Lowlands Farming Systems Research Team

LFSRT

Occasional Paper 1

A REVIEW OF WORK ON LEUCAENA PSYLLID AND IMPLICATIONS FOR RESEARCH

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June 1989

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Abstract

A Review of Work on Leucaena Psyllid and Implications for Research

Malchus Arura

Leucaena psyllid, Heteropsylla cubana, is a recent important insect pest in the Pacific, Australia and Asia. This pest is endemic to Central America and has spread rapidly to these regions in a short period of time. Leucaena crop is vital for increased animal and crop production in some countries, while in others it is considered as a major weed pest.

Natural enemies of this pest have been identified and some of them have been used as biocontrol agents with some degree of success in some countries, particularly Hawaii. Chemical control, although effective, need to be repeated regularly and is expensive. Resistant Leucaena species and cultivars have been identified and areas where further research should be done, with the aim of developing alternative and/or combination of control measures, are suggested. Funding for research in these areas is vital from the countries concerned.

Contents

1. INTRODUCTION

Leucaena psyllid, *Heteropsylla cubana* Crawford (Hemiptera: Psyllidae) has recently received a much greater attention for being the major pest of the leguminous plant in the genus *Leucaena* in the Pacific, Australia and Asia. The pest is endemic in America and has spread rapidly throughout most of the Pacific, some parts of Australia and some Asian countries. However, very little is known about this and other related species of *Heteropsylla*. This paper is mainly based on *H. cubana* but where relevant other species are also mentioned.

This paper reviews biological and ecological aspects of *H. cubana* including work on its control. Based on the review, possible areas of research are identified and suggestions made for control of this pest.

2. ORIGIN AND DISTRIBUTION

The genus *Heteropsylla* is native to the region, extending from the Southern United States to temperate South America. *H. cubana* occurs in the central part of this range. The species that was originally thought to attack *Leucaena leucocephala* in the Pacific, (*H. incisa*), has now correctly been referred to as *H. cubana* (Burckhardt 1986).

H. cubana was first described in 1914 from specimens collected in Cuba (Burckhardt 1986, Crawford 1914). It is also known to occur in Argentina, Bahama Is, Bermuda and the Dominican Republic, Mexico, Nicaragua, Puerto Rico, Tobago, Trinidad, Virgin Is and probably throughout much of South America (Nakahara and Lai 1984).

3. SPREAD OF PSYLLID

In late 1983, *H. cubana* was found to be causing severe damage to *Leucaena* in Florida in the United States (Anon 1986) and in April 1984 it was reported to be causing defoliation first on *L. leucocephala* and later on monkeypod (*Samanea saman*) in Hawaii (Nakahara and Lai 1984, Waterhouse and Norris 1987). It was next reported in Western Samoa in February 1985 (Hollingsworth et al. 1985).

Before the end of 1985 it was reported for the first time from Cook Is, Fiji, Guam, New Caledonia, Niue, Philippines, American Samoa, Saipan, Solomon Is, Tonga, Vanuatu and Yap (Micronesia) (Waterhouse and Norris 1987). In February 1986 it was observed in Ciawi (Indonesia) (Waterhouse and Norris 1987) and in early March 1986 it was in Papua New Guinea (PNG), rapidly spreading throughout most of the provinces. In April 1986 it was reported on the central coast of Queensland in Australia, and in May the same year it was discovered on Christmas Is (Indian Ocean)

(Cameron 1988, Mitchell and Waterhouse 1986, Waterhouse and Norris 1987).

By June 1986, it had not spread to French Polynesia, Marquesas, Taiwan, Thailand, Tokelau or Tuvalu but by now probably it has reached these countries including other Asian countries (G. Walter pers. comm. 1988). The very rapid spread of this pest over a large area is suggested to be due to moving air masses (Waterhouse and Norris 1987).

4. SPECIES OF PSYLLID

Two other species of Heteropsylla occur in Hawaii and these are H. huasachae and H. fusca. H. huasachae occurs on slender mimosa (Desmanthus virgatus), Koa (Acacia koa) and on monkeypod. It was first collected in Hawaii in 1974 from D. virgatus and occurs also on this plant in Saipan (Waterhouse and Norris 1987). It is previously known from Mexico, Guatemala and Puerto Rico. H. fusca on the other hand occurs on Acacia farnesiana and was previously known from Dominican Republic, Puerto Rico and Haiti. These species may not be restricted to these hosts and may be spreading throughout the Pacific and other regions (Waterhouse and Norris 1987).

