	15.6	4.6	35.3	5.1	25.5	4.8	38.2
2	*Boehmeria rugulosa* Wedd.	Dark brown, rough and deeply furrowed, 2.6cm thick	20.2	6.0	43.5	6.5	28.6	6.2	42.3
3	*Toona ciliata* Roem.	Dark grey or reddish-brown, rough with shallow reticulate cracks, exfoliating in irregular woody scales, 1.3-1.7cm thick	30.3	5.9	50.5	6.5	40.6	6.1	48.0
4	*Pinus roxburghii* Sarg.	Grey or pinkish-brown, very rough and deeply fissured longitudinally, shallow cracks into irregular scales	40.2	4.4	80.6	4.8	50.2	4.5	85.2
5	*Quercus incana* Roxb.	Pale grey or dark-reddish brown, rough with shallow cracks, exfoliating in irregular woody scales, 1.3-2.6 cm thick	42.0	6.0	68.8	6.6	40.2	6.2	68.8
6	*Quercus floribunda* Rehder	Dark grey or dark reddish-brown, rough with shallow cracks, exfoliating in irregular woody scales, 1.3-2.6cm thick	40.2	5.8	70.2	6.2	48.4	5.5	72.2
7	*Rhododendron arboreum* Smith	Pinkish brown, rough, exfoliating in thick flakes, 0.5-1.3cm thick	56.3	4.8	85.2	5.4	63.0	4.8	126.2
8	*Cupressus torulosa* D. Don	Pale or dark brown-reddish, rough deep vertical fissure, exfoliating in fibrous strips, 1.3-4cm thick	59.0	5.7	120.7	5.9	76.2	6.0	125.0
9	*Cedrus deodara* Loud.	Brown often reddish, deep furrows separated by woody ridges, 3.5-5cm thick	45.6	5.2	80.2	5.6	39.2	5.3	88.3
10	*Quercus semecarpifolia* Smith	Silvery grey to blackish rough with shallow cracks, exfoliating in irregular woody scales, 1-2.6cm thick	36.4	5.8	60.4	6.1	40.6	5.8	60.2

3.5. Chemical content

It is often suggested that the chemical nature of the bark is important in determing the composition of epiphytic communities. Various workers emphasized the importance of the chemical nature of barks. Some of them are Barkman (1958) and Smith (1982). In present study, total organic carbon percent in all barks varied between 73.88 (*Quercus incana* Roxb.) to 88.84 (*Rhododendron arboreum* Smith). Gymnospermous tree barks had higher total organic content than angiospermous barks, it ranged from 83.50 (*Cedrus deodara* Loud.) to 87.18 (*Pinus roxburghii* Sarg.) (Table 2).

Among all the tree barks, total nitrogen percent varied between 0.28 (*Cedrus deodara* Loud.) to 0.50 (*Cupressus torulosa* D. Don and *Quercus semecarpifolia* Smith), while remaining species showed a mixed pattern of total nitrogen (Table 2).

The percent phosphorus varied in bark species from 0.008 (*Shorea robusta* Gartn. f.) to 0.55 (*Cedrus deodara* Loud.). The content of percent potassium varied from 0.10 (*Quercus incana* Roxb.) to 0.17 (*Quercus semecarpifolia* Smith), while the percent magnesium ranged from 0.011 (*Rhododendron arboreum* Smith) to 0.020 (*Quercus incana* Roxb.) (Table 2).

On the other hand, all the tree barks were fairly rich in calcium content. Percent calcium ranged from 1.90 (*Cupressus torulosa* D. Don) to 6.10 (*Rhododendron arboreum* Smith). In general, the angiospernous tree barks had higher calcium content in comparison to the gymnosperms. In gymnospermous tree barks, it ranged from 1.90 (*Cupressus torulosa* D. Don) to 2.60 (*Cedrus deodara* Loud.) while 2.60 (*Shorea robusta* Gartn. f.) to 6.10 (*Rhododendron arboreum* Smith) in angiospermous trees (Table 2).

