



A REVIEW OF DIFFERENT INSECTS ASSOCIATED WITH THE NEEM TREE, *AZADIRACHTA INDICA* (MELIACEAE)

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(Received on December 01, 2023; Revised on December 20, 2023; Accepted on December 24, 2023)

ABSTRACT

Azadirachta indica, also known as Neem, has gained widespread attention in recent years due to its diverse medical and insecticidal benefits. Neem has been widely utilized in various medicinal fields like Ayurvedic, Unani, and Homeopathy. Neem produces a varied range of physiologically active chemicals that are both chemically and structurally complex. Many insects have been reported on Neem so far causing damage and destruction. This review summarises the various insects associated with the neem along with their nature of damage.

Keywords: *Azadirachta indica*, Neem, insect, pest, damage, infestation.

INTRODUCTION

Azadirachta indica A. Juss, also known as “Neem” is a resourceful tree of the family Meliaceae (Figure 1). The family Meliaceae is distinguished by the constant occurrence of characteristic compounds called meliacins or limonoids (Das et al. 1984). Neem has also been named as *A. indica*, which is derived from the Persian language and means “the free tree of India” (Kumar and Navaratnam, 2013). It is native to upper Burma and other parts of south India (Roxburgh 1874). The center of origin of *Azadirachta indica* A. Juss is in the forests of Karnataka or the dried inland forest of Myanmar (Gamble 1902). In Africa, neem was introduced from India. Some old trees were also found on the island of Gran Canaria in Las Palmas (Schmutterer 1995). Isolated compounds from the neem have medicinal and therapeutic properties to combat various diseases (Biswas et al. 2002), and owing to its multifaceted properties neem is rightly called the

‘Village pharmacy’ or ‘doctor tree’ or ‘Wonder tree of India’ or ‘The bitter gem’(Girish and Shankara 2008). Various parts of the neem tree are known to contain over 40 bitter principles belonging to the diterpenoid, triterpenoid, limonoid, and flavonoid groups of natural products (Thakur et al. 1981). The products obtained from neem provide many benefits to human health (Kumar and Navaratnam 2013) as well as livestock health (Esch 2012).

A Neem Tree, *Azadirachta indica*

Despite the presence of various phytochemicals responsible for insecticidal properties, there were numerous insects have been recorded to cause damage to the plant (Boa 1995; Ciesla, 1993; Council 2002; Kiyanthi and Mikunthan 2009; Schmutterer 1998; Sharma 2016). There were many insects reported on Neem belonging to different orders are described below:

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S.No.	Order	Family	Name of insect	Damage causing stage	Nature of damage	References
1	Lepidoptera	Geometridae	<i>Cleora cornaria</i> Guenee	Larvae	Voracious feeder of leaves	(Mishra and Omkar, 2012; Sabo et al., 2018)
2	Lepidoptera	Geometridae	<i>Ascotis selenaria</i> (Denis & Schiffermuller, 1775)	Larvae	Defoliators of tenders leaves and shoots	(Chander and Singh, 2017)
3	Lepidoptera	Geometridae	<i>Macaria notata</i> (Linnaeus, 1758)	Larvae	Defoliators of leaves leaving the midrib	(Kiyanthi and Mikunthan 2009)
4	Lepidoptera	Geometridae	<i>Boarmia variegata</i> Moore	Larvae	Leaf feeders and defoliators of nurseries	(Rishi et al. 2013; Tewari, 1992)
5	Lepidoptera	Erebidae	<i>Leptocneria reducta</i> Walker	Larvae	Defoliators of leaves and fresh shoots	(Erskine 2014)
6	Lepidoptera	Tortricidae	<i>Loboschiza koenigiana</i> (Fabricius, 1775)	Larvae	Borers of seedlings and young plants. Also they roll up the leaves for shelter	(Kiyanthi and Mikunthan, 2009)
7	Coleoptera	Scarabaeidae	<i>Holotrichia serrata</i> (Fabricius)	Grubs	Defoliators of young seedlings and feeders of roots	(Theurkar et al. 2013; Tippannavar 2013)
8	Coleoptera	Curculionidae	<i>Myllocerus viridis</i> , <i>M. discolor</i> , <i>M. Subfaciatus</i> , and <i>M. maculosus myllocerus tenuicornis</i> Faust	Adults Larvae	Consumers of leaves except midrib Create tunnels inside the roots for attacking seedlings and other parts	(Kiyanthi and Mkunthan 2009)
9	Coleoptera	Bostrichidae	<i>Apate terebrans</i>	Adults & larvae	Create tunnels and feed on wood	(de Souza et al. 2009)



