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INGLISIA BIVALVATA GREEN (HEMIPTERA:COCCIDAE), CAUSAL AGENT FOR THE DIEBACK AND DEATH OF SANDAL *(SANTALUM ALBUM)*

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REMADEVI, O.K. & RAJA MUTHUKRISHNAN. 1998. *Inglisia bivalvata* Green (Hemiptera: Coccidae), causal agent for the dieback and death of sandal (*Santalum album*). *Inglisia bivalvata* Green (Hemiptera: Coccidae) causes dieback of branches and, in severe cases, death of saplings and young trees of sandal, *Santalum album.* Scales are attached to twigs. Female scales look like bivalved shells. While adult males are winged, females are wingless and sedentary. Nymphs move out from underneath the scales of females and settle on tender branches to suck the sap. Insects occur throughout the year. Parasites and predators help in the biological control of this pest. Five hymenopteran parasites are reported for the first time from this coccid. Quinalphos and chlorpyriphos were found to be effective in controlling the pest attack. In this study, *Polyalthia longifolia, P. pendula, Acacia mangium* and *Dalbergia sissoo* are reported as new plant hosts.

Key words: Sandal - *Inglisia bivalvata* - coccid - dieback - death - control

REMADEVI, O.K. & RAJA MUTHUKRISHNAN, 1998. *Inglisia bivalvata* Green (Hemiptera: Coccidae), agen penyebab mati rosot dan kematian sandal (*Santalum album*). *Inglisia bivalvata* Green (Hemiptera : Coccidae) menyebabkan mati rosot ranting dan dalam kes yang teruk, menyebabkan kematian anak pokok dan pokok muda sandal, *Santalum album.* Teritip melekat pada ranting. Teritip betina kelihatan seperti siput berkulit dua. Teritip jantan dewasa bersayap manakala teritip betina dewasa tidak bersayap dan duduk setempat. Nimfa keluar dari bawah teritip betina dan duduk pada ranting yang lembut untuk menghisap getahnya. Serangga muncul di sepanjang tahun. Parasit dan pemangsa membantu mengawal biologi perosak. Lima parasit himenoptera dilaporkan muncul kali pertama daripada koksid ini. Quinalphos dan klopirifos berkesan mengawal serangan perosak. Dalam kajian ini, *Polyalthia longifolia, P. pendula, Acacia mangium* dan *Dalbergia sissoo* dilaporkan sebagai tumbuhan perumah yang baru.

Introduction

Santalum album L. (sandal), distributed all over India, is a tree of great economic importance because of its fragrant heartwood oil. Although about 150 species of insects are known to be associated with sandal, only a few like *Kerria lacca,* the lac insect, are reported (Remadevi *et al.* 1997) to cause mortality of the plant. While

Chatterjee and Ayyar (1936) and Mathur and Singh (1960) have recorded as many as 12 coccids on sandal, it was only in 1992 that the occurrence of *Inglisia bivalvata* was reported (Srinivasan *et al.* 1992).

In the present study, a severe attack of the coccid on saplings and small trees of S. *album* was observed. The present paper reports the distribution, range of host trees, seasonal occurrence, nature of attack, bionomics and control measures for this pest.

Materials and methods

Survey of the sandal trees in the campus of the Institute of Wood Science and Technology, Bangalore, in the sandal field stations at Hoskote (Karnataka), and also in natural forests and plantations of the southern states, viz. Karnataka, Tamil Nadu, Andhra Pradesh and Orissa, was conducted once each in the summer (February-May), rainy (June-September) and winter (October-January) seasons from 1993 to 1996. Random sampling was done to assess the occurrence of different pests on the saplings/trees. The sample size varied from 10 to 50 % of the population in an area depending on the accessibility to the trees. Incidence of *Inglisia bivalvata* was located by observing the shiny encrustations on the twigs or by the presence of dieback symptoms. Other trees like *Pongamia pinnata, Polyalthia* spp., *Dalbergia sissoo, Acacia* spp., *Albizia* spp., *Casuarina* spp., *Leucaena* sp., etc. found either naturally or planted as host trees for sandal, which is a root parasite, were also surveyed simultaneously to know whether they were collateral hosts for any of the sandal pests. Twigs infected with *Inglisia bivalvata* were collected to study the different stages and also nature of attack. Infested branches were kept in glass troughs covered with glass plates and also in cotton plugged glass tubes and parasites were collected. Observations on nymphal stages and different parasites attacking this pest were carried out using Wild M-10 zoom stereo microscope.

