INSECT PESTS OF PASSION FRUIT (*Passiflora edulis*): Hosts, Damage, Natural Enemies and Control

Joy P. P. & Sherin C. G., Pineapple Research Station (Kerala Agricultural University), Vazhakulam-686 670
Muvattupuzha, Ernakulam, Kerala, India, Tel. & Fax: +914852260832, Email: prsvkm@gmail.com

Passion fruit is a vigorous perennial vine included in the Passifloraceae family. The most popular cultivated varieties are Yellow, Purple and Giant granadilla. The flowers are single and fragrant, 5-7.5 cm wide and borne at a node on the new growth. Fruits are dark-purple or yellow, rounded or egg shaped and contain numerous small, black wedge-shaped seeds that are individually surrounded by deep orange-colored sacs that contain the juice, the edible part of the fruit. Passion fruit develops well in tropical and subtropical regions, where the climate is hot and humid. Temperature, relative humidity, light intensity and precipitation have important influence on the longevity and the yield of the plants, but also favour the incidence of pests and diseases.

Passion fruit is attacked by several pest species of insects and mites that feed upon all parts of the plant. A limited number of species are clearly of major economic importance. Few have key pest status, while some species are secondary pests because they are sporadic or occur at low population levels and therefore do not require control strategies. Insect and mite pests that are frequently associated with passion fruit are described below, including their description, behavior, hosts, damage and control. (Santo, 1931; Lordello, 1952b; Correa et al., 1977; ICA, 1987; Dominguez-Gil et al., 1989; Figueiro, 1995; Lima and Veiga, 1995).

PRIMARY PESTS

Primary pests are those that can cause severe damage to the entire crop. Their occurrence will be in high numbers and proper control measures will have to be adopted to save the cultivars.

♦ LEPIDOPTEROUS DEFOLIATORS

Three heliconiine species, *Dione juno juno* Cramer, *Agraulis vanillae vanillae* Linnaeus and *Eueides isabella huebneri* Ménétries (Nymphalidae), are the most common lepidopterans feeding upon foliage of passion fruit (Dominguez-Gil and McPheron, 1992). *Dione juno juno* is the key pest which causes severe damage of the plant. *Juno* has orange wings with black borders and venation. The *A. vanillae* butterfly has red-orange wings, with black markings and venation, and silver spots on the underside. Two-thirds of the forewing of *Eueides isabella huebneri* is dark brown, almost black, with irregular yellow spots, and one-third is orange with black stripes. The hind wings are orange with black borders and a central stripe.

Fig 1: (A) Egg of Agraulis vanillae vanillae (B) Larvae (C) Adult Agraulis vanillae vanillae

