Appendix 4 - Pest data sheets

Baris sp. [Coleoptera: Curculionidae]

Synonym(s) and changes in combination(s): Not known.

Common name(s): Weevil.

Host(s): *Ananas comosus* (pineapple) (Martínez, 1976).

Species of *Baris* attack a wide variety of crop plants, including *Armoracia rusticana* (horseradish) (Anon., 1977a), *Brassica napus* (rape) (Anasiewicz and Szczygiel Bylicka, 1977), *Dianthus caryophyllus* (carnation) (Zemkova *et al*., 1975), *Medicago sativa* (lucerne) (Anon., 1980), *Morus* sp. (mulberry) (Kikuchi, 1976), and *Parthenium* sp. (McClay, 1980).

Plant part(s) affected: Pineapple fruit, causing gummosis (Martínez, 1976).

Larvae of other species feed on roots (Anon., 1977b, McClay, 1980; Zemkova *et al*., 1975).

Distribution: Venezuela (Martínez, 1976).

The genus occurs in China (Zhen *et al*., 1990), Egypt (Awadallah *et al*., 1980), France (Leterme, 1990), India (Thompson, 1973), Iraq (Al-Janabi *et al*., 1983), Japan (Kikuchi, 1976), Mexico (McClay, 1980), Morocco (Lahmer *et al*., 1992), Poland (Anasiewicz and Szczygiel Bylicka, 1977), Puerto Rico (Schotman, 1989), Ukraine (Zemkova *et al*., 1975), Europe (Anon., 1977a), Middle East (Thompson, 1973), and introduced into the United States (Anon., 1977a).

Biology: The biology of *Baris* sp. on pineapple has been inadequately reported.

In Venezuela, this species attacks pineapple fruit, causing gummosis (Martínez, 1976). Other species in the genus *Baris* are root-boring weevils that have potential for biological control of weeds (McClay, 1980), or pests whose adults form galls on the stems of *Brassica* spp. (Anon., 1977b). Larvae feed on roots (Anon., 1977b). Many weevils are parthenogenetic with males unknown or rarely produced (Zimmerman, 1994).

Most weevils are able flyers but many have reduced wings and are flightless (Zimmerman, 1994).

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Cholus spinipes (Fabricius, 1781) [Coleoptera: Curculionidae]

Synonym(s) and changes in combination(s): *Curculio spinipes* Fabricius, 1781; *Cholus wattsi* Marshall, 1922.

Common name(s): Pineapple weevil.

Host(s): *Ananas comosus* (pineapple) (Marshall, 1922; O'Brien, 1994).

Plant part(s) affected: Crown, developing fruit, fruit suckers, leaf, stalk (Marshall, 1922).

Distribution: Grenada (O'Brien, 1994; Marshall, 1922; Vaurie, 1976).

Biology: *C. spinipes* is known to be a pest of pineapples (O'Brien, 1994). Injury to the pineapple is caused by the feeding of the larvae and adults (Marshall, 1922). Larvae feed in the fruit stalk, in the centre of the developing fruit, and in the crown (Marshall, 1922). The feeding punctures of adults in developing fruit, fruit suckers, stalk, the crown, and leaves of the base of suckers (Marshall, 1922; O'Brien, 1994), and excavations made by the female for egg-laying cause considerable damage (Marshall, 1922). From field observations, it appears that eggs are laid in shallow, oval excavations in the flower stalk (Marshall, 1922). The larva travels up or down, feeding on the fruit stalk (Vaurie, 1976). Larvae were found burrowing upward in the stalks into the base of the fruit and downward into the crown (Marshall, 1922; O'Brien, 1994). The larva can penetrate into the fruit, and can eat out the base of the crown (Marshall, 1922).

Adults are 16.5–22 mm in length. Feeding punctures made by the adults in stalks and fruit are small and circular (Marshall, 1922). These feeding punctures often completely spoil the fruit. A badly attacked pineapple shows a gummy exudate, and will be deformed and undersized (Marshall, 1922). Attacked pineapples often lose their crowns, even if the fruit itself is uninjured (Marshall, 1922). Loss of the crown is common and the greatest damage is loss of fruit due to breakage of the fruiting stalk by the weight of the fruit (Marshall, 1922; O'Brien, 1994). Adult weevils in captivity fed on the fruit, stalk, crown, and the leaves of the base of suckers, as well as perforating the leaves of the crown and suckers (Marshall, 1922). Vegetative portions of the plants, roots, root-stock, stem and leaves, are not attacked (Marshall, 1922).

Control of this weevil appears to lie in good cultivation practices (i.e. well-kept fields, with plants in straight and regular rows, and clean weeded), and the absence of shade (Marshall, 1922). Damage appears to be worst in fields that are neglected and overgrown with weeds, or partly shaded (Marshall, 1922).

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Cholus vaurieae (O'Brien, 1994) [Coleoptera: Curculionidae]

Synonym(s) and changes in combination(s): None.

Common name(s): Pineapple weevil.

Host(s): *Ananas comosus* (pineapple) (O'Brien, 1994).

Plant part(s) affected: Crown, flower stalk, fruit, leaf (O'Brien, 1994).

Distribution: Venezuela (O'Brien, 1994; Salas and O'Brien, 1997).

Biology: Adults vary in size from 10.6–18.2 mm in length. This species is regarded as a serious pest of pineapples in plantations in northern Venezuela (O'Brien, 1994).

Most eggs are laid at the base of the flower stalk. The female excavates a small oviposition hole and lays one egg inside. More rarely, females lay eggs at the base of the crown and in the basal shoots (O'Brien, 1994). The larva feeds inside the flower stalk, moving up or down from the point of entry (O'Brien, 1994). Occasionally it bores through the central, woody part of the fruit (O'Brien, 1994). The damage caused by the larva is the destruction of the inner tissue of the flower stalk, which inhibits the normal growth of the fruit, and is characterised by lack of formation of the crown (O'Brien, 19944). Fruits attacked when fully developed and in the process of ripening may rot (O'Brien, 1994; Salas and O'Brien, 1997).

Adults normally feed on the leaves, making holes, which can be recognised by their necrotic edges (O'Brien, 1994). When they attack the basal part of the leaves, a gummy sap exudes from the resulting wounds (O'Brien, 1994). When high populations are present, small fruits may also be attacked (O'Brien, 1994).

This species is considered to be a serious pest of pineapples in plantations in northern Venezuela (O'Brien, 1994).

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Cholus zonatus (Swederus, 1787) [Coleoptera: Curculionidae]

Synonym(s) and changes in combination(s): *Curculio zonatus* Swederus, 1787; *Curculio tricinctus* Fabricius, 1792; *Polyderces zonatus* (Swederus).

Common name(s): Weevil.

Host(s): *Ananas comosus* (pineapple) (Schotman, 1989); *Cocos nucifera* (coconut) (Anon., 1972; Schotman, 1989).

Plant part(s) affected: Fruit, stalk (pineapple) (Schotman, 1989); leaf (coconut) (Parasram and Mederick, 1971).

Distribution: Dominica (Vaurie, 1976); Grenada (Vaurie, 1976); Guadeloupe (Vaurie, 1976); Martinique (Schotman, 1989); Trinidad (Anon., 1972); Saint Lucia (Parasram and Mederick, 1971; Schotman, 1989).

Biology: This species is closely related to *C. spinipes*. Adults are 11–16 mm in length with four conspicuous alternating yellow and mottled black coloured stripes on the thorax and elytra (Schotman, 1989). The larvae tunnel into the fruit and stalks of the pineapple (Schotman, 1989).

In coconuts in Saint Lucia, the larvae tunnel into the leaves (Parasram and Mederick, 1971). Damage caused to the leaves included drying up and breaking, and young palms were sometimes killed under heavy attack (Parasram and Mederick, 1971). Eggs were laid singly in cavities on the lower surface of the midrib of the leaves and on the axis of the inflorescence (Parasram and Mederick, 1971). No predator or parasites were found. From tests made in the field, the removal and destruction of infested leaves, especially those already dead is recommended (Parasram and Mederick, 1971).

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Cotinis mutabilis (Gory and Percheron, 1833) [Coleoptera: Scarabaeidae]

Synonym(s) and changes in combination(s): *Gymnetis mutabilis* Gory and Percheron, 1833; *Gymnetis atrata* Gory and Percheron, 1833; *Cotinis mutabilis* var. *atrata*; *Gymnetis nigrorubra* Gory and Percheron, 1833; *Cotinis mutabilis* var. *nigrorubra*; *Gymnetis mexicana* Gory and Percheron, 1833; *Cotinis mutabilis* var. *mexicana*; *Gymnetis palliata* Gory and Percheron, 1833; *Cotinis mutabilis* var. *palliata*; *Cotinis palliata*; *Gymnetis sobrina* Gory and Percheron, 1833; *Cotinis sobrina*; *Cotinis sobrina* var. *cabira* Burmeister, 1842; *Cotinis malinus* Janson, 1880; *Cotinis malina*; *Cotinis mutabilis* var. *cuprascens* Bates, 1889; *Cotinis mutabilis* var. *cuprascenti* Bates, 1889; *Cotinis mutabilis* var. *subcastanea* Bates, 1889; *Cotinis mutabilis* var. *intergenea* Bates, 1889; *Cotinis mutabilis* var. *aurantiaca* Bates, 1889; *Cotinis mutabilis* var. *robusta* Bates, 1889; *Cotinis sobrina* var. *schafraneki* Nonfried, 1894; *Cotinis mutabilis* var. *piciventris* Kraatz, 1898; *Cotinis mutabilis* var. *nigrovariegata* Kraatz, 1898; *Cotinis mutabilis* var. *cupraea* Kraatz, 1898; *Cotinis mutabilis* var. *atropurpurea* Kraatz, 1898; *Cotinis mutabilis* var. *atra* Kraatz, 1898; *Cotinis texana* Casey, 1915; *Cotinis arizonica* Casey, 1915; *Cotinis abdominalis* Casey, 1915; *Cotinis abdominalis* subsp. *discolor*; *Cotinis obliqua* subsp. *coahuilae* Casey, 1915; *Cotinis obliqua* subsp. *viridicauda* Casey, 1915; *Cotinis obliqua* subsp. *commiscens* Casey, 1915; *Cotinis mutabilis ovicornuta* Casey, 1915; *Cotinis capito* Casey, 1915; *Cotinus mutabilis* (*sic*).

Common name(s): Fig beetle; fig eater; green fig beetle; peach beetle.

Host(s): *Ananas comosus* (pineapple) (Camino-Lavín *et al*., 1996); *Baccharis sarothroides* (seep willow) (Thomas, 1981); *Ficus carica* (fig) (Stone, 1982); *Prunus persica* (peach) (Stone, 1982); *Vitis* sp. (grapevine) (Stone, 1982).

Plant part(s) affected: Adults feed on fruit and larvae damage roots (Camino-Lavín *et al*., 1996; Moron and Deloya, 1991).

Distribution: El Salvador (McGuire and Crandall, 1967); Mexico (Camino-Lavín *et al*., 1996; Deuve, 1992); northern South America (Goodrich, 1966); United States (Arizona, California, Mexico, New Mexico, Texas (Goodrich, 1966)).

Biology: The biology of this insect on pineapple has not been reported.

This beetle is very variable in colour, hence the large number of synonyms. These forms intergrade, and are considered by Goodrich (1966) to represent a single variable species.

In California, over 60 eggs are laid in the soil in August, and hatch after 12 days. Eggs are whitish and large (2.1 × 2.6 mm) and are easily detected in the soil (Stone, 1982). Newly emerged larvae are whitish with brownish head and legs. With abundant food they develop rapidly and reach a size of 12–50 mm before pupation (Stone, 1982). The first two instars are usually completed by autumn, and the third instar occurs in spring of the second year. Larvae are soil dwelling and feed on organic matter on the soil surface (Coviello and Bentley, 2000). Mature larvae may be 2 inches long and are cream coloured with tan head capsules and legs. Rows of short, stiff, brown hairs on the back of thorax are used for locomotion rather than the legs. Mature larvae form hollow cells in the soil and pupate there (Coviello and Bentley, 2000).

In California, the pupa is formed in June–July in an earthen case constructed by the mature larva. The case may vary in size depending on the size of the pupa and gender. The average pupa size is 15 × 25 mm. The duration of the pupal period ranges from 25–27 days. In California, pupation outdoors may occur from early May up until August.

Newly formed pupae are whitish and becoming cream coloured as they mature. Traces of green colour appear as the pupa matures.

Adults are velvet green on top with a brownish yellow band around the edge of the wings and a bright metallic green colour on its ventral side. Female adults are larger, averaging 17×25 mm, as compared with 13×22 mm for males. The head is equipped with a short horn-like process on the front which is used for puncturing the skin of hard-skinned fruits (Stone, 1982). Adults occur in California from June until November (Stone, 1982). Adults are strong fliers (Chappell, 1984). Egg laying females are especially attracted to compost and manure piles (Stone, 1982).

Adults damage figs by scraping a hole in the fruit and feeding on the flesh inside (Coviello and Bentley, 2000). Their excrement stains the skin of the fruit. Adults are attracted to traps containing chemicals from pineapple (Camino-Lavín *et al.*, 1996). Reported as a destructive pest of peaches, figs and grapes in southern California (Stone, 1982).

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Cryptophlebia leucotreta (Meyrick, 1913) [Lepidoptera: Tortricidae]

Synonym(s) and changes in combination(s): *Argyroploce leucotreta* Meyrick; *Cryptophlebia roerigii* Zacher; *Olethreutes leucotreta* Meyrick; *Thaumatotibia roerigii* Zacher.

Common name(s): Citrus codling moth; false codling moth; orange codling moth; orange moth.

Host(s): This species has been recorded feeding on over 50 species of plants (van der Geest *et al.*, 1991), including *Abelmoschus esculentus* (okra) (Pearson, 1958; Reed, 1974); *Ananas comosus* (pineapple) (Krüger, 1998; Pinhey, 1975); *Annona reticulata* (custard apple) (Pearson, 1958; Reed, 1974); *Camellia sinensis* (tea) (Krüger, 1998; Pinhey, 1975); *Capsicum annuum* var. *annuum* (sweet pepper) (Bourdouxhe, 1982); *Citrus aurantium* (laranja, sour orange) (Krüger, 1998; Pinhey, 1975); *Citrus* × *paradisi* (grapefruit) (Carter, 1984); *Citrus* spp. (Krüger, 1998; Pinhey, 1975; Schwartz and Milne, 1972); *Coffea arabica* (arabica coffee) (Krüger, 1998; Pinhey, 1975); *Diospyros virginiana* (persimmon) (Pearson, 1958; Reed, 1974); *Ficus* sp. (wild fig) (Pearson, 1958; Reed, 1974); *Garcinia mangostana* (mangosteen) (Pearson, 1958; Reed, 1974); *Gossypium* sp. (cotton) (Angelini and Couilloud, 1972; Pearson, 1958; Reed, 1974); *Harpephyllum caffrum* (Kaffir plum) (Willers, 1979); *Hibiscus* sp. (Pearson, 1958; Reed, 1974); *Litchi chinensis* (litchi, lychee) (Anon., 1974); *Mangifera indica* (mango) (Javaid, 1986); *Olea europaea* (olive) (Pearson, 1958; Reed, 1974); *Persea americana* (avocado) (du Toit *et al.*, 1979); *Pimenta dioica* (pimento) (Bourdouxhe, 1982); *Piper* sp. (pepper) (Krüger, 1998; Pinhey, 1975); *Prunus domestica* (plum, prune) (Blomefield, 1989; Krüger, 1998; Pinhey, 1975); *Prunus persica* (peach) (Blomefield, 1989; Daiber, 1976); *Prunus persica* var. *nucipersica* (nectarine) (Blomefield, 1989); *Psidium guajava* (guava) (Krüger, 1998; Pinhey, 1975); *Punica granatum* (pomegranate) (Krüger, 1998; Pinhey, 1975); *Quercus robur* (English oak) (Zhang, 1994); *Quercus* spp. (acorn, oak) (Anderson, 1986; Krüger, 1998; Pinhey, 1975); *Ricinus communis* (castor bean) (Krüger, 1998; Pinhey, 1975; Valle-y-March, 1972); *Sorghum bicolor* (sorghum) (Pearson, 1958; Reed, 1974); *Zea mays* (maize) (Reed, 1974; Whitney, 1970).

