Article

A study on insect pest occurrence of silver oak, *Grevillea robusta* A. Cunn. in Northern India

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Abstract
Silver oak, *Grevillea robusta* A. Cunn. is an important exotic tree species component of urban forestry in India. However, the occurrence of insect-pests in exotics causes tremendous impact on the production and yield in nurseries as well-established plantations; consequently, reducing profits and inducing high expense to stakeholders. Thus, a detailed account of insect-pests infestation and their impact becomes important. Therefore, present study was undertaken to find out the insect pest occurrence on *G. robusta* in the nursery, plantation established at different geographical region of northern India from 2018-2022. The study result exhibited infestation of ten insect-pests for the first time on *G. robusta*. Six species were defoliator in nature *viz. Ascotis selenaria*, *Chrysodeixis includens*, *Ectropis bhurmitra*, *Helicoverpa armigera*, *Hyposidra talaca*, and *Olene inclusa*; while infestation of four species of sap sacking nature *viz. Asterolecanium sp.*, *Ceroplastes rusci*, *Drosicha stebbingi*, and *Oxyrachis tarandus*. The seasonal incidence and nature of damage were also recorded for the first time of these insects on *G. robusta*. This is the first attempt to report insect-pests of *G. robusta*, which gave an overview of the possible potential threat in India. The study would be beneficial for future reference with respect to pest management of *G. robusta*, when the species is taken up for tree improvement program in the long run.

Keywords *Grevillea robusta*; defoliator; sap feeder; silver oak; new record.

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1 Introduction

Grevillea robusta A. Cunn. a tree species of family: Proteaceae, commonly known as silk oak, southern silky oak, silver oak, grevillea, river oak, etc. It is a large canopy tree species size up to 80 m with solid pole without branches up to 50% bole, conical crown, with less branches projecting upwards. Flowers showy, yellowish, numerous, paired, on long slender stalks 1-2 cm, composed of 4 narrow yellow or orange sepals of 12 mm long. *G. robusta* is native to Australia and successfully introduced in China, Eritrea, Ethiopia, India, Indonesia,

Jamaica, Kenya, Laos, Malawi, Malaysia, Mauritius, Nepal, Pakistan, Philippines, South Africa, Sri Lanka, Tanzania, Uganda, United States of America, Vietnam, Zambia, Zimbabwe and this is a suitable species for regions of altitude 0-2300 m with annual temperature ranged from 14-23 to 25-31^{0}C and annual precipitation 600 to 1700 mm (Pickford, 1962; Kriek, 1967; Harwood, 1989; Orwa et al., 2009).

G. robusta valued especially for its attractive fern-like 15-30 cm long foliage and brilliant orange to yellow-coloured attractive flowers, preferred for ornamental tree; often grown in gardens, street tree and also planted extensively in tea and coffee gardens in India, Sri Lanka, Hawaii and Brazil (Fenton et al., 1977; Rao, 1961; Sharma, 1966; Streets, 1962; Orwa et al., 2009; Phillips and Rix, 1998; Whistler, 2000; Barwick, 2004).

G. robusta has proven itself as an insect pest resistant species due to very few records of insect infestation, and only bark eating caterpillar, *Inderbela sp*. has been recorded as insect pest on the bark of the tree under humid conditions in India (Verghese et al., 2014). Though, few insect pests were recorded viz. Oleander pit scale insect, *Asterolecanium pustulans* from Puerto Rico and termite infestation in Africa was recorded (Schieber and Zentmeyer, 1978; Nayar, 1987; Marrero, 1950). The investigation on insect pest becomes more important when a large-scale plantation of exotic species is made in any newer geographical region. It is crucial to monitor and understand the potential insect pest issues that may arise. This is particularly significant in areas with variable environmental conditions and diverse geography. Therefore, survey was undertaken to find out the insect pest occurrence on *G. robusta* in northern India.

2 Materials and Methods

The present study was conducted in Haryana, Punjab and Uttarakhand provinces of Northern India during 2018-2022. Monthly field survey was conducted to find out the insect pest occurrence on *G. robusta* plantation and nurseries. Observation was taken plantation at nursery, road side, urban parks, school and collages campus and insect pest infestation was observed visually and pictures were taken. Subsequently, some of the insect stages were collected from the field and brought to the laboratory and reared on natural plant part under BOD incubator at 25±0.5℃ and 80±5% RH. Nature of damage of each insect pest was recorded in the field and laboratory. The nature of damage of these insect pests were also confirmed and correlated with secondary source of information. Based on the record of occurrence and infestation in the field, seasonal incidence was concluded. The insects were identified with the help of published literature and insect specimen study from collection of National Forest Insect Collection, FRI, Dehradun. The pictures of insect stages collected with plant parts were taken with digital camera and microscopic camera fitted over sterio-zoom microscope Leica M 205 C.