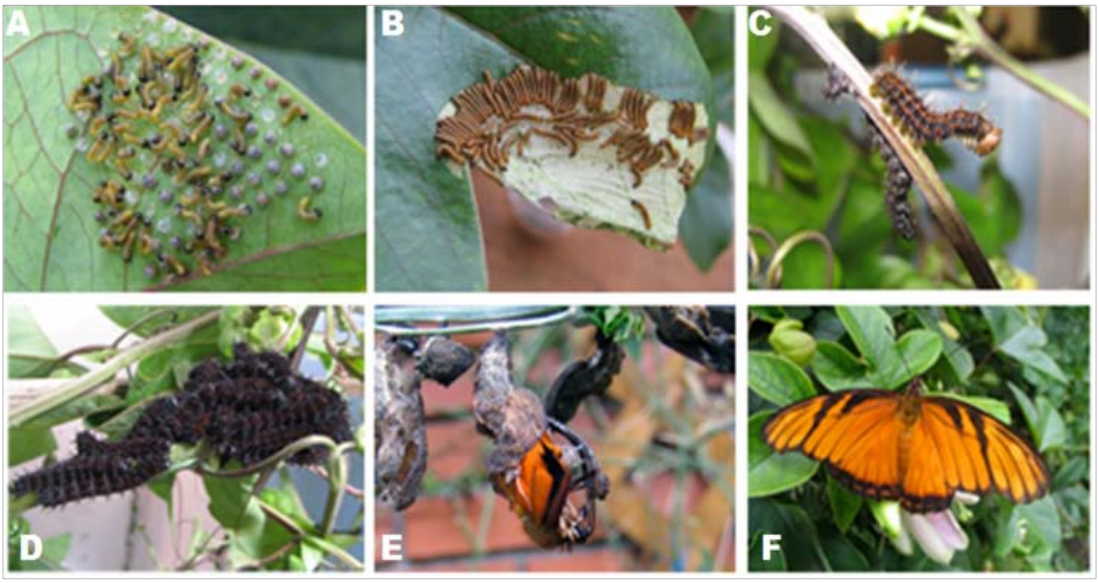

Fig 2: Life Cycle of *Dione juno juno Cramer*

Hosts

Caterpillars of *D. juno* feed on all Passiflora species, except *P. foetida* (Echeverri et al., 1991; Carter, 1992). According to Boiça Júnior et al. (1993), *P. alata, P. setacea* and the hybrid *P. alata* × *P. macrocarpa* are more resistant to attack by *D. juno* than *P. edulis, P. cincinnata, P. caerulea* and the hybrid *P. edulis* × *P. alata*.

Damage

Heliconiine defoliators reduce leaf area, thereby indirectly reducing yield. *Dione juno* usually causes damage that is more serious because of its gregarious behavior. Besides defoliation, the caterpillars may feed on the apical buds, flowers or stems (De Bortoli and Busoli, 1987).

Natural Enemies

Several predators and parasitoids have been reported for these heliconiids. However, these natural enemies are not considered to be effective.

Control

Control measures are crop inspection which includes hand picking and destruction of eggs and cater-pillars (Rossetto et al., 1974). On the other hand, these methods require considerable time and labour and are often impractical for a large-scale cultivation. In this case, injurious populations of defoliating caterpillars infesting passion fruit must be controlled with insecticidal sprays. Action thresholds have not been defined. Growers spray the foliage, often starting with appearance of the pest, and continue at regular intervals until the crop is harvested. In passion fruit it is very important to protect pollinating insects by timing insecticidal treatments when pollinators are not present in the field. Choosing an insecticide that is selective for the pest and less toxic to pollinators, predators and parasitoids is important in these agro-ecosystems. (Rossetto et al., 1974).

♦ COREID BUGS

In passion fruit producing areas, three main species of coreids are reported: *Diactor bilineatus Fabricius, Leptoglossus* spp. and *Holhymenia* spp. *D. bilineatus* is the most common species, and is known as the passion fruit bug because it feeds only on fruit of *passiflora spp.* Among the *Holhymenia*, *H. clavigera* (Herbst.) and *H. histrio* (Fabricius) are the most common species attacking passion fruit. The bugs *Leptoglossus*, *L. gonagra* Fabricius and *L. australis* Fabricius, usually cause damage to passion fruit. *D. bilineatus* are orange on the ventral face of the head, and the dorsal face is dark metallic green with two orange longitudinal lines that continue on the prothoracic tergum and the scutellum, both of which are dark metallic green. The adult body of *Holhymenia spp.* is black with orange spots. The legs are reddish orange. The head, the prothoracic tergum and the scutellum are black with white spots (De Bortoli and Busoli, 1987; Brandão et al., 1991; Dominguez-Gil, 1998).

Fig 3: *Gonagra Fabricius*

Fig 4: *L. australis* Fabricius

Fig 5: *Leptoglossus phyllopus*

Hosts

Besides passion fruit, *H. clavigera* feed on guava (Fancelli and Mesquita, 1998). *L. gonagra* feeds on a large number of host plants, including passion fruit, chayote, citrus, tobacco, guava, sunflower, cucumber, grape, pomegranate, São Caetano melon (*Cayaponia espelina*), bixa (*Bixa orellana*), araçazeiro (*Psidium araca*) and *Anisosperma passiflora* (Chiavegato, 1963).

Damage

Passion vine bugs migrate from surrounding scrub to infest passion fruit plantations. Neglect of vines may allow populations of the bug to build up. Feeding usually occurs on flowers or green-mature fruit. Nymphs often cluster on fruit when feeding. Damage to mature fruit is not pronounced; however, young fruit develops dimple-like surface blemishes at the feeding sites (Murray, 1976). Both immature and adult bugs injure the crop, piercing stems, leaves, fruits and flowering buds, by sucking plant juices. However, the nymphs prefer to feed on flowering buds and young fruits, usually resulting in excessive dropping. The adults may also attack leaves, stems and fruits at any stage of ripening. If larger fruits are fed upon, they wilt and show a wrinkled surface. *Leptoglossus gonagra* often causes misshaping or dropping of young fruits (Chiavegato, 1963). In small passion fruit producing areas, hand picking and destruction of eggs, nymphs and adults is recommended (Mariconi, 1952).