Plant part(s) affected: Larvae attack ears of maize (Whitney, 1970), cotton bolls (Nyiira, 1974), citrus fruit (Schwartz and Milne, 1972), avocado fruit (du Toit *et al.*, 1979), macadamia nuts (Wysoki *et al.*, 1986) mango fruit and leaves (Javaid, 1986), acorn nuts (Anderson, 1986), and pineapple fruit (Pinhey, 1975).

Distribution: Angola (CIE, 1976); Benin (CIE, 1976); Burkina Faso (CIE, 1976); Burundi (CIE, 1976); Cameroon (CIE, 1976); Chad (CIE, 1976); Congo Democratic Republic (CIE, 1976); Côte d'Ivoire (CIE, 1976); Ethiopia (CIE, 1976); Gambia (CIE, 1976); Ghana (CIE, 1976); Israel (Wysoki, 1986; Wysoki *et al.*, 1986); Kenya (CIE, 1976); Madagascar (CIE, 1976); Malawi (CIE, 1976); Mali (CIE, 1976); Mauritius (CIE, 1976); Mozambique (CIE, 1976); Niger (CIE, 1976); Nigeria (CIE, 1976); Rwanda (CIE, 1976); Réunion (CIE, 1976); Saint Helena (CIE, 1976); Senegal (CIE, 1976); Sierra Leone (CIE, 1976); Somalia (CIE, 1976); South Africa (CIE, 1976); Sudan (CIE, 1976); Tanzania (CIE, 1976); Togo (CIE, 1976); Uganda (CIE, 1976); Zaire (Zhang, 1994); Zambia (CIE, 1976); Zimbabwe (CIE, 1976).

Biology: The biology of this insect on pineapple has not been reported.

Eggs are translucent white, flattened, oval, ridged and flanged with a diameter of 0.9 mm (Pinhey, 1975; van der Geest *et al.*, 1991). Females deposit 100–400 eggs, usually laid singly, on fruits or cotton bolls of the respective crops (van der Geest *et al.*, 1991). In contrast, eggs may be laid in groups on the surface of citrus fruits (Pinhey, 1975). The

eggs hatch after about a week and the creamy-white larvae (with brown heads) often feed on the rest of the eggs (whether hatched or not) or even on other larvae (Pinhey, 1975). The larva then burrows into the citrus fruit and feeds on the inner rind and pulp but not on the juicy pulp (Pinhey, 1975). There is often a distinct sunken brown patch in the skin marking the entry point of the larva but this is not always obvious (Carter, 1984). Dark frass may also been seen at the point of entry (van der Geest *et al.*, 1991). Secondary fungal and bacterial rots may cause additional damage to infested fruits (van der Geest *et al.*, 1991). Fully mature larvae are pinkish or orange red in colour. The larval activity causes premature ripening of the citrus fruit and it may fall. Larvae leave the fruit to pupate in silken cocoons decorated with soil and leaf fragments, on the surface of the soil (Pinhey, 1975), or in cracks in the ground (Carter, 1984). The pupal stage varies with temperature, ranging from 8–12 days in Kenya (Hill, 1975). Adults are about 17 mm with dark greyish brown forewings, patterned with reddish brown and black; the hind wings are dark greyish brown. Adults are nocturnal. This species is uncommon in areas with a long dry season, possibly due to the fact this species has no diapause stage (van der Geest *et al.*, 1991). This species must breed continuously to survive, and in areas with long dry periods, irrigated crops such as citrus provide a breeding area (van der Geest *et al.*, 1991).

In laboratory studies conducted in South Africa by Daiber (1980), oviposition and adult life span were observed at constant temperatures of 10, 15, 20 and 25°C. Both sexes lived longest at 15°C, while most eggs were laid at 25°C. At 20 and 25°C oviposition increased rapidly soon after the first egg was laid, but at 15°C it increased slowly to reach a peak some time after the first egg was laid. Very few eggs were laid at 10°C. The development time for each stage varies considerably with temperature, and up to five generations can be completed in a year (Daiber, 1980). Under natural conditions, fewer generations might develop because of less optimal food (Daiber, 1980).

In a study conducted by Catling and Aschenborn (1974) on citrus orchards in South Africa, egg populations are low during winter, apparently owing to lethal midwinter temperatures. Only dead eggs were recorded during the coldest months of June–August. Larval counts revealed that means of 3.8 and 7.5% of the fruits were infested during the winter. The first eggs appeared on the new crop in early November and a peak in the egg population of 0.6 live eggs/fruit was reached in February. About one-third of the fruits were infested with live eggs at this time. Populations then declined steadily until no live eggs were recorded at the end of April. Low larval populations in the fruits indicated high mortality of first-instar larvae during the season. Small numbers of fruit that dropped in early December were infested with larvae. A *Trichogrammatoidea* egg parasite was active in most groves, and at times up to 92% of the eggs were parasitised in the summer (Catling and Aschenborn, 1974). A host-parasite lag of eight weeks developed, the first parasites being recorded in January. Activity increased rapidly thereafter, and from early February onwards parasites attacked about three-quarters of the host eggs. During this period, the moth population declined steadily (Catling and Aschenborn, 1974).

On cotton in the Ivory Coast, the eggs are laid either on the leaves or on the bolls, where they are protected by the bracts from the effects of insecticide sprays and weather (Angelini and Labonne, 1970). Eggs are laid on cotton bolls and the emergent larvae feed on large, but not mature, bolls (van der Geest *et al.*, 1991). Young larvae feed inside the wall of the cotton boll. As the larvae mature, they move on to the cavity of the boll to feed on the seeds and lint (van der Geest *et al.*, 1991). In more humid climates, secondary fungal and bacterial rots may cause additional damage to infested bolls (van der Geest *et al.*, 1991). Adult emergence peaks occurred in September and December. Adults live for about 8 days and each female produces 150–200 eggs (Angelini and Labonne, 1970). After 14–20 days the larvae pupate in soil, and the pupal stage lasts for about 10 days (Angelini and Labonne, 1970).

A study conducted by Reed (1974) on cotton in Uganda showed that only cotton, maize and sorghum were important food-plants, and that populations of larvae were bimodal, with peaks on cotton in January and maize in July.

On peach in South Africa, both egg numbers and the degree of infestation increased from low in spring when the first peach cultivars matured, to high in mid-summer when the last peaches were harvested (Daiber, 1975). Summer temperature stimulated the development and fertility of the moth, while winter temperatures delayed its development, reduced its fertility, and together with low humidity, increased egg mortality. Peaches were susceptible to attack from about six weeks before harvest (Daiber, 1975).

In the laboratory and field, Daiber (1975) observed *C. leucotreta* in peaches in South Africa. Both egg numbers and the degree of infestation increased from low in spring when the first peach cultivars matured to high in mid-summer when the last peaches were harvested. Summer temperature stimulated the development and fertility of the tortricid, while winter temperatures delayed its development, reduced its fertility, and together with low humidity, increased egg mortality. Peaches were susceptible to attack from about six weeks before harvest.

On litchi in South Africa, the rate of oviposition on fruit was low early in the season at 0.02 eggs/fruit, but increased rapidly to 0.21 eggs/fruit after ripening began (Newton and Crause, 1990). There were no differences in the numbers of eggs deposited at different deposited on leaf surfaces near to fruit panicles or on terminal branches without fruit panicles heights or aspects of the tree. Few eggs were deposited on leaf surfaces near to fruit panicles or on terminal branches without fruit panicles (Newton and Crause, 1990). (Newton and Crause, 1990).

This moth is a serious pest of citrus in Southern Africa and of cotton in many parts of Africa. It also affects maize in West Africa. In South Africa, citrus crop losses of 10–20% are common (van der Geest *et al.*, 1991). Reed (1974) described losses of between 42 and 90% in late crops of cotton in Uganda. It has also become a significant pest of macadamia in Israel (Wysoki, 1986). Blomefield (1989) reported losses of up to 28% in a late peach crop in South Africa.

Control of this pest is difficult due to the wide host range and potential for reinfestation (CABI, 2000). Parasitoids have been identified but are unlikely to be a cost effective control strategy. Insecticides and chitin inhibitors may be effective for some crops and pheromones have been identified for mating disruption of this species (CABI, 2000).

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Dysmicoccus grassii (Leonardi, 1913) [Hemiptera: Pseudococcidae]

Synonym(s) and changes in combination(s): *Pseudococcus grassii* Leonardi, 1913; *Dysmicoccus alazon* Williams, 1960.

Common name(s): Mealybug.

Host(s): *Acacia* sp. (wattle) (Ben-Dov *et al.*, 2001; Williams and Granara de Willink, 1992); *Ananas comosus* (pineapple) (Ben-Dov *et al.*, 2001; Williams and Granara de Willink, 1992); *Andira inermis* (angelin, cabbagebark) (Ben-Dov *et al.*, 2001; Williams and Granara de Willink, 1992); *Annona squamosa* (sugar apple) (Ben-Dov *et al.*, 2001; Williams and Granara de Willink, 1992); *Artocarpus* sp. (breadfruit) (Ben-Dov *et al.*, 2001; Williams and Granara de Willink, 1992); *Asparagus* sp. (Ben-Dov *et al.*, 2001; Williams and Granara de Willink, 1992); *Chromolaena odorata* (bitterbush) (Ben-Dov *et al.*, 2001; Williams and Granara de Willink, 1992); *Coccoloba uvifera* (sea-grape) (Ben-Dov *et al.*, 2001; Williams and Granara de Willink, 1992); *Codiaeum* sp. (croton) (Ben-Dov *et al.*, 2001; Williams and Granara de Willink, 1992); *Coffea arabica* (arabica coffee) (Ben-Dov *et al.*, 2001; Williams and Granara de Willink, 1992); *Crescentia cujete* (calabash) (Ben-Dov *et al.*, 2001; Williams and Granara de Willink, 1992); *Dasylirion longissimum* (Ben-Dov *et al.*, 2001; Williams and Granara de Willink, 1992); *Ficus benjamina* (Benjamin-tree, weeping fig) (Ben-Dov *et al.*, 2001); *Mangifera indica* (mango) (Ben-Dov *et al.*, 2001); *Musa* × *paradisiaca* (banana) (Ben-Dov *et al.*, 2001); *Musa acuminata* (dwarf banana) (Ben-Dov *et al.*, 2001); *Musa* sp. (banana, plantain) (Ben-Dov *et al.*, 2001); *Passiflora edulis* (purple granadilla) (Ben-Dov *et al.*, 2001; Williams and Granara de Willink, 1992); *Persea* sp. (Ben-Dov *et al.*, 2001; Williams and Granara de Willink, 1992); *Punica granatum* (pomegranate) (Ben-Dov *et al.*, 2001; Williams and Granara de Willink, 1992); *Sechium edule* (chayote) (Ben-Dov *et al.*, 2001; Williams and Granara de Willink, 1992); *Tectona grandis* (teak) (Ben-Dov *et al.*, 2001; Williams and Granara de Willink, 1992); *Terminalia catappa* (Indian-almond) (Ben-Dov *et al.*, 2001; Williams and Granara de Willink, 1992); *Theobroma cacao* (cocoa) (Ben-Dov *et al.*, 2001; Williams and Granara de Willink, 1992).

Plant part(s) affected: Fruit, leaf.

Distribution: Bahamas (Ben-Dov *et al.*, 2001; Williams and Granara de Willink, 1992); Belize (Ben-Dov *et al.*, 2001; Williams and Granara de Willink, 1992); Colombia (Ben-Dov *et al.*, 2001; Williams and Granara de Willink, 1992); Costa Rica (Ben-Dov *et al.*, 2001; Williams and Granara de Willink, 1992); Cuba (Ben-Dov *et al.*, 2001; Williams and Granara de Willink, 1992); Dominican Republic (Ben-Dov *et al.*, 2001; Williams and Granara de Willink, 1992); Ecuador (Ben-Dov *et al.*, 2001; Williams and Granara de Willink, 1992); Honduras (Ben-Dov *et al.*, 2001; Williams and Granara de Willink, 1992); Italy (Sicily (Ben-Dov *et al.*, 2001)); Mexico (Ben-Dov *et al.*, 2001; Williams and Granara de Willink, 1992); Nigeria (Ben-Dov *et al.*, 2001); Panama (Ben-Dov *et al.*, 2001; Williams and Granara de Willink, 1992); Peru (Ben-Dov *et al.*, 2001; Williams and Granara de Willink, 1992); Puerto Rico (Ben-Dov *et al.*, 2001; Williams and Granara de Willink, 1992); Spain (Canary Islands (Ben-Dov *et al.*, 2001)); Trinidad and Tobago (Trinidad (Ben-Dov *et al.*, 2001; Williams and Granara de Willink, 1992)).

Biology: There is no published information on the biology of *D. grassii*.

The following is a general description of the biology and life history of mealybugs. The life histories of all mealybugs are very similar and differ only slightly in appearance (Metcalf and Flint, 1962), but these can vary depending on the species (Baker, 2002).

Mealybugs are slow-moving, soft bodied, oval shaped insects. They are covered with a thin coating of white, cottony or mealy wax secretion, which extends into filaments around the edge of the body. These marginal filaments of wax may be wedge-shaped or spine-like, but others lack marginal filaments entirely. This makes them appear like small spots of cotton on the plant (Baker, 2002).

Mealybugs are divided into two groups: short-tailed mealybugs and long-tailed mealybugs. Short-tailed mealybugs reproduce by laying eggs and producing a compact, cottony, waxy sac called an ovisac to cover and protect the eggs (Mau and Kessing, 2000). All the filaments about the body are about equal in length with none exceeding one-fourth the length of the body. In comparison, long-tailed mealybugs give birth to their young as active crawlers (Mau and Kessing, 2000). They have four long filaments at the tip of their abdomen which may be as long as their body.

Adult females may lay up to 600 eggs, usually in a cottony-like ovisac beneath her body (Baker, 2002). Egg production may last for 1–2 weeks, as seen in *Pseudococcus jackbeardsleyi* (Mau and Kessing, 2000). Soon after egg production has ceased, the female mealybug dies (Metcalf and Flint, 1962). Egg sacs may be found at the base of branching stems or leaves but may be found elsewhere on the plant (Mau and Kessing, 2000). Eggs hatch in 6–14 days and the first instars (or crawlers) disperse to suitable feeding sites on new plant parts or hosts (Baker, 2002). The crawler stage is the primary dispersal stage in all mealybug species (Kessing and Mau, 1992). Crawlers can survive only about a day without feeding, and once they insert their stylets to feed they generally remain anchored permanently (Baker, 2002).

Mealybugs in general have four female and five male developmental stages or instars (including the adults). Both sexes have three larval stages. As immatures, male and female mealybugs look similar, but as adults they are quite different (Baker 2002). Females become adults after the last moult and males go into a pupal stage (Metcalf and Flint, 1962). Adult females are generally 3–4 mm in length (Smith *et al.*, 1997), and wingless throughout life (Metcalf and Flint, 1962). Male mealybugs go through five instars and feed only in the first two instars (Baker, 2002). When the male nymphs are fully grown, they enclose themselves in a white case in which they develop into an adult male (Metcalf and Flint, 1962). Only males pupate. Adult males are small, two-winged, fly-like insects (Baker, 2002; Metcalf and Flint, 1962). They do not feed (have no functional mouthparts) and exist solely to fertilise the females (Baker, 2002). They live only a day or two (Baker 2002), and die soon after they have mated (Mau and Kessing, 2000).