			(Pallas			
10	Coleoptera	Anthribidae	<i>Araecerus fasciculatus</i> de geer	Larvae Adults	Defoliators of seeds Create holes to come out	(Beeson 1941; Biosci et al. 2014)
11	Coleoptera	Silvanidae	<i>Oryzaephilus acuminatus</i> Halstead	Larvae	Defoliators and consumers of seeds	(Thomas and Woodruff, 2011)
12	Heteroptera	Miridae	<i>Helopeltis antonii</i> Signoret	Adults	Drying symptoms including exudation of gum	(Sundararaju & Sundara babu 1998)
14	Homoptera	Coccidae	<i>Pulvinaria maxima</i> Green	Nymphs and adults	Infest whole tree and suck sap	(Schmutterer 1999)
15	Homoptera	Coccidae	<i>Macropulvinaria jacksoni</i>	Nymphs and adults	Sap-sucking and causes yellowing of leaves	(Hodges 1992)
16	Homoptera	Coccidae	<i>Ceroplastes ceriferus</i> (Fabricius)	Nymphs and adults	Drying and yellowing	(Muniappan et al. 2002)
17	Homoptera	Coccidae	<i>Pseudococcus</i>	Nymphs and adults	Cause severe damage to seedlings by sucking sap	(Sharma 2016)
18	Homoptera	Coccidae	<i>Paracoccus marginatus</i> (Williams and Granara de Willink)	-	Yellowing and wilting of leaves but plant normally survived	(Sakthivel et al. 2012)
19	Homoptera	Cydnidae	<i>Scaptocoris castanea</i> Perty	Adults	Cause damage to seedlings by attacking radicles Symptoms include yellowing, wilting and drying	(Matias et al., 2011)

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20	Homoptera	Diaspididae	<i>Aonidiella orientalis</i> (Newstead)	Adults and nymphs	Yellowing, retarded growth and death of tree	(Ensaf et al. 2016; Lale 1998; Schmutterer, 1990a, 1998)
21	Orthoptera	Acrididae	<i>Orthacris simulans</i>	Adults and nymphs	Defoliation of leaves	(Sharma 2016)
22	Orthoptera	Tettigoniidae	<i>Microcentrum retinerve</i> (Burmeister, H., 1838)	Adults	Defoliation of leaves	(Chockalingam and Noorjahan 1984)
23	Hymenoptera	Formicidae	<i>Acromyrmex</i> species	Adults	Defoliation by cutting of leaves	(Schmutterer 1990a)
24	Isoptera	Termitidae	<i>Microtermes mycophagus</i> (Desneux, 1906)	Adults	Fungus growing termite causes deterioration of wood	(Iqbal et al. 2015)
25	Isoptera	Termitidae	<i>Microtermes naidensis</i> Harris	Adults	Infest and cause big tunnels inside the wood	(Al-Ghamdi et al. 2009)
26	Isoptera	Termitidae	<i>Coptotermes frenchi</i> (Hill)	Adults	Infest and cause big tunnels inside the wood	(Suganthy and Pretheepkumar, 2019)
27	Isoptera	Termitidae	<i>Coptotermes formosanus</i> Shiraki	Adults	Severe infestation in trunk and branches	(Delate and Grace, 1995)

Table 1. List of different insect pest of Neem and their nature of the damage



Figure 1. A Neem tree, *Azadirachta indica* (© Photographed by Barish E. James)

Order-Lepidoptera

Family-Geometridae

***Cleora cornaria* Guenee**

Larvae of this semi-looper moth are voracious feeders and cause damage to the neem tree by chewing the young leaves of the plant in a semi-circular manner. Adults are creamish with brown patterns on the wings. Newly hatched larvae are bright green and are the most active feeders of the leaves. They show semi-looper movements but as they reach to pre-pupal stage they become sluggish (Mishra & Omkar, 2012; Sabo et al., 2018).