Natural Enemies

Natural enemies are present for many of the passion vine bugs. *D. bilineatus* eggs are parasitized by *Hadronotus barbiellinii* Lima (Scelionidae). Eggs of *H. clavigera* are reported to be eaten up by *Hexacladia smithii* Ashmead (Encyrtidae) (Silva *et al*., 1968).

Control

Removal of the alternate cucurbit host, 'São Caetano melon', a preferred host of *L. gonagra*, and avoiding the cultivation of chayote and *Anisosperma passiflora* in adjacent areas can reduce pest densities (Chiavegato, 1963). Regular inspection during the summer months aids to detect any build-up of *L. australis* (Murray, 1976).

♦ STEM WEEVIL

The stem weevil, (*Philonis spp*.) is included in the Curculionidae family. They are nocturnal. Adults of P. *passiflorae* are about 7 mm in length, brown with whitish elytra with two brown stripes. Adults of *P. crucifer* are 4 mm in length, brown with black markings.

Fig 6: Stem weevil (*Philonis* sp

Hosts

Yellow passion fruit is susceptible to attack by *Philonis* spp. while *Passiflora alata*, *P. maliformis*, *P. serrato digitada* and *P. caerulea* are not infested by this pest (Oliveira and Busoli, 1983). Cruz *et al*. (1993) observed that yellow passion fruit is very much susceptible to *Philonis obesus* attack, but *P. alata* and *P. giberti* show some plant resistance.

Damage

Larvae of *Philonis* spp. feed within the stems, opening longitudinal galleries inside stems that prevent plant development. The attacked stems are easily identified by the presence of excrement and sawdust (Santos and Costa, 1983). As the larva develops, infested stems become weak, frail and die (Fancelli, 1992a). Simultaneous attack of several larvae is characteristic of weevil infestations, which causes hypertrophy in stems where the pupal cell will be constructed (Rossetto *et al*., 1978; Oliveira and Busoli, 1983; Racca Filho *et al*., 1993). Attack by the stem weevil also causes fruit drop before maturation (Costa *et al*., 1979).

Control

Periodic inspection of the crop is essential for an early detection of weevil-infested stems (Fancelli, 1992a). When infestation symptoms are detected on the crop, affected stems should be pruned and burned (De Bortoli and Busoli, 1987). According to Leão (1980) and Costa *et al*. (1979), a contact insecticide (e.g. decamethrin at 25% (5–10 g a.i. ha^{-1})) should be applied during early afternoo n hours for stem weevil control, at the time of adult emergence. After 4–5 days, systemic insecticides for control of future stem infestations should be used.

♦ FLIES

Anastrepha Schiner (Tephritidae) and *Lonchaea* Fallén (Lonchaeidae), *A. consobrina* are the common genera of flies damaging passion vines. *A. curitis* Stone, *A. dissimilis* Stone, *A. fraterculus* (Wiedmann), *A. kuhlmanni* Lima, *A. lutzi* Lima, *A. pseudoparallela* (Loew), *A. striata* Schiner, and *A. xanthochaeta* Hendel are the most common species associated with passion fruit (Santos and Costa, 1983; Teixeira, 1994; Zucchi, 1988, 2000). *Anastrepha pallidipennis* (Chacón and Rojas, 1984), the oriental fruit fly, *Bactrocera dorsalis* (Hendel), melon fly, *Bactrocera cucurbitae* Coquillett and the Mediterranean fruit fly, *Ceratitis capitata* Wiedmann, are known to attack the passion fruit vines in Hawaii, USA (Back and Pemberton, 1918); however, the relative importance of each species appears to vary with respect to location of the vineyard (Akamine *et al*., 1954).

Fig 7: *Lonchaea fallén*

Anastrepha adults are 6.5–8.0 mm in length, predominantly yellow in colour, with brown and yellow markings on the wings. The adult Medfly is a smaller colorful insect with yellow and black markings on the body and black and orange markings on the wings. The adult of *Bactrocera tryoni* is wasp-like in appearance, about the size of a house fly, with transparent wings bearing a dark band on the front margin. Bright yellow patches interrupt the general reddish brown body colour. The adult *Dasiops curubae* is blackish blue. The wings are hyaline and slightly smoky yellowish, while the calypters and wing fringes are pale yellowish (Steyskal, 1980). The adult *Dasiops inedulis* is bright metallic dark blue with hyaline wings; the calypters and wing fringes are yellowish to nearly white (Steyskal, 1980).