An undescribed species of Heteropsylla has been found to attack and severely damage giant sensitive plant Mimosa invisa. The plant is one of the most serious weeds in the Pacific and Australia (Garcia 1985).

5. HOST PLANT RANGE

Plant species where insect development from egg to adult is not complete are not considered true host plants (Hodkinson 1974, Nakahara and Lai 1984).

The genus Leucaena is of Latin American origin and is a member of the family Mimosaceae. The plant contains the amino acid mimosine (Jones 1979, Jones 1986, Waterhouse and Norris 1987) which was first found in the closely-related genus Mimosa (Brewbaker 1983, Waterhouse and Norris 1987). There are 12 species of Leucaena in Hawaii. H. cubana can complete its life cycle on 8 of them (Waterhouse and Norris 1987). The four remaining species are not fed upon by H. cubana nymphs. This is implied to be due to the presence of hairs on their shoots (Nakahara and Sorensson 1984). The 12 species of Leucaena are diversifolia, greggii, lanceolata, leucocephala, macrophylla, pulverulenta, shannonii, trichodes, collinsii, esculenta, pallida and retusa. In Western Samoa, fewer nymphs were found to feed on L. collinsii than on L. leucocephala (Hollingsworth et al. 1985).

H. cubana occurs on two other species of trees belonging to the Mimosaceae in Hawaii as well. These are the royal poinciana (Delonix regia) and kiawe (Prosopis pallida) in which eggs and first nymphal instars were found but no later stage nymphs (Nakahara and Lai 1984). Similar situation is recorded from Pipladenia sp. in the Americas (Hodkinson and White 1981). However these plants are not their true hosts.

6. LIFE CYCLE

H. cubana eggs have basal pedicel through which fluids are taken up from the leaf surface of new terminal growths of the host plants (Hodkinson 1974, Takara et al. 1986). The eggs hatch in 2 to 3 days and the duration of nymphal period is 8 to 9 days (Takara et al. 1983, Waterhouse and Norris 1985). There are 5 nymphal instars (Takara et al. 1983, Hodkinson 1974) and the adult females live for an average of 10.6 days and males for 6.4 days (Takara et al. 1983, Waterhouse and Norris 1987). Preovipositon period ranges from 1 to 3 days and the female lays an average of 394 eggs (Takara et al. 1983, Waterhouse and Norris 987).

7. DEVELOPMENTAL BIOLOGY

Psyllids are monomorphic, sexually reproducing and oviparous i.e. they are bisexual with males having heterogametic sex (Hodkinson 1974).

8. ADULT BIOLOGY

8.1 Dispersal

Adult psyllids fly and it is believed that they can disperse long distances with the aid of air currents. Distance of up to 13 km is reported (Hodkinson 1974).

8.2 Host Plant Selection

Host plant selection by adults is suggested to be chemogustatory (Hodkinson 1974).

8.3 Mating and Oviposition

Mating behaviour is straight forward in which the aggressive male approaches the passive female from the side, rotates its abdomen and grasp the female valves with its parameres before inserting the aedeagus (Hodkinson 1974). In other species of psylloidea, precopulatory behavioural patterns such as males repeatedly attempting to copulate with females rejecting them and stridulation are known (Hodkinson 1974). Copulation lasts from 30 minutes up to 4 hours. Females copulate repeatedly and each male may fully inseminate up to 4 females. Egg fertility of mated females reaches 100% for large part of egg laying period but declines to 75% towards the end (Hodkinson 1974).

9. FEATURES OF PSYLLID DEVELOPMENT

Climatic factors such as rainfall and temperature are important for psyllid development. One of the mortality factors involved in reducing psyllid numbers is rainfall. In PNG _H. cubana_ population is reduced during wet seasons (Arura and Gwaisuk unpublished, Moxon 1986). Similar observation is reported for Western Samoa (Waterhouse and Norris 1987).

In addition, Hodkinson (1974) suggests that psyllid nymphs are susceptible to desiccation at high temperatures particularly during moulting when the ability to retain water is reduced. However, the nymphs have mechanisms by which water loss is reduced i.e. moulting or hatching of nymphs is controlled by combination of light-dark periodicity and temperature (Hodkinson 1974).

10. HOST PLANT EFFECT ON PSYLLID DEVELOPMENT

Host plants affect psyllid development in two ways:

1. developmental differences between host plant species due to presence of certain plant structures (e.g. presence of hairs) and

2. developmental differences within host plant species due to variability in nutritive status (e.g. presence of high nitrogen contents on terminal growths).