***Ascotis selenaria* (Denis & Schiffermuller, 1775)**

These are the giant looper moths and their larvae are polyphagous. Larvae are the ones that defoliate the plant by feeding on the young tender leaves and shoots of *Melia azedarach* which leads to the loss of growth and defoliation of the plant (Beeson, 1941; Browne, 1968). Also, an outbreak of this moth is observed on Neem (*Azadirachta indica*) and Bakain (*Melia azedarach*) in Haryana and Punjab in India causing harm to the trees (Chander and Singh 2017).

***Macaria notata* (Linnaeus, 1758)**

Peacock moth, *Macaria notata* were the defoliators of Neem. At first, larvae were green in color and became brown as they developed toward the later stage. They consumed the whole leaves from the margin except the midrib (Kiyanthi & Mikunthan, 2009).

***Boarmia variegata* Moore**

The looper larvae of this moth are the major pest of *Melia azedarach* in North East India cause defoliation while feeding on the leaves completely and leaving the midrib and some basal parts of the leaves (Board 2003; Rishi et al. 2013; Tewari 1992). This defoliating insect causes serious damage to nurseries in arid regions (Farooqi and Sreeramu 2004).

Family-Erebidae

***Leptocneria reducta* Walker**

Australian white cedar moth, *Leptocneria reducta* was found to be consuming the leaves and fresh shoots of the plant. The hairy caterpillars are voracious feeders and defoliators of *Melia azedarach* and feed on leaves at night and gather at the base of the tree during the day. Once they caused the infestation to one plant they invaded other plants for further defoliation (Erskine 2014).

Family-Tortricidae

***Loboschiza koenigiana* (Fabricius, 1775)**

The tortricid moth, *Loboschiza koenigiana* causes damage to seedlings and young plants by boring into the terminals and then feeding on them. Larva of this

moth lives inside the leafy shelter made on its own, by rolling the leaves of their host plant and joining it together with silk where it gets pupated and grows well (Kiyanthi and Mikunthan 2009).

Order- Thysanoptera

Adults and nymphs feed on the sap of neem flowers. The insects' feeding causes ovarian abortion. The flowers fade and drop prematurely, and no fruit develops in such flowers. Its life cycle takes 13-18 days to complete (Ananthkrishnan 1973).

Order-Coleoptera

Family-Scarabaeidae

***Holotrichia* sp.**

Holotrichia sp. is also known as Chaffer beetle or May-June beetle. Adults of *Holotrichia serrata* (Fabricius) were collected from the host plant (Neem) at the population site of Khed Taluka (Northern Western Ghats, India) are dull brown and about 22 mm in length and 14 mm in width. A heavy infestation is found on the host plant in June-August (Theurkar et al. 2013). Their larvae are the white grubs feeding on roots and cause heavy damage to young seedlings. Adults feed on foliage at night (Srivastava et al. 1971; Tippannavar 2013).

Family-Curculionidae

***Myllocerus* sp.**

These beetles are generally polyphagous, but they have a limited host range. Adults are 2.5 mm to 6.2 mm long, with numerous blackish spots or lines on the thorax and elytra. The color ranges from yellowish-green to light to dark green, and grey to brown, which allows them to blend in with the color of the leaves, stems, and thorns and thus avoid predation (Kumar et al. 2016). The adults are the defoliators and consume the whole leaf except the midrib while the larvae damage the plant by feeding activity making the roots hollow by keep advancing upwards making tunnels and attacking seedlings and other parts of the plant (Paunikar 2015). Four species of *Myllocerus* such as *M. viridis*, *M. discolor*, *M. subfaciatus*, and *M. maculosus* cause damage to the



leaves (Kiyanthi and Mikunthan 2009). *Myllocerus tenuicornis* Faust is found to be infesting leaves of neem, *Azadirachta indica* in India.

Family-Bostrichidae

Apate terebrans (Pallas)

Adults of *Apate terebrans* (Pallas) are first found attacking a neem plantation in Brazil. The damage is identified as a hole in the trunk, from where the shot-hole-borer entered by constructing tunnels and feeding on the wood (de Souza et al. 2009).

Family-Anthribidae

Araecerus fasciculatus De Geer

It was reported for the first time on *Melia azedarach* in Iran. Larvae of the beetle cause damage to the plant by feeding on its seeds where they fed, developed, pupated and adults are only responsible for boring holes to come out of the seeds. No other part of the plant was attacked by this beetle (Biosci et al., 2014). It is also affecting the seeds of *Acacia nilotica*, *Aleurites fordii* and *Ficus glomerata* (Beeson, 1941).

