Climate Warming Studies in Alpine Habitats of Indian Himalaya, using Lichen based Passive Temperature-enhancing System

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Abstract: Increase in the average annual temperature of the planet is posing an intimate threat to global biodiversity. Though high altitude alpine habitats, due to their physico-chemical constrains are some of the extremely fragile habitats, they harbor unique diversity of life forms. Indian Himalayan habitats are abode of a diverse lichen community, and have evolved into various growth forms. Lichens inhabit nearly all the terrestrial and boreal domains of the region. Lichens are more sensitive to changes in environmental conditions than all other plant forms. Passive temperature enhancing systems (PTES) such as open top chambers (OTC) are most appropriate devices to experimentally simulating the global temperature alleviation as they use trapped solar energy to enhance the ambient temperature of experimental area. PTES experimental setups utilizing lichens can be a very efficient method for studying effect of temperature alleviation on plants.
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1. Introduction:

1.1Alpine plant life

Plant life at high elevations is constrained by physico-chemical components of the environment. Geographic isolation, tectonic uplift, climatic changes, glaciations and strong macrohabitat differentiation in high altitude alpine habitats lead to a high degree of taxonomic richness (Körner 2003).The limitations posed by high altitude alpine habitats is exemplified by the growth forms of the vegetation of the area, usually characterised by low statured desiccation-tolerant plants. Cryptogams (bryophytes and lichens) constitute an important group of plants in alpine habitats adapted for alpine life.

1.2 Himalayan alpine habitats

Alpine habitats in Himalaya, by virtue of their stressed climatology (i.e. higher environmental lapse rate, high wind velocity, high UV radiation, low atmospheric pressure and low precipitation), and delimiting nutrient and exposure regime, support relatively simple ecosystems, characterised by limited trophic levels and relatively very few plant growth forms and species. Despite these constrains alpine habitats of Himalaya harbor some of the unique biodiversity of the region which is vital in the overall ecosystem functioning and stability.

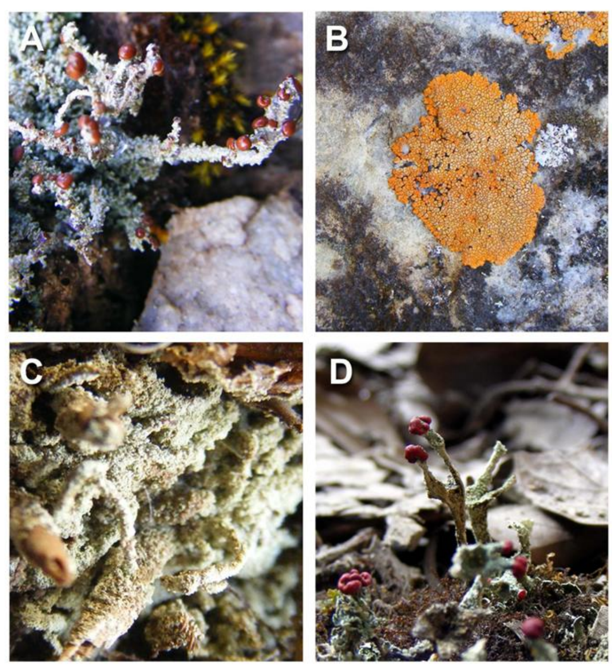

Figure 1: Diversity of Alpine Lichens; A. Fruticose-*Stereocaulon foliolosum*, B.Crustose- *Ioplaca pindarensis*, C. Leprose-*Lepraria* spp., D.Dimorphic-*Cladonia coccifera*

1.3 Lichens in Himalaya

Lichens constitute a very important part of cryptogamic vegetation in alpine habitats of Himalaya (Upreti 1998). Their peculiar symbiotic mode of anatomy, nutrition and physiology enable lichens to survive the harsh environment of alpine Himalaya. This adaptability has resulted into very high diversity of growth forms (e.g.crustose, foliose, squamulose, leprose, fruticose and dimorphic-squamulose and fruticose) and habitat subsets (e.g.corticolous- on bark, saxicolous-on rocks, terricolous- on soil, muscicolous- on moss and ramicolous -on twigs) in alpine lichens (Figure1). Slow growth rate and need of stable habitat conditions for establishment, make lichens suitable natural sensors. The simple and fragile alpine habitats along with their sensitive lichen species can be used efficiently for monitoring a very broad spectrum of environmental conditions, either natural or unnatural (anthropogenic).