Mealybugs are generally one of the more active groups of scale insects as most of them retain well-developed legs and remain mobile throughout their life (Baker, 2002). However, they generally move little once a suitable feeding site is found (Baker, 2002). Mealybugs commonly crowd together in sheltered sites (Baker, 2002). They may also occur on developing fruit branches. Adults and larvae damage the host plant by feeding on plant sap using their sucking mouthparts, and injecting toxins or plant pathogens into the plant (Baker, 2002). In addition, they excrete a sugary liquid called honeydew onto nearby plant surfaces, coating them with a shiny, sticky film (Baker, 2002). Sooty mould often develops on these deposits. Fouling of plant leaves by honeydew and sooty mould blocks out air and light, impairing photosynthesis and ruining the plant's appearance (Baker, 2002). Feeding by mealybugs can cause premature leaf drop, dieback, and may even kill plants if left unchecked (Baker, 2002).

The main economic damage caused by mealybugs is from the downgrading of fruit quality due to sooty mould fungus growth on the honeydew (Smith *et al.*, 1997).

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Dysmicoccus neobrevipes Beardsley, 1959 [Hemiptera: Pseudococcidae]

Synonym(s) and changes in combination(s): *Dysmicoccus brevipes* (grey form) (Ito, 1938).

Common name(s): Annona mealybug; gray pineapple mealybug; pineapple grey mealybug.

Host(s): *Acacia farnesiana* (sweet wattle) (Beardsley, 1959; Ben-Dov, 1994); *Acacia koa* (Hawaiian mahogany) (Beardsley, 1959; Ben-Dov, 1994); *Agave sisalana* (sisal agave) (Beardsley, 1959; Ben-Dov, 1994); *Aglaonema treubii* (arum) (Ben-Dov, 1994); *Alpinia purpurata* (red ginger) (Beardsley, 1959; Ben-Dov, 1994); *Ananas comosus* (pineapple) (Ben-Dov, 1994; Williams and Watson, 1988); *Annona muricata* (prickly custard apple) (Williams and Watson, 1988); *Annona reticulata* (custard apple) (Beardsley, 1965; Ben-Dov, 1994); *Arachis hypogaea* (peanut) (Ben-Dov, 1994; Williams and Watson, 1988); *Artocarpus altilis* (breadfruit) (Ben-Dov, 1994; Williams and Watson, 1988); *Barringtonia asiatica* (fish-killer tree) (Beardsley, 1965; Ben-Dov, 1994); *Basella* sp. (Anon., 1979); *Brassavola cordata* (Ben-Dov, 1994); *Cajanus cajan* (pigeon pea) (Ben-Dov, 1994); *Citrus aurantiifolia* (lime) (Ben-Dov, 1994; Williams and Watson, 1988); *Citrus limon* (lemon) (Ben-Dov, 1994; Williams and Watson, 1988); *Citrus sinensis* (navel orange) (Ben-Dov, 1994); *Clerodendrum* sp. (fragrant clerodendron) (Ben-Dov, 1994; Williams and Watson, 1988); *Coccoloba* sp. (sea-grape) (Williams and Watson, 1988); *Coccoloba uvifera* (sea-grape) (Ben-Dov, 1994; Williams and Watson, 1988); *Cocos nucifera* (coconut) (Beardsley, 1965; Ben-Dov, 1994); *Codiaeum* sp. (croton) (Ben-Dov, 1994); *Coffea arabica* (arabica coffee) (Ben-Dov, 1994; Williams and Watson, 1988); *Coffea canephora* (robusta coffee) (Ben-Dov, 1994; Williams and Watson, 1988); *Cordia alliodora* (Spanish elm) (Ben-Dov, 1994); *Crescentia alata* (Beardsley, 1965; Ben-Dov, 1994); *Cucurbita maxima* (giant pumpkin) (Ben-Dov, 1994; Williams and Watson, 1988); *Ficus* sp. (fig) (Anon., 1979); *Garcinia mangostana* (mangosteen) (Beardsley, 1965; Ben-Dov, 1994); *Gossypium* sp. (cotton) (Ben-Dov, 1994); *Guettarda speciosa* (Ben-Dov, 1994; Williams and Watson, 1988); *Heliconia latispatha* (Ben-Dov, 1994); *Lycopersicon esculentum* (tomato) (Ben-Dov, 1994; Williams and Watson, 1988); *Machaerium robinifolium* (Ben-Dov, 1994); *Mangifera* sp. (Anon., 1979); *Manilkara zapota* (sapodilla) (Beardsley, 1965; Ben-Dov, 1994); *Messerschmidia argentea* (Beardsley, 1959; Ben-Dov, 1994); *Musa* × *paradisiaca* (banana) (Beardsley, 1965; Ben-Dov, 1994; Williams and Watson, 1988); *Musa* sp. (banana, plantain) (Williams and Watson, 1988); *Nothopanax* sp. (Beardsley, 1959; Ben-Dov, 1994); *Opuntia megacantha* (mission prickly-pear) (Beardsley, 1959; Ben-Dov, 1994); *Pandanus* sp. (screw palm, screwpine) (Beardsley, 1959; Ben-Dov, 1994); *Phaseolus* sp. (bean) (Ben-Dov, 1994; Williams and Watson, 1988); *Philodendron* sp. (Ben-Dov, 1994); *Pipturus argentea* (Beardsley, 1965; Ben-Dov, 1994); *Piscidia piscipula* (fish-poison-tree) (Beardsley, 1965; Ben-Dov, 1994); *Pluchea* sp. (Anon., 1979); *Plumeria* sp. (frangipani, temple tree) (Anon., 1979); *Polianthes tuberosa* (tuberose) (Beardsley, 1959; Ben-Dov, 1994); *Portulacaria* sp. (Anon., 1979); *Psidium* sp. (guava) (Anon., 1979); *Punica granatum* (pomegranate) (Ben-Dov, 1994); *Samanea saman* (French tamarind, monkeypod) (Beardsley, 1959; Ben-Dov, 1994); *Solanum melongena* (aubergine, eggplant) (Ben-Dov, 1994; Williams and Watson, 1988); *Tectona grandis* (teak) (Ben-Dov, 1994; Williams and Watson, 1988); *Theobroma cacao* (cocoa) (Beardsley, 1965; Ben-Dov, 1994; Williams and Watson, 1988); *Thespesia populnea* (Pacific rosewood, portia tree) (Beardsley, 1959; Ben-Dov, 1994; Williams and Watson, 1988); *Tournefortia argentea* (Ben-Dov, 1994; Williams and Watson, 1988); *Vigna unguiculata* subsp. *sesquipedalis* (asparagus bean, yard-long bean) (Ben-Dov, 1994; Williams and Watson, 1988); *Vitex* sp. (Anon., 1979); *Vitis* sp. (grape, grapevine) (Anon.,

1979); *Yucca guatemalensis* (spineless yucca) (Ben-Dov, 1994); *Zea mays* (corn, maize) (Ben-Dov, 1994; Williams and Watson, 1988).

Plant part(s) affected: Developing fruit (pineapple) (Beardsley, 1993); leaf (pineapple) (Ito, 1938); aerial roots, flower, fruit, leaf, stem (Kessing and Mau, 1992).

Distribution: American Samoa (Ben-Dov, 1994; Williams and Watson, 1988); Antigua and Barbuda (Ben-Dov, 1994); Bahamas (Ben-Dov, 1994); Brazil (Ben-Dov, 1994); China (Taiwan (Rohrbach *et al.*, 1988)); Colombia (Ben-Dov, 1994); Cook Islands (Ben-Dov, 1994; Williams and Watson, 1988); Costa Rica (Ben-Dov, 1994); Dominican Republic (Ben-Dov *et al.*, 2001); Ecuador (Ben-Dov, 1994); El Salvador (Ben-Dov, 1994); Fiji (Beardsley, 1965; Ben-Dov, 1994); Guam (Beardsley, 1965; Ben-Dov, 1994); Guatemala (Ben-Dov, 1994); Haiti (Ben-Dov, 1994); Honduras (Ben-Dov, 1994); Italy (Sicily (Ben-Dov, 1994)); Jamaica (Beardsley, 1965; Ben-Dov, 1994); Kiribati (Ben-Dov, 1994; Williams and Watson, 1988) (Gilbert Islands (Beardsley, 1965; Ben-Dov, 1994)); Marshall Islands (Ben-Dov, 1994); Malaysia (Kessing and Mau, 1992); Mexico (Beardsley, 1965); Micronesia, Federated States of (Kessing and Mau, 1992); Northern Mariana Islands (Rota Island) (Beardsley, 1965; Ben-Dov, 1994); Panama (Ben-Dov, 1994); Peru (Ben-Dov, 1994); Philippines (Beardsley, 1965; Ben-Dov, 1994); Puerto Rico (Vieques Island (Ben-Dov, 1994)); Suriname (Ben-Dov, 1994); Trinidad and Tobago (Ben-Dov, 1994); United States (Florida (Anon., 1979), Hawaiian Islands (Beardsley, 1965; Ben-Dov, 1994)); United States Virgin Islands (Ben-Dov, 1994); Vietnam (Ben-Dov, 1994); Western Samoa (Ben-Dov, 1994; Williams and Watson, 1988).

Biology: *D. neobrevipes* reproduces sexually, and mating must occur for young to be produced (Beardsley, 1965; Ito, 1938; Rohrbach *et al.*, 1988). No eggs are laid; the young emerge from the female as fully developed first instar larvae called crawlers. The crawler stage is the primary dispersal stage (Rohrbach *et al.*, 1988). Crawlers move about actively for a short period of time, no more than a day, and may be dispersed on to other plants up to several hundred yards by wind (Rohrbach *et al.*, 1988). Larvae only feed during the first instar and the early part of the second instar (Kessing and Mau, 1992).

Females undergo three larval stages (moults) before reaching maturity; each larval stage lasts for 11–23 days, 6–20 days and 7–28 days respectively (Kessing and Mau, 1992), or an average of 8–14 days (Ito, 1938). The total larval period varies from 26–52 days, averaging about 35 days (Kessing and Mau, 1992). When the adult female emerges, there is a period of about 25 days before it produces its first larvae (Kessing and Mau, 1992). During this period the female is mated by males. Further mating can take place at any time after the maturation of the female. The female then produces larvae for a period of about 30 days (Kessing and Mau, 1992). Females die about four days after they cease to produce young (Ito, 1938; Kessing and Mau, 1992). Each female can produce up to 350 larvae (Ito, 1938), but there are some that produce up to 1000 young (Kessing and Mau, 1992). Unmated females live for an average length of 148 days, while mated females an average of 95 days (Ito, 1938). Duration of female adult life varies from 48–72 days, averaging about 61 days (Kessing and Mau, 1992). In comparison, males are short lived and live for only 2–7 days (Kessing and Mau, 1992).

Male moult four times before reaching the winged, adult stage; each larval stage lasts for 11–19 days, 7–19 days, 2–7 days and 2–8 days respectively (Kessing and Mau, 1992), or an average of 3–13 days (Ito, 1938). The total larval period varies from 22–53 days (Kessing and Mau, 1992). Feeding is limited to the first and second stages, which together last for about 20 days. The second, third and fourth moults of the male take place inside a waxy cocoon, during a period of about 12 days. When the adult male emerges from this cocoon, it is a fragile insect about 1 mm long, with a pair of membranous wings. It has no mouthparts, and lives for only a few days (Ito, 1938). Winged adult

males live for an average length of 37 days (Ito, 1938). The lifespan from first instar to adult death varies from 59–117 days, averaging 90 days (Kessing and Mau, 1992).

Adults appear predominantly grey in colour as their common name implies. In actuality their bodies are brown to greyish-orange, but take on a greyish appearance in combination with the waxy exudation that covers them (Kessing and Mau, 1992). The body is broadly oval and measures about 1/17 inch long by 1/25 inch wide. The back is heavily coated with tiny tufts of white mealy wax. Short filaments of wax extend from around the margin of the entire body. Lateral wax filaments are usually less than one fourth as long as the breadth of the body and those towards the back of the insect are one-half as long as the body.

In pineapple fields in Hawaii, mealybug populations were mostly confined to the actively growing portions of the plant, such as young leaves and developing fruit (Beardsley *et al.*, 1982). They are normally found on the aerial parts of its hosts such as leaves, stems, aerial roots, and flower and fruit clusters (Kessing and Mau, 1992). However, mealybug populations declined rapidly as the fruits and foliage approached maturity (Beardsley *et al.*, 1982). Following the harvest of the first fruit crop new shoot growth could again support large mealybug populations, and both mealybug and ant populations increased (Beardsley *et al.*, 1982). Sustained heavy rain may also cause a decline in ant and mealybug populations, but pest populations can recover after the return of dry weather (Beardsley *et al.*, 1982).

In pineapple fields in Hawaii, *D. neobrevipes* is tended by *Pheidole megacephala* (big-headed ant). This ant greatly encourages the mealybug by interfering with their natural enemies, and maintaining the health of the mealybug colony by removing excess honeydew (Beardsley *et al.*, 1982). Ants move mealybugs from one plant to another, and control of mealybugs depends on control of the ants (Beardsley *et al.*, 1982; Carter, 1973; McEwen *et al.*, 1979). The ant that attends and encourages this mealybug, *Pheidole megacephala*, is common in eastern and northern Australia (Shattuck, 1998). However, in the absence of natural enemies and inclement weather, the ants do not move mealybugs from one plant to another and do not cause an increase in mealybug populations (Jahn and Beardsley, 1996). Attempts to use natural enemies to control mealybugs have been unsuccessful unless the ants were also controlled (Rohrbach *et al.*, 1988). Infestations of mealybugs and their attendant ants originate along field margins and gradually move inwards. Mealybug wilt spreads from single infested plants to adjacent plants. Cultivation destroys ant populations, and newly-prepared fields are re-invaded slowly from adjacent infested fields. Pesticide treatment around the margins of new plantings would prevent the establishment of new ant populations, and hence prevent the establishment of mealybug populations (Beardsley *et al.*, 1982).

D. neobrevipes is the principal vector of pineapple wilt disease (Beardsley, 1965; McEwen *et al.*, 1979; Rohrbach *et al.*, 1988), which appears to be caused by a virus (Carter, 1963). Pineapple wilt, or mealybug wilt, is the most serious type of damage and is the principal cause of crop failure in Hawaii (Kessing and Mau, 1992). It can cause complete loss of pineapple crops if not controlled (Beardsley, 1993). There are two types of wilt, “quick wilt” and “slow wilt”. Both types cause the collapse of roots by the invasion of saprophytic organisms or by drying up (Kessing and Mau, 1992). “Quick wilt” is produced by a short period of feeding by a large colony of mealybugs and is characterized by discolouration of leaves to yellows or reds and the loss of rigidity in leaves (Kessing and Mau, 1992). “Slow wilt” occurs after the development of a large colony of mealybugs and shows fewer colour changes (Kessing and Mau, 1992). Leaves will be covered with mealybug feeding sites, leaf tips are browned, outer leaves droop, and the leaf will be flaccid to the touch (Kessing and Mau, 1992). Pineapple wilt has also been called “edge wilt” because the margins of the field would be affected first and the

infection would move inward as the mealybug infestation dispersed. Fortunately, this disease has been controlled for the last three decades by routine ant control (Kessing and Mau, 1992). However, it may once again become prevalent if mealybugs are not continually suppressed by limiting ant populations (Kessing and Mau, 1992).

D. neobrevipes is also implicated as a vector of green spot disease on pineapple leaves (Beardsley, 1993; Carter, 1933; Kessing and Mau, 1992). Green spotting is characterised by the production of welt-like simulations of galls. The galls are produced by a secretion of this mealybug that reacts with the plant tissues (Kessing and Mau, 1992).

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Fusarium subglutinans (Wollenweb. and Reinking) P.E. Nelson, T.A. Tousson and Marasas [Mitosporic fungi]

Synonym(s) and changes in combination(s): Basionym: *F. moniliforme* J. Sheld. var. *subglutinans* (Wollenweb. and Reinking); *Fusarium sacchari* (Butler) Gams var. *subglutinans* (Wollenw. & Reinking) Nirenberg; *Fusarium moniliforme* Sheldon emend. Snyd. & Hans 'subglutinans' sensu Snyd., Hans. & Oswald.

