OBSERVATIONS ON THE PINK SUGARCANE MEALYBUG, *SACCHARICOCCUS SACCHARI* (COCKERELL), IN AUSTRALIA *(HOMOPTERA: PSEUDOCOCCIDAE)*

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ABSTRACT

Saccharicoccus sacchari (Cockerell) was the only species of mealybug found in a recent survey of commercial crops of sugarcane in Australia. Though, on occasions, this mealybug causes some losses of sugar, population levels are apparently kept at below the economic threshold and its life cycle is greatly influenced by agricultural practices. Those mealybugs which survive burning and chopper-harvesting of the cane move underground, often with the aid of ants. There they colonise the cane tissue (including roots) and emerge to re-establish aerial colonies once storage tissue is formed above ground level. Distribution of mealybugs is aided by the planting of insect-infested canes and by the current practice of retaining the leaf sheaths on cane plants, as well as by ants.

Natural controlling factors include the fungus *Aspergillus parasiticus* Spear, the encyrtid wasp *Anagyrus saccharicola* Timberlake and larvae of the drosophilid fly *Cacoxenus perspicax* Knab). There was no conclusive evidence of parasitism of *S. sacchari* by *A. parasiticus,* but the mealybug mortality observed may have been due to the high concentrations of aflatoxins (B_1 and G_1) associated with infected mealybugs. This is the first definitive record of established *A. saccharicola* in Australia.

Both apterous and alate males of *S. sacchari* are found and the apterous morph is more plentiful than the alate. The abundance of males suggests that the main mode of reproduction is sexual rather than parthenogenetic.

INTRODUCTION

Mealybugs have long been considered of no economic importance in the Australian sugar industry. However, the correct situation probably resembles that described by Beardsley[4] for Hawaii, *i.e.* these insects cause losses of sugar which, to date, have not been quantified. Certainly, significant levels of exudate are produced by mealybugs during certain times of the year in Australia, especially on cane varieties to which the trash adheres tightly. Recently, there has been an increase in the number

Keywords: ***Homoptera: Pseudococcidae*, mealybugs, *Saccharicoccus sacchari* (Cockerell), Sugarcane mealybugs, *Aspergillus parasiticus* Spear, Aflatoxins, *Anagyrus saccharicola* Timberlake**

of tightly trashing varieties introduced into the Australian sugar industry. Thus, in addition to the damage known to be caused to the plant (Ali and Rao[13]), it is possible that heavy infestations of mealybugs could lead to processing difficulties during sugar manufacture (Dick[8] and Dymond[9]).

Field studies of mealybugs have been described for Hawaii (Beardsley[3]) and other countries (Dick[8]). However, no comparable study has been reported for the Australian situation where agricultural practices differ significantly from those of most other countries (Foster[10] and Mason[11]). Thus, field surveys were carried out to determine the identity of the mealybugs and, as far as possible, the influence of Australian agricultural practices on their behaviour.

METHODS AND MATERIALS

Surveys were carried out from 1982 to 1985 in large commercial cane fields along the east coast of Queensland and northern New South Wales. Insects were collected on cane and carefully returned to the laboratory for preliminary identification. Laboratory cultures of mealybugs were maintained on cut lengths of cane bearing leaf sheaths, the cut ends being sealed with parafilm. The canes were contained in cotton wool-stoppered fleakers, to which silica gel was added, to assist in moisture control. Late instar male nymphs were placed individually in glass vials and observed daily. Predatory fly larvae were reared to adulthood on mealybugs *ex cult.* and immature hymenopterous parasites within dead, mummified hosts (mummies) were confined pending emergence of the adult parasites.

Accumulated exudate (honeydew) from mealybug colonies was collected from leaf sheath pockets of cane. Fresh honeydew was also collected *ex ano* of large adult female mealybugs with the aid of a micropipette. The monosaccharide composition of exudates was determined by high performance liquid chromatography using a Waters silica pak column and a mixed solvent of acetonitrile and water (85:15). Mealybugs heavily infected with the fungus *Aspergillus parasiticus* Spear were collected from the field, extracted with chloroform and examined for aflatoxins by means of thin-layer chromatography.