2. Effects of climate change on plants:

Climate change induced rise in annual mean temperature, in recent decades is influencing the overall diversity and ecophysiology of plant forms in alpine habitats. This warming of environment is so rapid that its effect on plant forms is unpredictable. However our present knowledge of eco-physiology of plants indicates that the warm atmospheric conditions will principally affect diversity (species richness-distribution), physiology (photosynthesis, biomass and nutrient accumulation) and phenology of plant forms in alpine habitats (Chaturvedi et al 2007). In order to predict future response of alpine vegetation to climate warming, there is an urgent need to better understand the potential effects of warming on overall ecosystem health using sensitive indicator systems like lichens.

3. Passive temperature-enhancing systems (PTES):

Studies on climate warming in alpine habitats needs experimental setup that can withstand the harsh climate of the area and should be able to minimize unwanted ecological effects (i.e. chamber overheating and altered light, moisture and wind conditions), usually encountered in setups involving active heating techniques: e.g. climate controlled greenhouses and heating by fluid heated pipes, electric heating cables or by infra-red heaters (Marion et al 1997, Luo et al 2009). Passive temperature-enhancing systems (PTES), which rely primarily on trapping of solar energy: e.g. open-top chambers (OTCs) increase mean daily temperature significantly (1.2^0C-1.8^0C) and minimise most unwanted ecological effects(Marion et al 1997) , qualifying them as a useful tool for studying the response of high-altitude ecosystems to warming (Figure 2).

4. Lichen based PTES:

Experimental warming studies through OTCs, carried out in alpine ecosystems such as tundra and Antarctic alpine heath, indicates that the open plant communities (lichen) were more negatively affected than dense communities e.g. dwarf shrubs and moss(Walker et al 2006, Bokhorst et al 2007). These PTES simulate warming conditions by increasing soil temperature (2.2^0 C- 5.2^0 C), which decrease soil moisture and create drought stress (Marion et al 1997, Bokhorst et al 2007).

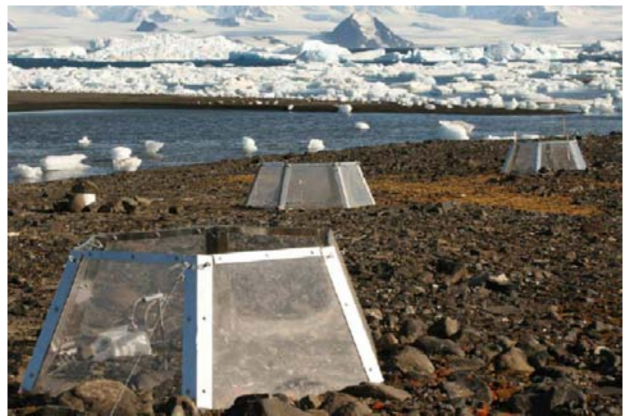

Figure 2: Hexagonal open-top chamber (OTCs) at James Ross Island, Antarctica. (Photo ©M.Bartak et al 2009, with permission).

In Himalayan alpine habitats, OTC based studies have been recently initiated. There are few studies conducted in Garhwal Himalaya-India, China and Tibetan plateau using elevated CO_2 conditions and assessing physiological response of alpine grassland flora to elevated temperature (Chaturvedi et al 2009, Luo et al 2009, Xu et al 2009, Chaturvedi et al 2010). These studies primarily involved species specific approach and none of them was carried out in context to lichens, which are well known for their relatively high sensitivity to climate warming, than other plant groups (Walker et al 2006, Bokhorst et al 2007, Barták 2009) . Thus there is need of such OTC based studies on lichens, which hold highest diversity in these harsh terrestrial domains (Upreti 1998). The low cost, low technique-easy assemblage and structural robustness of passive open-top chambers can be easily utilized in simulating the global warming conditions, thus providing better insight in effect of warming on alpine vegetation. The findings of such studies will be useful in understanding the physiological and phytosociological responses of alpine vegetation to global warming which can be instrumental in formulating better and overall sustainable conservation strategies for the region.

