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An overview on outbreak of *Eucalyptus* gall wasp, *Leptocybe invasa* (Hymenoptera: Eulophidae) in Northern India

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Abstract

A survey of Northern India was carried out from 2010 to 2014 in different *Eucalyptus* growing areas of Uttarakhand, Uttar Pradesh, Haryana and Punjab. Gall wasp infestation was observed in both young plantations and nurseries. Observations revealed that in northern India *Eucalyptus* growing areas were under threat of attack by gall wasp, *Leptocybe invasa*. Biological control of *Leptocybe invasa* has been applied in Punjab, from 2012 to 2016, where infestation of gall wasp was regularly decreased and came below 10 % by April 2016.

Keywords: *Eucalyptus*; Gall wasp; *Leptocybe invasa*; *Quadrastichus mendeli*. *Megastigmus viggianii*, Biological control

1. Introduction

Eucalyptus spp. are the native species of Australia and Tasmania, which were introduced in India in 1790^[1] and regular plantations were taken up after 1851. The new clonal *Eucalyptus* plantations were started from 1992 onwards and nearly 2, 50,000 ha of land are covered under clonal plantations^[2]. More than 65 *Eucalyptus* spp. and various provenances were tried in India^[3]. *Eucalyptus* plantations are major sources of timber, firewood, honeybee foraging areas, recreation areas, shelterbelts, windbreaks etc. Out of 800 species, *Eucalyptus camaldulensis* is the best-known eucalyptus tree species which is an economically important hardwood species of dry lowland in the entire Mediterranean and Middle East regions^[1]. More than 16 million ha of *Eucalyptus* is planted around the world for various purposes including pulp for paper, solid wood, structural timbers and woodlots for fuel^[4]. With an area of 8 million ha, India ranks first in area planted with *Eucalyptus* and has a productivity of 146 tonne/ha^[5]. Indian pulp and paper industry is highly dependent on *Eucalyptus* fibre and consumes nearly 7 million tonnes of wood annually, derived from farm forestry^[6]. *Eucalyptus* being an exotic tree species established very well in Indian conditions and faced very little or negligible damage by insect pests. *Eucalyptus* spp. are attacked by about 60 insect species^[7]. Out of which important insect pests are termites which cause considerable damage to the young plants. Two species of beetles namely *Celosterna scabrator* and *Psiloptera fastuosa* are also causing moderate damage^[8]. Other insects, recorded on *Eucalyptus* spp. are not considered as pests of economic importance.

In the year 2000, a chalcid wasp *Leptocybe invasa* belonging to the family Eulophidae accidentally escaped from its natural habitat, Australia, and got introduced into the Mediterranean countries where it caused severe injury to the young foliage of *Eucalyptus camaldulensis* by inducing galls, mainly on growing shoots, seedlings in nurseries, saplings in plantations and coppiced shoots. Its rapid population growth was recorded in the absence of natural enemies^[9]. The presence of this exotic wasp was first noticed in Israel. Later Fisher and La Salle described it under a newly erected genus and as a new species *Leptocybe invasa* in the year 2004^[9]. In its native place, Australia, this insect and its damage were so negligible that it was never noticed. Within a couple of years, *Eucalyptus* plantations and nurseries throughout the tropical and subtropical countries came under the attack of this wasp^[9, 10, 11] and brought havoc in *Eucalyptus* plantations and ultimately exerted a pressure on plantation industry. *Leptocybe invasa* is a classic example to show that how an insect species, lives in harmony in its native habitat; while its population explodes to dangerous levels, in the absence of its natural enemies, when introduced intentionally or accidentally into an exotic habitat.

In this paper four different states (Haryana, Punjab, Uttar Pradesh and Uttarakhand) have been surveyed and recorded gall intensity in Eucalyptus growing areas. Literature on the subject, especially from India has been reviewed thoroughly.

2. Material and methods

Four different states (Haryana, Punjab, Uttar Pradesh and Uttarakhand) from Northern India were surveyed (Table:1) for Eucalyptus gall infestation and different Eucalyptus growing areas were also visited for taking the observations of Eucalyptus gall wasp infestation. Visual observations were recorded on eucalyptus gall infestations. Literature on the subject, especially from India has been reviewed thoroughly.