RESULTS AND DISCUSSION

Species and host plants

The only species of mealybug encountered in the field on sugarcane was the pink mealybug, *Saccharicoccus sacchari* (Cockerell) (Mungomery[12]) though the pseudococcids *Dysmicoccus boninsis* (Kuwana), *D. brevipes* (Cockerell) and *Ripersia* sp. have also been previously reported from sugarcane in Queensland (Box[5], Mungomery[12] and Williams[20]). *D. brevipes* was however found on sugarcane in a glasshouse in southern Queensland.

No host plants other than sugarcane have been found to be infested by *S. sacchari,* despite the close proximity of other known host plants such as sorghum, rice and Johnson grass (Clausen[6] and Williams[19]). Though nut grass *Cyperus rotundus)* was found to host *D. brevipes* underground in suburban garden plots, no species of mealybug was observed on this weed in cane fields.

Life cycle of *S. sacchari* in Australia

The mealybug cycles on sugarcane as these apply under Australian conditions are shown diagrammatically in Figure 1.

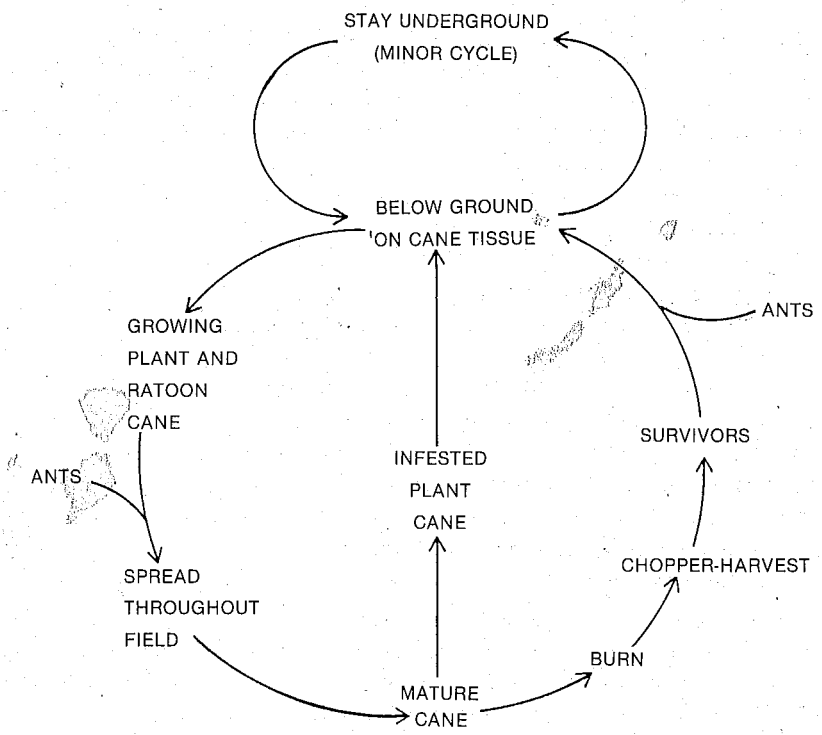


FIGURE 1. Mealybug cycles on sugar cane under Australian conditions.

(a) Survival of mealybugs after harvesting

The harvesting of sugarcane is preceded by burning. Studies revealed that the young nymphs (crawlers) within the leaf sheaths near the top of the cane stalk were the principal survivors, the number depending on the intensity of the burn. Even in an extremely good burn, not all of the cane around the edges of the field is severely burnt, which ensures that some mealybugs survive to reinfest the field. During harvesting with mechanical chopper-harvesters, the air draft from the blower disperses the extraneous matter and tops (and thereby the mealybugs) over a distance of up to 50 metres. Thereafter, this material is left to dry in the field for about five days, then raked into windrows and burnt. During this period the mealybugs move underground.