Family-Silvanidae

Oryzaephilus acuminatus Halstead

It thrives well on stored dry neem seeds. Although these seeds were reported to have insecticidal properties, the chemicals do not appear harmful to them (Thomas and Woodruff, 2011)

Order- Hemiptera

Order- Heteroptera

Family Miridae-

Helopeltis antonii Signoret

It is known as the tea mosquito bug also widely spread in Asia and considered a serious pest of neem in India. It causes drying symptoms and it's sucking mouthparts

contribute to causing the tender shoots to exude a gum-like which on exposure to air becomes hardened (Pillai & Gopi, 1990; Sharma, 2016).

Family- Pentatomidae

Halys dentatus (Fabricius) 1775

Halys dentatus, commonly known as Neem bug is a phytosuccivorous bug infesting neem, *Azadirachta indica*. They tend to feed singly or in groups in the various plant including Neem. They show defensive behavior against their natural enemies such as camouflage, fake death, ejection of foul smell from the metathoracic scent gland, and yellow-colored excretory fluid from the anal part (Dhiman and Yadav, 2003). The first instar stage is a non-feeding stage and the rest of the stages include active feeders of tender as well as harder twigs and also the side branches of the tree (Dhiman et al. 2019).

Order-Homoptera

Family-Coccidae

Pulvinaria maxima (*Megapulvinaria maxima*) Green

This scale insect was found on neem in the Delhi region in India and is a serious pest of neem by infesting the tree and can be recognized by a thick coating of white mealy patches, the egg sacs on the foliage, shoots, and bark (Schmutterer 1999; Tyagi et al. 2014)

Macropulvinaria jacksoni

A large yellowish-brown scale of neem from Niger was identified as *Macropulvinaria jacksoni* by the International Institute of Entomology (IIE). Further, it was also collected from Maradi and Niamey. The symptoms are general yellowing of leaves due to severe infestation (Hodges 1992)

Ceroplastes ceriferus (Fabricius)

The Indian wax scale, *Ceroplastes ceriferus* is attacking neem plants, and their infestations were observed on the tender stems of the plant (Muniappan et al. 2002)

Family-Pseudococcidae

Pseudococcus spp.

It causes severe damage to the seedlings of Neem (Sharma 2016).

Paracoccus marginatus (Williams and Granara de Willink)

It is a serious pest of Papaya in Tamil Nadu, India. Apart from other plants and crops, the status of infestation is low in *Azadirachta indica* with less presence of all stages of mealybug. There are no adverse symptoms like leaf distortion observed. The infestation is moderate in *Melia dubia* as all stages of mealybug are present in large numbers. Symptoms observed are wilting and yellowing of plant leaves and the plants normally survived (Sakthivel et al. 2012).

Rastrococcus invadens Williams

It is a polyphagous pest and there is a low infestation recorded on neem besides other plants found in West Africa (Agoukéné et al. 1988).

Family-Cydnidae

Scaptocoris castanea Perty

Scaptocoris species are also known as Brown burrower bugs due to their burrowing habit and pattern of damaging the plant. It was found on *Azadirachta indica* in Brazil and causes damage to the seedlings by attacking the root system, especially the radicles. Symptoms observed are yellowing and wilting of the leaves, stem drying, and reduction in root size resulting in the death of the plant (Matias et al. 2011).

Family-Diaspididae

Aonidiella orientalis (Newstead)

Aonidiella orientalis (Newstead) is one of the dangerous species of scale on neem and infests neem trees in different countries including the Lake Chad

Basin, Brazil, Sudan, Kenya, and also some Asian countries like Sri Lanka, and India (Boa 1995; Costa et al. 2013; Ensaf et al. 2016; Lale 1998; Schmutterer 1998) due to its feeding activity the affected part of the leaflets turned yellowish (Kiyanthi and Mikunthan, 2009). *Aonidiella orientalis* attacks the whole neem tree and causes the yellowing of leaves, defoliation, retarded growth, and death of heavily infested seedlings and trees. Furthermore, heavy infestations are responsible for the reduced strength of the neem tree and lead to premature leaf fall and death of infested young shoots (Ensaf et al. 2016).