The strain of the fungus in Brazil was also reclassified as *Fusarium guttiforme* Nirenberg & O'Donnell, 1998.

Teleomorph: *Gibberella subglutinans* (Edwards) Nelson, Toussoun & Marasas comb. nov.; *Gibberella fujikuroi* (Sawada) Wollenw. var. *subglutinans* Edwards.

Common name(s): Fruitlet core rot; pineapple fusariosis; pineapple gummosis.

Host(s): *Ananas comosus* (pineapple) (Kimati and Tokeshi, 1964); *Citrus decumana* (Matos, 1995); *Mangifera indica* (mango) (Viljoen *et al*., 1995); *Musa* spp. (banana, plantain) (Matos, 1995); *Narcissus* sp. (daffodil) (Matos, 1995); *Oryza sativa* (rice) (Matos, 1995); *Pinus elliottii* var. *elliottii* (slash pine) (Kuhlman *et al*., 1978); *Pinus taeda* (loblolly pine) Kuhlman *et al*., 1978); *Pinus patula* (jelecote pine, Mexican weeping pine) (Viljoen *et al*., 1995); *Saccharum officinarum* (sugarcane) (Aguilar, 1982; Matos, 1995); *Theobroma cacao* (cocoa) (Matos, 1995); *Triticum aestivum* subsp. *aestivum* (wheat) (Matos, 1995); *Sorghum bicolor* (sorghum) (Aguilar, 1982); *Zea mays* (corn, maize) (Aguilar, 1982; Viljoen *et al*., 1995).

Isolates of *F. subglutinans* (*Gibberella fujikuroi* var. *subglutinans*) from *Pinus* spp. represent a specific forma specialis within the species (Viljoen *et al*., 1995). Cross pathogenicity of isolates of *F. subglutinans* from pineapple on other reported hosts and vice-versa has not been extensively studied. *F. subglutinans* (*Gibberella fujikuroi* var. *subglutinans*) from maize, sorghum, sugarcane and millet were not pathogenic to pineapple but isolates on pineapple can infect maize and sugarcane (Aguilar, 1982).

Plant part(s) affected: All parts of the pineapple plant, causing the exudation of a gum-like substance from the infected tissues.

Distribution: Bolivia (Matos *et al*., 1992); Brazil (Kimati and Tokeshi, 1964; Laville, 1980; Matos 1995).

Another strain of the fungus attacking pineapple fruits causing fruitlet core rot or fruit collapse has been reported in Argentina (Carrera, 1954); Chile (Montealegre and Luchsinger, 1990); Cuba (Perez *et al*., 1994); United States (Hawaii) (Rohrbach and Pfeiffer, 1976); Honduras (Wollenweber and Reinking, 1925); Kenya (Kidd and Tomkins, 1928); Queensland, Australia (Pegg, 1993; Simmonds, 1966); South Africa (Edmonstone-Sammons, 1957); Philippines (BPI, 2000); Malaysia (Lim, 1985); Thailand (Giatgong, 1980). Pineapple fusariosis is listed as a scheduled pest in Queensland (Plant Protection Act 1989 – Plant Protection (Prescription of Pests) Regulation 1993).

Biology: On fruit *F. subglutinans* incites a soft rot of the flesh, gum accumulation in the locules of the ovary and gum exudation from the infected fruitlet (Kimati and Tokeshi, 1964). In a later stage of disease development the peel of the infected fruitlet changes to a reddish to brown colour. Due to exhaustion of the tissues, as a consequence of the gum exudation, the infected fruitlets appear at a lower level than the surrounding healthy ones (Matos, 1995).

A pineapple plant propagated from an infected asexual propagative part can show, besides the characteristic gum exudation, one or more of the following symptoms: bending of the stem (usually to the side where the lesion is located); changing of the plant phyllotaxis (increasing the number of leaves per spiral); changing of the plant architecture (appearance of a funnel; shortening of the leaves; reduction of overall development; shortening of the stem; death of the apical meristem; and chlorosis (Pissarra *et al.*, 1979). Due to the disease development in the stem and base of the leaves, the water flow is reduced, the plant stops growing and the leaves show a reddish colour. In a later stage of infection the plant wilts and dies (Matos, 1995).

F. subglutinans does not survive for long periods of time in the soil (Maffia, 1980) because it has no resistant structures (Matos and Cunha, 1980). Thus, contaminated soils does not play an important role in the dissemination of Fusariosis. Another characteristic of the pathogen is that its survival ability on infected pineapple leaves, buried under field conditions, decreases gradually (Maffia, 1980), reaching the lowest level eight months later. Since the flowering induction treatment is usually carried out nine months or more after planting, crop debris does not function as source of inoculum for developing inflorescence in the same planting area. Crop debris probably play no significant role in the dissemination of Fusariosis to developing plants since the pathogen depends on a wound on the plant surface for infection (Matos, 1978). Infected volunteers constitute a source of inoculum and are important for the dissemination of this disease (Matos, 1995).

F. subglutinans survives on pineapple asexual propagative parts (suckers, slips and crown) that are infected while still attached to the mother plant (Matos, 1986). Infected propagules brought into orchards constitute the initial inoculum for new planting areas.

Humans are the most efficient agent for the dissemination of Fusariosis by moving infected propagules from one producing area to another (Matos, 1995). Once introduced to a production area Fusariosis is disseminated by several abiotic and biotic agents like rain splashes and winds (Matos and Caldas, 1986; Matos *et al.*, 1981) and insects such as *Trigona spinipes* (Aguilar and Sanches, 1982), *Lagria villosa* (Ventura and Maffia, 1980), *Bitoma* sp. (Rossetto *et al.*, 1976), *Thecla basilides* (Chalfoun and Cunha, 1984), *Apis mellifera*, *Lybindus dichrous*, *Bombus* sp., *Polistes* sp. and *Solenopsis* sp. (Costa and Lordello, 1988). *F. subglutinans* has been found in associated with those vectors on pineapple inflorescences.

Open flowers constitute the main infection sites for this pathogen (Bolkan *et al.*, 1979) and inoculations carried out from the 4^{th} to the 10^{th} week after forcing result in the highest levels of infection (Matos, 1986; Matos and Souto, 1985). Insect injuries, natural growth cracks (eg due to lateral bud development and by root development) and wounds (e.g. due to severe weather) are also sites through which the pathogen can infect.

The incidence of fusariosis on pineapple varies according to the time of harvest, which indicates a strong seasonal effect on disease development (Matos *et al.*, 1981). Control of the disease can potentially be achieved by disease evasion program where by the flowering induction treatment is carried out at a time that allows inflorescences to develop under environmental conditions that are unfavourable for infection by the pathogen (Matos, 1987).

In small planting areas fungicide applications can be replaced by protecting the developing inflorescence from infection with a paper bag (Matos and Cabral, 1987a). This control measure also protects the developing fruit against attack by the pineapple fruit borer, *T. basilides*. Sprays of fungicides may also be replaced by the application of the 2-chloro-ethyl- phosphonic acid at weekly intervals during flowering. This treatment inhibits the anthesis, thus preventing infection of the developing fruit (Cunha and Matos, 1987).

Fusariosis is best controlled by the use of resistant cultivars. The potential for disease resistance as a control measure has been reported under field conditions (Giacomelli and Teófilo Sobrinho, 1983) and using artificial inoculation (Cabral *et al.*, 1985; Matos and Cabral, 1987b; Matos *et al.*, 1991; Souto and Matos, 1978). A range of pineapple varieties have been identified as resistant to *F. subglutinans*: Alto Turi, Huitota, Roxo de Tefé (Souto and Matos, 1978). Piña Negra, Rondon, Tapiricanga, Amapá, Amarelo-de-Uaupés, Cabezona, Turi Verde, Ver-o-peso (Giacomelli and Teófilo Sobrinho, 1983), Perolera (Cabral *et al.*, 1985; Giacomelli and Teófilo Sobrinho, 1983), Fernando Costa, Inerme CM, BGA 6073 (Cabral *et al.*, 1985), Blanca, Samba, Angelita 1 and Iris 1 (Matos *et al.*, 1991).

Fusariosis is the most serious disease of pineapples in Brazil where it was first reported in the State of São Paulo (Kimati and Tokeshi, 1964). In addition to causing losses as high as 80% of marketable pineapple fruits (Robbs *et al.*, 1965) this pathogen infects approximately 40% of the asexual propagative materials and kills about 20% of the pineapple plants prior to harvest (Aguilar, 1981). The Brazilian pineapple industry is based on the cultivars Pérola, Jupi and Smooth Cayenne, all of which are susceptible.

F. subglutinans has been identified as the causal agent of a pineapple disease on the cultivar Red Spanish in Bolivia (Matos *et al.*, 1992) and has also been observed in Chile (Montealegre and Luchsinger, 1990).

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Melanaspis bromeliae (Leonardi, 1899) [Hemiptera: Diaspididae]

Synonym(s) and changes in combination(s): *Aonidiella bromeliae* Leonardi; *Aspidiotis bromeliae*; *Pseudischnaspis bromeliae*; *Pseudischnaspis anassarum* Lindinger; *M. bromiliae* (misspelling).

Melanaspis smilacis (Comstock) is a different species that does not occur on pineapple (Beardsley, 1966; Deitz and Davidson, 1986; Nakahara, 1982). The record of *M. smilacis* on pineapple by BPI (2000) actually refers to *M. bromeliae*.

Common name(s): Brown pineapple scale.

Host(s): *Ananas comosus* (pineapple) (BPI, 2000; Ferris, 1941; Nafus *et al.*, 1999).

Plant part(s) affected: Fruit (BPI, 2000; Deitz and Davidson, 1986); leaf (BPI, 2000).

Distribution: Micronesia, Federated States of (Caroline Islands) (Nafus *et al.*, 1999); Northern Marianas Islands (Nafus *et al.*, 1999); Philippines (BPI, 2000); Portugal (Azores Islands) (Ferris, 1941); Seychelles (Ferris, 1941); United Kingdom (England) (on pineapple imported from Canary Islands) (Ferris, 1941).

Biology: The biology of *M. bromeliae* on pineapple has not been specifically studied.

Generalisations from other species of *Melanaspis* may be applied to this species. The eggs hatch into crawlers which hide in cracks and other sheltered places on the food plant (Deitz and Davidson, 1986). They feed and produce a cap, under which they develop into the second instar. Females remain attached to the food plant, while males develop wings and move around on the plant mating with females (Deitz and Davidson, 1986). Feeding by *M. bromeliae* produces yellow spots on leaves and fruit (BPI, 2000).

M. bromeliae has been transported on pineapple fruit from the New World to England and the Seychelles (Ferris, 1941).

Scale insects are notorious plant pests and populations of many species can build up to damaging levels under favourable conditions (Kosztarab, 1990)

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Melanoloma canopilosum Hendel, 1933 [Diptera: Richardiidae]

Synonym(s) and changes in combination(s): Not known.

Common name(s): Pineapple fruit fly.

Host(s): *Ananas comosus* (pineapple) (Bello Amez *et al.*, 1997; Julca Otiniano *et al.*, 1992).

Plant part(s) affected: Fruit (Bello Amez *et al.*, 1997; Julca Otiniano *et al.*, 1992).

Distribution: Paraguay (Steyskal, 1968); Peru (Bello Amez *et al.*, 1997; Julca Otiniano *et al.*, 1992).

Biology: The adult is a fly with a body 6 mm long and a wingspan of 12 mm. Flies oviposit on fruit. Larvae burrow into pineapple fruit causing cavities which grow and coalesce. This causes the condition known as "spot with galleries", accompanied by premature maturation and fermentation of the fruit. This sometimes results in externally visible discoloured spots on the skin of the fruit (Bello Amez *et al.*, 1997).

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Melanoloma viatrix Hendel, 1911 [Diptera: Richardiidae]

Synonym(s) and changes in combination(s): Not known.

Common name(s): Pineapple fruit fly.

Host(s): *Ananas comosus* (pineapple) (Arévalo Peñaranda and Osorio Ospina, 1995; de Martínez *et al.*, 2000).

Plant part(s) affected: Fruit (Arévalo Peñaranda and Osorio Ospina, 1995; Martínez *et al.*, 2000).

Distribution: Bolivia (Steyskal, 1968); Colombia (Arévalo Peñaranda and Osorio Ospina, 1995); Venezuela (Martínez *et al.*, 2000).

Biology: The adult is a fly with a body length of 5–6.5 mm and a wingspan of 1 cm. The body is black and covered with short hairs. The eggs are white in colour and about 1.2 mm long and they gather in small groups. The shell is reticulated and has several folds on its centre part which look like bands or rings.

The larvae are worm-shaped and yellowy-white in colour. The body is made up of 11 segments: 3 located in the thoracic region and 8 in the abdomen. They develop into a larva, which eventually matures/grows to a length of 9.5 mm. The larvae are found principally between the skin and fleshy part of the fruit, in some causes they have been found in areas near the heart of the fruit. When they are ready to pupate, they jump with an arching movement of the body, holding their exterme posterior by means of hooks in their mouth, and then jump to propel themselves.

The pupa is a cylindrical-shaped capsule or a reddish coffee colour, with 11 segments, It has a length of approximately 5 mm and a diameter of 1.8 mm. The rear spirals are quite noticeable and the cephalic area can be seen quite clearly. Pupation occurs on the ground under the leaves and under laboratory conditions the insect emerges from the fruit to pupate. The pupa stage lasts between 15–20 days under laboratory conditions.

The damage that this insect causes is due to the development of larvae inside the fruit, which causes the fruit to ripen in uneven manner and exhibit small burrows internally (Martínez *et al.*, 2000).

The damage this insect causes happens because of the development of the larvae inside the fruit, which presents as non-uniform ripening and small galleries in the internal part causing subsequest rotting. The larvae burrow into pineapple fruit, making burrows, and causing the fruit to mature unevenly (Martínez *et al.*, 2000).

This species is reported as causing severe yield reductions in pineapple crops in Colombia (Arévalo Penarañda and Osorio Ospina, 1995).

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Paracoccus marginatus Williams and Granara de Willink, 1992 [Hemiptera: Pseudococcidae]

Synonym(s) and changes in combination(s): None.

Common name(s): Papaya mealybug.

Host(s): This species is recognized as being highly polyphagous (Anon., 2000). Hosts include: *Acacia* sp. (wattle) (CAB International, 2001); *Acalypha* sp. (copperleaf) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Ambrosia cumanensis* (Ben-Dov *et al.*, 2001); *Ananas comosus* (pineapple) (CAB International, 2001); *Annona muricata* (soursop) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Annona* sp. (custard apple) (CAB International, 2001); *Annona squamosa* (sugar apple) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Bidens* sp. (burr-marigold) (CAB International, 2001); *Cajanus cajan* (pigeon pea) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Capsicum annuum* (bell pepper, capsicum) (CAB International, 2001); *Carica papaya* (papaya) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Cestrum nocturnum* (night-scented cestrum) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Citrus sinensis* (navel orange) (CAB International, 2001); *Dahlia pinnata* (CAB International, 2001); *Erythrina* spp. (coral tree) (CAB International, 2001); *Eugenia uniflora* (Surinam cherry) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Gossypium hirsutum* (cotton) (CAB International, 2001); *Guazuma ulmifolia* (bastard-cedar) (CAB International, 2001); *Hibiscus rosa-sinensis* (China-rose) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Hibiscus sabdariffa* (Jamaica sorrel, roselle) (CAB International, 2001); *Hibiscus* sp. (rosemallow) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Ipomoea* sp. (morning glory) (CAB International, 2001); *Jatropha integerrima* (Ben-Dov *et al.*, 2001); *Lablab purpureus* subsp. *purpureus* (hyacinth-bean) (CAB International, 2001); *Ligustrum* sp. (privet) (CAB International, 2001); *Lycopersicon esculentum* (tomato) (CAB International, 2001); *Malpighia glabra* (acerola) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Malvaviscus arboreus* (wax mallow) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Mangifera indica* (mango) (CAB International, 2001); *Manihot chlorosticta* (Ben-Dov *et al.*, 2001); *Manihot esculenta* (cassava) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Mimosa pigra* (giant sensitive-plant) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Mussaenda* sp. (Ben-Dov *et al.*, 2001; CAB International, 2001); *Pachystachys lutea* (lollipop-plant) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Parthenium hysterophorus* (parthenium weed) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Persea americana* (avocado) (CAB International, 2001); *Phaseolus* sp. (bean) (CAB International, 2001); *Plumeria alba* (wild frangipani) (Ben-Dov *et al.*, 2001); *Plumeria* sp. (frangipani) (CAB International, 2001); *Punica granatum* (pomegranate) (CAB International, 2001); *Rosa* sp. (rose) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Sida* sp. (Ben-Dov *et al.*, 2001; CAB International, 2001); *Solanum melongena* (aubergine) (CAB International, 2001); *Solanum nigrum* (black nightshade) (CAB International, 2001); *Solanum torvum* (turkeyberry) (CAB International, 2001); *Tetramnus labialis* (Ben-Dov *et al.*, 2001); *Theobroma cacao* (cocoa) (CAB International, 2001); *Vigna* sp. (cowpea) (CAB International, 2001).