(b) Movement underground

Although the crawlers are highly mobile, field observations indicated that many were carried underground by ants. On numerous occasions, ants were observed carrying young mealybugs around in their mouth parts, especially those mealybugs encountered outside the leaf sheath. Furthermore, first and second nymphal instars

were found below ground, feeding on plant tissue after harvesting, whereas they were not detected below ground in the same fields of cane prior to harvesting.

Mealy bugs exhibited a strong preference for feeding on actively growing tissue both above and below ground. Underground colonies were normally found around the base of the new shoots developing from the original harvested stool, and sometimes on the original stools of ratoon cane, setts of plant cane and roots. In the latter case, *S. sacchari* has been observed in low numbers colonising cane roots up to 30 cm below ground and up to one metre from the cane stool. *S. sacchari* has previously been found subterraneously (Dick[8]), but has only once been reported to feed on the roots of sugarcane (Williams[19]).

(c) Reappearance above ground

The reappearance of mealybugs above ground coincided with the formation of aerial cane storage tissue and a decline in their numbers below ground. In addition, the rainfall pattern by its significant effect on the development of sugarcane influenced the time of emergence of *S. sacchari.* A similar observation has been made in Hawaii (Beardsley[3]). *S. sacchari* could, however, be found underground at any time of the year in some fields of sugarcane. Female instars of all forms were observed at these subterranean sites.

The movements of crawlers above ground were observed prior to formation of storage tissue; though, in general, colonies were not established at that stage. Crawlers moved upwards on cane either individually or in groups and generally under the protection of the leaf sheath. However, on occasions, crawlers have been observed moving in a group up the outside of the leaf sheath to the blade where they migrated down the inside of the leaf sheath to the nearest node. The subsequent degree of mealybug infestation was directly influenced by the tightness of the leaf sheath and by the ability of a cane variety to retain its leaf sheath.

(d) Dispersal of mealybugs

In view of the activity of ants and crawlers, the planting of infested cane opens the way to heavy infestation of plant cane by mealybugs. Thereafter, their survival may be greatly assisted by the current Australian practice of retaining the leaf sheaths on the cane plants. A similar effect has also been reported from South Africa (Dick[7]). Under these conditions, mealybugs exhibited considerable resistance to desiccation. For example, healthy colonies could still be found on cane with the leaf sheaths attached after four months of storage. In contrast, Uichanco[18] claims that the survival of S. sacchari on stored cane is limited to about 40 days.

Several species of ants were observed carrying mealybugs within cane fields and they probably protect the mealybug from natural enemies. This intimate relationship has been widely observed during these studies and in other countries (Barber[2], Beardsley[3], Dick[8] and Dymond[9]). The role of ants is especially important because of the number of times cane is ratooned in Australia. Though wind dispersal of crawlers has been reported (Beardsley[3]), this method of dispersal was not examined in this study.

(e) Factors influencing mealybug numbers

Factors probably influencing the numbers of mealybugs on cane under field

conditions in Australia include the presence of ants, the rainfall pattern, the tightness of the leaf sheath as discussed above and the incidence of predators and parasites.

Predators were numerous, and included larval *Cacoxenus perspicax* (Knab) [*Gitonides perspicax*] (Diptera: Drosophilidae), larval *Coccodiplosis* sp. (Diptera: Cecidomyiidae), the coccinellid beetle *Cryptolaemus montrouzieri* Mulsant (Coleoptera: Coccinellidae), and the anthocorid bug *Oplobates woodwardi* Gross (Hemiptera: Anthocoridae).