Pinnaspis strachani (Cooley)

Pinnaspis strachani is a scale insect that infests Neem trees in Asia, Africa, and Latin America (Tomar et al. 2008). In Brazil, it causes heavy infestation on the trunk which appears as a white paint and also they develop and reproduce by feeding solely on neem plants. Apart from the trunk, it also infests the stems and leaves of the plant (De Castro et al. 2020).

Order-Orthoptera

Family-Acrididae

Orthacris simulans

Greenish wingless grasshoppers are the defoliators and feed on mature leaves of neem (Sharma, 2016; Tyagi et al., 2014).

Family-Tettigoniidae

Microcentrum retinerve (Burmeister, H., 1838)

These are feeding on leaves of neem in the laboratory (Chockalingam & Noorjahan 1984).

Order- Hymenoptera

Family: Formicidae

Solenopsis species.

Solenopsis sp. causes damage to the neem plants of 3 to 6 years of age in Andhra Pradesh, India (Raghunath et al. 1982).



Acromyrmex species.

These leaf-cutting ants cause defoliation of the neem leaves except the midribs and other strong veins (Schmutterer 1990b; Tomar et al. 2008)

Order- Isoptera

Family Termitidae :

***Microtermes mycophagus* (Desneux, 1906)**

A fungus-growing termite, *Microtermes mycophagus* shows a slightly superficial preference for neem wood apart from twenty other wood species (Iqbal et al. 2015).

***Microtermes najdensis* Harris**

Najdian termite, *Microtermes najdensis* infests *Azadirachta indica* in Hada Al-Sham with other host plants including *Eucalyptus rostrata*, *Phoenix dactylifera*, *Tamarix nilotica*, *Ficus infectoria*, *Olea europea*, *Pithecellobium dulce*, *Conocar puserectus*, *Ziziphus spinachrista*, and *Simmondsia chinenses*. The diameters of the termite tunnels varied between 0.5 cm to 15 cm (Al-Ghamdi et al. 2009).

***Odontotermes feae* (Wasmann)**

It is also known as a fungus-growing termite and belongs to the family Termitidae. This termite species infests live trees of *Melia dubia* in Tamil Nadu, India, and is identified as the South Asian wood-destroying termite (Suganthi and Pretheepkumar 2019).

Family :Rhinotermitidae

***Coptotermes frenchi* (Hill)**

It is also known as the Australian Subterranean Termite and infests live trees of *Azadirachta indica* in Tamil Nadu, India (Suganthi and Pretheepkumar 2019).

***Coptotermes formosanus* Shiraki**

The Formosan subterranean termite, *Coptotermes formosanus* Shir. is found on neem plants causing a severe infestation in the trunk and branches of the old neem tree (Delate and Grace 1995).

CONCLUSION

Since the Neem tree and its products provide many benefits to human as well as livestock health so it is beneficial to conserve this valuable medicinal plant for the future. Studies and research should be done more on the insects found on this plant and the causes of deterioration of the plant parts whether related to feeding, egg-laying, boring into the stems, etc.

Funding- This research received no external funding

Authors contribution

Conceptualization, Sheetal Anand and Sheetal Anand and Barish E. James writing—revision, review and editing—Sheetal Anand. All authors have read and agreed to the published version of the manuscript.

Acknowledgements

The authors would like to thank authorities of University of Lucknow specially Prof. Omkar and Dr. Geetanjali Mishra, (LBRL, University Of Lucknow) and Dr. V. Prakash (Principal), Isabella Thoburn College who approved this joint collaborative research arrangement between Isabella Thoburn College and University of Lucknow. This review article forms the basis for future collaborative research.

Conflicts of interest - There is no conflict of interest .

Data Availability- Not applicable.

REFERENCES

Agouké D, Agricola U, Bokonon-Ganta HA (1988).

