특별보고

Infestation of oak trees by the flowering parasite (*Taxillus Vestitus* (Wall.) danser) at Nainital in Uttaranchal, India

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1. Introduction

The most striking feature of the earth is the existence of life, and the most striking feature of life is its diversity (Tilman 2000). Topography, soil, climate and geographical location of a region influence the vegetation diversity of the forest ecosystem. The Himalayan forest vegetation ranges from tropical dry deciduous forests in the foothills to alpine meadows above timberline (Singh and Singh 1992). Forest diversity is the main source of livelihood of the people living in Uttaranchal, Central Himalaya. India is among the important megabiodiversity centres of the world, with a lot of contribution from the Himalayan ecosystem. Biodiversity is used variously for fodder, fuel wood, timber, leaf litter for manuring crop fields, construction, industrial raw material and several non-timber forest produce.

Forests of this region are mainly dominated by *Pinus roxburghii* Sarg. (Chir Pine) and *Quercus leucotrichophora* A. Camus. (Banj oak). Chir pine often forms a pure crop in this area, but sometimes it also mixes with certain broadleaved species like *Q. leucotrichophora, Quercus glauca* Thumb, *Pyrus pashia* Ham., *Myrica esculanta* Linn. and *Rhododendron arborium* Sm. *Q. leucotrichophora* prefers cooler aspects below 1900 m asl (Saxena et al. 1984) and is found in either pure or mixed with other broadleaved species. Five evergreen species, namely *Q. glauca* (phaniyat oak), *Q. leucotrichophora* (banj oak), *Q. floribunda* (tilonj oak), *Q. lanuginosa* (rianj oak) and *Q. semecarpifolia* (brown oak) occur in the Central Himalaya between 1000 and 3600 m amsl and represent the climax vegetation. They have assumed considerable relevance not only for their economic use but also for the general health of the fragile ecosystem (Singh and Singh 1986).

We observed that oaks are heavily infected by the flowering parasite, *Taxillus vestitus* (Mistletoes) in the Nainital forest division as well as in other areas of Uttaranchal Himalaya (Figure 1) (Ram et al. 2005). *T. vestitus* is a perennial evergreen shrub. It belongs to the family *Loranthaceae*, a parasite family widely distributed from the tropics to temperate region with 77 genera and 950 species (Polhill and Weins 1999). Mistletoes also function as keystone sources in many ecosystems (Watson 2001). The parasite spreads through birds and wind dispersed seeds and causes deformity in twigs and trunks. The seeds of the stem

parasite, which have a sweet taste, are very sticky. Incidentally, birds love to eat these sweet sticky seeds. When birds nibble at these seeds some of these get stuck to their beaks and from there to the stems and branches of the oak trees.

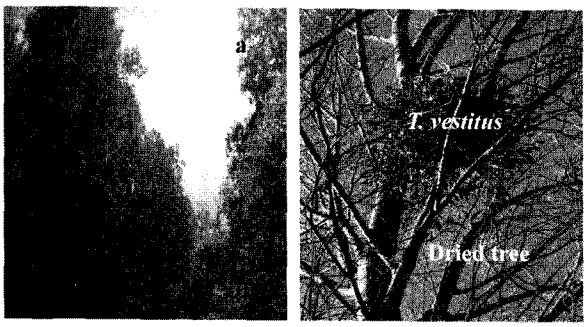

Figure 1 *Quercus* (Oaks) tree a) before and b) after attack by *Taxillus vestitus*