Plant part(s) affected: Inflorescence, leaf, stem, fruit, whole plant (CAB International, 2001).

P. marginatus has only been recorded feeding on above-ground parts of its hosts, particularly on leaves and fruit (Miller *et al.*, 2001).

Distribution: Antigua and Barbuda (CABI/EPPO, 2000); Barbados (CABI/EPPO, 2000); Belize (Ben-Dov *et al.*, 2001; CABI/EPPO, 2000; Williams and Granara de Willink,

1992); British Virgin Islands (CABI/EPPO, 2000); Cayman Islands (CABI/EPPO, 2000); Costa Rica (Ben-Dov *et al.*, 2001; CABI/EPPO, 2000; Williams and Granara de Willink, 1992); Cuba (CABI/EPPO, 2000); Dominican Republic (CABI/EPPO, 2000); French Guiana (Ben-Dov *et al.*, 2001; Matile-Ferrero *et al.*, 2001); Guadeloupe (Ben-Dov *et al.*, 2001; CABI/EPPO, 2000; Matile-Ferrero and Étienne, 1998) (Saint Martin (Pollard, 1999), Saint Barthélemy (Ben-Dov *et al.*, 2001; CABI/EPPO, 2000)); Guatemala (Ben-Dov *et al.*, 2001; CABI/EPPO, 2000; Williams and Granara de Willink, 1992); Haiti (CABI/EPPO, 2000); Mexico (Ben-Dov *et al.*, 2001; CABI/EPPO, 2000; Williams and Granara de Willink, 1992); Montserrat (CABI/EPPO, 2000); Netherlands Antilles (CABI/EPPO, 2000) (Saint Martin (Pollard, 1999)); Puerto Rico (CABI/EPPO, 2000); Saint Kitts and Nevis (CABI/EPPO, 2000); United States (restricted distribution) (Florida (Pollard, 1999; CABI/EPPO, 2000)); United States Virgin Islands (CABI/EPPO, 2000).

Biology: There is no published information on the biology of *P. marginatus* on pineapple.

First instar larvae (crawlers) are 0.3 mm long and yellow in colour. Immature and newly matured females have yellowish bodies dusted with mealy white wax that is often thinner between the segments, giving the body a slightly barred appearance. Short, waxy filaments develop around the margin in the adult female, each less than a quarter as long as the body. Like other mealybugs, female *P. marginatus* can be expected to have three larval stages before moulting to the larviform adult stage. The male is likely to have two immature larval stages that feed, followed by non-feeding pre-pupal and pupal stages before it moults to a short-lived, winged adult.

This species is known to reproduce sexually (CAB International, 2001). Adult females are 2.5–4 mm in length with a yellowish body and body fluid. They are wingless, soft-bodied, elongate oval and slightly flattened in shape. Their bodies are covered with a white wax with lateral and caudal wax filaments. On maturation they begin to secrete sticky, elastic, white waxy filaments from the edges of their abdomen to form a protective ovisac for her yellow eggs. Each female lays a considerable number of eggs in the white, waxy ovisac (CAB International, 2001). The ovisac can be as much as twice as long as the body, or more (Miller *et al.*, 2001). Sometimes the yellowish body colour of the mature female is not immediately apparent if she has become buried under white, waxy secretions. Soon after egg production has stopped, the female mealybug dies (Metcalf and Flint, 1962). Adult males are short-lived, small insects with long segmented antennae; six legs each bearing a single claw; one pair of simple wings coated with white wax powder; a pair of long, white waxy filaments at the posterior of the abdomen; and no mouthparts. They do not feed and die soon after they have mated. Under greenhouse conditions, it takes about one month for the completion of one generation (egg to adult) (Metcalf and Flint, 1962).

As for most mealybugs, the first instar crawlers disperse short distances by walking (CAB International, 2001). Crawlers can survive a day or so without feeding while it locates a suitable feeding site (CAB International, 2001). Those on exposed parts of the plant may be carried to other hosts over somewhat greater distances by gusts of wind (CAB International, 2001). The larval stages and adult female (but not the male prepupa or pupa) are capable of crawling, but seldom do so unless conditions become unfavourable (CAB International, 2001). Passing animals, including man, may accidentally pick up crawlers as they brush past infested plants, and transfer them to new host plants by the same means (CAB International, 2001). Vehicles moving through a crop, or pruning and harvesting activities, can help carry crawlers from one plant to another (CAB International, 2001).

Adults and larvae damage the host plant by feeding on phloem sap and excreting honeydew onto nearby plant surfaces around and below the colony. Sooty mould often

develops on these deposits. Fouling of plant leaves by honeydew and sooty mould blocks out air and light, impairing photosynthesis and reducing plant productivity (CAB International, 2001). Fruit covered by honeydew or sooty moulds may be reduced in value or unmarketable. External damage to host plants include distortion and rosetting of leaves, abnormal leaf formation, and presence of honeydew or sooty mould; dieback, stunting and rosetting of stems; abnormal fruit shape, premature drop and reduced fruit size, and presence of honeydew or sooty mould (CAB International, 2001). Ants may be attracted to colonies in search of honeydew, and their presence can deter natural enemies from attacking the mealybugs (CAB International, 2001). Heavy infestations by *P. marginatus* cause deformation of new growth, leaf yellowing, leaf curl and early fall of fruit (Anon., 2000). Fruit may become completely covered by a layer of mealybugs and wax secretions (Miller *et al.*, 2001).

P. marginatus may show very similar symptoms to pink hibiscus mealybug (*Maconellicoccus hirsutus*) on *Hibiscus*, *Annona* species and other ornamental plants. *M. hirsutus* is the more serious pest of the two (Pollard, 1999). Although superficially similar in the field, they can be distinguished by the colour of the body contents when crushed on white paper: *P. marginatus* is yellow; *M. hirsutus* is pink. When preserved in 80% alcohol, *P. marginatus* turn black (Miller *et al.*, 2001) within 24–48 hours, whereas *M. hirsutus* specimens turn darker brown but do not go black. When adult females are mounted on microscope slides, the species can be easily distinguished: *P. marginatus* has eight-segmented antennae and dorsal oral rim ducts located only in marginal areas; *M. hirsutus* has nine-segmented antennae and rows of dorsal oral rim ducts across all the body segments.

The climatic preferences of *P. marginatus* have not been documented, but its occurrence in countries that mostly lie less than 30° from the equator suggests that it probably does not tolerate cold conditions (CAB International, 2001). As for most scale insects, heavy rain is likely to cause increased mortality of *P. marginatus*, especially of the mobile first-instar crawlers (CAB International, 2001). In tropical conditions the generations are not synchronized and there are several each year - possibly as many as 15 generations in favourable conditions, like the similar *M. hirsutus* (CAB International, 2001).

As an exotic introduction to the Caribbean islands, there are good prospects for control of *P. marginatus* by hymenopteran parasitoids originating from its area of origin in Central America (Pollard, 1999). In situations where the mealybugs are heavily attended by ants for their honeydew, control of ants by the use of sticky bands on the trunk or branches may help enhance the effectiveness of natural enemies (CAB International, 2001). Spacing or pruning of trees, to ensure their canopies do not touch, will reduce the spread of mealybugs between trees (CAB International, 2001).

There is little information available on natural enemies of *P. marginatus*. The use of hymenopteran parasitoids and hyperparasites are being investigated for use in biological control (Anon., 2000). The predatory ladybeetle used to control pest mealybugs, *Cryptolaemus montrouzieri*, was observed to be reluctant to feed on *P. marginatus* in the British Virgin Islands (CAB International, 2001). A predatory dipteran larva (*Diadiplosis* sp.) has been observed eating the eggs of *P. marginatus* in Antigua (CAB International, 2001). Matile-Ferrero *et al.* (2001) recorded two unidentified predators from French Guyana belonging to the Diptera: Cecidomyiidae, and the Coleoptera: Coccinellidae.

P. marginatus causes significant damage to cassava in Central America, and has the capacity to cause serious damage to papaya, other tropical fruit and ornamentals such as *Annona* and *Hibiscus* spp. (Anon., 2000; Miller *et al.*, 2001). Since its accidental introduction to Cuba in 1999, *P. marginatus* has been under close surveillance; so far no economic damage has been observed on major crops there (Anon., 2000).

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Phenacoccus hargreavesi (Laing, 1925) [Hemiptera: Pseudococcidae]

Synonym(s) and changes in combination(s): *Pseudococcus hargreavesi* Laing, 1925; *Pseudococcus bukobensis* Laing, 1929.

Common name(s): Mealybug.

Host(s): *Ananas comosus* (pineapple) (Ben-Dov *et al.*, 2001; Strickland, 1947); *Bauhinia* sp. (Ben-Dov *et al.*, 2001); *Coffea arabica* (arabica coffee) (Ben-Dov *et al.*, 2001); *Coffea canephora* (robusta coffee) (Ben-Dov *et al.*, 2001); *Ficus asperifolia* (Ben-Dov *et al.*, 2001; Strickland, 1947); *Saccharum officinarum* (sugarcane) (Ben-Dov *et al.*, 2001); *Sterculia tragacanthai* (Ben-Dov *et al.*, 2001; Strickland, 1947); *Theobroma cacao* (cocoa) (Ben-Dov *et al.*, 2001; Campbell, 1983); *Trema orientale* (Indian charcoal-tree) (Ben-Dov *et al.*, 2001; Strickland, 1947).

Plant part(s) affected: Fruit, leaf.

Distribution: Angola (Ben-Dov *et al.*, 2001); Cameroon (Ben-Dov *et al.*, 2001); Côte d'Ivoire (Ben-Dov *et al.*, 2001); Ghana (Ben-Dov *et al.*, 2001; Campbell, 1983; Strickland, 1947); Nigeria (Ben-Dov *et al.*, 2001); Sudan (Ben-Dov *et al.*, 2001); Tanzania (Ben-Dov *et al.*, 2001; Laing, 1929); Uganda (Ben-Dov *et al.*, 2001).

Biology: There is no published information on the biology of *P. hargreavesi* on pineapple.

The following is a general description of the biology and life history of mealybugs. The life histories of all mealybugs are very similar (Metcalf and Flint, 1962), but this can vary depending on the species (Baker, 2002).

Mealybugs are slow-moving, soft bodied, oval shaped insects. They are covered with a thin coating of white, cottony or mealy wax secretion, which extends into filaments around the edge of the body. These marginal filaments of wax may be wedge-shaped or spine-like, but others lack marginal filaments entirely. This makes them appear like small spots of cotton on the plant (Baker, 2002).

Mealybugs are divided into two groups: short-tailed mealybugs and long-tailed mealybugs. Short-tailed mealybugs reproduce by laying eggs and producing a compact, cottony, waxy sac called an ovisac to cover and protect the eggs (Mau and Kessing, 2000). All the filaments about the body are about equal in length with none exceeding one-fourth the length of the body. In comparison, long-tailed mealybugs give birth to their young as active crawlers (Mau and Kessing, 2000). They have four long filaments at the tip of their abdomen which may be as long as their body.

Mealybugs in general have four female and five male developmental stages or instars (including the adults). Adult females may lay up to 600 eggs, usually in a cottony-like ovisac beneath her body (Baker, 2002). Egg production may last for 1–2 weeks, as seen in *Pseudococcus jackbeardsleyi* (Mau and Kessing, 2000). Soon after egg production has ceased, the female mealybug dies (Metcalf and Flint, 1962). Egg sacs may be found at the base of branching stems or leaves but may be found elsewhere on the plant (Mau and Kessing, 2000). Eggs hatch in 6–14 days and the first instars (or crawlers) disperse to suitable feeding sites on new plant parts or hosts (Baker, 2002). The crawler stage is the primary dispersal stage in all mealybug species (Kessing and Mau, 1992). Crawlers can survive only about a day without feeding, and once they insert their stylets to feed they generally remain anchored permanently (Baker, 2002).

Both sexes have three larval stages (or instars). As immatures, male and female mealybugs look similar, but as adults they are quite different (Baker 2002). Females become adults after the last moult and males go into a pupal stage (Metcalf and Flint, 1962). Adult females are generally 3–4 mm in length (Smith *et al.*, 1997), and wingless throughout life (Metcalf and Flint, 1962). Male mealybugs go through five instars and feed only in the first two instars (Baker, 2002). When the male nymphs are fully grown, they enclose themselves in a white case in which they develop into an adult male (Metcalf and Flint, 1962). Only males pupate. Adult males are small, two-winged, fly-like insects (Baker, 2002; Metcalf and Flint, 1962). They do not feed (have no functional mouthparts) and exist solely to fertilise the females (Baker, 2002). They live only a day or two (Baker 2002), and die soon after they have mated (Mau and Kessing, 2000).

Mealybugs are generally one of the more active groups of scale insects as most of them retain well-developed legs and remain mobile throughout their life (Baker, 2002). However, they generally move little once a suitable feeding site is found (Baker, 2002). Mealybugs commonly crowd together in sheltered sites (Baker, 2002). In Ghana, *P. hargreavesi* is prevalent in cocoa tree canopies, where they infest branches and vegetative buds (Campbell, 1983). This species is more abundant on unshaded than shaded plots of cocoa trees (Campbell, 1984). Mealybugs may also occur on developing fruit branches. Adults and larvae damage the host plant by feeding on plant sap using their sucking mouthparts, and injecting toxins or plant pathogens into the plant (Baker, 2002). In addition, they excrete a sugary liquid called honeydew onto nearby plant surfaces, coating them with a shiny, sticky film (Baker, 2002). Sooty mould often develops on these deposits. Fouling of plant leaves by honeydew and sooty mould blocks out air and light, impairing photosynthesis and ruining the plant's appearance (Baker, 2002). Feeding by mealybugs can cause premature leaf drop, dieback, and may even kill plants if left unchecked (Baker, 2002).

The main economic damage caused by mealybugs is from the downgrading of fruit quality due to sooty mould fungus growth on the honeydew (Smith *et al.*, 1997). *P. hargreavesi* is a vector of cocoa swollen shoot virus disease (CSSV) in Ghana (Bigger, 1981).

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Planococcoides njalensis (Laing, 1929) [Hemiptera: Pseudococcidae]

Synonym(s) and changes in combination(s): *Pseudococcus njalensis* Laing, 1929; *Pseudococcus exitiabilis* Laing, 1944.

Common name(s): Cacao mealybug; west African cocoa mealybug.

Host(s): *P. njalensis* is polyphagous and has been recorded from woody hosts belonging to 34 plant families (Ben-Dov, 1994), including Rubiaceae, Fabaceae, Solanaceae, Sterculiaceae, and Euphorbiaceae.