3 Results

The result revealed that (Table 1) ten insect pests were exhibited to be infesting *G. robusta*. Among these six insects were recorded as defoliator i.e., *Ascotis selenaria* Walk (Lepidoptera: Geometridae); *Chrysodeixis includens* (Walker) (Family: Noctuidae), *Ectropis bhurmitra* Hubner (Lepidoptera: Geometridae), *Helicoverpa armigera* Hubner (Hubner) (Family: Noctuidae), *Hyposidra talaca* Walker (Family: Geometridae), *Olene inclusa* Walker (Lepidoptera: Erebidae). Additionally, four insects i.e. *Asterolecanium* sp. (Hemiptera: Asterolecaniidae), *Drosicha stebbingi* Green (Hemiptera: Coccidae) and *Ceroplastes rusci* Linn. (Hemiptera: Margerodidae), *Oxyrachis tarandus* Feb. (Hemiptera: Membracidae) were recorded as sap feeders. Though, there was no major infestation of these insects in the nursery or field plantation of *G. robusta*, however, these insects were first records of attack on *G. arborea* in India.

Table 1 Insect pests occurrence of *G. robusta* in northern India.

Insect species	Common name	Order	Family	Nature of damage
***Ascotis selenaria* Walk.**	Giant looper	Lepidoptera	Geometridae	Defoliator
***Chrysodeixis includens* Walk**	Soybean Looper	Lepidoptera	Nouctidae	Defoliator
***Ectropis bhurmitra* Hubner**	Tea twig caterpillar	Lepidoptera	Geometridae	Defoliator
***Helioverpa armigera* (Hubner)**	Cotton ballworm	Lepidoptera	Nouctidae	Defoliator
***Hyposidra talaca* Walk**	Black inch worm	Lepidoptera	Geometridae	Defoliator
***Olene inclusa* Walk**	Tussock moth	Lepidoptera	Erebidae	Defoliator
Asterolecanium sp.	Oleander Pit Scale	Hemiptera	Asterolecaniidae	Sap feeder
***Ceroplastes rusci* Linn.**	Fig wax scale	Hemiptera	Coccidae	Sap feeder
***Drosicha stebbingi* Stebb.**	Mealy bug	Hemiptera	Margarodidae	Sap feeder
***Oxyrachis tarandus* Linn.**	Tree hopper	Hemiptera	Membracidae	Sap feeder

***Ascotis selenaria* Walk** (Fig. 1-2). The larva of this insect was recorded feeding young growing leaves of *G. robusta* and the seasonal occurrence was recorded to be from June to September (Table 2). The larvae were reared in the laboratory up to adult emergence. The initial identification was done with the colour pattern vary from green to yellow or brown resembling host twigs. Identification was confirmed with the adult specimens emerged from the laboratory reared larvae. The front wings of the adult are characterized by a yellowish-white ground colour, it has also numerous dark grey markings and two brownish sharply toothed transverse lines.

***Chrysodeixis includes* (Walker)** (Fig. 3). It is recorded feeding young foliage as a minor feeder on *G. robusta* in the month of March to October from some nursery and some trees under plantation (Table 2). The larva was predominantly light to dark green and typically has white stripes running down the dorsal and lateral portions of its body. The body of the looper is easy to differentiate from many alike species by inspecting the number of abdominal prolegs. The larvae of *C. includens* can be easily distinguished from other green caterpillars with three or more abdominal prolegs. Larvae generally feed for 2-3 weeks before undergoing pupation.

***Ectropis bhurmitra* Hubner** (Fig. 4). The infestation of this insect was recorded as defoliator of *G. robusta*, seasonal occurrence was recorded to be during June to October (Table 2). The larva appears a hue of light grey-brown, with a body featuring a darkened diagonal ridge terminating at a dorsal tubercle. The head exhibited a light grey shade with a herringbone pattern in darker brown on its lobes, along with a horizontal streak atop the dorsally diamond situated on mid-abdominal segments. The larval infestation was documented within the New Forest Campus under plantation and nursery conditions. The larvae of this particular species were observed causing damage to newly emerged leaves of plants in both nursery and plantation settings.