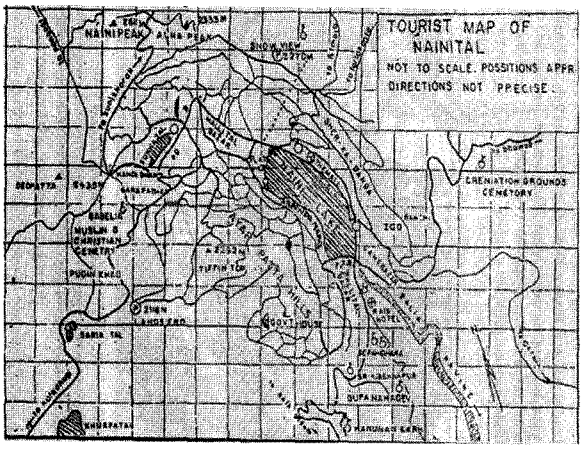

Figure 2 Study area

Mistletoes are hemiparasites (Pant 2005). They rely completely upon their host for water and minerals but capable of producing their own supply of photosynthate to a certain extent (Ehleringer et al. 1985; Marshall and Ehleringer 1990; Johnson and Choinski 1993). Comparison between host and parasite with respect to leaf conductance and leaf water potential show that the potential for leaf conductance was considerably higher for parasite than the host. Parasitism of *Q. floribunda* and other species by *T. vestitus* is common in areas where trees are subject to lopping for fodder or other purposes. Photosynthetic rate of mistletoes is very low compared to other higher plants (Marshall *et al.* 1994), although transpiration rates in mistletoes are high (Davidson *et al.* 1989; Goldstein *et al.* 1989), up to 9 times higher than those of their host (Ullmann *et al.* 1985). The objective of the present study was to analyse the incidence of the parasite in oak forest of Nainital. Seasonal gas exchange and water relations of *T. vestitus* and its host *Q. floribunda* were also studied under natural field conditions.

Table 1 Site characteristics

Site	Location	Elevation (m)	Aspect	Forest type
1	Pines	1900	N - E	Mixed oak forest
2	Kailakhan	1900	N - E	Oak dominated forest
3	University	2000	N - E	Oak dominated forest
4	D. S. B. Campus	2000	N - E	Mixed oak forest
5	Ayar Patta	2100	N - E	Mixed oak forest
6	Raj - bhawan 2100	2100	N - E	Mixed oak forest
7	Sanik School	2150	S - W	Oak conifer forest
8	Sher wood	2150	N - E	Oak dominated forest
9	Snow View	2300 N - E	N - E	Oak dominated forest
10	Birla School	2300	S - E	Mixed oak forest
11	Tiffon top	2350	N - E	Mixed oak forest

N - E, North east; S - W, South west.

2. Materials and Methods

Kumaun and Garhawal Mountains form the central sector of Indian Himalaya continuing in the southeast into Nepalese Himalaya. The mid altitudes i.e. approximately between 1500 and 3000 m of the central Himalaya are covered with Himalayan moist temperate forests with one or more species of oaks forming climax vegetation. The study area is situated at 29°24'N and 79°25'E between 1900 and 2400 m elevation in the Himalayan forest (Figure 2). Mean monthly temperature ranged from less than 0° to 28°C. Frequent snowfall during winter is the characteristic feature of the area. The area is latitudinally located within the subtropical belt and is influenced greatly by the southwest monsoon. A temperate environment prevails because of the high elevation, and the functional behaviour of vegetation represents a transition between strongly seasonal tropical & temperate conditions (Singh and Singh 1992). The study was conducted during 2003-2004.

After a through reconnaissance of the infected oak forest, 11 sites were selected (Table 1). Total tree density was determined by placing ten, 10 x 10 m quadrats on each site. Infection frequency of the parasite was determined as:

$$\text{Infection frequency} = \frac{\text{Number of infected trees}}{\text{Total number of trees}} \times 100$$

Infestation intensity was also determined by counting the total number of branches and number of infected branches on a tree as:

$$\text{Infestation frequency} = \frac{\text{Number of infected branches on a tree}}{\text{Total number of branches on tree}} \times 100$$

Relationship between tree girth classes and infection frequency was studied.