Hosts

The highly polyphagous *Anastrepha* spp. infest approximately 270 plant species and are considered to be the major fruit pests of tropical and subtropical America. Passiflora act as host for the larvae of two groups of *Anastrepha* namely *chiclayae and seudoparallela.* (Norrbom and Kim, 1988; Stefani and Morgante, 1996). Larvae of *A. limae* Stone feed upon fruits of *P. quadrangularis* (Stone, 1942; Caraballo, 1981). Lordello (1954) observed infestations by *Anastrepha* and *Lonchaea* species on *Passiflora quadrangularis* and *P. macrocarpa*. *Dasiops inedulis* is reported to be a serious pest of purple granadilla, *P. edulis* (Steyskal, 1980). This species has been implicated in 21–65% loss of flowering buds of passion fruit in the Cauca Valley (Colombia) (Peñaranda et al., 1986). *Dasiops passifloris* attacks fruits of *P. suberosa* (Steykal, 1980).

Damage

Fly species feed upon the fruits of Passiflora spp., and also attack flowering buds. *Neosilba pendula* and *Dasiops* sp. (Lonchaeidae) are the most common species attacking flowering buds of passion fruit (Rossetto *et al*., 1974; Silva, 1982; Fancelli and Mesquita, 1998). Other flies such as *Lonchaea cristula* McAlpine (Lonchaeidae) and *Zapriothrica salebrosa* Wheeler (Drosophilidae) may also feed upon flowering buds (Chacón and Rojas, 1984).

Fruit fly adult damage is caused by oviposition in green fruits, causing disfigurations of the fruit surface. The larvae damage the fruit by feeding on its pulp, contaminating it with bacteria and fungi and causing premature fruit drop (Medina *et al*., 1980; Santos and Costa, 1983; Morgante, 1991). The oriental, melon, and Mediterranean fruit flies puncture the fruit while the rind is still tender (Akamine *et al*., 1954). As the fruit enlarges, a woody area (callus) develops around the puncture. If the fruit is small and undeveloped, the damage may be sufficient to cause it to shrivel and fall from the plant. If the fruit is well developed, it may continue to maturity. At the time of ripening, the area around the puncture has the appearance of a small, woody crater, which disfigures the outer appearance of the fruit, but does not impair pulp quality. Although oviposition scars are present on ripening fruits, they generally do not contain living larvae. Larvae appear to be able to develop better in immature than in mature fruit. Oviposition by *B. tryoni* in immature green fruit also results in the formation of calluses in the skin of the fruit at the puncture site. Punctured fruits may persist on the plant to maturity but are not acceptable for fresh market sale because of the damage (May, 1953; Hargreaves, 1979).Passion fruit increase rapidly in size during the first 10–15 days after fruit set. During this period the skin of the fruit is turgid and easily punctured by the ovipositor. Infested immature fruit shows characteristic skin blemishes. The woody tissue, which forms around the eggs, develops a hard raised area around the puncture mark. Egg laying or puncture often causes young fruit to shrivel and drop. Puncture marks are difficult to detect on ripe fruit. A few days after larval infestation, mature fruit will show wrinkling and breakdown.

Natural Enemies

Natural enemies of fly species are larval parasitoids. *Doryctobracon enderlein*, *Diachasmimorpha viereck*, *Opius wesmael*, *Psyttalia walker* and *Utetes foerster* are the most common larval parasitoids of tephritid fruit flies (Wharton, 1996). *Pachycrepoideus vindemiae* (Rondani) and *Spalangia endius* walker (Pteromalidae) are pupal parasitoids of Medfly (Back and Pemberton, 1918). Larvae of *N. pendula* are parasitized by *Alysia lonchaeae* Lima, *Ganaspis carvalhoi* Dettmer, *Tropideucoila weldi* Lima (Cynipidae), and *Opius* sp. and preyed

upon by *Belonuchus rufipennis. (*Silva *et al*. (1968)

Control

One of the most important steps in controlling fruit flies is the elimination of over-ripe fruits in which the flies breed and on which the adults feed. Santos and Costa (1983) recommended that passion fruit must be planted far away from coffee plantations and wild host plants that grow adjacent to the passion fruit crop should be removed. Fruit flies may be controlled using bait sprays composed of molasses (7%) or protein hydrolysate (1%) and an insecticide. The bait is sprayed over 1 m^2 of the plant canopy, using 100–200 ml of bait per plant (Santos and Costa, 1983). The bait should be applied during the night (Rossetto *et al*., 1974). Bud flies may be controlled by insecticide baits composed of fenthion, molasses and water. (Boaretto *et al*., 1994) The bait is applied at the beginning of the flowering peak, and usually three applications spaced at 8–10 days are necessary.