Phloem sap is not a nutritious food source and changes in quality of sap, particularly changes in amino acid concentration, affect psyllid development. The soluble nitrogen increases with water stress in host plant tissues. Both increased nitrogen and flushing of new growths can increase nymphal survival and growth rate while decrease in soluble nitrogen due to aging of leaves reduces fecundity and results in a shorter life span of adults (Hodkinson 1974).

11. POPULATION PROCESSES

Tropical pest species may have up to 10 generations per year with each female producing an average of 300 eggs. Population increase, therefore, is dependent on generation time rather than on individual female fecundity (Hodkinson 1974).

12. PEST STATUS

12.1 Importance of Leucaena

Leucaena is an important crop and has multiple uses. It was introduced to the Pacific, Asia and Caribbean coasts in the sixteenth century. It reached Hawaii and Australia in the nineteenth century as an ornamental plant (Cameron 1988). As early as 1940's this was considered as an important alternative forage for animals in Australia.

Leucaena is increasingly becoming important crop for animal forage in Australia and areas planted for this purpose are increasing (Shelton 1986, Wilden 1986). In Central Queensland, three thousand hectares were planted in March 1985 and it was predicted that by 1986 sixteen thousand hectares would have been planted (Wilden 1986).

The crop has also become increasingly important for use as shade trees for perennial cash crops (cocoa, coffee and other crops), pelleted feed meal, mulching, green fertilizer, firewood, soil erosion, alley cropping and human consumption in the Asian-Pacific region (Jones 1985, Waterhouse and Norris 1987). The young seed pods are used as a vegetable, and so are the young growing tips in Indonesia, Thailand and Mexico (Jones 1986).

It is, however, considered important as a weed in some Pacific countries (Niue, Western Samoa, Solomon Is, American Samoa, Cook Is, French Polynesia and Vanuatu). It is naturalised and had formed dense thickets of little value in these countries (Waterhouse and Norris 1987).

12.2 Psyllid Damage

H. cubana's damage to Leucaena is primarily on new growths with some feeding on older plant tissues. Hodkinson (1974) reviews similar damages by other members of the group Psylloidea and points that nymphal instars and fertile adult females feed on new growths where nitrogen content is higher than in older plant tissues. Eggs are deposited on new growths and large number of psyllids remove the sap rapidly thus causing the new growth to become stunted. Salivary injection by the psyllids causes break down of tissues releasing soluble amino acids and also kills plant cells.

In addition, deposition of honeydew on the terminals and older leaves allows sooty mould growth which in turn affects plant growth. When new growths are attacked repeatedly, there is severe defoliation, increased bud formation (apical dominance) and, in some cases, death of terminals and plant.

Repeated defoliation over periods of more than 10 months in Western Samoa (Thomas and Liebregts 1987) and more than 12 months in PNG have resulted in death of trees over considerable areas. Where damage is not severe, flowering is prevented and no seeds are set. These effects are serious under dry conditions (Arura and Gwaisuk unpublished, Moxon 1986, Nakahara and Lai 1984).

12.3 Disease Transmission

Other members of the group Psylloidea are known vectors of plant diseases (Hodkinson 1974). However, H. cubana has not been found to be a disease transmitter (Nakahara and Lai 1984).

13. CONTROL MEASURES

13.1 Natural Enemies

Evidence on host specificity among parasites attacking Psylloidea are lacking (Hodkinson 1974). There are no records of egg parasites (Waterhouse and Norris 1987). Wasp parasites generally attack specific nymphal instars. Thus host parasite synchronisation will occur when the wasp parasites are released as biocontrol agents.

Psyllid predators show little specificity and are general feeders. Predator populations are often poorly synchoronised with and are slow in responding to changes in psyllid population (Hodkinson 1974). Bray and Sands (1986) give list of predators attacking H. cubana in Australia. There are, at least seven species of coccinellids, two species of syrphid fly larvae, ants, spiders and a reduviid bug; none of which is host specific.

A number of natural enemies are recorded in Hawaii attacking psyllids with some degree of control (Waterhouse and Norris 1987). They include 10 species of coccinellids, 2 species of syrphids, various spiders, an unidentified green lacewing (Chrysopidae), a reduviid, a mirid and an anthocorid. These natural enemies are also not host specific. The predatory Hemiptera (Paratriphleps laevisculus) has effect during initial population explosion but subsequently plays a minor role in influencing psyllid numbers (Waterhouse and Norris 1987). The important predators in Hawaii are larvae and adults of several species of coccinellids. The most abundant and important one is Curinus coeruleus, the adults of which are general feeders. It was introduced to Hawaii in 1922 from Mexico for controlling the coconut mealybug (Nipaecoccus nipae) and recently has had some degree of control over psyllids.

