Large scale infestation of blue pine by Himalayan dwarf mistletoe in the Gangotri National Park, Western Himalaya

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Abstract: Large scale forest degradation and mortality associated with dwarf mistletoes infestation has been reported across the world. During recent surveys in the Gangotri National Park, Western Himalaya, we recorded infestation on Blue pine, Pinus wallichiana over large area by Himalayan dwarf mistletoe, Arceuthobium minutissimum. The infestation was never recorded in this landscape. Long term climate data indicates trends of change in minimum and average temperature during last two decades which may serve as suitable conditions for growth and intensify pathogenicity of the dwarf mistletoe in future scenarios.

Key words: Arceuthobium minutissimum, Climate change, Infestation, Pathogen, Pinus wallichiana.

The forest ecosystems are affected by several anthropogenic and natural disturbance including fire, drought, landslides, avalanches, insect pests and other pathogens. The extent and severity of these disturbances are also influenced by climatic factors which may trigger extreme events and outbreak of insects and diseases (Walther et al. 2002; McNulty & Aber 2001). Susceptibility of forests to pathogens depends on the interaction among the hosts, pathogens and environmental conditions such as extremes of temperature and moisture, which may increases host susceptibility or fitness of pathogens (Burdon et al. 2006). Among the forest pathogens, parasitic plants have special adaptations and profound effects on the hosts. About 4000 species of parasitic plants have been recorded all over the world across various biomes (Press & Phoenix 2005). Among them, dwarf mistletoe (Arceuthobium spp; Viscaceae) play a significant role in tree mortality and the genus includes species that are among the most damaging parasites of important conifers across the world (Fig. 1). These parasites cause reduction in tree growth, loss of seed and cone production and increased tree mortality and susceptibility. All species of this genus induce ‘Witch’s brooms’ which cause their hosts retarded growth and mortality (Hawksworth & Wiens 1970).

Arceuthobium comprises 42 species across the world distributed in northern hemisphere (Fig. 1). In the Himalayan region, three species viz. Arceuthobium minutissimum, A. oxycedri and A. sichuanense are reported, of which first two are distributed in Western and north-western Himalaya and last one in Bhutan, eastern Himalaya (Naithani & Singh 1989). Arceuthobium minutissimum Hooker is the smallest known dicotyledonous plant as described by J. D. Hooker (1886). The visible part above the bark of host is ca. 5mm high and often resemble with needle scars on the stem. Flowers are unisexual except one report of presence of hermaphrodite flower in one specimen (Datta 1951). In India, A. minutissimum is reported from cold arid regions of Jammu and Kashmir, Himachal Pradesh and Uttarakhand. In the Himalayan region it occurs only in the inner dry ranges on its principal host blue pine, Pinus wallichiana (Gorrie 1929) except one record of infestation on another commercially important conifer, Pinus gerardiana in Pakistan (Chaudhary & Badshah 1984). Its global distribution extends from Pakistan to Bhutan. Extensive tree mortality

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due to infestation by Arceuthobium has been reported from the Himalayan region in the past (Bagchee 1952).

During a recent ecological survey in the Gangotri National Park, authors recorded infestation by A. minutissimum over large areas on the Pinus wallichiana forest. Intensive survey on the extent of spread of this pathogen reveals that over 250 ha area from Gangotri to Devgad area was infested sporadically on both slopes of the valley. It is noteworthy that this area has been extensively studied in terms of eco-floristics (Chandola 2009; Pusalkar & Singh 2012) in the past and there is no report on the occurrence of Himalayan dwarf mistletoe from the Park. The present report indicates fresh infestations in new areas in the Western Himalaya. We recorded the infestation on the mature trees of Pinus wallichiana in the Gangotri National Park between 3000 to 3400 m elevation. Symptoms of heavy infestation were evident in the form of Witches broom, yellowing of needles and dying branches and entire trees (Fig. 2).

Surveys of occurrence, slope association, and severity of infestation of several dwarf mistletoe species across various parts of globe revealed that the spread of dwarf mistletoes is limited by low temperature which reflects differences in incidence and severity among geographic areas (Williams 1971). The upper elevational limits in which several species of mistletoe reported indicates that the growing season is not long enough for the fruits to mature towards autumn and, warming could prolong growing season and allow for geographic range expansion. Long term climatic data reveal an increase of 0.98 °C in annual maximum temperature over the Western Himalaya (Dash & Hunt 2007), where greater Himalaya shows an increase in maximum and minimum temperatures of 1 and 3.48 °C, respectively (Shekhar et al. 2010). The present study area is devoid of long-term climatic data and we used two decadal data (1986–1995 and 1996–2005) obtained from NASA (https://eosweb.larc.nasa.gov/sse/) which revealed that minimum and average temperature of the infestation site has been increased during February to April (Fig. 3) and in the post monsoon season (September and October). Relative humidity during April to July also showing decreasing trends. These extended warm and dry conditions are likely to create conditions favourable for growth and maturity towards end of growing period. Warming associated forest pest and pathogen outbreak and large scale degradation of coniferous forest has been already reported across the globe as well as in the Western Himalaya (Uniyal & Uniyal 2009). The interactive effects of Arceuthobium infestation, fungal diseases
and insect pests are reported to cause high pine mortality during years of average precipitation which is more frequent in the presence of other stress factors, such as drought (Schultz & Allison 1982). The annual as well as monsoon rainfall has been declined in high altitudes of Western Himalaya during last 5–6 decades and negative trends of post monsoon and winter precipitation is also evident (Singh & Mal 2014). These conditions may favour maturity and dispersal of seed of the dwarf mistletoe which is limited by the cold temperature towards the end of growth period.

Upward shift in elevation range of mistletoes due to climate change has been reported from elsewhere (Dobbertin et al. 2005). Climatic limits for distribution of *A. minutissimum* also depends on the distribution and population density of its principal host. Interestingly, large scale regeneration and elevation range shift of *P. wallichiana* is reported from the Western Himalaya (Dubey et al. 2003). These conditions may serve as suitable precursor of further spread of dwarf mistletoe at higher elevation. Current patterns of unusual and extreme climatic conditions in Western Himalaya may cause eruptions of mistletoe populations leading to mass mortality of host species (Jenkinson 1990). Blue pine contributes significantly to the forest cover in the high altitudes where climatic uncertainty and trends of long dry season may favour infestation over large areas and its dense patches may help in rapid spread. Increasing period of dry season may favour spread of the species and increase in its pathogenicity (Dore 2005). Climate change associated extreme events in this region...
such as long dry periods in summer and post monsoon season may provide ideal condition for the spread of this pathogen. It may also make the infested trees more vulnerable to attack by other diseases and insect pests. Therefore, it is feared that rapid spread of this species in the park might become detrimental to the growth and regeneration of blue pine. Further, detailed studies on the patterns of infestation and extent of Himalayan dwarf mistletoes are important because they are serious pathogens of coniferous trees which are valuable ecologically and economically in the Himalayan region. Also, this species can serve as indicator of changes in environmental conditions over time where long term monitoring with past records will be important to track impacts of climate change on these ecosystems.

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