♦ MITES

Brevipalpus phoenicis (Geijskes) (Tenuipalpidae), the red spider mites *Tetranychus mexicanus* (McGregor) and *T. desertorum* Banks (Tetranychidae) are known to infest passion fruit plants. Warm temperature and low precipitation favour development of these species (Haddad and Millán, 1975; Oliveira, 1987; Brandão *et al*., 1991) *Polyphagotarsonemus latus* (Tarsonemidae) prefers high temperatures and greater than 80% relative humidity (Oliveira, 1987; Brandão *et al*., 1991)

Hosts

Brevipalpus phoenicis feeds on citrus, coffee, cashew, papaya, banana, guava, pomegranate, apple, loquat, peach, pear, grape, grevillea, and various weeds (Oliveira, 1987). *Tetranychus desertorum* occurs on cotton, sweet potato, bean, papaya, passion fruit, strawberry, peach, tomato, grape, and certain ornamentals. *Tetranychus mexicanus* feeds upon cotton, citrus, apple, papaya, passion fruit, pear, peach, cacao, walnut, and ornamentals (Flechtmann, 1989). Hosts of *P. latus* are bean, potato, cotton, coffee, citrus, apple, pumpkin, walnut, grape, peach, pepper, rubber plantation, and various weeds (Oliveira, 1987).

Damage

Brevipalpus phoenicis is responsible for general discoloration of the leaves, and necrosis, culminating in leaf drop. Attacked young stems dry from the extremity to the base and eventually die (Flechtmann, 1989). *B. papayensis*, known as red mite, is one of the most troublesome pests of passion fruit, but it is usually most damaging in areas of low rainfall and during prolonged dry weather. Passion fruit vines display yellowing, shriveling, and falling of the leaves. With heavy and prolonged infestation, leaf fall increases and the vine has the appearance of dying back. At the same time, developing fruit may begin to shrivel and fall prematurely from the plant. Close examination reveals the presence of mites as scattered reddish patches on the surface of the fruit, particularly around the stem end, along the midrib and veins of the leaf, especially on the under-surface. If red spider mites are left uncontrolled, the plant may eventually die (Akamine *et al*., 1954). Red spider mites cause a general weakening of the plants. Initial damage to foliage appears as fine silver speckling on the lower surface of the leaves, which turn brownish on the upper side as mites continue to feed. If large numbers of mites are present, entire leaves or plants turn yellow. (Oliveira, 1987). Photosynthesis and transpiration of the plants are suppressed. Dense populations of spider mites produce silken webs that cover the leaves. Heavy infestations cause leaves to drop and plants to lose vigor (Oliveira, 1987). *P. latus* induces malformations in developing leaves, which later dry and drop. It may attack flowering buds, causing a reduction in the number of flowers, and in turn, of fruits produced per plant (Oliveira, 1987; Flechtmann, 1989).

Natural Enemies

Important natural enemies of spider mites are predacious mites belonging to Phytoseiidae. The life history of these predators is closely related to that of their host. Larvae and adults of *Stethorus* sp. (Coccinellidae) were also observed as predators of *T. mexicanus* in passion fruit plantations.

Control

Periodic inspections of the orchard and other adjacent hosts, including weeds, are essential to verify the occurrence and first symptoms of mite attacks (Oliveira, 1987; Brandão *et al*., 1991). Selective miticides, dosages, timing, and refining application techniques may be useful in an integrated mite management system. The four principal requirements for a practical operation are: (i) presence of predacious mites in the orchard; (ii) knowledge of the appearance and habits of plant feeding and predacious mites; (iii) careful examination of relative numbers of predators and plant-feeding mites, particularly during a period when rapid population changes are occurring; and (iv) knowledge of pesticides to use, how to use them, and what pesticides to avoid, in order to conserve predators. Fenthion, propargite, chlorfentezine, and avermectin are effective miticides.

SECONDARY PESTS

Secondary pests include various species of insects that may become abundant, and occasionally damage the passion fruit crop. The insects in this group are either associated frequently with a particular environmental condition or else occur within limited geographical areas.