The other important group of predators are Olla -v-nigrum in some areas and Coccinella septempunctata in others, followed by Scymnus sp., Hippodama convergens, Azya orbigera and Coelophora inequalis. Predators other than coccinellids did not appear to give significant control of psyllids.

In Panama solitary wasps were observed to feed on the nymphs while in Western Samoa, coccinellids and syrphid fly larvae were observed attacking them. In addition, flocks of swifts (Collocalia spodiopygia) were observed feeding on psyllid adults (Hollingsworth et al. 1987).

The impact of natural enemies on psyllid numbers in Vanuatu was similar to that in other countries discussed above. The predatory coccinellids, a syrphid fly larvae, wasps and the common swift C. vanikorensis were observed attacking psyllids but their impact was not significant (Waterhouse and Norris 1987).

13.2 Biological Control

Natural enemies from the Caribbean and tropical America were introduced in Hawaii and were studied in quarantine but they have been found to lack host specificity. These were an eulophid wasp, (Tetrastichus triozae), an encyrtid wasp (Psyllaephagus nr rotundiformis) and a coccinellid predator (Cycloneda conjugata) (Nakahara and Funasaki 1986, Nakahara and Lai 1984).

C. coeruleus has been collected in Hawaii for introduction in the Philippines, Indonesia, Guam, Saipan and PNG (Merrett 1988, Waterhouse and Norris 1987). Release of this predatory bug in PNG was in question during early stages and was dropped due to its non host specificity and conflict of interests between Australia and PNG. If introduced in PNG, the predator may attack the beneficial undescribed Heteropsylla if the latter is also to be introduced to aid in the control of M. invisa. The beneficial Heteropsylla from Brazil is to be introduced into Australia for further study in quarantine as possible biocontrol agent for M. invisa. It has been reported that this species is host specific and should it prove to have desirable characteristics, it may be introduced into countries where M. invisa is a problem.

Another conflict of interest arises, as in PNG, where Leucaena is an important shade tree for cash crops (cocoa, robusta coffee and cardamom) and some useful Homoptera are associated with it (J.E. Moxon pers. comm. 1986). The mealybug (Planococcus pacificus) is associated with Leucaena and the honeydew produced by this bug helps to encourage and maintain high populations of crazy ant (Anoplolepsis longipes) which is a predatory ant of Pantorhytes weevils of cocoa; a serious and major pest of cocoa. Loss of shade trees would lead to reduction in cash crop production (J.E. Moxon pers. comm. 1986).

However, it was pointed out that C. coeruleus might also prey on P. pacificus since the predator was initially introduced in Hawaii for mealybug control (Waterhouse and Norris 1987). P. nr rotundiformis, the encyrtid wasp was being considered for introduction in PNG in 1986 (J.E. Moxon pers. comm. 1986) but the state of this proposal is not clear.

13.3 Plant Resistance

Several species of Leucaena and their cultivars have been reported to be resistant to H. cubana infestation. L. leucocephala is most susceptible of the eight species of Leucaena while L. pulverulenta and L shannonii were most resistant in Florida (Othman and Prine, 1984, Waterhouse and Norris, 1987). A line of L. diversifolia appeared resistant including a number of lines from susceptible cultivars such as Cunningham, El Salvador, Peru and K8 in Indonesia (Waterhouse and Norris, 1987). L. leucocephala, particularly the giant types from North West Mexico have lines K527, K584, K591, K636, K656 and K658 which have been reported to show high level of resistance in Hawaii (Anon, 1986).

13.4 Chemical Control

Chemical control is mainly in the form of systemic insecticides (diazinon, dimethoate and acephate) but these treatments have to be repeated at short intervals due to rapid reinfestation (Anon, 1986, Othman and Prine, 1984).

14. POSSIBLE AREAS OF RESEARCH

Leucaena obviously is an important crop. However, this importance varies from country to country depending on what their priorities are for the use of this crop. Some countries consider H. cubana as a major insect pest on Leucaena while other countries consider Leucaena itself as a major weed pest. The degree of priority for this crop will determine the chances of funding in these countries for further research. A few countries (e.g. Hawaii) are involved in some basic research with limited funding. However, funding is needed for both fundamental and applied research on the insect pest and host plant, possibly on regional level involving countries that see Leucaena psyllid as a major problem hindering agricultural production and improvement.

