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Impact of anthropogenic factors on abundance variability among lichen species in southern Assam, north east India

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Abstract: The paper deals with a study of species abundance pattern in lichen communities. Three areas with different anthropogenic pressure levels were evaluated for lichen community structure. It is observed that the area with least anthropogenic pressure shows a general universal pattern of natural communities i.e. a J-curve pattern where majority of the species are rare and few are abundant. With a small change in anthropogenic pressure there is little effect on rare species but the abundant species increased. With major changes both the rare and the abundant species decrease changing the overall community composition. The J-curve changes to a uni-modal curve; the moderately abundant species are found to be resilient against anthropogenic pressure levels. The community ecology of organisms has its root in evolutionary history, succession, and biogeography. The studies on community ecology, therefore, may help in throwing significant light on these important aspects and can also be used as indicators of ecosystem health.

Resumen: El artículo reporta un estudio delos patrones de abundancia de las especies en comunidades de líquenes. Se evaluó la estructura de la comunidad de líquenes en tres áreas con diferentes niveles de presión antropogénica. El área con menor presión antropogénica mostró un patrón universal general de las comunidades naturales, es decir un patrón de curva con forma de J en el que la mayoría de las especies son raras y pocas son abundantes. Un cambio pequeño en la presión antropogénica tuvo poco efecto en las especies raras pero las especies abundantes incrementaron. Con cambios de mayor magnitud tanto las especies raras como las abundantes disminuyeron,modificando la composición de la comunidad en general. La curva con forma de J cambióa una curva unimodal.Se encontró que las especies medianamente abundantes son resilientes alos varios niveles de presión antropogénica. La ecología de comunidades deorganismos tiene su raíz en la historia evolutiva, la sucesión y la biogeografía. Por lo tanto, los estudios de ecología de comunidadespuedenarrojar mucha luz sobre estos importantes aspectos y también se pueden utilizar como indicadores de la salud de los ecosistemas.

Resumo: Este artigo debruça-se sobre o estudo do padrão de abundância de espécies em comunidades de líquenes. Foram avaliadas três áreas com níveis diferentes de pressão antrópica para estrutura da comunidade de líquens. Observa-se que a área com menor pressão antropogénica mostra um padrão geral universal de comunidades naturais ou seja, um padrão de curva J onde a maioria das espécies são raras e poucas são abundantes. Com uma pequena mudança na pressão antrópica há pouco efeito sobre as espécies raras, mas as espécies abundantes aumentaram. Com mudanças maiores tanto as espécies raras como as abundantes diminuíram alterando a composição conjunta da comunidade. A curva J altera-se para uma curva unimodal; as espécies moderadamente abundantes mostraram-se ser resilientes em

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relação à pressão antrópica. Os estudos na ecologia de comunidades de organismos tem sua raiz na história evolutiva, na sucessão e na biogeografia. Assim, os estudos sobre a ecologia de comunidades, podem ajudar a esclarecer estes aspectos importantes e também podem ser usados como indicadores da saúde do ecossistema.

Key words: Anthropogenic pressure, community ecology, lichen metacommunity, species abundance.

Introduction

Species abundance distribution in any community is one of the important aspects of community ecology. Such study provides information about the number and relative abundance of the species encountered in a sample from a given community. Most ecologists agree that species abundance represent an empirical tool to draw a rough characterization of ecological communities (McGill *et al.* 2007). Species interact in their communities based on their phenotypic differences and similarities and such phenotypic variations have a basis in evolutionary history (Webb *et al.* 2002). Even ecological character of species in present plant communities reflects the biogeographic history of the species and their recent ancestors (Lechowicz 1984; ter Steege & Hammond 2001). Findings of community composition dynamics may thus address fascinating ecological questions of evolution, diversification, biogeography, and succession. Lichens play an important role by contributing to tropical forest biodiversity (Rout *et al.* 2010) and nutrient cycling in temperate forests (Rawat *et al.* 2011). Among lichens, the physically distinct thalli or any thallus material which is genetically uniform with respect to the fungal symbiont is considered as an individual (Fahselt 2008). The individuals of all lichen species that potentially interact within a local area constitute a community and the set of lichen communities that are linked by dispersal of multiple interacting lichens is its metacommunity. In most ecological communities, a few species proliferate while most others are more or less rare. Such differences in quantitative importance among the species in a community are found irrespective of the measures used, be it the number of individuals or measures like biomass and productivity (Whittaker 1965). Patterns of species quantitative importance (Loreau 1992) usually indicate a regular trend even in different species types. Hubbell (2001) related phylogeny with the relative abundance of species and suggested that older species should be more abundant and widespread than younger species. Species abundance pattern can be used as environmental indicators, indicative of the health of an ecosystem (Bakkes 1994). The objective of this paper is to see the variability in community structure with changes in external factor (anthropogenic pressure). The change in pattern will thus indicate a change from 'normal' sustaining condition of species in community and may throw light with respect to their role in evaluating the community dynamics and as ecological indicators.