For observations on water relations, six average sized trees (about 50 cm diameter at breast height) of *Q. floribunda* infested by mistletoe were selected from site 6. Fully illuminated adjacent twigs/leaves of host and parasite located on the periphery of the crown were sampled. Leaf water potential (Ψ) was measured on leafy shoot sampled from parasitized branches using a pressure chamber (Model 1000 PMS Instrument CO, Corvallis). Water potential (Ψ) was measured as described by Zobel and Singh (1995), Garkoti *et al.* (2000) before dawn when plant Ψ should be maximum. Stomatal conductance (m mol m^{-2} s^{-1}) of host and parasite was assessed at 9 AM and 1 PM by using Ap4-type porometer (Delta-T Devices, Cambridge, England). Data from two to three leaves from each plant were averaged while interpreting the results. Foliage was maintained in natural orientation during conductance measurements. However, for larger trees or in case of infestation on the crown top large twigs were cut for measurements.

Table 2 Frequency (%) and intensity (%) of the parasite in different forests

	Q. leucotrichophora		*Q. leucotrichophora*	
Sites*	Frequency	Intensity	Frequency	Intensity
1	64	62	73	41
2	18	25	40	38
3	73	71	67	58
4	64	25	66	45
5	17	13	27	33
6	71	43	84	69
7	65	39	84	59
8	33	47	45	74
9	33	47	45	74
10	27	80	60	60
11	30	45	74	66

*Sites 1 - 11 same as in Table 1.

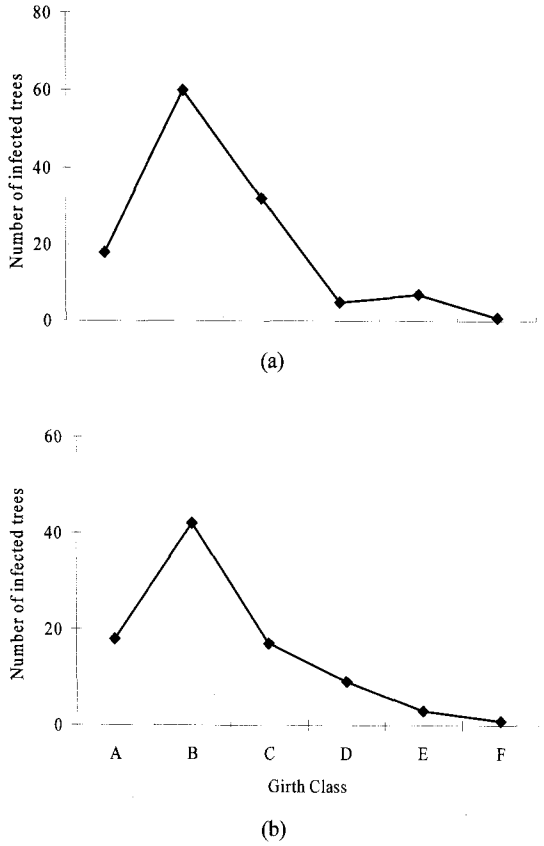

Figure 3 Relationship between girth classes and infection frequency. (a) *Q. floribunda*; (b) *Q. leucotrichophora*. A - F girth classes are: A, 30 - 80 cm; B, 80 - 130 cm; C, 130 - 180 cm; D, 180 - 230 cm; E, 230 - 280 cm; F, > 280 cm.