♦ APHIDS

Aphids (Aphidae) are known to attack passion fruit vines, although they seldom cause serious damage. Three species of aphids, *Myzus persicae* (Sulzer), *Aphis gossypii* (Glover), and *Macrosiphum solanifolii* Ashmead (*M. euphorbiae)* must be regarded as potentially important pests of passion fruit.

Hosts

Peach is the preferred primary host of *M. persicae*. It may infest other Prunus species, in particular almond and plum. Its secondary host plants include numerous wild and cultivated plants, such as passion fruit (Barbagallo et al., 1997). *Aphis gossypii* infests numerous species of dicotyledonous plants, including passion fruit. Favoured hosts are in the *Malvaceae* (cotton, hibiscus, etc.) and Cucurbitaceae (pumpkin, cucumber, watermelon, melon) (Barbagallo et al., 1997). M. solanifolii is a very polyphagous species, showing preference for the Solanaceae, i.e. potato, tomato, etc. (Barbagallo et al., 1997).

Damage

Aphids cause malformation in foliage, and they are more important as disease vectors. *Myzus persicae* and *A. gossypii* transmit virus disease that causes hardening of fruits. (Brandão *et al*., 1991; Piza Júnior and Resende, 1993). *Myzus persicae* and *M. solanifolii* are vectors of the passion fruit woodiness virus.

Natural Enemies

Naturally occurring predators and parasites are effective against aphids. The Coccinellidae are effective against cotton aphids and in particular the larval stage of *Scymnus*. Other predators include the Chrysopidae (*Chrysoperla*), Cecidomyiidae (*Aphidoletes*) and Syrphidae (*Syrphus*). Parasitism by *Lysiphlebus* sp. (Aphidiidae) has been reported (Barbagallo *et al*., 1997). According to Grasswitz and Paine (1993), *Lysiphlebus testaceipes* (Cresson) parasitizes *Myzus*, *Aphis*, and *Macrosiphum*. Silva *et al*. (1968) reported parasitism of *M. solanifolii* by *Aphidius platensis* Brèthes, *A. brasiliensis* Brèthes, *Diaeretiella rapae* (McIntosh) (Aphidiidae), and predation by *Bacha clavata* (F.) (Syrphidae), *Coccinella ancoralis* Germar, *Cycloneda sanguinea* (L.) and *Eriopis connexa* (Germar) (Coccinellidae).

Control

Proper use of insecticides and avoidance of host plantations near to the passion fruit wine yards can control the attack of aphids in passion crop cultivars.

♦ CATERPILLARS

Caterpillars of *Azamora penicillana* (Walker) (Pyralidae) are defoliators of passion fruit (Santos and Costa, 1983; Fancelli, 1992b; Fancelli, 1993). *Peridroma saucia* (Hübner) (Noctuidae) attacks the floral structure and may reduce fruit production (Chacón and Rojas, 1981). *Pyrausta perelegans* (Hampson) (Pyralidae) is also associated with passion fruit flowers. Caterpillars of *Aepytus* (*Pseudodalaca*) *serta* (Schaus) (Hepialidae) and *Odonna passiflorae* Clarke (Oecophoridae) are passion fruit stem borers (Chacón and Rojas, 1984).

Host

A. penicillana was reported damaging a wild species of passion fruit (*Passiflora cincinnata*) (Fancelli, 1993) *P. saucia* damages and causes reduction in fruit production of curuba (*Passiflora mollissima*). It is a polyphagous insect, feeding on potato (*Solanum tuberosum*), oak (*Quercus suber*), *Calendula officinallis*, cotton, tobacco, bean, tomato, lucerne, soybean, and beet (Chacón and Rojas, 1981).

Damage

Caterpillers of A. penicillana cause defoliation, the most serious damage is caused by the phytotoxic effects of the fluid secreted by the caterpillar on the leaves and young stems. Heavy infestations cause leaves to dry and drop, and passion fruit plants lose vigour and bear fewer flowers. In Bahia, Brazil, the population peak of this pest occurs during the rainy season (April to June) (Santos and Costa, 1983; Fancelli, 1992b, 1996). *P. saucia* larvae feed upon floral structures of *P. mollissima*. Young larvae migrate from leaves to the flowers where they feed on the floral tube, nectary and gynophore, causing flower dropping. The sixth instar larvae may occasionally continue feeding on the young fruit, or drop onto the soil to pupate. In Colombia, *P. saucia* infested 64% of the flowers during the summer (July to September) (Chacón and Rojas, 1981). Larvae of *A. serta* bore into roots located near the surface, and occasionally bore into stems. Stem injury is characterized by the presence of sawdust. A single larva is regularly found in 1-year-old plants, while in 6–8-year-old plants, up to five larvae may develop (Chacón and Rojas, 1984). The damage of *O. passiflorae* caterpillars is characterized by the presence of sawdust outside the principal and lateral stems. Several larvae in different stages of development attack simultaneously at the same point of the stem, and cause cellular hypertrophy. They form galleries in different directions, resulting in total destruction of the stem. The caterpillars of *P. perelegans* infest 6-month-old plants and remain during the whole vegetative period. They attack the buds and developing flowers, feeding on nectaries, gynophores, and young fruits (Chacón and Rojas 1984).