***Hyposidra talaca* Walker** (Fig. 5-6). The larvae were collected during the month of July to September from field survey in Dehradun (Table 2). Only larval stage of this pest was found to be damaging the leaves. Black looper larva feed on tender leaf from margin followed by defoliation of entire leaf. It was also observed that initially larva was black coloured and become creamy brown coloured at maturity. It was found that the 4th and 5th instar larval stage are most destructive for young leaves.

***Helicoverpa armigera* (Hubner)** (Fig. 7). It was recorded from the field feeding on tender shoots of the tree under plantation and nursery. The seasonal occurrence of this insect pest was recorded during March to July (Table 2). Larva feed the leaf from margin and subsequently defoliates the tender leaves of tree. The larva was green to greyish with a dark stripe on the lateral sides of the body and also bears inconspicuous tubercles and scattered small hairs. It has six larval instars and the entire larval development takes 20-25 days. After 10-15 days of pupal period adult was emerged out.

***Olene inclusa* Walker** (Fig. 8-9). The larva was recorded from nursery and young plantation during April to September at New Forest Campus, Dehradun, Uttarakhand (Table 2). Larva was dark brown in colour, with a tuft of long hair at lateral side; head reddish-brown in colour; two white colour dorsal lines found on 4^{th}somite and dorsal tufts of silky reddish-brown hair from $4^{th}$to 7^{th} somite. The larval period was from 14 to 17 days. Pupa was formed inside a tightly woven cocoon. Pupation period was recorded from 5 to 6 days. The moth was dark brown in colour with indistinct lines and waved brown band beyond the post-medial line and hind wing light brown in colour.

***Asterolecanium* sp. (Pit scale insect)** (Fig. 10). It was recorded as a sucking insect pest of *G. robusta* in the nursery and young plants at New Forest campus, Dehradun (Uttarakhand) during January to June (Table 2). The small young nymph settles down on a small twig and secretes glassy wax filaments on the dorsal surface and around the body and as the plant grows bark of the twig depressed down.

***Ceroplastes rusci* (Linn.)** (Fig. 11). It is a sucking insect pest and commonly known as fig wax scale is of great economic importance. The nymph and adult both the stages were recorded to be feeding on the thin branches of *G. robusta* during February to November (Table 2). This insect was recorded from the road side plantation at Pinjore (Haryana), New Forest Campus, Dehradun (Uttarakhand) and Pantnagar (Uttarakhand).

***Drosicha stebbingi* Green** (Fig. 12). Commonly known as mango mealy bug 1.0-1.5 cm long, oval white body. Infestation of this bug was recorded from Pinjore (Haryana), and Pantnagar (Uttarakhand). The nymph and adult both the stages were observed to be infesting tender parts of the plant during February to July (Table 2). The late instar nymph and adult female was flat, oval and waxy white. They remained stationary and adhered to the total length on shoots. Infested shoot part was covered by the sooty mould.

Table 2 Seasonal incidence of insect pests of *G. robusta* in northern India (presence denoted by '+').

Insect species	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.
***Ascotis selenaria* Walk.**						+	+	+	+		
***Chrysodeixis includens* Walk**			+	+	+	+	+	+	+	+	
***Ectropis bhurmitra* Hubner**						+	+	+	+	+	
***Helioverpa armigera* (Hubner)**			+	+	+	+	+				
***Hyposidra talaca* Walk**					+	+	+	+	+		
***Olene inclusa* Walk**				+	+	+	+	+			
Asterolecanium sp.	+	+	+	+	+						
***Ceroplastes rusci* Linn.**		+	+	+	+	+	+	+	+	+	+
***Drosicha stebbingi* Stebb.**		+	+	+	+	+	+				
***Oxyrachis tarandus* Linn.**			+	+	+	+	+	+	+	+	+

***Oxyrachis tarandus* Feb.** (Fig. 13). The insect commonly known as tree hopper, triangular shaped body measured 4-7 mm long, yellow eyes, winged with three pairs of legs, two curved horns like projections on the thorax. Infestation of this hopper was recorded from aerial apical parts of *G. robusta* on the roadside plantation at Pantnagar and new Forest Campus, Dehradun (Uttarakhand) during March to November. Female of this insect lay eggs in the tender shoots and both nymph and adult feed gregariously on tender shoot. Both nymph and adult suck sap from tender parts of the plant.