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References:

1) Barták, M., Kamil, L., Pavel, P., Josef, H., Peter V., Long-term study on vegetation responses to manipulated warming using open top chambers installed in three contrasting Antarctic habitats. In In: M. Barták, J. Hájek, P. Váczi (eds.): Structure and Function of Antarctic Terrestrial Ecosystems. Book of Abstracts and Contributed Papers. Electronic Conference on Interactions between Antarctic Life and Environmental Factors, IPY- related Research Brno, October 22th-23th, 2009. Masaryk University, Brno, Czech Republic. Vyd. 1st edition, 2009. Brno: Masaryk University, Brno, 2009. 48-51
2) Bokhorst S, Huiskes A, Convey P, Aerts R.The effect of environmental change on vascular plant and cryptogam communities from the Falkland Islands and the Maritime Antarctic.BMC Ecology (2007); **7**:15
3) Chaturvedi AK, Prasad P, Nautiyal MC,Lesser chamber effect inside open top chambers provides near-natural microenvironment for CO2 enrichment studies in an alpine region of India. Journal of American Science 2010; 6(3): 109-117
4) Chaturvedi AK, Vashistha RK, Prasad P, Nautiyal MC, Need of innovative approach for climate change studies in alpine region of India. Current Science 2007 ; 93(12): 1648-1649
5) Chaturvedi AK, Vashistha RK, Rawat N, Prasad P, Nautiyal MC. Effect of CO_2 Enrichment on Photosynthetic Behavior of *Podophyllum Hexandrum*Royle, an Endangered Medicinal Herb. Journal of American Science 2009; 5(5):113-118
6) Körner C. The Alpine Life Zone. In: Christian Körner, Alpine Plant Life: Functional Plant Ecology of High Mountain Ecosystems (2nd Ed.). Springer, Berlin 2003:9-20
7) Luo C, Xu G, Chao Z, Wang S, Lin X, Hu Y, Zhang Z, Duan J, Chang X, Su A, Li Y, Zhao X, Du M, Tang Y, Kimball B. Effect of warming and grazing on litter mass loss and temperature sensitivity of litter and dung mass loss on the Tibetan plateau. Global Change Biology 2010; 16(5): 1606–1617
8) Marion GM, Henry GHR, Freckman DW, Johnstone J, Jones G, Jones MH, Lévesque E, Molau U, Mølgaard P, Parsons AN, Svoboda J, Virginia RA. Open-top designs for manipulating field temperature in high-latitude ecosystems. Global Change Biology 1997, 3(S1): 20-32.
9) Upreti, D.K. Diversity of Lichens in India, In Perspectives in Environment (eds.Agarwal S.K., Kaushik J.P., Kaul K.K., and Jain A.K.),APH Publishing Corporation, New Delhi, 1998, 71-79
10) Walker MD, Wahren CH, Hollister RD, Henry GHR, Ahlquist LE, Alatalo JM, Bret-Harteh MS, Calefh MP, Callaghani TV, Carrolla AB, Epsteinj HE, Jónsdóttirk IS ,Kleinl JA, Magnússonm B, Molaug U, Oberbauerf SF,Rewan SP, Robinsono CH, Shaverp GR,Sudingq KN,Thompsonr CC, Tolvanens A,Totlandt Ø, Turneru PL,Tweediev CE, Webberw PJ, Wookeyx PA. Plant community responses to experimental warming across the tundra biome. Proc Natl Acad Sci 2006;103(5):1342–1346
11) Xu ZF, Hu TX, Zhang L, Zhang YB, Xian JR, Wang KY. Effects of simulated warming on the growth, leaf phenology, and leaf traits of Salix eriostachya in sub-alpine timberline ecotone of western Sichuan, China.Ying Yong Sheng Tai Xue Bao 2009; 20(1):7-12.

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