Acacia pennata (Ben-Dov *et al.*, 2001; Strickland, 1947); *Albizia ferruginea* (Ben-Dov *et al.*, 2001; Strickland, 1947); *Alchornea cordifolia* (Ben-Dov *et al.*, 2001; Hall, 1945); *Anacardium occidentale* (cashew) (Ben-Dov *et al.*, 2001; Strickland, 1947); *Ananas comosus* (pineapple) (Ben-Dov *et al.*, 2001; CAB International, 2001; Hall, 1945); *Annickia chlorantha* (African whitewood) (Ben-Dov *et al.*, 2001; Strickland, 1947); *Annona muricata* (soursop) (Ben-Dov *et al.*, 2001); *Antidesma laciniatum* (Ben-Dov *et al.*, 2001; Strickland, 1947); *Aspilia latifolia* (Ben-Dov *et al.*, 2001; Strickland, 1947); *Baphia nitida* (camwood) (Ben-Dov *et al.*, 2001; Strickland, 1947); *Blighia sapida* (akee-apple) (Ben-Dov *et al.*, 2001; Strickland, 1947); *Bombax buonopozense* (Gold Coast bombax) (CAB International, 2001); *Brillantaisia nitens* (Ben-Dov *et al.*, 2001; Strickland, 1947); *Canthium glabriflorum* (Ben-Dov *et al.*, 2001; Hall, 1945); *Carissa edulis* (carandas-plum) (Ben-Dov *et al.*, 2001; Strickland, 1947); *Carpolobia lutea* (Ben-Dov *et al.*, 2001; Strickland, 1947); *Ceiba pentandra* (kapok) (Ben-Dov *et al.*, 2001; Hall, 1945); *Chidlowia sanguinea* (Ben-Dov *et al.*, 2001; Strickland, 1947); *Chytranthus* sp. (Ben-Dov *et al.*, 2001; Hall, 1945); *Clerodendrum* sp. (fragrant clerodendron) (Ben-Dov *et al.*, 2001; Hall, 1945); *Codiaeum* sp. (croton) (Ben-Dov *et al.*, 2001; Strickland, 1947); *Coffea arabica* (arabica coffee) (CAB International, 2001); *Coffea canephora* (robusta coffee) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Coffea liberica* (liberica coffee) (Ben-Dov *et al.*, 2001; Strickland, 1947); *Coffea liberica* var. *dewevrei* (excelsa coffee) (Ben-Dov *et al.*, 2001; Hall, 1945); *Coffea* sp. (coffee) (CAB International, 2001); *Cola acuminata* (abata cola) (Ben-Dov *et al.*, 2001; Strickland, 1947); *Cola chlamydantha* (Ben-Dov *et al.*, 2001; Strickland, 1947); *Cola cordifolia* (Ben-Dov *et al.*, 2001; Strickland, 1947); *Cola* sp. (CAB International, 2001); *Cola togoensis* (Ben-Dov *et al.*, 2001; Hall, 1945); *Combretodendron africanum* (Ben-Dov *et al.*, 2001; Strickland, 1947); *Conopharyngia* sp. (Ben-Dov *et al.*, 2001; Strickland, 1947); *Craterispermum ceranthum* (Ben-Dov *et al.*, 2001; Strickland, 1947); *Cussonia* sp. (cabbage tree) (Ben-Dov *et al.*, 2001; Strickland, 1947); *Cuviera acutiflora* (Ben-Dov *et al.*, 2001; Hall, 1945); *Delonix regia* (gold mohar) (Ben-Dov *et al.*, 2001; Hall, 1945); *Desplatsia chrysochlamys* (Ben-Dov *et al.*, 2001; Strickland, 1947); *Desplatsia dewevrei* (Ben-Dov *et al.*, 2001; Strickland, 1947); *Desplatsia lutea* (Ben-Dov *et al.*, 2001; Strickland, 1947); *Diospyros canaliculata* (Ben-Dov *et al.*, 2001); *Erythrina nitida* (Ben-Dov *et al.*, 2001; Strickland, 1947); *Fagara xanthoxyoides* (Ben-Dov *et al.*, 2001; Strickland, 1947); *Ficus sur* (Ben-Dov *et al.*, 2001); *Gliricidia sepium* (Nicaraguan cocoashade) (CAB International, 2001); *Hallea stipulosa* (abura) (Ben-Dov *et al.*, 2001; Strickland, 1947); *Harungana madagascariensis* (dragon's-blood-tree) (Ben-Dov *et al.*, 2001); *Homalium* sp. (Ben-Dov *et al.*, 2001; Hall, 1945); *Hymenostegia afzelii* (Ben-Dov *et al.*, 2001; Strickland, 1947); *Lecaniodiscus cupanioides* (Ben-Dov *et al.*, 2001; Hall, 1945); *Leptoderris* sp. (Ben-Dov *et al.*, 2001); *Lonchocarpus* sp. (Ben-Dov *et al.*, 2001; Strickland, 1947); *Lophira alata* (ironwood) (Ben-Dov *et al.*, 2001; Hall, 1945); *Macaranga barteri* (Ben-Dov *et al.*, 2001; Strickland, 1947); *Macaranga heudolotii* (Ben-Dov *et al.*, 2001; Strickland, 1947); *Mangifera indica* (mango) (CAB International, 2001); *Microdesmis puberula* (Ben-Dov *et al.*, 2001; Strickland, 1947); *Motandra guineensis* (Ben-Dov *et al.*, 2001; Strickland, 1947); *Musanga cecropioides* (corkwood)

(Ben-Dov *et al.*, 2001; Strickland, 1947); *Myrianthus arboreus* (Ben-Dov *et al.*, 2001; Hall, 1945); *Napoleona parviflora* (Ben-Dov *et al.*, 2001; Strickland, 1947); *Napoleona voegelii* (Ben-Dov *et al.*, 2001; Hall, 1945); *Newbouldia laevis* (Ben-Dov *et al.*, 2001; Strickland, 1947); *Octolobus spectabilis* (Ben-Dov *et al.*, 2001; Hall, 1945); *Parkia filicoidea* (Ben-Dov *et al.*, 2001; Strickland, 1947); *Paullinia pinnata* (barbasco, timbo) (Ben-Dov *et al.*, 2001; Strickland, 1947); *Pergularia extensa* (Ben-Dov *et al.*, 2001; Strickland, 1947); *Persea americana* (avocado) (CAB International, 2001); *Persea americana* var. *americana* (avocado) (Ben-Dov *et al.*, 2001; Strickland, 1947); *Phialodiscus unijugatus* (Ben-Dov *et al.*, 2001; Strickland, 1947); *Platystoma africana* (Ben-Dov *et al.*, 2001; Strickland, 1947); *Psychotria* sp. (Ben-Dov *et al.*, 2001; Strickland, 1947); *Ricinodendron africanum* (Ben-Dov *et al.*, 2001; Strickland, 1947); *Rothmannia whitfieldii* (Ben-Dov *et al.*, 2001; Strickland, 1947); *Sabicea ferruginea* (Ben-Dov *et al.*, 2001); *Senna siamea* (Siamese senna) (Ben-Dov *et al.*, 2001; Strickland, 1947); *Solanum torvum* (turkeyberry) (Ben-Dov *et al.*, 2001; Strickland, 1947); *Sterculia elegantifolia* (Ben-Dov *et al.*, 2001; Strickland, 1947); *Sterculia rhinopetala* (brown sterculia) (Ben-Dov *et al.*, 2001; Hall, 1945); *Sterculia setigera* (Ben-Dov *et al.*, 2001; Hall, 1945); *Sterculia tragacantha* (Ben-Dov *et al.*, 2001; Strickland, 1947); *Strombosia pustulata* (Ben-Dov *et al.*, 2001; Hall, 1945); *Synsepalum dulcificum* (miracle-fruit) (Ben-Dov *et al.*, 2001; Strickland, 1947); *Telfairea occidentalis* (Ben-Dov *et al.*, 2001; Strickland, 1947); *Tetrapleura tetraptera* (Ben-Dov *et al.*, 2001); *Theobroma cacao* (cocoa) (Ben-Dov *et al.*, 2001; Laing, 1944); *Trema guineensis* (Indian charcoal-tree) (Ben-Dov *et al.*, 2001; Strickland, 1947); *Uvariodendron* sp. (Ben-Dov *et al.*, 2001; Strickland, 1947); *Vernonia conferta* (Ben-Dov *et al.*, 2001; Strickland, 1947); *Vitex grandifolia* (Ben-Dov *et al.*, 2001; Strickland, 1947); *Voacanga africana* ((Ben-Dov *et al.*, 2001; Hall, 1945); *Xylopia parviflora* (Ben-Dov *et al.*, 2001).

Plant part(s) affected: Fruit, inflorescence, leaf, stem, whole plant (CAB International, 2001).

Distribution: Benin (CAB International, 2001); Cameroon (Ben-Dov *et al.*, 2001; CIE, 1974; Entwistle, 1972); Congo Democratic Republic (CAB International, 2001); Congo (Entwistle, 1972); Côte d'Ivoire (Ben-Dov *et al.*, 2001; Entwistle, 1972); Ghana (Ben-Dov *et al.*, 2001; Campbell, 1983; Entwistle, 1972; Laing, 1944); Guinea (Ben-Dov *et al.*, 2001; CIE, 1974); Liberia (Ben-Dov *et al.*, 2001; CIE, 1974; Entwistle, 1972); Nigeria (Ben-Dov *et al.*, 2001; CIE, 1974; Entwistle, 1972); São Tomé and Principe (Ben-Dov *et al.*, 2001; CIE, 1974); Senegal (Cox and Freeston, 1985); Sierra Leone (Ben-Dov *et al.*, 2001 CIE, 1974; Entwistle, 1972; Laing, 1929, 1944); Togo (Ben-Dov *et al.*, 2001; CIE, 1974); Zaire (Ben-Dov *et al.*, 2001; CIE, 1974);.

Biology: There is no published information on the biology of *P. njalensis* on pineapple.

There are conflicting opinions concerning whether reproduction in *P. njalensis* is purely sexual (Bigger, 1981; James, 1937; Magnin, 1953), parthenogenetic (Entwistle, 1958; Strickland, 1951a) or both (Padi, 1997a).

Strickland (1951a) obtained eggs from each of eight females reared from isolated first instar nymphs on potted cocoa seedlings in gauze cages. He concluded they reproduced parthenogenetically since they could not have had access to males. However, a single female which, in the absence of males, survived 65 days but died without reproducing. Magnin (1953) studied the development of this species on cocoa in the laboratory. He consistently showed fertilisation was necessary for reproduction. However, he was surprised to find that isolated females gave parthenogenetic birth to only female offspring. In Ghana, Padi (1997a) demonstrated that both parthenogenesis and sexual reproduction occurred on sprouting potato tubers under insectary conditions. Fecundity was generally higher in mated (54–129 offspring) than in unmated (14–90 offspring) females. Also, there were no significant differences in the sex ratios or in the rate of

survival to maturity of nymphs produced by sexual reproduction and parthenogenesis. The mean sex ratio (females:males) was 1.04:1.01. The average female longevity ranged from 46–51 days, with no significant differences between mated and unmated females (Padi, 1997a).

Magnin (1953) observed mating to occur during the first two days after the female had moulted to the adult stage, though reproduction did not take place for about two weeks. Egg laying lasted about 15–20 minutes and about 45 minutes elapsed between egg deposition and the nymph first walking. Larval production covered 5–6 days, with the adult female dying soon afterwards. In comparison, Strickland (1951a) found larval production to cover a period of up to 20 days and females lived for 10–14 days thereafter. Both authors agree that reproduction in *P. njalensis* is ovoviviparous i.e. females give birth to living young as active nymphs. The small eggs are hardly ever seen since the species is ovoviviparous (CAB International, 2001). Detailed information and descriptions of the nymphal stages is lacking. Female nymphs are similar to the adults, but are much smaller and initially wax free.

Newly hatched nymphs move a few millimetres away from the parent and settle down to feed (CAB International, 2001). Mealybugs in general have four female and five male developmental stages or instars (including the adults). Both sexes have three larval stages. The duration of each developmental stage varies greatly depending on the host plant. Strickland (1951a) observed the following developmental times on cocoa seedlings: first instar, 4–13 days; second instar, 3–10 days; third instar, 5–9 days; and adult to oviposition, 18–23 days. These were slightly lower than those determined by Magnin (1953) on cocoa beans which were as follows: first instar, 9–16 days; second instar, 11–19 days; third instar, 18–26 days; and adult to oviposition, 32–40 days.

Male nymphs cease to feed at the end of the second instar and spin a cocoon in which to moult successively to the prepupa and pupal stages (CAB International, 2001). The winged adult male emerges from the cocoon one or two days after attaining the imaginal state and lives only 5–6 days (CAB International, 2001). Adult males are minute, two-winged, fly-like insects. They possess two long caudal wax filaments, a pair of 10-segmented antennae, and have rudimentary mouthparts. They are unable to feed and exist solely to fertilise the females. Adult males are 604.17–975.08 µm in length (Neave, 1996), with a membranous abdomen that is semi-transparent and yellowish brown in colour.

Adult females are neotenic (i.e. retain characters of the immature stages), soft bodied and wingless (CAB International, 2001). The body is broad oval in shape and shows distinct segmentation. The dorsum is covered with a mealy wax secretion that is thinnest along the inter-segmental membranes and is absent in each segment along the mid-dorsal line, forming a prominent dorsal median streak. The body colour beneath the wax covering is generally pink but may vary from light chocolate brown dorsally, merging into flesh pink ventrally to a light yellow or even dark reddish brown (Entwistle, 1972). There are 18 pairs of marginal wax filaments of which the anal pair is the longest, the 16th and 17th pairs a little shorter but still longer than the rest.

The presence of groups of simple disc pores in the median region and near the margin of the dorsum distinguishes *P. njalensis* from other species within the genus (CAB International, 2001). See CAB International (2001) for more detail on the type and location of the simple disc pores.

The microscope slide-mounted female exhibits a wide range of variation in measured and meristic characters, both within and between populations from different localities and host plants (Hall, 1945; Ezzat and McConnell, 1956; De Lotto, 1964, Padi and Hollander, 1996). From extensive studies conducted on individuals from cocoa, *Gliricidia sepium*

and *Coffea canephora* populations, Padi and Hollander (1996) recorded mean body lengths of 1557.4 µm ± 286.4 to 2158.2 µm ± 270.4 for the cocoa populations, and 1537.4 µm ± 158.3 and 1786.1 µm ± 112.9 for the *Gliricidia* and coffee populations, respectively. The most variable measured characters recorded were the body length, length of clypeolabral shield, diameter and length of the anterior spiracular apodeme and the length of the hind tibia.

On cocoa trees in Ghana, the majority of *P. njalensis* can be found in the canopy 3–4 metres above ground level and in crevices (CAB International, 2001). They occur on leaves, shoots, bark and pods (Strickland, 1951a), and naturally occurring stem cavities in *C. glabriflorum* (Strickland, 1951a). Only 9.6% and 3.2% occurred on the bark and pods on the tree trunk and on side branches, respectively. New canopy shoots are preferred most (CAB International, 2001). They are also more abundant on unshaded than on shaded plots of cocoa (Bigger, 1981). The negative phototropic and positive tactile responses of *P. njalensis* and other mealybugs are presumably the reasons for their accumulation in such sites as terminal buds, below leaf petioles, at the base of pod stalks, and in aggregation in cankers which, in West Africa, mostly stem from mirid damage (CAB International, 2001). Its distribution in the field is patchy, rendering it difficult to locate. However, *P. njalensis* can be detected by the presence of white masses on plant surfaces (Entwistle, 1972), and signs of wilting of leaves, shoots, and pods (CAB International, 2001).