4 Discussion

Ascotis selenaria Walk is a phytophagus insect pest reported from many forestry species viz. *Albizia procera, Casuarina equisetifolia, Dalbergia sissoo Melia azadirach, Santalum album, Schleichera oleosa, Shorea robusta, Tectona grandis, Moringa pterigosperma, Pongamia pinnata* and *Toona ciliata* (Chatterjee, 1935; Beeson, 1941; Browne, 1968, Srinivasan et al., 1969; Tewari, 1994; Kulkarni et al., 1995; Kulkarni et al., 1996). Though, it is a minor leaf feeder on *G. robusta*. *A. selenaria* is one of the reported insects observed also in *Eucalyptus* sp. and *Tectona grandis* causes moderate to heavy damage (Graziosi et al., 2020).

C. includens is a major insect pest of soybean but is recorded as a polyphagous pest of 174 plants species of field crop, vegetable, forestry and ornamental crops viz. soybean, cotton, sunflower, tobacco, *Amaranthus* sp., *Oxalis* sp., kudzu, lantana, ground cherry, and cocklebur (Martin et al., 1976, Navarro et al., 2009; Barrionuevo et al., 2012; Specht et al., 2015).

We have recorded *E. bhurmitra* insect for the first time on *G. robusta*, though it is widely distributed across the Asian-Pacific regions and has been well-documented in areas such as Borneo, Buru, Java, India, New Guinea, Peninsular Malaysia, the Philippines, Solomon Islands, Sumatra, Sri Lanka, Sulawesi, Taiwan, and Thailand (Sato, 2007). While this species has been noted on a diverse range of host plants including *Aleurites montana, Artemisia vulgaris, Bombax malabaricum, Lantana aculeata, Phoebe lanceolata, Shorea robusta,* and *Tectona grandis* (Beeson, 1941), this marks the first recorded instance of *E. bhurmitra* on *G. robusta*. The prevalence of numerous alternative host plants has contributed to the issue of looper infestations in tea gardens across many regions of Assam and West Bengal in India (Antony, 2012).

H. talaca is a major insect pest of tea in peninsular India as well as tea-producing countries like China, Kenya and Sri Lanka (Smith, 2016; Hazarika et al., 2009; Antony et al., 2011). It is also known as black inch looper or tea looper. About 90 plant species are recorded as host of *H. talaca* worldwide, though 23 host plants were recorded from India (Basu Majumder 2010; Robinson et al. 2010). Notably, the black inch caterpillar *Hyposidra talaca* has earned considerable importance as a defoliator during the last decade in India (Roy et al., 2017); which mainly attacks *Acacia mearnsii* (Cai et al. 2006), *Leucaena leucocephala* (Room and Smith, 1975), *Terminalia arjuna* (Basu Majumder and Ghosh 2004), *Melia azedarach* (Chutia et al., 2011), and *Albizia falcataria* (Wood and Fee, 1992).

H.armigera is an important polyphagous pest with worldwide occurrence. It is well recorded as a major pest of cotton, tomato, castor, pigeon pea, sunflower, chickpea, black gram maize, okra, potato, tobacco, peach and many other crops. inflicting substantial crop losses every year (Reed and Pawar, 1982; Manjunath et al., 1989; Sharma, 2001). The high mobility and fecundity of this pest combined with its ability to develop resistance to synthetic insecticides commonly used for its control, make it a distinct and challenging pest (Armes et al., 1996; Kranthi, 1997; Ramasubramaniam and Regupathy, 2004).

O. inclusa is also recorded as polyphagous species. The larval host range recorded are species of *Annona, Averrhoa, Durio, Ricinus, Leea, Pelagonium, Acer, Arachis, Crotalaria, Derris, Erythrina, Macuna, Ficus, Musa, Calyptranthes, Eugenia, Rosa, Citrus, Theobroma, Muntingia, Conggea* (Holloway, 1999); *Octomeles*

sumatrana (Chung et al., 2008); *Solanum melongena, Casuarina* sp. (Robinson et al., 2010). This species was also recorded as endemic form on *Shorea waltonii* and *Shorea kudatensis* in Sabah (Chung et al., 2013).