Saplings or small trees very severely affected by coccid were selected for preliminary experiments with the insecticides. Three concentrations (0.1, 0.2 and 0.3%) in water, of each of the insecticides, chlorpyriphos, dimethoate and quinalphos, were used for spraying on the affected trees. Each treatment was done on randomly selected five trees. Observations on insecticidal effect were taken after a week and thereafter monthly for four months.

Observations

Distribution

This pest was recorded on sandal only in Bangalore and the Hoskote district of Karnataka. On an infested tree, 10 to 80% of branches were found harbouring the pest. Infestation was mostly found localised with all the adjacent trees in an area showing the attack. (In a small population of closely grown trees, the

infection was from 80 to 100 %.) This indicates the slow nature of spreading and lack of wide dispersal. Survey in other places of Karnataka, Orissa, Tamil Nadu, etc. did not indicate its incidence. Hence, the extent of infestation is very low when the whole sandal population in a district is taken into account. *Inglisia bivalvata* was first described by Green (1903) from specimens collected in Rameswaram Island and later, its occurrence in Godavari district and Coimbatore was recorded (Ayyar 1929).

Host spectrum

Thespesia populnea, Cajanus cajan and *Pongamia* sp. are already known as hosts of this coccid (Ayyar 1929). *Inglisia chelonioides* Green has been recorded on the twigs of *Gelonium lanceolatum* and *Pithecolobium dulce* in Ceylon and on *Parkinsonia aculeata* in India (Ayyar 1929). Bhasin *et al.* (1958) reported the occurrence of *I. chelonioides* on *Casuarina equisetifolia* in India. The South African scale insect, *Inglisia lounsburyi* (Ckll.), which infests species of *Pelargonium* and *Geranium* in S. Africa, was reported from Italy on *Pelargonium* sp. (Tranfaglia & Marotta 1982, Tranfaglia 1983). In addition to the other hosts mentioned, *Polyalthia longifolia, P. pendula, Acacia mangium* and *Dalbergia sissoo* were recorded as new hosts for *I. bivalvata* in our study. It is assumed that the insects might have spilled over to trees growing adjacent to the affected sandal plants.

Nature and symptoms of attack

Appearance of dried twigs without leaves or with brown leaves indicated attack of these insects (Figure 1). On close observation, it was noticed that twigs were covered with many creamy brown, conical scales (Figure 2). Scales on the twigs looked like a chain of bivalved shells. During the early stages of infestation, tender shoots appeared to have a pinkish shiny encrustation (Figure 3), even up to the petioles and flower stalks. Leaves on the infested twigs appeared blackish because of black sooty moulds growing on them due to honeydew secreted by active coccids. Ants were also found to frequent infected branches. Due to the active feeding stages of the insect on flower- and fruit-bearing branches, flowers withered and fell off and fruit formation was also reduced. Leaves started browning and later fell off. Dieback of many branches slowly led to the death of severely affected saplings (Figure 4). Small trees, which were unhealthy due also to attack by stem borers (*Aristobia octofasciculata* and *Zeuzera coffeae*), also gradually dried and finally died, if the coccid attack persisted longer.