Another associated symptom of *P. njalensis* infestation is sooty mould growth, but this is not common, since the mealybug is regularly attended by several ant species that feed on the profuse honeydew it produces (CAB International, 2001). In Ghana, over 70 species of ants have been recorded having some degree of association with *P. njalensis* (Strickland, 1951b). Attendant ants are mainly of the genera *Crematogaster*, *Pheidole* and *Camponotus*, of which the former group is by far the most frequent. *Crematogaster* species usually construct a small shelter composed of cemented fragments of vegetable material often called carton tents. Workers of the soil-nesting genus *Pheidole*, and *Camponotus* species construct shelters made of soil particles. These tents occur on many parts of the tree but the largest number occur on the pod and pod stalks and may cover colonies as large as of 3000 individuals (CAB International, 2001).

Attendant ants remove the sticky honeydew, the accumulation of which would otherwise trap and drown the mealybugs, particularly the first instar nymphs (crawlers), and promote the development of moulds which are believed to be parasitic or injurious to the mealybugs by blocking spiracles and so preventing respiration (Entwistle, 1972). They also alleviate parasite pressure by disturbing them within the restricted space of the tents, and preventing them from ovipositing (CAB International, 2001). Moreover, the tents constructed by attendant ants protect the mealybugs against rain and insolation, factors to which *P. njalensis* is susceptible (CAB International, 2001). These tents probably do much to prevent even greater population decline than already occurs in the wet season in Ghana (Entwistle, 1972).

Information on the effects of ant presence on attack by predators are conflicting. Population densities of *P. njalensis* in the field has been found to be high when the more important tending species of ants are present and extremely low in their absence (Strickland, 1951b). In comparison, a laboratory experiment conducted by Strickland (1951a) showed that mealybug infestation on cocoa seedlings were higher (429 ± 127) in the absence of ants than in the presence of *Crematogaster africana* Mayr (151 ± 52), suggesting that the ants ate some of the mealybugs they attended. This is supported by Strickland (1951a), who directly observed predation of *P. njalensis* by several species of associated ants.

The majority of *P. njalensis* colonies are composed of adults and premature stages but may be exclusively of one or the other (CAB International, 2001). In the eastern region of Ghana, at any given time, about 41% of cocoa trees are infested with *P. njalensis* at a mean infestation rate of just over 65 per tree (CAB International, 2001). However, the distribution is skewed (Cornwell, 1955), with only a few trees having most of the mealybugs. The reasons for the skew distribution are not known but might be a combination of several factors. For example, any edaphic (soil) factors affecting the uptake of nitrogen, such as water logging or water shortage would, in either shaded or exposed conditions, result in nitrogen deficiency in plants and could reduce mealybug populations as demonstrated for *P. citri* (Fennah, 1959). Moreover, cocoa tree populations, especially under the uneven growth conditions experienced in farms as opposed to plantation cocoa, are unlikely to be of even nutritional status of the crop and could well cause unevenness in mealybug distribution (CAB International, 2001. The average number of *P. njalensis* per tree in both Ghana and Nigeria is 7–8 but can be as high as 3758 per tree (Strickland, 1951a).

In Ghana, the number of *P. njalensis* colonies declined during the first six months of the year and rose to a maximum during October–November. In contrast, the proportion of trees infested was highest during the first three months of the year, probably because wind dispersal is greatest during the dry season, which usually extends into that period (Cornwell, 1957; Strickland, 1950). Populations of Crematogasterine ants closely follow the seasonal changes in incidence of *P. njalensis* and fluctuations in numbers of the mealybug has been attributed to alterations in abundance of parasites and predators (Cornwell, 1957). Observations by Bigger (1973) differed slightly as he showed that population peaks occurred in February–March and October–November. One of the difficulties in the study of seasonal population fluctuations of *P. njalensis* and other mealybugs is their very low population densities and high degree of aggregation (skewed distribution) (Bigger, 1973).

In cocoa trees, dispersal of *P. njalensis* occurs mainly by first instar nymphs (or crawlers), moving across the interlocking tree canopy (CAB International, 2001). In Ghana, Cornwell (1958) reported that 92% of moving individuals are first instar nymphs which move intensively soon after hatching, before they start feeding; less than 2% are adults. Crawlers can walk at the speed of 4.5 cm a minute and cover at least 8 metres if that is necessary (Entwistle, 1972). Adults tend to be immobile to the extent that they even fail to leave wilting tissue to search for more suitable feeding sites (CAB International, 2001). Furthermore, movement occurs mainly by mid-afternoon, since the species becomes active at temperatures above 23.5°C. In Ghana, the greatest activity is likely to occur during the dry season from December–February, during which period temperatures frequently exceed 32°C (Cornwell, 1958).

Available evidence indicates that ants carry mealybugs over short distances only (6 feet or less) and are, therefore, not considered as important dispersal agents contrary to general belief (CAB International, 2001). Strickland (1950) demonstrated regular dispersal of *P. njalensis* (and other cocoa mealybugs) by wind currents. Movement was especially marked during the dry months. Mealybugs were caught in sticky traps at topographical altitudes of 230–700 m above sea level and the relative size of catches at different heights in closed canopy tends to support the idea that mealybugs fall from the cocoa and are then passively dispersed by air currents.

Although there is no evidence to show conclusively that mealybugs, when dispersing by trans-canopy migration or wind currents, are capable of transmitting cocoa viruses, field observations reveal similarities between the spread of virus outbreaks and the dispersal of vector species (Strickland, 1950).

The use of chemicals, biological control agents (natural enemies, predators), and pathogens have been used in the past to control *P. njalensis*. There has been limited success with the above-mentioned methods, but most have not been pursued further for various reasons. See CAB International (2001) for more detail on the effectiveness and/or success of each method.

Efforts at the biological control of *P. njalensis* and other cocoa mealybugs have recently been revived at the Cocoa Research Institute of Ghana. Preliminary laboratory investigations into the possible use of the exotic predator, *Cryptolaemus montrouzieri* Mulz. of Australian origin and the pathogenic fungus *Beauveria bassiana* are in progress (Padi *et al.*, 2000b).

P. njalensis is regarded as the commonest and most important vector of various strains of the swollen shoot virus disease (CSSV) (CAB International, 2001). CSSV is widespread in most of the cocoa areas in Côte d'Ivoire, Ghana and Nigeria and is known from Sierra Leone (CAB International, 2001). *P. njalensis* apparently transmits several isolates of the virus, including the virulent strain 1A (Strickland, 1947, 1951a, b; Sutherland, 1953). It is also a vector of the cocoa mottle leaf virus, which occurs in cocoa growing areas in Ghana (Legg and Bonney, 1968), and in scattered outbreaks in an area in Togo, near Alaparun in Nigeria.

Annual crop losses attributed jointly to CSSV and capsid damage in Ghana is estimated at 25–30% (CAB International, 2001). Infested trees are eventually killed, since there is no treatment for the disease apart from the destructive method of removing infected trees and their contacts. Due to CSSV, the eastern region of Ghana (which was once the most intensive cocoa-growing area of Ghana) has now been overtaken by the Western, Ashanti and Brong Ahafo Regions (CAB International, 2001).

P. njalensis may be indirectly associated with symptoms of CSSV such as leaf chlorosis, root necrosis, stem swelling, dieback and red vein banding; but this perhaps is rather far fetched since disease symptoms on trees appear long after the mealybugs have fed on them (CAB International, 2001).

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Pseudococcus jackbeardsleyi Gimpel and Miller, 1996 [Hemiptera: Pseudococcidae]

Synonym(s) and changes in combination(s): *Pseudococcus elisae* Borchsenius (misidentification).

Pseudococcus jackbeardsleyi was recently discovered to be a cryptic component within what was previously called *P. elisae.* True *P. elisae* occurs in Central America, northern South America, and is common on bananas (CAB International, 2001). *P. jackbeardsleyi* is much more widely distributed and has a larger host range than *P. elisae* (CAB International, 2001).

Common name(s): Jack Beardsley mealybug.

Host(s): *P. jackbeardsleyi* is reported on a diverse array of fruits, vegetables, and ornamentals from 88 genera in 38 plant families (CAB International, 2001). Hosts include: *Abelmoschus esculentus* (gumbo, okra) (Ben-Dov *et al.*, 2001); *Acacia* sp. (wattle) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Acalypha wilkesiana* (copperleaf) (Ben-Dov *et al.*, 2001); *Acanthocereus* sp. (Ben-Dov *et al.*, 2001); *Acosmium subelegans* (Williams and Granara de Willink, 1992); *Aeschynomene americana* (American joint-vetch) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Agave* sp. (Ben-Dov *et al.*, 2001; CAB International, 2001); *Aglaonema commutatum* (Ben-Dov *et al.*, 2001; CAB International, 2001); *Aglaonema roebelinii* (Williams and Granara de Willink, 1992); *Aglaonema simplex* (Ben-Dov *et al.*, 2001); *Aglaonema* sp. (Ben-Dov *et al.*, 2001; CAB International, 2001); *Aglaonema treubii* (Williams and Granara de Willink, 1992); *Alpinia purpurata* (gingerlily, red ginger) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Alpinia* sp. (ornamental ginger) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Ananas comosus* (pineapple) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Anisomeles* sp. (Williams and Granara de Willink, 1992); *Annona cherimola* (cherimoya) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Annona muricata* (soursop) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Annona* sp. (custard apple) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Annona squamosa* (sugar apple) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Anthurium* sp. (flamingo flower) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Apium graveolens* (celery) (Ben-Dov *et al.*, 2001); *Apium graveolens* (celery) (CAB International, 2001); *Aralia* sp. (Ben-Dov *et al.*, 2001; CAB International, 2001); *Begonia* sp. (Ben-Dov *et al.*, 2001; CAB International, 2001); *Bidens bipinnata* (Spanish-needles) (Ben-Dov *et al.*, 2001); *Blighia sapida* (akee-apple) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Brassica oleracea* var. *capitata* (cabbage) (Williams, 1988); *Cajanus cajan* (pigeon pea) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Capsicum annuum* (bell pepper, capsicum) (Williams, 1988); *Capsicum frutescens* (chilli pepper, red pepper) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Capsicum* sp. (chilli, pepper) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Carica papaya* (papaya) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Cassia* sp. (Williams, 1988); *Cattleya* sp. (Ben-Dov *et al.*, 2001; CAB International, 2001); *Cereus hildmannianus* (Peruvian-apple, spiny tree cactus) (Ben-Dov *et al.*, 2001); *Cereus* sp. (Ben-Dov *et al.*, 2001; CAB International, 2001); *Chamaesyce* sp. (Ben-Dov *et al.*, 2001); *Chrysophyllum cainito* (star-apple) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Citrus* × *paradisi* (grapefruit) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Citrus aurantiifolia* (lime) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Citrus* sp. (Ben-Dov *et al.*, 2001; CAB International, 2001); *Coccinia gris* (Ben-Dov *et al.*, 2001); *Cocos* sp. (coconut) (Ben-Dov *et al.*, 2001); *Codiaeum* sp. (croton) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Codiaeum variegatum* (croton) (CAB International, 2001); *Coffea arabica* (arabica coffee) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Coleus* sp. (Ben-Dov *et al.*, 2001; CAB

International, 2001); *Conocarpus erectus* (buttonwood) (CAB International, 2001); *Cordia curassavica* (Ben-Dov *et al.*, 2001; CAB International, 2001); *Coryphanta cubensis* (Ben-Dov *et al.*, 2001); *Cosmos bipinnatus* (garden cosmos) (CAB International, 2001); *Croton* sp. (Ben-Dov *et al.*, 2001); *Cucumis melo* (melon) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Cucurbita pepo* (ornamental gourd) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Cucurbita* sp. (marrow, pumpkin, squash) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Cycnoches* sp. (Ben-Dov *et al.*, 2001); *Cymbopogon citratus* (West Indian lemongrass) (Ben-Dov *et al.*, 2001); *Dendrobium* sp. (Ben-Dov *et al.*, 2001; CAB International, 2001); *Dendrobium tortile* (Ben-Dov *et al.*, 2001); *Dieffenbachia* sp. (dumb cane) (Ben-Dov *et al.*, 2001); *Diospyros hispida* (Williams and Granara de Willink, 1992); *Dracaena* sp. (Ben-Dov *et al.*, 2001; CAB International, 2001); *Eugenia* sp. (Ben-Dov *et al.*, 2001; CAB International, 2001); *Euphorbia* sp. (spurge) (CAB International, 2001); *Fernaldia* sp. (Ben-Dov *et al.*, 2001); *Ficus elastica* (Indian rubbertree) (Ben-Dov *et al.*, 2001); *Ficus* sp. (fig) (Ben-Dov *et al.*, 2001); *Ficus tricolor* (Ben-Dov *et al.*, 2001); *Gardenia jasminoides* (Cape-jessamine) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Gossypium barbadense* (Sea Island cotton) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Gossypium* sp. (cotton) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Haematoxylum campechianum* (logwood) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Heliconia* sp. (Ben-Dov *et al.*, 2001; CAB International, 2001); *Hevea brasiliensis* (rubbertree) (Williams, 1988); *Hibiscus cannabinus* (kenaf) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Hibiscus* sp. (rosemallow) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Hoya carnosa* (waxplant) (Ben-Dov *et al.*, 2001; ; CAB International, 2001); *Hura crepitans* (sandboxtree) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Ipomoea batatas* (sweet potato) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Ipomoea* sp. (morning glory) (Ben-Dov *et al.*, 2001); *Iris* sp. (flag, iris) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Ixora* sp. (jungle flame) (Williams, 1988); *Jatropha curcas* (physic nut) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Jatropha* sp. (Ben-Dov *et al.*, 2001; CAB International, 2001); *Lantana camara* (lantana) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Litchi chinensis* (lychee) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Lycopersicon esculentum* (tomato) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Lycopersicon* sp. (tomato) (Gimpel and Miller, 1996); *Macadamia* sp. (Ben-Dov *et al.*, 2001); *Macadamia* sp. (CAB International, 2001); *Mangifera indica* (mango) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Manihot aesculifolia* (Williams and Granara de Willink, 1992); *Manihot esculenta* (cassava) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Manihot pringlei* (Williams and Granara de Willink, 1992); *Melocactus* sp. (Ben-Dov *et al.*, 2001); *Melochia tomentosa* (Ben-Dov *et al.*, 2001); *Mentha* sp. (mint) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Moringa oleifera* (horseradish-tree) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Mormolyca balsamina* (Ben-Dov *et al.*, 2001); *Morus* sp. (mulberry) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Mucuna* sp. (velvetbean) (Ben-Dov *et al.*, 2001); *Musa* × *paradisiaca* (banana, plantain) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Musa* sp. (banana, plantain) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Nephelium lappaceum* (rambutan) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Nephelium* sp. (Ben-Dov *et al.*, 2001; CAB International, 2001); *Nerium oleer* (Ben-Dov *et al.*, 2001; CAB International, 2001); *Ocimum* sp. (basil) (Ben-Dov *et al.*, 2001); *Paphiopedilum* sp. (lady's slipper orchid) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Parthenium hysterophorus* (parthenium weed) (Williams and Granara de Willink, 1992); *Pelargonium* sp. (Ben-Dov *et al.*, 2001; CAB International, 2001); *Persea* sp. (Ben-Dov *et al.*, 2001; CAB International, 2001); *Phaeomeria* sp. (Ben-Dov *et al.*, 2001); *Phaseolus lunatus* (butter bean, Lima bean) (CAB International, 2001); *Phaseolus lunatus* var. *lunatus* (butter bean, Lima bean) (Ben-Dov *et al.*, 2001); *Physalis peruviana* (Cape-gooseberry) (Ben-Dov *et al.*, 2001); *Physalis pubescens* (downy ground-cherry) (Ben-Dov *et al.*, 2001); *Pilea microphylla* (artillery-plant, gunpowder-plant) (Williams and Granara de Willink, 1992); *Piper nigrum* (black pepper) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Pluchea odorata* (Williams, 1988);

Plumeria sp. (frangipani) (Ben-Dov *et al.*, 2001); *Psidium guajava* (guava) (Ben-Dov *et al.*, 2001); *Psidium* sp. (guava) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Pueraria phaseoloides* var. *javanica* (tropical kudzu) (Ben-Dov *et al.*, 2001); *Pueraria* sp. (CAB International, 2001);*Punica granatum* (pomegranate) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Rhipsalis mesembryanthemoides* (Ben-Dov *et al.*, 2001); *Rivina humilis* (rougeplant) (Lit and Calilung (1994); *Rumex* sp. (Ben-Dov *et al.*, 2001); *Salvia* sp. (sage) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Sechium edule* (chayote) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Solanum melongena* (aubergine, eggplant) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Solanum* sp. (nightshade) (Ben-Dov *et al.*, 2001); *Solanum tuberosum* (potato) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Spondias* sp. (hog-plum, mombin) (Ben-Dov *et al.*, 2001); *Spondias* sp. (mombin) (CAB International, 2001); *Tamarindus indica* (tamarind) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Tamarindus* sp. (Ben-Dov *et al.*, 2001; CAB International, 2001); *Theobroma cacao* (cocoa) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Vitis* sp. (grape) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Yucca* sp. (Ben-Dov *et al.*, 2001; CAB International, 2001); *Zea mays* (corn, maize) (Ben-Dov *et al.*, 2001; CAB International, 2001); *Zingiber* sp. (ginger) (Ben-Dov *et al.*, 2001; CAB International, 2001).