Table 2. Chemical content of bark of dominant tree species

C= Organic carbon, N= Nitrogen, P= Phosphorous, K= Potassium, Ca= Calcium, Mg=Magnisium.

Sl. No.	Name of host tree	Chemical contents in percent					
		C	N	P	K	Ca	Mg
1	*Shorea robusta* Gartn. f.	86.21	0.30	0.008	0.04	2.60	0.013
2	*Boehmeria rugulosa* Wedd.	74.82	0.37	0.009	0.05	2.92	0.016
3	*Toona ciliata* Roem.	76.81	0.40	0.010	0.05	3.21	0.016
4	*Pinus roxburghii* Sarg.	87.18	0.28	0.007	0.03	2.30	0.012
5	*Quercus incana* Roxb.	73.88	0.40	0.021	0.10	5.70	0.020
6	*Quercus floribunda* Rehder	75.88	0.44	0.012	0.06	4.80	0.019
7	*Rhododendron arboreum* Smith	88.84	0.34	0.014	0.02	6.10	0.011
8	*Cupressus torulosa D. Don*	83.54	0.50	0.017	0.06	1.90	0.015
9	*Cedrus deodara* Loud.	83.50	0.28	0.055	0.06	2.60	0.017
10	*Quercus semecarpifolia* Smith	78.92	0.50	0.018	0.17	4.30	0.016

3.6. Epiphytic fern diversity

Rhododendron arboreum Smith displayed high species richness of ferns (15 species), followed by *Quercus incana* Roxb. (12 species) and *Q. floribunda* Rehder (12 species). Besides, a high species richness was also noticed on *Pinus roxburghii* Sarg. (8 spp.), *Cedrus deodara* Loud. (7 spp.), *Toona ciliata* Roem. (9 spp.), *Boehmeria rugulosa* Wedd. (7 spp.), *Cupressus torulosa* D. Don (6 spp.) and *Quercus samecarpifolia* Smith (4 spp.). However, poor richness of ferns was displayed by *Shorea robusta* Gartn. f. on which only two species were recorded. While in case of *Cupressus torulosa* D. Don, trees restricted to certain localities of forest i.e. forest marginal trees, supported epiphytic ferns but in general their growth was rather poor and scanty.

Earlier, a few workers have emphasized that generally the gymnospermous trees lack epiphytic ferns (Mehra 1939, Dhir, 1980). In contrast to general belief that epiphytic ferns shun coniferous bark, a rich ferns growth on a number of gymnospermous trees vis. *Pinus roxburghii* Sarg. and *Cedrus deodara*

Loud. was observed. Between 2400-2611m the *Cedrus deodara* Loud. tree supported an abundant growth of *Lepisorus kashyapii* (Mehra) Mehra and *Drynaria mollis* Bedd.. Similarly, at certain localities at lower altitudes, the chir pine (*Pinus roxburghii* Sarg.) trees were also frequently inhabited by the ferns. This indicates that the ferns may grow and flourish on any host including gymnosperms, if the conditions are favourable.

The substratum is the most tangible element of plant environment, on or in which the plant grow. Culberson (1955) found that there was no direct correlation between epiphytic communities and hardness of bark. Khullar (1981) suggested that the trees with cracked up (spongy) barks are generally more suitable for epiphytic fern growth. This statement seems to be correct because in case of tree saplings and many shrubs, the poor representation of epiphytic ferns were observed and this may be due to their compact and intact barks. *Cupressus torulosa* D. Don also had poor growth of epiphytic ferns owing to its nature of bark. While *Rhododendron arboreum* Smith had smooth and spongy bark, which accumulate higher humus and thus rendering it most suitable host for the growth and prevalence of epiphytic ferns. Martin (1938) and Iwatsuki (1960) suggested that the chemical nature of bark is important in determining the composition of epiphytic communities. All the chemicals except calcium showed mixed pattern of range. Calcium percent was higher in angiospermous tree barks compared to gymnospermous tree barks.

