1. Project title: Insect Pests of Western Himalayan Oaks and their Control.
Name of PI : Dr. Arun Pratap Singh
Year of Project duration : 2017-2021
Funding agency's full name : ICFRE
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Overview of project :

The Western Himalayan state of Uttarakhand is represented by five species of oaks of the genus *Quercus* namely: *Q. glauca* (phaliyant), *Q. leucotrichophora* (banj), *Q.floribunda* (moru), *Q. lanuginosa* (rianj) and *Q. semecarpifolia* (kharsu)] that are important for their multiple utilization values for local communities living in the region by providing livelihood and sustenance ie. fodder & firewood. Besides, these temperate forests play an important role in recharging of ground water and are rich in Himalayan biodiversity. The entire western Himalaya is today witnessing an 'oak decline' throughout it distributional range. Oak forests today are under threat mainly due to anthropogenic pressures along with attack by many species of insects. Cerambycid wood borers are responsible for damaging the living trees thereby causing large scale tree mortality followed by attack by secondary borers and fungi that render the timber useless for utilization. Damage to acorns by weevils leads to poor regeneration. Hence, there is a need to fully understand the insect pest spectrum of oak forests and identify and study the biology of important pests which can cause significant damage and work out management options.

As such field surveys across the oak forests of the state were carried out for 3 years (2017-2020) in the entire temperate oak forest zone of the state. First hand data on insects infesting these species of oaks were recorded and a database prepared on all The insects recorded so far in the state. Experiments were carried out on studying the ecology of stem woodborers and their control using bio-pesticides and fumigants. Management of key important pests i.e stem and wood borers, defoliators, shoot borers, acorn weevils and sap sucking insects by using IPM methods worked out are suggested.

Objectives :

Long term

- Evaluation and management of insect pests of west Himalayan oaks

Short term

- Identification of insect pests of oaks and areas of frequent infestation/outbreaks
- Studies on the biology, life history and ecology of important pests and their natural enemies.
- Evaluation of the extent of damage caused by these pests to oak forests during the study period.
- Identification of a biotic & biotic factors linked to insect/pest outbreaks.
- Evolving control methods/management strategies for controlling the outbreak of important pests.
- Preparation of a database on insect pests of Western Himalayan oaks with images and maps.

Significant findings / outcome :

•Documentation of all the insects infesting oaks recorded so far in Uttarakhand state by creation of a database on 233 insects (117 Lepidoptera; 99 Coleoptera; 16 Hemiptera and1 Diptera) infesting oaks of the western Himalaya. GIS based maps were generated depicting sites under taken for studies in Uttarakhand, for defoliator and borer infestation. The database includes information on i) Classification & taxonomy (ii) specimens records with details in collections iii) distribution range (iv) host plant range (v) habits & habitat (vi) life cycle duration of different stages with their morphological characters (vii)images on the different life history stages -larva, pupa, adults (male & female) and also eggs of some species (viii) extent of damage/status and (ix) references and sources of literature for each species. Life cycle of over 50 species was studied. The extent of damage of each insect infesting western Himalayan oaks is provided and of database in the form of a book made available on line free of cost to the users at the ICFRE website [https://www.icfre.gov.in/books-file/book24.pdf]

•Biology and morphology of different life history stages of the wood borers X*ylotrechus basifuliginosus*, heller 1926 and *Rosalia lateretia* (cerambycidae: coleoptera) was studied for the first time. Biotic and biotic factors responsible for borer outbreaks on oaks were identified as mainly extensive lopping and grazing. By carrying out studies on density diameter of oak trees in borer infested and un-infested Kharsu oak and ban oak forest stands a relationship was established between the degree of past disturbance in these oak stands and the degree of borer infestation. More severe the disturbance, more is the borer infestation and vice-versa. It is recommended that prohibition on lopping of oak trees in badly borer infested oak stands to prevent them from egg laying will therefore help in checking the further spread of the borer infestations besides burning of oak slash, removing of dead infested trees and logs from the infested sites. *Current Science*.122 (3): 327-332. https://doi.org/10.18520/cs/v122/i3/327-332