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- Rastrococcus* invadens Williams (Hemiptera: Pseudococcidae), a serious exotic pest of fruit trees and other plants in West Africa. *Bull Ent Res* 78(4), 695–702. <https://doi.org/10.1017/S0007485300015558>
- Al-Ghamdi KM, Aseri AA, Mayhoub JA (2009). Field study on tunnel shapes of the small Najdian Termite, *Microtermes najdensis* (Isoptera: Macrotermitidae) and the percentage of infestation in its host plants in Makkah Al-Mokaramah Province. *Journal of King Abdulaziz University - Meteorology, Environment and Arid Land Agriculture Sciences*, 20(1), 23–43. http://prod.kau.edu.sa/centers/spc/jkau/Data2/Review_Artical.aspx?No=2614#Abstract
- Beeson CFC (1941). The ecology and control of the forest insects of India and the neighbouring countries. *The Ecology and Control of the Forest Insects of India and the Neighbouring Countries*.
- Biosci IJ, Ardakani AS, Nasserzadeh H (2014). First record and biology of coffee bean weevil, *Araecerus fasciculatus* De Geer, on pesticide plant, *Melia azedarach* L. from Iran. *Int J Biosci* 5(12), 486–491. <https://doi.org/10.12692/ijb/5.12.486-491>
- Biswas K, Chattopadhyay I, Banerjee RK, Bandyopadhyay, U (2002). Biological activities and medicinal properties of neem (*Azadirachta indica*). *Curr Sci* 82(11), 1336–1345.
- Boa ER (1995). *A guide to the identification of diseases and pests of neem (Azadirachta indica)*. August. https://www.researchgate.net/profile/Eric_Boa/publication/280720956_A_Guide_to_the_Identification_of_Diseases_and_Pests_of_Neem_Azadirachta_indica/links/5c28c3f08aea2d9bdbfec4a.pdf
- Board N (2003). *Hand Book on Neem & Allied Products*. Asia Pacific Business Press. <https://books.google.co.in/books?id=iBCfCWAAQBAJ>
- Browne FG (1968). Pests and diseases of forest plantation trees: an annotated list of the principal species occurring in the British Commonwealth. *Pests and Diseases of Forest Plantation Trees: An Annotated List of the Principal Species Occurring in the British Commonwealth*.
- Chander J, Singh S (2017). Outbreak of *Ascotis selenaria* (Lepidoptera: Geometridae) on Neem and Bakain in the State of Haryana, India. *Indian Forester*, 143(5), 436–440.
- Chockalingam S, Noorjahan A (1984). Consumption and utilization of neem leaves by *Microcentrum retinerve* (Orthoptera: Tettigonidae)[*Azadirachta indica*]. *Annals of Entomology*.
- Ciesla WM. (1993). *Pests and diseases of neem, Azadirachta indica*.
- Costa EM, Godoy MS, Araujo EL, Silva RIR, Wolff VR dos S (2013). Primeiro relato de infestação da *Azadirachta indica* a. Juss por *Aonidiella orientalis* (Newstead) (Hemiptera: Diaspididae) no Brazil. *Bioscience Journal*, 29(5), 1441–1445.
- Council NR (2002). *Neem: a tree for solving global problems*. The Minerva Group, Inc.
- Das GF, Da Silva MF, Gottlieb OR, Dreyer DL. (1984). Evolution of limonoids in the Meliaceae. *Biochemical Systematics and Ecology* 12(3), 299–310. [https://doi.org/10.1016/0305-1978\(84\)90053-X](https://doi.org/10.1016/0305-1978(84)90053-X)
- De Castro MT, Montalvão SCL, Wolff VR, dos S (2020). *Pinnaspis strachani* (Cooley) (Hemiptera: Diaspididae) infesting neem trees (*Azadirachta indica* A. Juss., Meliaceae) in Bahia, Brazil. *EntomoBrasilis*, 13, e0880. <https://doi.org/10.12741/ebrasilis.v13.e0880>
- de Souza RM, dos Anjos N, Mourão SA (2009). *Apaterebrans* (Pallas) (Coleoptera: Bostrychidae) atacando árvores de nim no Brasil. *Neotropical Entomology* 38(3), 437–439. <https://doi.org/10.1590/s1519-566x2009000300023>
- Delate KM, Grace JK (1995). Susceptibility of neem to attack by the Formosan subterranean termite, *Coptotermes formosanus* Shir. (Isopt., Rhinotermitidae). *J Appl Ent* 119(1–5), 93–95. <https://doi.org/10.1111/j.1439-0418.1995.tb01250.x>
- Dhiman SC, Yadav YK (2003). Host plants and defence behaviour of *Halys dentatus* Fabr. (Heteroptera: Pentatomidae). *J Exper Zool India* 6(1), 205–209.
- Dhiman S, Makassar UF, Yadav YK. (2019). *Life history of a phytosuccivorous bug, Halys dentatus Fabr. (Heteroptera: Pentatomidae), a pest of neem tree, Azadirachta indica A. Juss., in western uttar pradesh. January 2008*.
- Ensaf SIM, Inaam AE, Manal HE. (2016). Outbreak of oriental yellow scale insect, *Aonidiella orientalis* (Newstead) (Homoptera: Diaspididae), on neem in Sudan. *EPPO Bulletin*, 46(1), 125–128. <https://doi.org/10.1111/epp.12264>
- Erskine, P. D. (2014.). *Reforestation in the Tropics and Subtropics of Australia Using Rainforest Tree Species*