3. Result and Discussion

(i) Eucalyptus Gall infestation in India: Infestation of gall wasp *Leptocybe invasa* was first noticed in 2001 in Mandya district of Karnataka and later in 2002 at Marakkanam in Villupuram district of Tamil Nadu. It was also spread rapidly in Andhra Pradesh, Kerala, Pondicherry, Gujarat, Maharashtra and Goa ^[12, 13]. In Karnataka, the gall wasp was reported to damage about 25 lakh eucalyptus saplings in the nurseries of two major paper and rayon industries (West Coast Paper Mills and Harihar Poly fibres) ^[14]. Within two to three years it rapidly spread throughout India, causing heavy damage in nurseries and plantations.

(ii) Gall wasp infestation in South India

A preliminary survey revealed that *Eucalyptus camaldulensis* plantations raised in Rangareddy, Nizamabad, Warangal,

Khammam East and West Godavari, Nellore and Chittoor districts of Andhra Pradesh and *E. tereticornis* plantations in Karur, Trichy, Pudukkottai, Sivaganga, Villupuram, Thiruvannamalai, Cuddalore and Coimbatore districts of Tamil Nadu were affected by the gall problem ^[15]. Kumari ^[16] has studied the biology and management of *L. invasa* in details.

(iii) Galls problem in the Northern India

For knowing the status of gall insect infestations in *Eucalyptus* plantations and nurseries. First survey was conducted during December, 2010 ^[17] and another survey of plantations and nurseries of Haryana was carried out in August 2011 ^[18]. *Eucalyptus* gall infestation was observed severe in young seedlings and saplings in nurseries and also in most of the plantations during 2010-12. Similarly during 2012-13, surveys of nurseries and plantations were conducted in different localities of Hoshiarpur, Punjab and recorded severe *Eucalyptus* gall wasp infestation. Seed origin Eucalyptus seedlings were severely infested; about 40-50 galls was recorded on each plant and about 90% plants were gall infested, despite regular application of chemical insecticides. At Satyal nursery Hoshiarpur observations were taken on different clones in the Vegetative Multiplication Garden. The intensity of galls on some *Eucalyptus* clones was veryhigh; as clone 2070 was having 62.39% leaves with galls; clone 316-F having 64.67% leaves with galls; Clone 316 P was having 41.67% leaves with galls; clone 526 was planted separately and it was having only 16.27% leaves with galls.



Fig 1: [A-D], A- Gall infestation in Yamunanagar, Haryana; B- Gall infestation in Saharanpur, Uttar Pradesh; C-Gall infestation in Hoshiarpur, Punjab; D- Gall infestation in Haridwar, Uttarakhand.

Table 1: Infestation of eucalyptus galls in different districts of Haryana, Punjab, Uttarakhand and Uttar Pradesh.

States	Districts	Localities	Date of survey	Infestation	Eucalyptus stock	Remarks
Haryana	1. Ambala	Ambala Yamunanagar road	December 2010	1-2 %	Seed raised	Roadside plantations and private plantations.
		Rampur Nursery, Ambala Cantt.	August, 2011	80-90 %	Seed raised	About 25000 seedlings, raised from mixed lot of seeds, started infestation from April 2011.
	2.Hisar	Hisar	December, 2010	5-10 %	Seed raised	Roadside plantations.
		Assandh and Bassi	December, 2010	20-70 %	Seed raised	Roadside plantations.
	3.Karnal	Bastada road side plantation	August, 2011	10 %	Clonal	Gall infestation despite regular pesticides treatment.
		Liberty Puram Plantation.		1-2%	Clone 10 Bhadrachalam	Free from galls, only a few leaves with midrib galls.
		Mangalpur Nursery		60-70 %	Seed raised 50,000 Plants	Nursery beds were packed with plants, the top portion of seedlings was heavily infested.
		Uchana Nursery		70-80 %	Seed raised 50,000 plants	Seedlings were raised from mixed seed lot and were observed with heavy gall infestation.
		Pastana Plantation		5-10%	Seed raised	Plantation of 2010, having gall infestation and little leaf disease.
	4. Kurukshetra	Seonhi	December, 2010	10-70 %	Clonal nursery	Heavy infestation despite pesticidal treatment.
Near Mohri Railway Station		August, 2011	60-70%	Seed raised 35,00 Plants	The plantation was having gall infestation and little leaf disease.	
5.Panchkula	Chaunki, Fatehpur and Raipur Rani	December, 2010	10-30 %	Seed raised	Roadside plantations were infested despite heavy treatment of pesticides.	
6.Yamuna Nagar	Meerpur and Manakpur	December, 2010	5-10 %	Seed raised	Plantations (Trees of 13-14 and 7-8 years old) with low galls infestation.	
Punjab	7. Bathinda	Forest Rest House Nursery,	March, 2014	6.76%	Clone 413	Plantations
				6.43%	Clone 316	
	8. Faridkot	Talwandi	April 2013	2-3 %	Seed raised	Road side plantations with gall infestation.
		Sadma panda	March, 2014	20%	Coppice	Road side trees.
	9. Ferozepur	Harayya	November, 2013	10%	Coppice	Road side plantations
		Meharsingh	March, 2014	4.72%	Seed raised	Road side plantations
	10. Hoshiarpur	Dasuya Road,	August, 2012	80%	Seed raised	Roadside plantations with gall infestation.
		Satyal Nursery		100%	VMG Clones	Clone 2070 was most susceptible.
		Bassi Jana Divisional Nursery		50%	Seed raised	18,000 Eucalyptus seedlings.
		Bassi Jana Research Nursey		50%	Clones	20,000 Eucalyptus plants.
		Baghpur, Barkian Tanoor, Bhunga, Hariana, Kharkan, Pindori, Satyal and Jatpur.	November 2012.	40-70 %	Seed raised	Nurseries and plantations were heavily infested with galls.
		Bassi Jana Divisional Nursery	March, 2014	90%	Seed raised	6000 Eucalyptus plants.
		Bagha purana		10 -20%	Coppice	Road side plantations
		Nasrala and Bijwada		20-30%	Coppice	Road side plantations
		Adampur, Jalandhar road		33.09%	Seed raised	Road side plantations
		Jhandu Singha, Jalandhar road		21.59%	Seed raised	Road side plantations
Aggar Nagar, Jalandhar road		12.50%		Seed raised	Road side plantations	
Kartarpur, Jalandhar road		4.00 %		Seed raised	Road side plantations	
Balchak, Amritsar road		15.89%		Seed raised	Road side plantations	
Golbat, Tarn taran road		27.10%	Seed raised	Road side plantations		