The parasitic wasp *Anagyrus saccharicola* Timberlake (Hymenoptera: Encyrtidae) has been reared in abundance from mummified *S. sacchari* collected in Cairns, Mourilyan and Mackay, which represent the first definitive records of established *A. saccharicola* in Australia. *A. saccharicola* was imported into Australia from Hawaii in 1952-53 and released in the Ormiston area of Queensland, east of Brisbane, but was believed not to have become established (Clausen[6] and Wilson[21]) (specimens introduced in 1935 were not liberated (Wilson[21]). Whether or not the presently recorded specimens are descendants of the Hawaiian introduction is not known. A limited survey of its present distribution is currently being conducted in Queensland.

The fungus *Aspergillus parasiticus* Spear (Fungi Imperfecti) was commonly associated with *S. sacchari* and its presence was usually associated with a significant reduction in mealybug numbers, especially in conjunction with wet weather. However, in contrast to the report by Spear[16], evidence strongly suggests that *A. parasiticus* is not parasitic on or in *S. sacchari,* but is saprophytic on its excreted honeydew. In chemical tests to investigate the possibility that *A. parasiticus* is toxic to *S. sacchari,* aflatoxins B_1 and G_1 were found at levels of about 300 and 100 μ g/g of mealybug, respectively, together with traces of aflatoxins B_2 and G_2.

The identification of *A. parasiticus* is as yet tentative and awaits confirmation of the Commonwealth Mycological Institute.

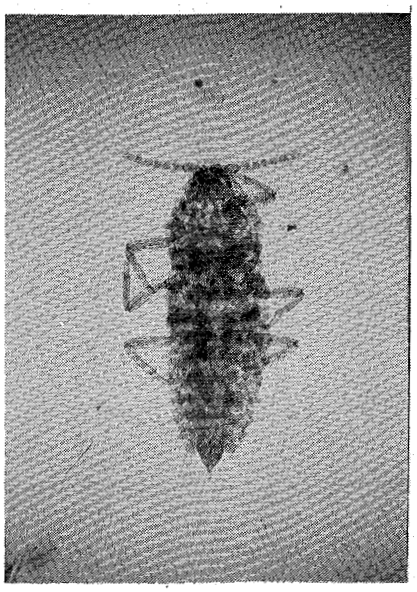
Production of mealybug exudate

During vigorous growth of cane storage tissue, some 1–2 mL of fluid (10–13° brix) were collected in leaf sheath pockets below heavy infestations of mealybugs. Considerably lesser amounts accumulated during other periods, particularly when *S. sacchari* was predominantly underground. The results suggest that though *S. sacchari* on occasions causes some loss of sugar, the numbers of this insect are not in plague proportions in Australia.

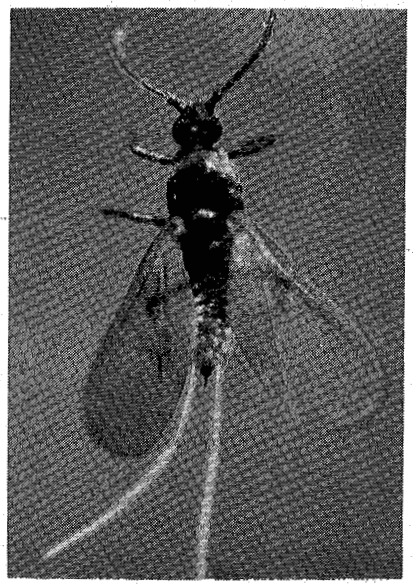
The carbohydrate components of fresh exudate were found to be fructose (60 per cent), glucose (20–30 per cent), sucrose (0–3 per cent) and other components (6–10 per cent). Except for the absence of glucose, a similar composition has been reported for *S. sacchari* honeydew by Salama and Rizk[15]). The difference in the results may lie in the possible preferential utilisation of glucose by microorganisms during the time between production of exudate by the insect and its subsequent collection from the cane surface.