Plant part(s) affected: Fruit, leaf, stem (CAB International, 2001; Gimpel and Miller, 1996).

Distribution: Aruba (Gimpel and Miller, 1996); Bahamas (Gimpel and Miller, 1996); Barbados (Gimpel and Miller, 1996); Belize (Gimpel and Miller, 1996); Bolivia (Williams and Granara de Willink, 1992); Brazil (Gimpel and Miller, 1996); Brunei Darussalam (Williams, 1988); Canada (Gimpel and Miller, 1996); China (Taiwan (Gimpel and Miller, 1996)); Colombia (Gimpel and Miller, 1996); Costa Rica (Gimpel and Miller, 1996); Cuba (Gimpel and Miller, 1996); Dominican Republic (Gimpel and Miller, 1996); El Salvador (Gimpel and Miller, 1996); Grenada (Gimpel and Miller, 1996); Guadeloupe (Saint Martin (Gimpel and Miller, 1996)); Guatemala (Gimpel and Miller, 1996); Guyana (Williams and Granara de Willink, 1992); Haiti (Gimpel and Miller, 1996); Honduras (Gimpel and Miller, 1996); Indonesia (Williams, 1988); Jamaica (Beardsley, 1986); Kiribati (Williams and Watson, 1988); Malaysia (Williams, 1988); Maldives (CAB International, 2000); Martinique (Gimpel and Miller, 1996); Mexico (Gimpel and Miller, 1996); Micronesia, Federated States of (Caroline Islands (Gimpel and Miller, 1996)); Montserrat (CAB International, 2001); Nicaragua (Williams and Granara de Willink, 1992); Panama (Gimpel and Miller, 1996); Papua New Guinea (Williams, 1988); Peru (CAB International, 2001); Philippines (Williams, 1988); Puerto Rico (Gimpel and Miller, 1996); Singapore (Gimpel and Miller, 1996); Thailand (Williams, 1988); Trinidad and Tobago (Gimpel and Miller, 1996); Turks and Caicos Islands (Gimpel and Miller, 1996); Tuvalu (Williams, 1988); United States (Florida (Gimpel and Miller, 1996), Hawaii (Nakahara, 1981), Texas (Gimpel and Miller, 1996)); United States Virgin Islands (Gimpel and Miller, 1996); Venezuela (Gimpel and Miller, 1996).

Biology: There is no published information on the biology of *P. jackbeardsleyi* on pineapple.

The life histories of all mealybugs are very similar and differ only slightly in appearance (Metcalf and Flint, 1962), but these can vary depending on the species (Baker, 2002). Adult females lay 300–600 eggs within a compact, cottony, waxy sac called an ovisac attached beneath their abdomen (Mau and Kessing, 2000), or the host plant (CAB International, 2001). Egg production lasts for 1–2 weeks (Mau and Kessing, 2000). Soon after egg production has stopped, the female mealybug dies (Metcalf and Flint, 1962). Eggs usually hatch in a few hours to a few days (CAB International, 2001). Egg sacs are

usually found at the base of branching stems or leaves but may be found elsewhere on the plant (Mau and Kessing, 2000). In greenhouse conditions, the eggs hatch in about 10 days (Metcalf and Flint, 1962).

First instars (crawlers) remain in the egg sac for a day or two after hatching before leaving the egg sac in search of a suitable feeding site on the host plant (Mau and Kessing, 2000). The crawler stage is the primary dispersal stage in all mealybug species (Kessing and Mau, 1992). They are light yellow in colour with oval, flattened, and smooth bodies. First instars are usually more mobile than other stages, and are sometimes transported by wind (CAB International, 2001). Once feeding has begun, they secrete a white, waxy material that covers their body and produces approximately 36 leg-like filaments around the perimeter of the body (Mau and Kessing, 2000).

Mealybugs in general have four female and five male developmental stages or instars (including the adults). Both sexes have three larval stages. Females change only slightly in appearance, except for growing in size to about 1/6 to ¼ inch when full grown. Females become adults after the last moult and males go into a pupal stage (Metcalf and Flint, 1962). Females do not form an ovisac until they are adults. Adult females are pinkish in colour, wingless, oval in shape, and measures approximately ? inch (2.8 mm) in length and 3/50 inch (1.5 mm) in width. The filaments about the body are about equal in length with none exceeding one-fourth the length of the body (Mau and Kessing, 2000). Adult mealybugs are very sluggish crawlers (Mau and Kessing, 2000).

Male first instars are similar to female first instars, but male second instars form a waxy sac and pass through two more, non-feeding instars (the prepupa and pupa) before becoming winged adults. When male nymphs are fully grown, they enclose themselves in a white case in which they develop into an adult male (Metcalf and Flint, 1962). Only males pupate. Adult males are tiny, active, two-winged, fly-like insects (Metcalf and Flint, 1962). They do not feed and die soon after they have mated (Mau and Kessing, 2000); they usually survive for no more than a day (CAB International, 2001). It is assumed that most mealybug males locate females by a pheromone. Males can often be seen in flight early in the morning or late in the day when winds are generally calm.

It takes about one month for the completion of one generation (egg to adult) under greenhouse conditions (Metcalf and Flint, 1962). Mealybugs have from one to eight or nine generations a year depending on the weather conditions and species of mealybug (CAB International, 2001).

Mealybugs usually occur in protected areas on the host such as on the undersides of leaves, in the axils of leaves, and in cracks and crevices on the trunk. They may also occur on developing fruit branches (CAB International, 2001). They are usually most visible when females form white waxy ovisacs surrounding the body (CAB International, 2001). The large white ovisacs are the most easily seen structure on the host.

Although it is likely that this species has an array of natural enemies, none has been reported in the literature (CAB International, 2001). Mealybugs usually have associated parasites in the Chalcidoidea, particularly the Encyrtidae, and predators in the Coccinellidae. Other natural enemies include fungi, lacewings, occasional flies, and mites.

Although *P. jackbeardsleyi* has never been reported as a serious pest, its wide range of economic hosts and its ability to expand its geographic range make it an ideal candidate as a pest of the future (CAB International, 2001). Williams and Watson (1988) state, "There are no records of actual damage but the species is polyphagous, in the absence of suitable natural enemies, it could be injurious".

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Strymon megarus (Godart, 1824) [Lepidoptera: Lycaenidae]

Synonym(s) and changes in combination(s): As a result of the comprehensive confusion over the identity of the Lepidoptera species that feeds on pineapple, one datasheet will be used to describe the damage associated with pineapple fruit.

Strymon megarus (Godart, 1824) – *Polyommatus megarus* Godart, 1824; *Tmolus basilides* Geyer, 1837; *Strymon basilides* (Geyer, 1837); *Thecla basilides* (Geyer, 1837); *Thecla thulia* Hewitson, 1868; *Thecla ziba* Hewitson, 1868. Various misspellings include *Thecla basilides* (Geyer) and *Thecla basiliodes* (Geyer); misidentified as *Tmolus echion* Linnaeus.

Tmolus echion (Linnaeus, 1767) – *Papilio echion* Linnaeus, 1767; *Ministrymon echion* (Linnaeus); *Thecla echion* (Linnaeus).

Common name(s): Echion hairstreak; four-spotted hairstreak; fruit borer caterpillar; fruit-borer caterpillar; hairstreak butterfly; larger lantana butterfly; pineapple borer; pineapple fruit borer; red-spotted hairstreak.

Host(s): Scott (1986) claims that records of *Tmolus echion* feeding on pineapple appear to refer to *Strymon basilides*.

Hosts include many species of tropical plants including some in the verbena, mint and potato families (Struttmann, 2000). Host include: *Ananas comosus* (pineapple) (CAB International, 2000; Epstein, 1999; Marie, 1995; Sanches *et al.*, 1985; Zhang, 1994; Zunti and Cardinali, 1970); *Aphelandra deppeana* (Scott, 1986); *Brugmansia arborea* (angel's-trumpet) (Scott, 1986); *Capsicum annuum* var. *annuum* (bell pepper, capsicum, paprika) (Scott, 1986); *Capsicum* spp. (chilli, pepper) (Zhang, 1994); *Clerodendrum chinense* (glory-bower) (Rutkowski, 1996); *Cordia sebestena* (geiger tree) (Scott, 1986); *Hibiscus furcellatus* (Rutkowski, 1996); *Hyptis* sp. (Scott, 1986); *Lantana camara* (lantana) (Scott, 1986); *Lantana* sp. (CAB International, 2000; Zhang, 1994); *Mangifera indica* (mango) (Scott, 1986); *Solanum americanum* (American nightshade) (Scott, 1986); *Solanum melongena* (aubergine, eggplant) (Zhang, 1994); *Solanum sanitwongsei* (Scott, 1986); *Solanum tuberosum* (potato) (Scott, 1986); *Stigmaphyllon emarginatum* (Scott, 1986).

Plant part(s) affected: Flower (pineapple) (Bello Amez *et al.*, 1997; Epstein, 1999); flower bud (*Clerodendrum* and *Hibiscus*) (Rutkowski, 1996); fruit (pineapple) (Epstein, 1999; Morton, 1987; Rhainds *et al.*, 1996); leaf (pineapple) (Sanches *et al.*, 1985).

Distribution: Argentina (Johnson *et al.*, 1990); Bolivia (Johnson *et al.*, 1990; Sanches *et al.*, 1985; Zhang, 1994; Zunti and Cardinali, 1971); Brazil (Austin and Johnson, 1997; Sanches *et al.*, 1985; Zunti and Cardinali, 1970); Costa Rica (Rhainds *et al.*, 1996); Fiji (Zhang, 1994); Guatemala (Zhang, 1994); Guyana (Zhang, 1994); Mexico (Johnson *et al.*, 1990; Zhang, 1994); Peru (Johnson *et al.*, 1990; Julca Otiniano and Bello Amez, 1993–4); Trinidad and Tobago (Zhang, 1994) (Trinidad (Marie, 1995)); United States (Hawaii (Rutkowski, 1996; Zhang, 1994), Texas (Pyle, 1981; Scott, 1986)); Venezuela (Martínez, 1976; Zhang, 1994).

Biology: Adult butterflies may be seen flying over pineapple beds at all hours of the day. Their flight is rapid and usually of short duration, as they pass from flower to flower. Females seek out pineapple flowers in a very early stage of development for the purpose of oviposition (Harris, 1927). The majority of eggs have been found on the small flowering heads while still down among the leaves, and few have been observed on heads after the first three rows of flowers have opened (Harris, 1927). Females are also known to oviposit on small, young pineapple fruits (Rhainds *et al.*, 1996). The female alights on

a flower or scale and moves about until a suitable oviposition site is found. The eggs are laid singly and widely separated on host plants (Harris, 1927; Struttmann, 2000). On pineapple, the maximum number of eggs found on any single head was 16, with no indication that this was the work of one insect (Harris, 1927). Under laboratory conditions, between 7–17 eggs can be found per fruit, but each fruit can produce an average of only one or two mature larvae (Rhainds *et al.*, 1996). Dissection of the ovaries of a newly emerged female showed that a female has the potential possibility of developing 150 eggs (Harris, 1927). The eggs are usually found on the buds, and some have been observed on the stem just below the head (Harris, 1927). The eggs hatch in 3–5 days.

The egg is circular, 0.8 mm in diameter, and flattened from above. It is glossy white, with a finely reticulated surface. On hatching, the larva is 1.5 mm in length, pale in colour with the abdomen almost transparent. The first instar bears little resemblance to its later forms. The abdomen bears four rows of long hairs, up to 0.5 mm long, and four rows of shorter ones. The end of the abdomen is flattened as in the later stages. The second and subsequent instars are similar in appearance to one another, merely increasing in size. Fully grown larvae vary in length, but are generally 18–20 mm with a width of 6 mm.

Emergent larvae immediately seek out a suitable place for entering the young pineapple fruit and complete development within the fruit (Rhainds *et al.*, 1996). The larva is very active at this stage. Generally, the larva attacks the tender fleshy base of a scale where it is attached to the main body (Harris, 1927). Opening flowers are eaten into directly through the petals to the ovary and unopened buds are entered at all points (Harris, 1927). That part of the stem immediately below the head and between the suckers is occasionally superficially eaten. Larvae have been observed feeding on the mesophyll of pineapple leaves in Brazil at a time when no inflorescences, in which the borer usually feeds, were available (Sanches *et al.*, 1985). This finding demonstrates the ability of this species to maintain itself in pineapple plantations throughout the vegetative cycle (Sanches *et al.*, 1985).

The initial burrows are usually shallow and confined to the lower parts of the fruit (Harris, 1927). Then the rapidly growing larvae seeks a further entrance this time with apparently less regard for the tenderness of the epidermis. Also by this time the fruit is further developed and flowering has finished. This time a cavity is made below the surface and the larva is less exposed to attack from predators. After a period of 13 to 16 days the larva reappear, ceases feeding and actively descends the fruit stalk to the leaves, which cluster about its base. Hidden away in this constricted space it becomes quiescent, and pupates within 24 hours. Pupae have also been found among basal suckers, but not in any great number (Harris, 1927).

The burrowing and feeding activities of a single larva can produce visible damage to the fruit in the form of production of frass and exudation of a sticky, gummy matter from the points of attack (Harris, 1927; Martínez, 1976; Rhainds *et al.*, 1996). At first, practically colourless and quite fluid, the gum hardens in contact with the air, going through pale amber of a final dark brown colour when quite hard. Removal of the gum shows either an irregular shallow depression or, more usually, a small circular hole leading into the interior (Harris, 1927; Thorold and Pickles, 1940). Inside the fruit, the larva usually makes a small cavity before proceeding towards the surface again. These burrows do not extend inwards for than one-third of the diameter of the fruit, unless the larvae are confined with an inadequate food supply (Harris, 1927). As the fruit develops, these holes fill up with gum, which preserves a stiff jelly-like consistency while turning a deep brown colour. The edges of the wound blacken. Such places frequently become secondarily infected with fungi and other arthropods such as Collembola, millipedes, small dipterous flies, and minute brown beetles, all of which disintegrate the fruit (Harris, 1927). Gum is

only exudated from the deeper holes, the shallow excavations apparently drying our rapidly. Some time lapses before the gum appears on the exterior. Larvae feeding on the fruit of some pineapple cultivars can result in misshapen fruits (Bello Amez *et al.*, 1997).

The size of the pupa depends to a great extent on the development of the larva, and when fully developed is about 13 mm in length. The second and third segments together form a characteristic dorsal hump on the thoracic region. The pupal stage occupies 7–11 days. The complete life cycle takes 23–32 days, with an average of 28 days under laboratory conditions. There are many flights all year in Hawaii and Mexico (Scott, 1986).

This species is one of the most injurious insect pests of pineapple in Venezuela and is thought to be responsible for the exudation of a gum-like substance from the fruits (Martínez, 1976). This species causes serious fruit damage in Latin America and the Caribbean (Nakasone and Paull, 1998).

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