		Daburji		8.11%	Seed raised	Road side plantations
	11. Jalandhar	Kansabu, Phillaur and Jalandhar Hoshiarpur bypass	April 2013	5-10 %	Seed raised and clones	Roadside plantations infested with galls; most of the plantations were clonal; in Phillaur forest nursery all VMG clone were infested with galls.
		Udaisian	March, 2014	20%	Coppice	Roadside plantations
	12. Ludhiana	Phillaur Nursery	August, 2012	80%	Seed raised and VMG clones	-----
		DFO, Nursey, Phillaur	March, 2014	50%	Seed raised	10,000 seedlings
	13. Moga	Dharamkot,	April 2013	2-4 %	Seed raised	Roadside plantation
		Gill	March, 2014	20%	Coppice	Road side trees.
		Singhan wala		10-20%	Coppice	Road side trees.
	14. Ropar	Rail majra	March, 2014	20 %	Coppice	Road side plantations
		Sangrur	November, 2013	20%	Coppice	Road side plantations
15. Sangrur	Harigarh	March, 2014	6.54%	Seed raised	Road side plantations	
Uttarakhand	16. Dehra Dun	Jakhan, Birpur, Premnagar and New Forest	March 2013	2-3 %	Seed raised	Plantations
	17. Haridwar	Bhagwanpur, Bahadarabad, Chidderwala, Patanjali and Shyampur	December 2010	40 to 60 %	Seed raised	Roadside plantations, the tree of 15-20 years old were suffering from a heavy infestation of galls on juvenile branches, arising from the lower parts.
		Chidiyapur Forest Department	December, 2011	100%	Seed raised	Plantations
	18. Nainital	Bhakra Range, Haldwani, Lal Kuan, PipalParau, Ramnagar and Terrai Central	December 2010	90 %	AP and Kerala Clones	In nurseries and plantations, all AP clones were severely infested (90-100%) and Kerala clones were free from galls.
19. Udham Singh Nagar	Bazpur, Gadaipur Terrai, Jaspur, Kashipur and Rudrapur	December 2010	20-30 %	Seed raised	Roadside Plantations were infested with galls	
Uttar Pradesh	20. Bijnor	Afzalgarh and Dhampur	December 2010	20-30 %	Seed raised	Plantations with juvenile branches arising from the lower parts of the stem were bearing galls.
		Najibabad, Road side plantations	December 2010	5-10 %	Seed raised plants and Some clones	Roadside plantations on Private land; poles were cut down and new growing coppices of one year old were heavily infested; some plants were free from gall infestation.
	21. Saharanpur	Bihariagarh, Ganeshpur, Mohand, Chutmalpur, Fatehpur and Sherpur	September 2009 & December 2010	60-80 %	Seed raised plants And clones	Roadside plantations were having gall infestations.