Materials and methods

In the present study, Silchar-Dargakona road, in Cachar district of northeast India (Fig. 1) which traverses areas with different levels of anthropogenic activities is considered for the lichen community study. Trees along both sides of the road harbour lichens and provide an excellent opportunity of comparative studies particularly with respect to the differences in anthropogenic activities. Since the saxicolous (growing on rocks) and terricolous (growing on soils) lichens in the study area exhibit their scarce representation, they are, therefore, not considered in the present study. The road is divided into three sections; A (Premtola point to Medical College), B (Medical College to National Institute of Technology, Silchar), and C (National Institute of Technology, Silchar to Dargakona village), on the basis of anthropogenic pressure (Table 1). Traffic load, human population, minor industrial activities, and lack of vegetation are the different decisive factors for evaluating the anthropogenic pressure in the three sections. Lichens up to two meters from soil level (Johnson 1979) along the road side are considered for the study. Many investigators have studied epiphytic lichens over as much of the tree

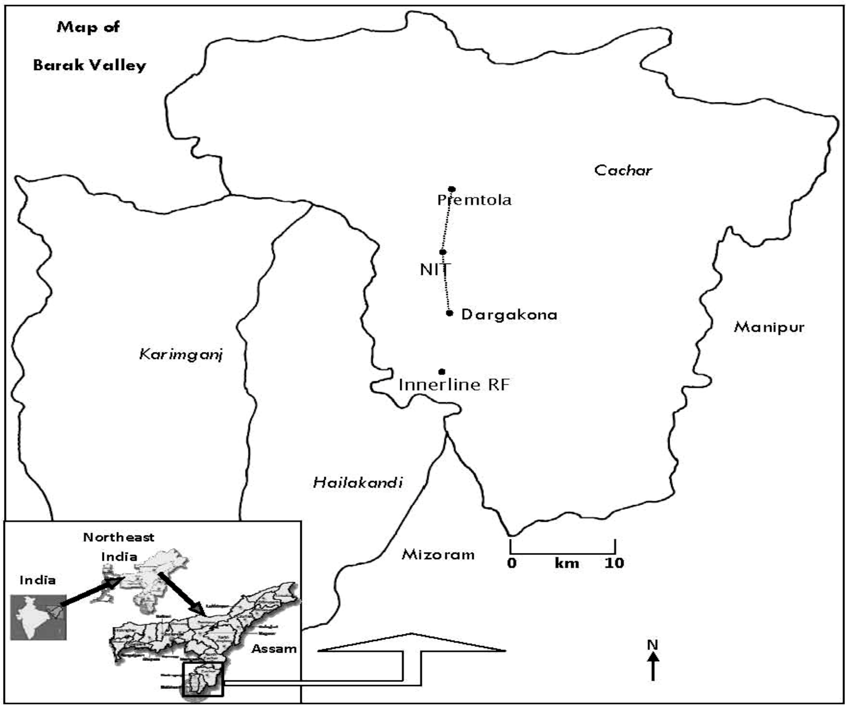

Fig. 1. Map showing the study area (Silchar-Dargakona road) and the adjacent places.

Table 1. Anthropogenic pressure matrix in three study areas A, B, C.

Study area	Traffic load	Human population	Industry/polluting workshops/ other activities	Vegetation loss
A	xxx	xxx	xxx	xxx
B	xx	x	x	xx
C	x	x	x	x

Key: x = low, xx = medium, xxx = high.

surface as could be viewed conveniently (Case 1980), while some researchers have suggested different ranges up to a height of two meters (Fuentes & Rowe 1998; Loppi & Nascimbene 1998). Total number of species present and number of individuals per species present is counted in each tree and abundance values are calculated for each species at each section. Number of species and number of individuals in each species are plotted in a scatter chart. The specimens were thoroughly examined morphologically, anatomically and chemically. The literature on lichens published by Awasthi (1988, 1991, 2000 & 2007), Walker & James (1980) and Orange *et al.* (2001) were utilized for authentic identification of the lichens. A one-way ANOVA test is used to detect if the difference in the abundance values at three sections are significant.