Edited by: June 2014.

- Esch SA van der (2012). Role of Neem in Animal Health. *World Neem Conference, 196*(3), 589-590,619-620. <http://www.ncbi.nlm.nih.gov/pubmed/23472348>
- Farooqi AA, Sreeramu BS (2004). *Cultivation Of Medicinal And Aromatic Crops*. Universities Press (India) Pvt. Limited. https://books.google.co.in/books?id=Meqij7-B0_8C
- Gamble JS (1972). A Manual of Indian Timbers, reprinted edition. *BS Mahendra Pal Singh, Dehradun, 313*.
- Girish K, Shankara BS (2008). Neem—a green treasure. *Electronic journal of Biology* 4(3), 102-111.
- Hodges CS, (1992). *Evaluation of a Disorder of Neem in Nigeria: A Report Submitted to Bureau for Africa, U.S. Agency for International Development, Washington DC*.<https://books.google.co.in/books?id=Nc8sAQAAMAAJ>
- Iqbal N, Khan HAA, Saeed S (2015). Response of *Microtermes mycophagus* (Isoptera: Termitidae) to twenty one wood species. *PeerJ*, 3, e1132.
- Kiyanthi S, Mikunthan G (2009) Association of Insect Pests with Neem , *Azadirachta indica* with Special Reference to Biology of Ash Weevils , *Myloccerus* sp in Jaffna , Sri Lanka. 4(4), 250–253.
- Kumar S, Kumar S, Centre DR (2016). Diversity of *myloccerus* species (Coleoptera : Curculionidae) associated with *Prosopis juliflora*. 29(2), 389–391.
- Kumar VS, Navaratnam V (2013). Neem (*Azadirachta indica*): Prehistory to contemporary medicinal uses to humankind. *Asian Pacific Journal of Tropical Biomedicine* 3(7), 505–514. [https://doi.org/10.1016/S2221-1691\(13\)60105-7](https://doi.org/10.1016/S2221-1691(13)60105-7)
- Lale NES (1998). Neem in the Conventional Lake Chad Basin area and the threat of Oriental yellow scale insect (*Aonidiella orientalis* Newstead) (Homoptera: Diaspididae). *Journal of Arid Environments*, 40(2), 191–197. <https://doi.org/10.1006/jare.1998.0419>
- Matias FI, Sampaio MV, Coelho L, Grazia J (2011). Occurrence of *Scaptocoris castanea* Perty (Hemiptera: Cydnidae) damaging *Azadirachta indica* (Meliaceae) seedlings in Brazil. *Neotropical Entomology*, 40(2), 288–289.<https://doi.org/10.1590/S1519-566X2011000200022>
- Mishra G, Omkar (2012). Neem, the wonder tree, under attack: A new major pest. *Curr Sci* 102(7), 969–970.
- Muniappan R, Marler T, Lawrence JH (2002). Pests of *Elaeocarpus joga* in Guam. *Micronesica*, 34(2), 109–111.
- Paunika S (2015). *Myloccerus Spp ., Serious Pest Of Tree Seedlings In Forest Nurseries Of North-Western And Central India*. 3(1), 353–355.
- Pillai SRM, Gopi KC (1990). Seasonal drying up of the distal shoots of neem (*Azadirachta indica* A. Juss.) and important insect pests associated with it. *Myforest*, 26(1), 33–50.
- Raghunath T, Allam MA, Venkaiah K (1982). Fire ant, (*Solenopsis* sp.) damaging neem (*Azadirachta indica* Juss.). *Indian Forester* 108(5), 375.
- Rishi RR, Borah RK, Kumar R, Pandey S (2013). Short Communication Evaluation of native Baculovirus on *Boarmia variegata* Moore . (Geometridae : Lepidoptera) a major defoliator of *Melia azedarach* L . 1(2), 131–133.
- Roxburgh W (1874). Description of Indian plants. Today and Tomorrow, New Delhi, 763.
- Sabo T, Singh A, Brar JS, Singh K (2018) Biology of *Cleora cornaria* , neem Looper (Lepidoptera : Geometridae) in Biology of *Cleora cornaria* , neem Looper (Lepidoptera : Geometridae) in Talwandi Sabo , Punjab. July, 1–5.
- Sakthivel P, Karuppachamy P, Kalyanasundaram M, Srinivasan T (2012). Host Plants of Invasive Papaya Mealybug, *Paracoccus marginatus* (Williams and Granara de Willink) in Tamil Nadu. *Madras Agricultural Journal* 99(79), 615–619.
- Schmutterer H (1990a). Beobachtungen an Schädlingen von *Azadirachta indica* (Niembaum) und von verschiedenen *Melia*-Arten. *J Appl Ent* 109(1–5), 390–400. <https://doi.org/10.1111/j.1439-0418.1990.tb00068.x>
- Schmutterer H (1990b). Properties and potential of natural pesticides from the neem tree, *Azadirachta indica*. *Ann Rev Entomol* 35(1), 271–297.