Morphology

Insects are stationary, appearing as non-living projections on twigs. There is clear sexual dimorphism. Female body is covered by two glassy shell-like plates joined along the median longitudinal line just like in a bivalved mollusc. Female scale measures 4 to 5.5 mm long and 3 to 3.5 mm broad. On splitting off the

two shells, which look yellowish- brown and translucent, the body of the coccid appears oval, strongly convex above, the dorsal area rising steeply into a bicuspid median point and without any distinct body part except for small antennae, hair-like feeding tube and legs. Adult male (Figure 5) is pinkish-red and has two wings, well-developed legs and protruding genitalia. Male puparium is covered by ornamental waxy laminae, which is brittle and easily detachable. Anterior extremity is with a single fluted plate, median dorsal area occupied by an elongated plate with a central cone surrounded by radiating ribs; posterior part is covered by a heart-shaped plate. Each side is occupied by two wings like laminae of striated wax with radiating lines giving the appearence of being ribbed. Length of puparium is about 2 mm.

Figure 1. A sandal tree with dried branches

Figure 2. Sandal twig with *Inglisia* scales

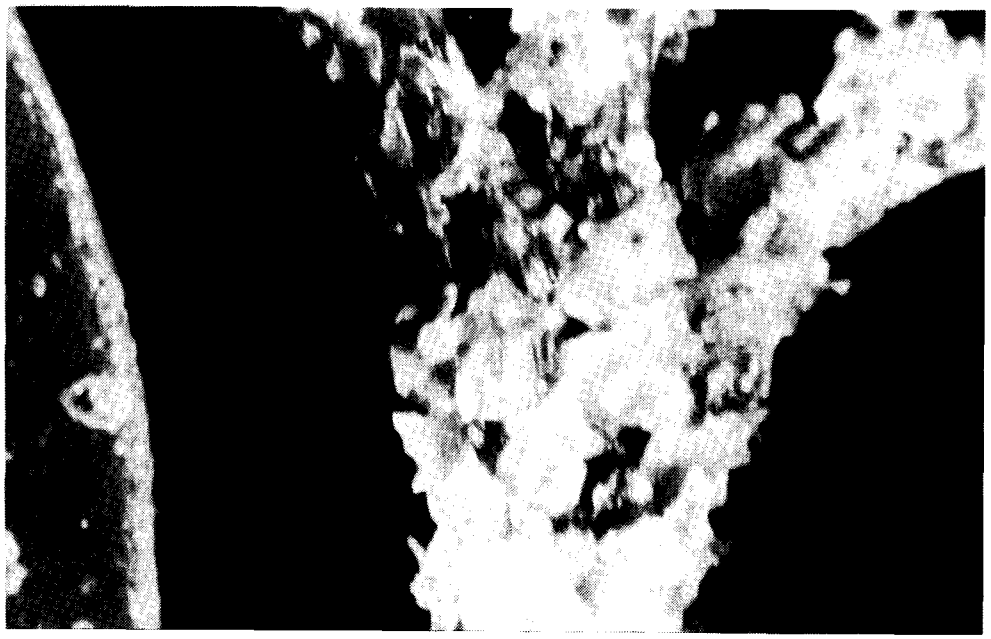

Figure 3. Tender shoot covered with male and female scales at early stages

Figure 4. A sandal sapling dead due to the attack

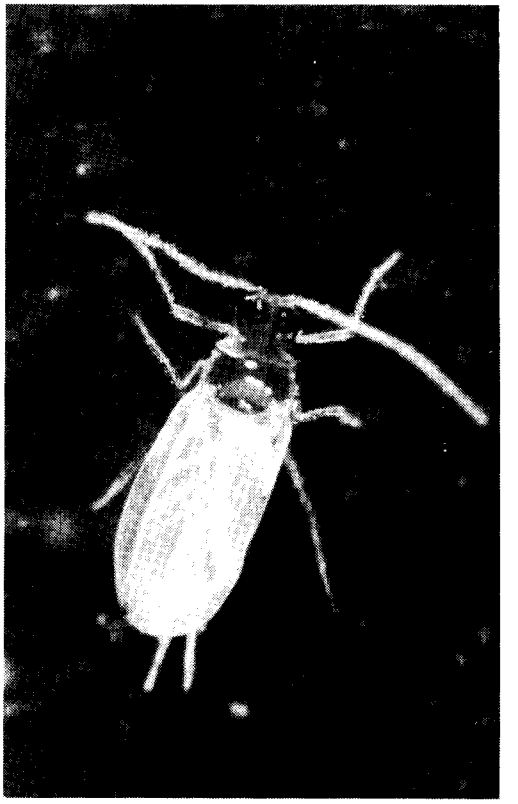

Figure 5. Adult male of *Inglisia bivalvata*

Bionomics

Mature females inhabit young nymphs beneath body walls protected by scales. Nymphs are soft, pinkish with feeding tube, three pairs of legs and a pair of anal cerci. They are oval at the anterior end, more or less pointed at the posterior and measure up to 0.5 mm in length. They come out from underneath the scales of females and start moving along the stem in search of tender and fresh twigs. Later, they settle on suitable places and start feeding on sap. They develop white waxy encrustations on the body, giving it a characteristic shape. Male nymphs usually settle on very tender twigs and petioles and fruit stalks. Females are more on thicker twigs. The life cycle of the male is shorter than that of the female. After a few moults, the winged male emerges from the puparium. Females do not come out of scales. The female body cavity is full of eggs in various developmental stages. Mature eggs are reddish oval. On lifting female scales, many nymphs were observed near the posterior region. The number of young ones found below females was 30 to 90 and eggs inside the body varied from 70 to 250. It is not known whether females produce batches of eggs and, if so, for how