Natural Enemies

Natural predators are effective against *P. saucia*. A tachinid fly, *Incamyia* sp., is an important factor for reducing the population of *P. saucia* caterpillars. Another dipterous parasitoid is *Megaselia scalaris* (Phoridae). Adults of the predator *Anisotarus* sp. (Carabidae) feed on caterpillars and prepupae. . The larval stage of *O. passiflorae* is infected with the fungus *Beauveria bassiana* and is parasitized by the hymenopteran, *Neotheronia* sp. (Ichneumonidae), *Sathon* sp. (Braconidae) and *Enytus* sp. (Ichneumonidae) parasitize larvae of *P. perelegans*.

Control

The infestation of *A. serta* depends on the wood used to make the trellises. Use of resistant wood such as mangrove (*Rhizophora mangle*) can check the infection of caterpillars. Wood of Barbados cherry (*Malpighia glabra*) and *Cassia tomentosa* are susceptible to attack by *A. serta* and are not recommended for trellises.

♦ MEALY BUGS

Citrus mealy bug, *Planococcus citri* Risso, and the passion vine mealy bug, *Planococcus pacificus* Cox (Pseudococcidae), are pests of lesser importance on passion fruit. Citrus mealy bug, *P. citri*, is a small, oval-shaped sucking insect commonly found on passion fruit. Mealy bugs characteristically aggregate on the plant, especially at leaf nodes and under dead leaves and trash. Aggregation may also occur under dried flower bracts. Secretion of a sugary solution from the mealy bugs promotes growth of a black fungal mould on the fruits and leaves. Ants are often found tending mealy bugs for this secretion and interfere with the natural control of the Mealy bugs by parasites and predators.

Fig 8: Mealy Bug on Passion fruit leaf

Damage

If a severe infestation occurs, loss of vigour, leaf drop, and fruit malformation may occur. Unchecked, an infestation may cause death of the plant (Murray, 1976; Swaine *et al*., 1985).

Natural Enemies

Lady beetles (Coccinellidae), especially mealy bug lady beetle, *Cryptolaemus montrouzieri* Mulsant and maculate lady beetle, *Harmonia octomaculata* (Fabricius), substantially reduce mealy bug numbers. Of secondary importance are small wasp parasitoids such as *Leptomastidea abnormis* (Girault) (Encyrtidae) and *Ophelosia* sp. and lacewing larvae (*Oligochrysa lutea* (Walker)) (Murray, 1978; Swaine *et al*., 1985). *P. citri* is parasitized by *Apanteles para guayensis* Brèthes (Braconidae), *Coccophagus caridei* (Brèthes) (Aphelinidae), *Anagyrus coccidivorus* Dozier, *A. pseudococci* (Girault), *Leptomastidea abnormis* (Girault), *Leptomatrix dactylopii* Howard (Encyrtidae) and *Pachyneu ron* sp. (Pteromalidae). *Leptomastix dactylopii* is commercially available. It is a yellowish brown wasp that lays its eggs in late instar nymphs and adult Mealy bugs. *Leptomastix* prefers hosts in warm, sunny, humid environments. It may complete one generation in 2 weeks at 30˚C or in 1 month at 21˚C (Fisher, 1963).

Control

Clusters of mealy bug on dead leaves are well protected from the insecticide sprays, and little control can be achieved unless vines are cleaned thoroughly to allow spray penetration. Pruning may enhance the effectiveness of the spray; however, this is often impractical, as laterals to be pruned are generally bearing fruits (Murray, 1976). According to Murray (1976), occasional outbreaks of this pest are best controlled by two sprays of 1 : 60 Neem oil or methidathion 0.05% combined with 1 : 100 Neem oil, 2 weeks to 1 month apart. Oil in the ratio 1:60 is preferred, as methidathion is highly toxic to the mealy bug's natural enemies. For good control, thorough coverage is essential.