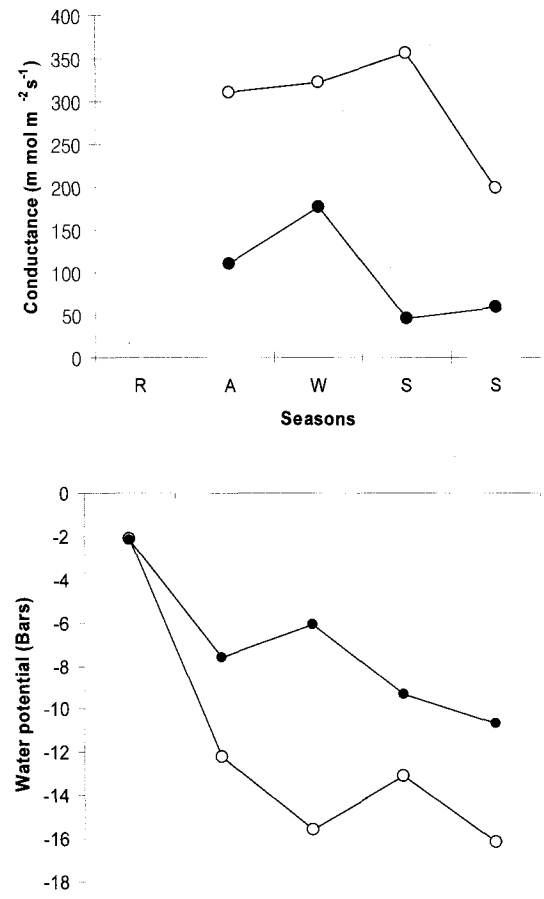

Figure 4. Seasonal courses of leaf conductance and water potential for: ● *Q. floribunda* and ○ *T. vestitus*. R = rainy, A = autumn, S & S are spring and summer seasons, respectively.

3. Results and discussion:

The infection frequency for *Q. floribunda* was >60% on all sites, except at sites 2, 5 and 9, whereas for *Q. leucotrichophora* >60% frequency was found only on 5 sites (Table 2). The number of infected trees was higher for *Q. floribunda* compared to *Q. leucotrichophora* in almost all the sites. Similarly, the infection intensity was greater for *Q. floribunda* except at sites 2, 3 and 10, whereas it was greater for *Q. leucotrichophora* (Table 2). Thus, *Q. floribunda* is more susceptible for the parasite because it is preferred as fodder. The relationship between different girth classes and infection frequency indicated that the trees of middle girth classes were highly susceptible to the parasite attack. The maximum number of infected trees was present in the girth class 80 and 130 cm in *Q. leucotrichophora* (Figure 1 b) and 80 and 180 cm in *Q. floribunda* (Figure 1 a).

Trees of middle girth classes being frequently used for leaf fodder, firewood and making agriculture implements may provide opportunity to establish the parasite more frequently than older trees, saplings and seedlings. High percent of infected trees occurred near human habitations while it was lower at inner sites of the forests. It indicated that anthropogenic disturbances trigger the infection by the parasite through

opening of the canopy. The frequency and infestation intensity of the parasite were higher in disturbed sites and for trees of middle girth classes and when compared for the two hosts, it was greater for *Q. floribunda*. The cutting of branches improves the light availability which in turn promotes the growth of the hemiparasite.

On all sampling dates water potential (Ψ) was more severe for the mistletoe than for the host (Figure 4). This enables the parasite to have access to host water in all seasons, even if the host is under considerable water stress. Although the water potentials of the mistletoe shoots were consistently lower than those of the host, the potential difference was not consistent. It seems that the parasite employs a more efficient osmotic adjustment for maintaining an unbroken supply of water from the host with higher water potentials. Consistent with the observations of Garkoti *et al.* (2000) the daily range of Ψ (ΔΨ = predawn Ψ - midday Ψ) in both mistletoe and the host in general, showed a similar pattern.

In natural stands, pathogens are difficult to control and become a challenge before the forest managers. Selective removal of infected trees would be the only option to control the parasite. The cut and burn of infected branches would also be helpful in controlling the parasite. Generally, the lower diameter classes like seedlings and saplings are less infected by the parasite. Thus, seedlings and saplings should be regularly monitored and protected for the better management of the forests. Precaution should be taken that no single stem of parasite would be present.

4. Acknowledgements

Head, Department of Forestry, Kumaun University, India and Prof Jeet Ram are thanked for providing necessary facilities. Funding from Council of Scientific and Industrial Research and Department of Science and Technology, New Delhi, India is acknowledged. The author gratefully acknowledge Prof Seung-Jin Maeng, Dept. of Agricultural & Rural Engineering, Chungbuk National University, Cheongju, Chungbuk for providing opportunity to carry doctoral research and for his motivation in writing the article

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