It is also obvious that the control methods identified so far are ineffective partly due to inadequate knowledge of the insect pest. Chemical control is ineffective and expensive. Predators and parasites are not host specific. This leaves host plant resistance as one option where several species and cultivars of Leucaena have been identified as resistant to H. cubana. Research should therefore be geared towards the following areas:

1. Development and identification of resistant or tolerant Leucaena species and cultivars; some have already been identified and mechanism of resistance understood.

2. Identification of chemical cues involved in mating and oviposition behaviour (e.g. pheromones).

3. Identification of chemical cues (if any) and plant

structures in host plants that determine oviposition and feeding.

4. Studies on stridulation aimed at developing a control method.

5. Behavioural study of the insect pest should be made. This would involve studies on emigration/immigration patterns, survival and collection of other essential data with the aim of building population models which may be used as an aid in deciding economic threshold levels and in managing pest populations.

6. Physiology of the insect need to be studied, especially looking at mechanisms involved in break down of toxic amino acid, mimosine and extraction of nitrogen. This may be useful in developing systemic insecticides analogous to mimosine which is safe to livestock but can not be broken down by insect body when taken in through their feeding activities.

7. Mechanism by which this insect pest is spread (air currents) needs to be studies. _H. cubana_ is thought to be spread by air currents.

8. Regional agreement by governments of all countries with psyllid pest problem is needed on best possible way(s) of minimising spread. This is because countries that consider _Leucaena_ as weed pest may use _H. cubana_ as biocontrol agent to control _Leucaena_ thus creating source for spread and reinfestation to countries that treat _Leucaena_ useful.

15. CONCLUDING REMARKS

Heteropsylla cubana obviously is an important invertebrate pest in countries that consider _Leucaena leucocephala_ as an important tree crop for agricultural production. However, Waterhouse and Norris (1987) report that 9 out of 17 Pacific countries consider _L. leucocephala_ a major weed pest and these countries are now reassessing its relative advantage and disadvantage. In PNG the crop is considered important for cash crop production. It is also an important crop for cattle forage (C. Maika pers. comm. 1989). _H. cubana_ is widespread in PNG and may now be considered one of the serious pests of _Leucaena_ in PNG.

Effective biological control agents, particularly the coccinellid beetles, could be introduced from Hawaii to other Pacific countries if _H. cubana_ is regarded as a priority problem and that _Leucaena_ is regarded as an important tree crop by these countries. However the undescribed _Heteropsylla_ species from Brazil is being considered to be used as a biocontrol agent against _Mimosa invisa_ in Australia. Should this species be found to have desirable characteristics it may be introduced to countries that regard M. invisa as major weed problem.

M. invisa has been rated one of top 10 weed pests and is widespread in PNG (Waterhouse and Norris, 1987). This situation creates conflict in deciding whether the priority problem is H. cubana or M. invisa particularly for PNG's case and other countries that have similar situations. It also creates conflict between countries that want to introduce biological control agents for H. cubana control and those who oppose it since these agents are general feeders and may feed on the beneficial Heteropsylla should it be introduced for control of M. invisa. The situation in PNG is even more complicated in that if Leucaena is defoliated by the psyllid the scale insects associated with Leucaena may not be present to support the crazy ant (A. longipes) populations thus Pantorhytes weevil populations will increase resulting in increased damage to cocoa trees. In addition the young cocoa seedlings will die or become badly stunted and yields may drop in mature stands. The ladybird predator (C. coeruleus) may be an effective predator for green scale Coccus celatus on coffee, or of other serious scale pests as well.

Biocontrol agents identified so far for control of H. cubana, particularly the predators are not host specific. Host specificity among parasites is also lacking. Wasp parasites are only specific to specific nymphal instars.

It is clear, therefore, that decisions to introduce natural enemies for control of this pest should be made very carefully after full consideration of advantages and disadvantages of such action and the long term benefit that the country or countries concerned would have.

Immediate control methods that should be investigated would be the use of resistant or tolerant cultivars of Leucaena. Other research proposals suggested above are long term and can be investigated depending on the importance and priority of the problem in countries concerned. In addition, regional agreement by governments of all countries on best possible way(s) of minimising spread and or reinfestation by this pest to countries that do not and or do have them should be made.

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