Biological control of *eucalyptus* gall wasp *leptocybe invasa*

(i) Natural enemies of *Eucalyptus* gall wasp in Australia and other countries

Israeli scientists searched natural enemies of *L. invasa* in Australia. The research in Australia on natural enemies of the gall wasp was funded mainly by friends of The Jewish National Fund (known in Israel as the Keren Kayemeth Le'Israel) – KKL-JNF Australia, Prof. John La Salle, head of the National Entomological Museum of Australia was actively associated with this work. Two parasitoids species of *L. invasa* belonging to Tetrastichinae (Hymenoptera: Eulophidae) from Australia were discovered and described namely *Quadrastichus mendeli* Kim & La Salle and *Selitrichodes kryceri* Kim & La Salle. These parasitoids have been successfully used in Israel as part of a biological control programme to check damage, caused by *L. invasa* to *Eucalyptus* plantations^[19]. *Selitrichodes neseria* parasitic wasp of *L. invasa* was discovered in April 2010 from Australia and released in South Africa for biological control of *L. invasa*.

Local parasitoids of *L. invasa* in various part of the world were also reported to colonise in larval and pupal stages. *Megastigmus* spp. and *Aprostocetus* spp. were reported as larval-pupal parasitoids^[19]. Native *Megastigmus* species are also known to parasitize *L. invasa* in Italy, Turkey and Israel^[20, 21]. Local *Megastigmus* spp. reported from different countries were not originally associated with *Eucalyptus* gall insect but have adapted to parasitize *L. invasa*. *Megastigmus* spp. are biparental larval and pupal parasitoid of *L. invasa*^[21].

(ii) Natural enemies of *Eucalyptus* gall wasp in India

The occurrence of *Aprostocetus* spp. on *L. invasa* from India and its new distribution was recorded from Karnataka^[22]. Ankita and Poorani reported the occurrence of *Megastigmus viggianii* on *L. invasa* from Karnataka^[23]. Kulkarni *et al.* reported the emergence of *Aprostocetus gala*, *Aprostocetus* spp., *Megastigmus* sp., *Paralaelaptera* sp. and *Telenomus* sp. from galls of *L. invasa*^[24]. Ramanagouda *et al.* recorded two parasitoids: *Megastigmus dharwadicus* and *Aprostocetus gala* from Karnataka, India and also recorded the parasitization of *Megastigmus dharwadicus* with the maximum parasitization 93.22% and *Aprostocetus gala* 15.08 % on *L. invasa* in Karnataka^[25]. Kulkarni, 2010 has carried out the screening of *Eucalyptus* species and clones at ITC nursery and plantations for resistance and susceptibility to *Eucalyptus* gall wasp. He concluded that *Eucalyptus tereticornis*, *E. camaldulensis*, *E. grandis* and their hybrids were severely affected by gall wasp. While, *E. alba*, *E. urophylla*, *E. citriodora* and *E. torelliana* were gall free.

(iii) Import of Australian parasitoids into India

The National Bureau of Agriculture Insect Resources (NBAIR), Bangalore imported *Quadrastichus mendeli* Kim & La Salle and *Selitrichodes kryceri* Kim & La Salle parasitoids of *L. invasa* into India. They under quarantine conditions conducted host specificity studies and thereafter recommended its release in the country during 2011-12^[15].

4. Conclusion

In northern India, warmer climate prevails for the most part of the year. This dry and intermediate zone may provide optimum conditions for the gall wasp development. Hence, *eucalyptus* gall wasp, *L. invasa* has firmly attacked in different locations, surveyed in North Western India. *E. camaldulensis* and *E. tereticornis* seem to be more attacked

than the other *Eucalyptus* species and heavy infestations, reaching 100% of the attack, were reported mainly in young plantations and nursery seedlings of these species. It was observed that young plants with fresh shoots both in the nursery and in plantations were mostly affected, while old trees with mature leaves and branches were less affected. *Leptocybe invasa* in the absence of natural parasitoids is causing an epidemic in India on *eucalyptus*.

Currently for controlling *L. invasa* in North India, *eucalyptus* twigs containing parasitized galls with two species of parasitoids (*Quadrastichus mendeli* and *Megastigmus viggianii*) were brought from NBAIR, Bangalore and multiplication was carried out in FRI, Dehra Dun and Satyal nursery Hoshiarpur, Punjab. It was observed that *Megastigmus* sp. was the most dominant and widespread native parasitoid, its potential as a biological control agent has been exploited for the management of *eucalyptus* gall wasp. Nowadays, application of parasitoid *Megastigmus* in the field has been started to control the *Eucalyptus* gall problem.

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