long. The female dies within the puparium after production of eggs. Males are more in the progeny, even double or more. It is not known whether females reproduce parthenogenetically.

Seasonal occurrence

Affected plants appeared to harbour these insects throughout the year. Dieback and mortality of plants were more noticeable during summer months when there was an acute scarcity of water. With sprouting of fresh leaves at the beginning of the rainy season, dispersal of nymphs occurred. All the different stages of life cycle were observed on the shoots from July to September (rainy season). The incidence was observed on sandals grown under rain-fed conditions.

Control measures

Since the insects are well protected inside thick scales, it is difficult to kill them. Also, as they are tightly attached to the twigs, it is not possible to shake them down. Even strong winds or heavy raindrops cannot dislodge them.

Parasites and predators

Inglisia bivalvata was found to be parasitised by five or more species of hymenopteran parasites (Figure 6). This is the first report of parasites from this coccid. The parasites along with their families were identified as

1. *Aprostocetus* sp. (Eulophidae)
2. *Philosindia* sp. (Encyrtidae)
3. *Coccobius* sp. (Aphelinidae)
4. *Marretta* sp. (Aphelinidae)
5. *Anagyrus mirzai* Agarwal and Alam (Encyrtidae)

Elasmus albomaculatus Gahan (Elasmidae) and *Sinophorus* sp. (Ichneumonidae) were also collected from the twigs attacked by *I. bivalvata.* It could not be ascertained whether they were also parasitic on *I. bivalvata.* Pupae of the five parasitoids listed above could be dissected out from the male or female scales. The total percentage of parasitism varied from 5 to 10 %. Some of them were endoparasites and others ectoparasites. Ectoparasitic larvae were found growing attached to the body wall inside the scale. Four or more larvae of the endoparasites were found inside the body cavity of individual female coccid (Figure 7).

Usually only one parasitic larva was found inside the male (Figure 8). The reason may be the small size of the male. Parasites emerged through small circular holes made on the dorso-lateral surface of shells. Many unidentified predators, including coccinellid beetles and a noctuid caterpillar, were found predatious on the *I. bivalvata* at different stages.