Majority of epiphytic ferns (*Aplenium ensiforme* Wall. Ex Hook. *et* Ching, *Oleandra wallichii* (Hook.) Presl, *Loxogramme involuta* (D.Don) Presl , *Leucostegia immersa* Ching *et* Kullar, *Microsoum membranaceum* (D.Don) Ching and *Vittaria flexuosa* Fe'e*)* were recorded from moist-shady places suggesting that these ferns demand high humidity and require very little light for their growth and survival. However, many of them like *Lepisorus nudus* (Hook.) Ching, *Pyrrosia* species and *Drynaria mollis* Bedd.etc. have well adapted for open and exposed conditions due to their thick leathery, hairy and sterile winter fronds., while *Araiostegia pseudocystopteris* (Kunze) Copel shows a wide range of distribution on different habitats.

Colour, texture and exfoliation rate of gymnospermous and angiospermous bark were of immense value regarding the presence or absence of the epiphytic vegetation. Trees with a cracked up (spongy) bark are generally suitable for epiphytic fern communities.

4. Conclusion

On the basis of the study, it can be concluded that only bark texture and moisture content are important for epiphytic fern communities. During monsoon, the humidity remains fairly high, thus epiphytic ferns attain their maximum development and complete their life cycle before the advent of early winter. The luxuriance of epiphytic ferns not only on angiospermous trees but even the gymnospermous trees has epiphytes on them. The climate and geography do play an important role in deterring the make up of epiphytic communities.

Acknowledgement

The authors are thankful to Prof. C.P. Barthwal, Vice Chancellor, Prof. R.C.Pant, Ex. Vice Chancellor, Prof. K.N. Pandey, Dean Science, Prof. C.S. Mathela, Head Chemistry and Prof. Uma Palni, Head Botany for encouragement and providing facilities. The financial assistance provided by Department of Biotechnology, New Delhi and Uttarakhand Council of Science and Technology, Dehradun is greatly acknowledged.

References

Barkman, J.J. Phytosociology and Ecology of Cryptogamic Epiphytes. Van Gorcum, Assen. Netherland, 1958.
Bates, J. W. *J. Ecol.* 1992; **80**:163-179.
Beals, E.W. *Oikos* 1965;16:1-8.
Billing, W. D. Drew, W. B. *Amer. Midl. Natur* 1938;20:302-330.
Brodo, I.N. The lichens, Academic Press, New york 1973: 401-441.
Culberson, W.L. *Ecological* Monographs 1955;25:215-231.
Dhir, K.K. *Bibliotheca Pteridologia* 1980;1:1-158.
Gilberts, O.I. *New Phytologist* 1970;69:605-627.
Gustafsson L., Eriksson I. *Journal of applied ecology* 1995; 32(2): 412-424.
Hauck, Marcus, Hoffman, Erika, Schmull, Michaela. *Ann. Bot. Fennici*2006; 43:1-12.
Iwatsuki, Z. *Jour. Hattori. Bot. Lab.* 1960;22:159-350.

Jackson, M.L. Soil Chemical Analysis, Prentice Hall Inc. Engle Woodcliffs. N.J. USA. 1958:1-498.
Khullar, S.P. Contemprary Trends in Plant Sciences Kalyani Publication, New Delhi. 1981:202-207.
Klaus, Mehltreter, Alejandra, Flores-Palacios, José G, Garcia-Franco. *Journal of tropical ecology* 2005; 21 (6): 651-660.
Martin, N.M. *J.Ecol.* 1938; 26:82-95.
Mehra, P.N. Ferns of Massuri P.U.Publ. Lahaur. 1939:1-59.
Pipper, C.S. soil and plant analysis Interspecies Publication Inc, New York.1944:1-368.
Smith, A.J.E. Bryophite Ecology Chapman and Hall, London 1982:191-227.
Tewari, L.M. Ph.D. Thesis Kumaun University, Nainital, 1992.
Walkey, K.E. Black, J.A. *Soil Science* 1934;37:29.

4/4/2009