Pit scales are found on a broad diversity of hosts but are especially common on bamboos, oaks, and many species of ornamentals. Although species of *Asterolecanium* have been found on at least (Russel, 1941). *Asterolecanium* is also reported as a serious pest of some ornamental plants of 37 plant families ranging from the Gramineae to the Compositae, Palmae and Fagaceae in the USA, Philippines, Iraq, Iran, Saudi Arabia, Egypt and Qatar (Ali, 1989; Mohamed, 2008; Manzanilla et al., 2006); Uzbekistan (Porcelli and Pelizzari, 2019); Europe, Africa, New Zealand (Gill, 1993), Ukraine (Vasil'eva, 1986) and particularly it is a pest of oaks, *Beta vulgaris, Hedera taurica,* bamboo, and palms (Landis, 1968; Russel, 1941; Vasil'eva, 1986; Vovlas et al., 2013; Kece et al., 2015). Similarly, *Asterolecanium pustulans* scale severely attacked plantations of peach, plum, pear, apple, apricot, mango guava, olive and *G. robusta* in lowland environments (Martorell, 1940; El-Minshawy, 1971).

C. rusci is primarily native to the Afrotropical region (Qin et al., 1994, 1998) and has also been reported from Palearctic, Neotropical, Oriental, Ethiopian, and Australian regions (Ben-Dov 1993; Waterhouse and Sands, 2001) and particularly in the countries like Italy Algeria, Cyprus, Egypt, Greece, Israel, Italy, Lebanon, Morocco, Spain, Tunisia, Turkey and India (Green, 1917; Talhouk, 1975; Kumar, 2013). Ithas a wide range of 153 host species worldwide *Chrysanthemum* sp.*, Ocimum gratissimum, Ficus benjamina, Ficus nataliensis, Grevillea robusta, Geijera parviflora, Dalbergia sissoo, Mangifera indica, Ficus benghalensis, Ficus carica, Ficus religiosa, Psydium* sp., *Syzygium cumini, Ziziphus mauritiana* were reported as its host plants in India (Kumar, 2013; Kumar and Pandey, 2022).

D. stebbingi is a major polyphagus sap sucking pest of forestry, horticulture and agriculture species as it has been recorded to be infesting *Shorea robusta, Mangifera indica, Carica papaya, Zizyphus jujuba, Prunus persica, Prunus domestica, Artocarpus heterophyllus, Bauhinia variegata, Helianthus annuus, Rosa indica, Althaea rosea,* Citrus sp., *Nerium odorum, Eugenia jambolana, Eriobotrya japonica, Vitis vinifera, Jasminum sambac, Albizzia lebbek, Hibiscus* sp., *Juglans regia, Pyrus malus, Pyrus communis, Litsaea polyantha, Butea frondosa, Holarrhena antidysenterica* and *Mallotus philippinensis* (Dutt, 1925; Latif, 1949; Beeson, 1941; Khan and Latif, 1944).

O. tarandus was found to be infesting *G. robusta* for the first time in the world. Though, this insect is a polyphagus pest recorded on many forestry species. The hopper fed on apical portions of the shoot apices, making them rough and woody in appearance, brown in colour that gradually dried and apical leaves shed off. *O. tarandus* is widely distributed in India and adjacent countries. Its nymphs and adults feed gregariously on the sap of the shoot of different host plants such as *Acacia catechu, A. nilotica, Albizia chinensis, A. lebbek, Cassia* fistula, *Prosopis juliflora Accacia sp., Zizyphus jujube,* and on eggplant *Solanum melongena* from India (Biwas et al., 1994; Yousuf and Gaur (1993). Kumar (2017) have recorded a Membracidae bug *Leptocentrus taurus* infesting *Dalbergia sissu*.

The presented study indicates that *G. robusta*, an exotic tree species, has experienced ten new insect pest infestations. This occurrence underscores the potential vulnerabilities of exotic species to new biotic threats in their non-native environments. The exotic species *G. robusta* exhibit narrow genetic base due to its limited genetic diversity present in India. This genetic uniformity can make them more susceptible to novel pests, as these pests can more easily exploit genetic weaknesses present across the population. Additionally, monoculture practices, which involve planting large expanses of a single species, create environments where pests can thrive due to the absence of natural predators and the lack of ecological diversity that might otherwise help mitigate pest pressures. Given the heightened vulnerability of exotic species to new natural enemies, such as the insect pests observed in *G. robusta*, it becomes imperative to regularly assess the

potential risks posed by these biotic threats. Vigilant monitoring of insect pest populations and their impacts within the exotic geographical range is essential. Such monitoring allows for the early detection of emerging pest issues and enables the implementation of timely and appropriate management strategies to mitigate their effects. In conclusion, the scientific elaboration of the concepts you've provided highlights the intricate interplay between plant communities, ecosystem establishment, the vulnerabilities of exotic species to new insect pests, and the importance of ongoing risk assessment and monitoring to ensure the health and sustainability of exotic tree species in their non-native habitats.

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