Male *S. sacchari*

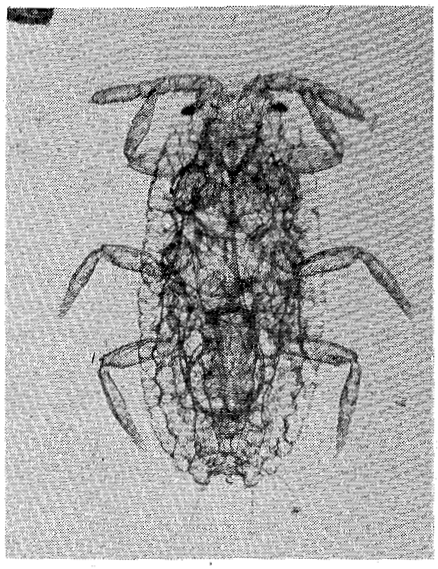
Males of *S. sacchari* were commonly found in the field. Two adult male morphs have been identified *viz.* apterous (wingless, Figure 2a) and alate (winged, Figure 2b). The apterous male was the most common. In the field, early instar male nymphs



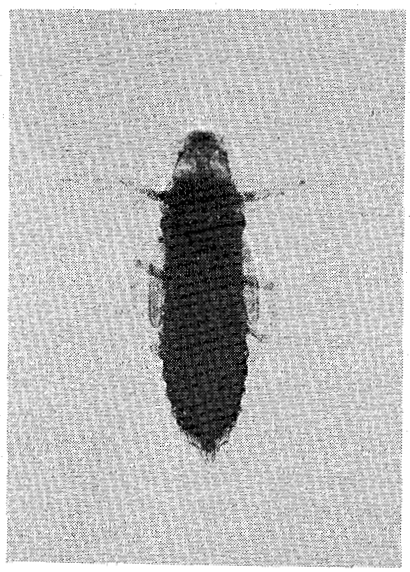
(a) Adult Apterous Male, mounted specimen (1.1 mm).



(b) Adult Alate Male, live specimen (1.0 mm).



(c) Female nymph, mounted specimen (0.7 mm).



(d) Alatoid Male Nymph, final instar showing wing buds, live specimen (1.1 mm).

FIGURE 2. *Saccharicoccus sacchari* (Cockerell)

could be distinguished from those of females (Figure 2c) by their greater mobility, slender body and darker colouration. Penultimate ('prepupal') and final ('pupal') nymphal instars (Figure 2d) of the alate male were arostrate, and therefore could not feed or be anchored by stylets in the host plant. Legs but not antennae were free. Both instars remained immobile unless disturbed, in a very loose, fine, waxy, filamentous cocoon. Nymphs destined to be apterous males underwent a similar resting phase, but whether this phase represented one or two instars was not determined. Some of the apterous males possessed obvious alatoid characteristics such as ventral eyes and an enlarged thorax. Females and males were usually co-existent in the colonies. The ratio of adult males to females exhibited wide variation in field-collected colonies, but nevertheless averaged about one male for every three females, which is similar to that found in Hawaii (Beardsley[4]).

Though the reproductive behaviour of *S. sacchari* was not investigated during the present study, the abundance of males in the field suggests that the principal, if not the only mode of reproduction of *S. sacchari* in Australia is sexual. A similar situation has been reported to apply in Hawaii (Beardsley[4]) but not in the Philippines (Uichanco[17]). In the latter case, alate males were rare and the apterous male was not observed, but may have been overlooked (Rao[14]) due to its small size (Beardsley[4]) (about 1 mm long) and similarity to early female nymphal instars. Thus, the claim that parthenogenesis is the main mode of reproduction in the Philippines may be inaccurate.

ACKNOWLEDGEMENTS

The authors are indebted to Drs R.J. Milner and D.H. Colless, CSIRO Division of Entomology, Canberra, Australia for identification of *A. parasiticus* and Diptera, respectively; Professor J.W. Beardsley, University of Hawaii, for confirmation of identification of *A. saccharicola;* Mr B. Blaney, Animal Research Institute, Brisbane, Australia for aflatoxin analyses and to Miss C.F. Brown for assistance in collection of male mealybugs.