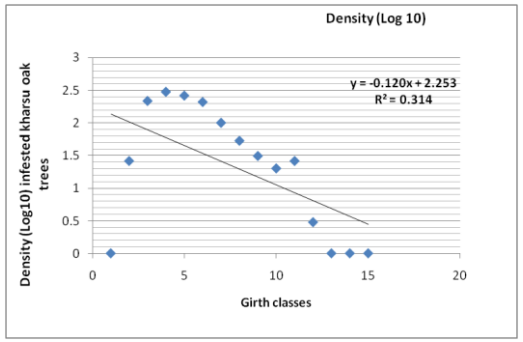
Chemical control measures worked out stem wood and timber borers by using a commercially available biopesticide- "TAG VERIA" an Entomo-pathogenic fungi (*Beauveria bassiana*)for secondary wood borers and also a fumigant (saturated sol of para- di-chlorobenzene in Kerosene oil) for primary borers. https://doi.org/10.18520/cs/v124/i11/1339-1342

•For defoliators are mainly surface feeders, ie Indian Gypsy Moth, *Lymantria obfuscata* Walker, 1865 and Pink Gypsy Moth, *Lymantria mathura* Moore, 1865 chemical spray using synthetic pyrethriods i.e 0.1%Cypermithrin or commercially available strain of *Bacillus thuringensis* (BT), are recommended in larval stage of these insects. Mechanical control using glue bands (15cm plastic bands coated with a sticky glue surface) applied around the full tree trunk circumference at breast height help the caterpillar population that climb down the tree trunks to overwinter besides egg mass collection and destruction.

•For shoot borers, acorn weevils and sap sucking insects, systemic insecticide i.e. Imidacloprid @0.5ml/litre by mixing it in soil close to the root system of the tree is recommended. Extension of this research work was done by means of presentations as scientific posters in various organization events and seminars, publication of research papers. https://doi.org/10.36808/if/2022/v148i6/165504

Extension aspect / Practical utility of the findings :The current findings have improved our understanding about the spectrum of insects infesting western Himalayan oaks in a better way. These findings will help in identification, evaluation and proper management of insects harmful to oak trees in the state. The database will help in research by identification of insects, understanding their life histories, distribution range, host plant spectrum, altitudinal distribution, habits, extent and nature of damage, natural enemies, pest status, cultural, chemical and give bio control methods for harmful insects and that will help in improving the health of oak forests in Uttarakhand. For more details please read the following articles:

Ecology & trials on management of stem borer *Xylotrechus basifuliginosus* of Kharsu oak,*Quercus semecarpifolia* using bio-pesticide *Beauveria bassiana* – commercial strain 'TAG VERIA', in the Garhwal Himalaya.



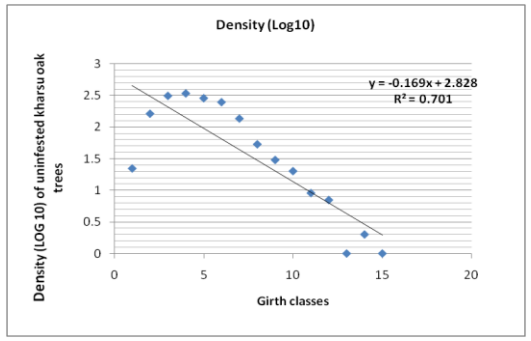


Fig. 4 Dried up foliage of kharsu oak tree in Deoban RF ,Chakrata Forest Division

Relationship between borer infestation and the degree of past disturbance in oak stands : Relationship between Kharsu oak tree density and girth classes in both borer infested and un-infested stands by studying 180 plots (90 in disturbed stands plots and 90 undisturbed stands of 10mx10m;2019-2020). Trees were divided in 13 GBH classes of 20 cm each varying from 20-300cm. It was found that borer infested sites revealed higher degree of past disturbance (fig.1; r^2= 0.314) as compared to un-infested oak stands with low degree of past disturbance (fig. 2 ; r^2= 0.701) .