Results and discussion

It is observed that among the three sections studied (A, B, and C), section A has highest level of anthropogenic pressure followed by section B, and section C (Table 1). The number of species per tree varies from 1 - 9, 1 - 13, and 1 - 15 and the total numbers of species are 15, 20, and 27 (Table 2) in sections A, B, and C respectively. The species abundance value ranges from 1 - 7.8, 1.7 - 11.8, and 4 - 15.3 in sections A, B, and C respectively. Some of the species which are specific to a particular section (anthropogenic pressure level) are *Arthonia antillarum, A. arctata, A. collectiva, Graphis persulcata, Lecanora helva,* and *Phaeographis instrata* (to section A), *G. chlorotica, G. glaucescens,* and *G. longiramea* (to section B), and *G. aquilonia, G. duplicata, G. garoana, G. inamoena, G. intermedialla, G. intricata, G. leptocarpa, Myriotrema albocinctum, Parmotrema disparile, Pertusaria coccodes,* and *Pyrenula costaricensis* (to section C). Species which are found in comparatively less affected section B and C, but not in section A are *Acanthothesis corcovadensis, Anthracothecium cristatellum, Arthonia impolitella,*

Table 2. Abundance value of lichens in three study areas A, B, C.

Area A		Area B		Area C	
Species	Abundance	Species	Abundance	Species	Abundance
Parmotrema tinctorum	1.0	*Arthonia tumidula*	1.7	*Graphis duplicata*	4.0
Graphis rimulosa	2.5	*Acanthothecis corcovadensis*	2.0	*Parmotrema saccatilobum*	4.3
Arthonia collectiva	2.6	*Anthracothecium cristatellum*	2.4	*Arthonia subgyrosa*	4.4
Parmotrema saccatilobum	2.6	*Arthothelium dispersum*	2.6	*Graphis chloroalba*	5.6
Lecanora helva	2.8	*Graphis longiramea*	3.5	*Arthonia impolitella*	6.0
Graphis persulcata	2.9	*Graphis nigroglauca*	3.6	*Graphis inamoena*	6.3
Lecanora cenisia	3.0	*Arthonia recedens*	4.0	*Dirinaria aegialita*	6.7
Dirinaria aegialita	3.2	*Parmotrema tinctorum*	4.0	*Acanthothecis corcovadensis*	6.7
Arthonia arctata	3.5	*Dirinaria consimilis*	4.2	*Graphis garoana*	7.0
Arthonia antillarum	4.0	*Lecanora cenisia*	4.4	*Arthonia recedens*	7.1
Phaeographis instrata	4.1	*Graphis scripta*	4.7	*Dirinaria consimilis*	7.4
Graphis scripta	4.3	*Arthonia impolitella*	5.0	*Graphis intricata*	7.4
Graphis chloroalba	4.3	*Parmotrema saccatilobum*	5.0	*Graphis aquilonia*	7.6
Pyxine cocoes	5.2	*Graphis glaucescens*	6.3	*Pyrenula costaricensis*	7.8
Arthonia recedens	7.8	*Pyxine cocoes*	7.9	*Arthothelium dispersum*	8.0
		Graphis rimulosa	8.4	*Graphis leptocarpa*	8.1
		Graphis subasahinae	9.1	*Anthracothecium cristatellum*	8.4
		Arthonia subgyrosa	10.1	*Arthonia tumidula*	8.5
		Graphis chlorotica	10.4	*Graphis nigroglauca*	8.6
		Dirinaria aegialita	11.8	*Parmotrema tinctorum*	8.8
				Parmotrema disparile	8.9
				Graphis intermediella	9.2
				Graphis scripta	9.6
				Graphis subasahinae	9.9
				Pertusaria coccodes	10.9
				Myriotrema albocinctum	13.5
				Pyxine cocoes	15.3

A. subgyrosa, A. tumidula, Arthothellium dispersum, Dirinaria consimilis, Graphis nigroglauca, and *G. subasahinae*. Scatter plot trendline for C reflects (Fig. 2) a 'lazy J-curve' (McGill *et al.* 2007) pattern similar to pattern exhibited by many other species in a community in different studies. The left arm of the curve indicates the less common (or rare) species and the right arm of the curve indicates the abundant species. Usually the rare species dominate over few abundant species. The curve for B reflects a little change in the community composition as there is a negligible decrease in rare species as compared to that in area C while there is a little increase in the abundant species. Area A exhibits a significant change in the lichen community composition as shown by the graph. The shape of the trendline changes from J-curve to a uni-modal curve. There is a decline in both rare and abundant species; the abundant species shows more decrease in comparison to the rare species. It is observed that the moderately abundant species exhibit little change in all the three areas. As can be observed (Table 2) that the limits (or range) of abundance values change from section A to section C along with the total number of species per section. *Pyxine cocoes* for example is one of the abundant species of highly anthropogenically affected area (section A) and also in the least affected area (section C) but the abundance value exhibits an