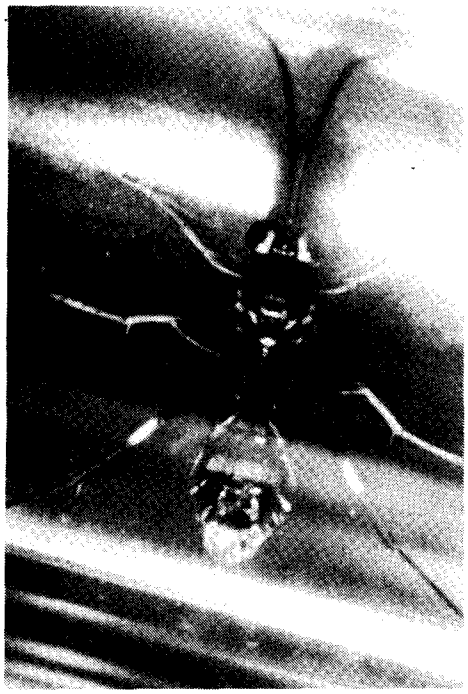

Figure 6. Hymenopteran parasite from the scale

Figure 7. Endoparasitic larvae from a female scale

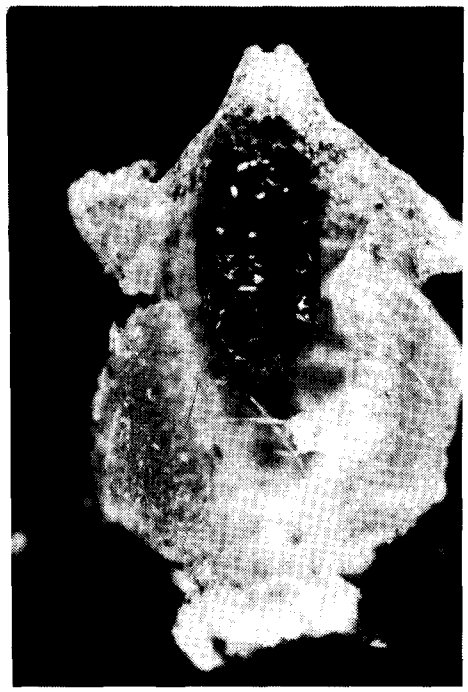

Figure 8. Pupa of a parasite inside a male scale

Insecticidal control

Studies were conducted to control the pest using insecticides. Chlorpyriphos, dimethoate and quinalphos at three concentrations (0.1, 0.2, 0.3%) were sprayed on the trees to drench the branches thoroughly. Quinalphos 0.2%/ 0.3% and chlorpyriphos 0.2% / 0.3% were effective in controlling the pest fully. Dimethoate 0.3% was useful in killing it at the early stages. The insects died and dried with the scales gradually falling off from the branches.The treatments at lower concentrations were effective in controlling the spread of nymphs. Further studies are in progress.

Discussion and conclusion

Inglisia fagi is considered one among the causal agents of dieback and death of beech in New Zealand, the others being *Armillaria* sp. and the pathogenic fungi *Sporothrix* sp. introduced by the beetle *Platypus* spp. (Mueller-Dombois *et al.* 1983). Hosking and Kershaw (1985) reported that many red beech *(Nothofagus fusca)* trees (up to 75% in the worst affected areas) died in parts of the Marina Valley between 1978 and 1980 following an outbreak of the scale insect *I. fagi.* They also reported that the annual diameter increment of trees and climatic data suggest the primary cause to be a series of spring droughts between 1974 and 1978. These observations indicate that coccid attack is not the sole reason for dieback and death of trees. In the present study also, dieback and death of sandal were observed in drier months and also when trees had infestation of stem borers.

The present observations reveal that, if not checked in time, the attack of these coccids can be harmful and even fatal to the sandal tree. It is already known that the scale insects, *Saissetia* spp., are responsible for the poor seed setting in sandal (Sivaramakrishnan *et al.* 1987). The lac insects also cause mortality of sandal (Remadevi *et al.* 1997). As the coccids suck the sap of plants, particularly when the plants are not irrigated in the dry summer months, chances of total drying of branches are more, leading to the total mortality of the plants. Hence, constant observations and appropriate control measures are absolutely necessary for successful growing of sandal plants.

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