REFERENCES

1. Ali, S.M. (1962). Coccids affecting sugar cane in Bihar. Indian J. Sug. Cane Res. Dev. 2:72–75.
2. Barber, E.R. (1923). The sugar cane mealybug and its control in Louisiana. Louisiana Planter and Sugar Manufacturer 20:308–309.
3. Beardsley, J.W. (1960). Observations on sugar cane mealybugs in Hawaii. Proc. Int. Soc. Sug. Cane Technol., 10th Congress, 954–961.
4. _____ (1962). Notes on the biology of the pink sugar cane mealybug, *Saccharicoccus sacchari* (Cockerell), in Hawaii (Homoptera: Pseudococcidae). Proc. Hawaii. Ent. Soc. 18:55–59.
5. Box, H.E. (1953). List of sugar cane insects. London, Commonw. Inst. Ent., 1–101.
6. Clausen, C.P. (Ed.) (1978). "Introduced parasites and predators of arthropod pests and weeds: A world review". U.S. Dept. Agric. Handbook 480:168–169.
7. Dick, J. (1957). Recent mealybug investigations. Rep. Exp. Stn S. Afr. Sug. Ass. 1956-57:30–32.
8. _____ (1969). The mealybugs of sugar cane. In "Pests of sugar cane", edited by Williams, J.R., Metcalfe, J.R., Mungomery, R.W. and Mathes, R., Elsevier

Publishing Company, Amsterdam, 343-365 and references therein.
9. Dymond, G.C. (1929). Mealybugs. Their effect on cane culture and manufacture in Natal. Proc. S. Afr. Sug. Technol. Ass. 3-51-53.
10. Foster, D.H., Inkerman, P.A. and McNeil, K.E. (1980). Studies on cane deterioration in Australia. Proc. Int. Soc. Sug. Cane Technol., 17th Congress, 2204-2220.
11. Mason, V., Allen, J.R., Foster, D.H. and Cullen, R.N. (1980). Review of cane harvester performance. Proc. Int. Soc. Sug. Cane Technol., 17th Congress, 782-798.
12. Mungomery, R.W. (1932). Ann. Rpt. Bur. Sug. Expt. Stn 32:55-57.
13. Rao, S.R.M. (1943a). Life history and bionomics of *Pseudococcus saccharicola* Takh. - a new pest of sugar cane in India. Proc. Indian Acad. Sci. (b) 16:79-85.
14. _____ (1943b). A note on the discovery of apterous males in the pink mealybug of sugar cane, *Trionymus sacchari* Ckll. Curr. Sci. 12:208.
15. Salama, H.S. and Rizk, A.M. (1969). Composition of the honeydew in the mealybug, *Saccharicoccus sacchari*. J. Insect. Physiol. 15:1873- 1875.
16. Spear, A.T. (1912). Fungi parasitic upon insects injurious to sugar cane. Expt. Sta., H.S.P.A. Pathological & Physiological Series Bull. 12:1-62.
17. Uichanco, L.B. and Villanueva, F.E. (1932). Biology of the pink mealybug of sugar cane, *Trionymus sacchari* (Cockerell), in the Philippines. The Philippine Agriculturist 21:205-276.
18. _____ (1935). Tolerance of mealybugs to drying of host tissue. The Philippine Agriculturist 23:886-890.
19. Williams, D.J. (1970). The mealybugs (Homoptera, Coccoidea, Pseudococcidae) of sugar cane, rice and sorghum. Bull. Ent. Res. 60:109- 188 and references therein.
20. Williams, D.J. (1985). In "Australian mealybugs". British Museum Natural History, London, 1-430 and references therein.
21. Wilson, F. (1960). In "A review of the biological control of insects and weeds in Australia and Australian New Guinea". Tech. Comm. No. 1. Commonwealth Inst. Biological Control, Ottawa, Canada. Commonwealth Agricultural Bureaux, Farnham Royal, Bucks, England, 27.