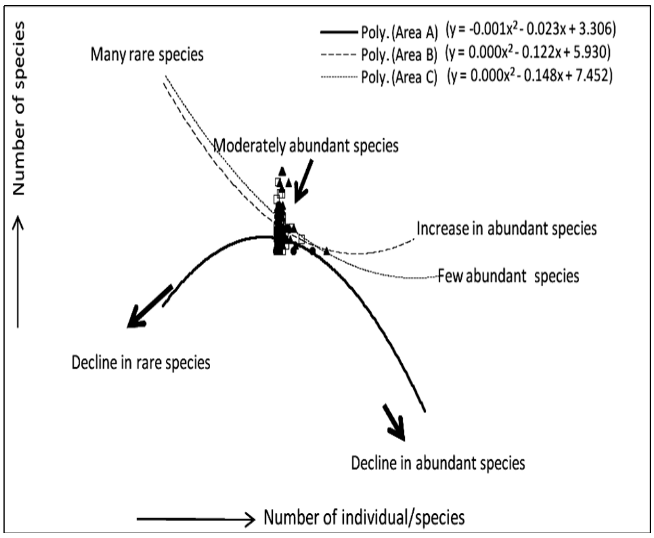

Fig. 2. Lichens species abundance distribution trendlines for three areas.

Table 3. One way ANOVA test of the abundance values of lichen species at three sites (*F* value significant at $P < 0.05$).

	Sum of squares	D.F.	Mean square	*F*
Among groups	197.01	2	98.51	15.71
Within groups	370.05	59	6.27	
Total	567.06	61		

increase of about 2.94 times. Similarly *Parmotrema saccatilobum* is one of the rare species in both section A and section C but the value in the later is about 1.7 times than that of the former; for many species the abundance value changes without changing their role in community dynamics. On the other hand some species like *Parmotrema tinctorum* and *Graphis rimulosa* are rare species in high anthropogenic pressure which becomes dominant in least affected and moderately affected areas respectively. This may be due to the affect of stress. Similarly species such as *Graphis chloroalba* which is a rare species in least affected area becomes common in the region with significant environmental stress. The study thus brings out the role of rare and abundant species in the community composition. The abundance values of lichens exhibit significant difference (ANOVA, $F = 15.71$, $P < 0.05$) (Table 3) among three study areas confirming the assumption of abundance variability with change in anthropogenic factors.

In particular, gradients of changing environment provide a natural experiment or comparative basis for testing theories about communities (McGill *et al.* 2006) including species abundances (McGill *et al.* 2007). Mouillot & Lepretre (2000) have also found that species abundance pattern perform well in distinguishing terrestrial communities under different influences and argue for their use as indicators. A theory on how effects of human activities propagate through the natural community composition dynamics and change the abundance of an individual species in any lichen community will be important to disentangle the causes of overall changes in the dynamics both spatial and temporal. Dispersal of lichen spores seems to play a key role in its community composition. At the metacommunity level dispersal among local communities occurs with variable rates. Colonization events based on different dispersal rates can regulate the assembly history (Leibold *et al.* 2004) of local community. The effect of anthropogenic pressure (pollution) appears to have the analogous impact. Air quality causes degeneration or death of some lichens while favouring others. This in the evolutionary history of any lichen community (e.g. tree trunk community) has a cumulative effect and has a deterministic role in lichen composition and its abundance pattern. One of the basic assumptions underlying the differences in abundance of a species is related to the fraction of the niche space it acquires, and this niche space has a fixed volume divided between competing species (Loreau 1992). In most of the communities, the majority of species at any time are uncommon or rare. Because of its majority in species number, the rare species help to increase the resistance of community to new species colonization. In case of lichens in the present study, the rare species along with the abundant ones seems to have resisted with a little increase in environmental stress (Area B), but with drastic change in the stress level it could not resist the stress and ultimately declined (Area A). Lichens have little biological control over gas exchange, and air pollutant gases are assumed to readily diffuse down to the photobiont layer. Local extinction of lichens may occur due to alteration of symbiotic balance between the photobiont and mycobiont resulting into the breakdown of lichen association mainly because of toxic concentrations of pollutants.

Conclusions

Community ecological research is important in understanding the impact and possible mitigation of global environmental changes. Present study provides a model of lichen community dynamics under different stress conditions in subtropical humid climate of north east India and thus may help in more such studies in future. The underlying mechanisms of lichen community composition patterns may thus help to assist in generating patterns in basic ecological concepts and facilitate its use as environmental indicator too.

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