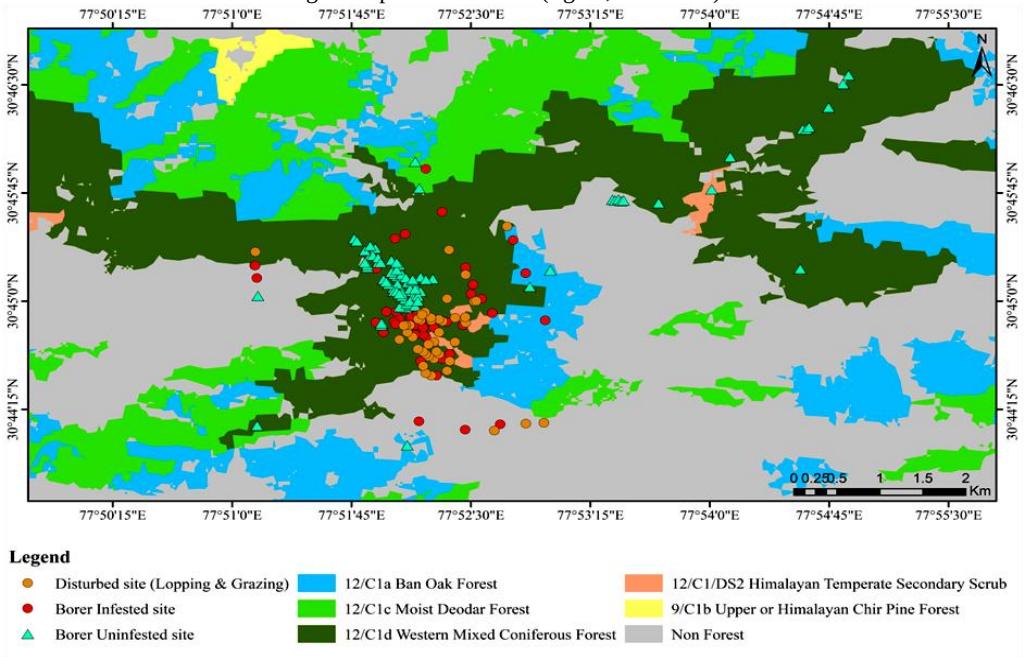


Fig. 3 GIS Map showing sampled sites for past disturbance in infested and un-infested kharsu oak stands, in Chakrata Forest Division, Uttarakhand

Fig. 4 Female *Xylotrechus. basifuliginosus*

Fig. 5 Ventral view of mature larva

Fig. 6. Cresent Shaped holes made by the larva on Kharsu oak stem and branches

Fig.7. T.S. of borer infested kharsu oak log showing damage caused to Kharsu oak wood by larval galleries and chambers

Fig.9-*Beauveria bassiana* – commercial strain 'TAG VERIA'

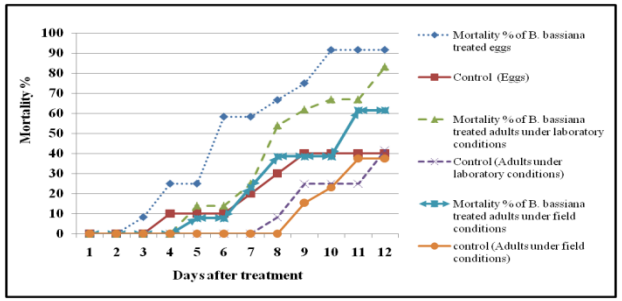


Fig .8 Fungal virulence of *B. bassiana* on *X. basifuliginosus* eggs and adults under both laboratory and field conditions.

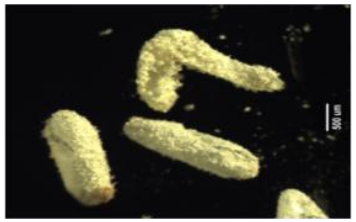


Fig .10. *B. bassiana* infested beetles eggs

Fig. 11& 12: Conidia on mouth parts, legs and sternites on adult beetles causing their mortality.