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- <https://doi.org/10.1146/annurev.en.35.010190.001415>
- Schmutterer H (1995). *The neem tree, Azadirachta indica A. Juss. and other meliaceous plants: source of unique natural products for integrated pest management, medicine, industry and other purposes.*
- Schmutterer H (1998). Some arthropod pests and a semi-parasitic plant attacking neem (*Azadirachta indica*) in Kenya. *Anzeiger Fur Schadlingskunde Pflanzenschutz Umweltschutz* 71(2), 36–38. <https://doi.org/10.1007/BF02770586>
- Schmutterer H (1999). The scale insects, whiteflies, aphids and psyllids of the neem tree, *Azadirachta indica* (Meliaceae). *Entomologica* 33, 339–345.
- Sharma M (2016). Insect Pests of Forestry Plants and Their Management. *Int J Adv Res* 4(8), 2099–2116. <https://doi.org/10.21474/ijar01/1427>
- Srivastava AS, Srivastava KM, Nigam PM (1971). On the Life History of White Grub, *Holotrichia consanguinea* Blanch. (Coleopt., Melolonthidae). *Zeitschrift Für Angewandte Entomologie* 68(1–4), 154–157. <https://doi.org/10.1111/j.1439-0418.1971.tb03137.x>
- Suganthi M, Pretheepkumar P (2019). Identification of termite species infesting live trees. 7(6), 79–82.
- Sundararaju D, Sundara Babu P. (1998). Life table studies of *Helopeltis antonii*. *J Ent Res* 22(3): 241–244.
- Tewari DN (1992). Monograph on neem (*Azadirachta indica* A. Juss.). International Book Distributors.
- Thakur RS, Singh SB, Goswami A (1981). Biological activities and medicinal properties of neem. *Curr Res Med Aromat Plants* 3, 135–140.
- Theurkar SV, Ghadage MK, Madan SS, Bhor GL, Patil SB (2013). Occurrence of white Grubs in ground nut Growing area of Khed Taluka , part of Northern Western Ghats , MS , India. *Res J Rec Sci* 2, 1–3.
- Thomas MC, Woodruff RE (2011). A Stored Products Pest , *Oryzaephilus acuminatus* (Insecta : Coleoptera : Silvanidae). *Ifas Extension, March*, 2–5.
- Tippannavar PS. (2013). Studies on present status of white grub, *Holotrichia serrata* (Fabricius) (Coleoptera; Scarabaeidae) in Belagavi District and its management. UASD.
- Tomar A, Singh KK, Phogat S, Dhillon RS (2008). Neem: An Introduction. In *Neem: A Treatise* (p. 546). IK International Publishing House Pvt. Ltd.
- Tyagi BK, Veer V, Prakash S (2014). *Pests of Forest Importance and Their Management*. Scientific Publishers (India). <https://books.google.co.in/books?id=V-g4DwAAQBAJ>