♦ SCALES

Soft brown scale (*Coccus hesperidum* Linnaeus) (Coccidae) may occasionally infest leaves and stems of passion fruit. California red scale, *Aonidiella aurantii* (Maskell) (Diaspididae) is most common on older passion fruit vines (Swaine *et al*., 1985).

Damage

Soft scales and diaspidids injure plants by sucking sap, and when in numerous can kill the plant. They sometimes heavily encrust the leaves, fruits, twigs or branches. Mealy bugs may be found on almost any part of the host plant from which they suck the sap (Murray, 1976; Swaine *et al*., 1985).

Natural Enemies

Parasitic wasps are important to control *A. aurantii*, mainly *Comperiella bifasciata* (Howard) and *Aphytis chrysomphali* (Mercet) (Aphelinidae). (Murray, 1976; Swaine *et al*.,1985). *Azya luteipes* Mulsant, *Coccidophilus citricola* Brèthes, and *Pentilia egena* Mulsant have been recorded as predators of California red scale. Two species of pathogenic fungi of California red scale are *Nectria coccophila* and *Myriangium duriaei* (Silva *et al*., 1968). According to Forster *et al*. (1995), *Aphytis melinus* is the most important parasitoid attacking California red scale. The female *A. melinus* feeds on and oviposits in immature scales, preferring the virgin adult female scale. The solitary, ectoparasitic larva leaves a flat and dehydrated scale body beneath the scale cover, where the parasitoid's cast skin and faecal pellets (meconia) may be observed. The parasitoid's short life cycle (10–20 days) results in two or three parasitoid generations for each scale generation. *Comperiella bifasciata* is an important encyrtid that parasitizes California red scale. Adult parasitoids are black, with two white stripes on the female's head. One parasitoid generation requires about 3–6 weeks to develop, with faster development occurring on larger (later instar) hosts and at warmer temperatures. Parasitoids of *C. hesperidum* in Argentina are *Aneristus coccidis* Blanchard, *Coccophagus caridei*, *Ablerus ciliatus* De Santis (secondary parasitoid) (Aphenilidae), *Aphycus flavus* Howard, *A. luteolus* (Timberlake) and *Cheiloneurus longisetaceus* De Santis (Encyrtidae). Among the predators is *Azya luteipes* Mulsant (Coccinellidae) (Silva *et al*., 1968).

Control

Chemical control is often not required since parasitization by small wasps substantially reduces populations. For effective chemical control, a 1: 60 Neem oil spray is satisfactory (Murray, 1976).

♦ TERMITES

Termites are increasingly common in passion fruit plantations. Three termite species, *Heterotermes convexinotatus* (Snyder), *Amitermes foreli* Wasmann, and *Microcerotermes arboreus* Emerson are observed to feed on roots and stems of 2–4-year-old passion plants.

Hosts

Termites penetrate and excavate the roots and continue upwards within the stems. The plant often dies and death may be associated with the presence of soil pathogens, which usually cause rotting, including *Fusarium* spp. and *Phytophthora* spp. (Dominguez-Gil and McPheron, 1992; Piza Júnior, 1992).

Control

The use of tillage operations to reduce populations of termites may change the physical condition of soil and expose the colony to the sun. After tillage, the soil should be treated with Hilban 2.5 ml/liter (Piza Júnior, 1992). The soil must be treated when it is wet to allow the penetration of the insecticidal solution. When the crop is already established, the insecticidal solution must be applied to the soil around the plants in large quantities to reach a depth of 35 cm.

♦ BEES

Benefits

The bee family consists of different species and the carpenter bees are normally counted as beneficial organisms as they enhance the pollination of passion fruit flowers. Passion fruit flowers are cross pollinated species. The floral structure of passion flower does not facilitate self pollination. Bees assisted pollination is usually happening in passion fruit vineyards which help in greater number of fruit setting.

Fig 9: Carpenter Bee

Fig 10: Honey Bee

Hosts

Trigona spinipes damages flowering buds and leaves of various plant species including mulberry, banana, citrus, coconut, mango, rose pine and fig (Silva et al. 1968).

Damage

Honey bee *Apis mellifera* L. (Apidae) is considered a pest since it robs the pollen from the carpenter bees, thereby causing a reduction of fruit set (Akamine *et al*., 1954). Adults of *Trigona spinipes* Fabricius (Apidae) attack leaves, stems, trunk, developing buds, developing fruits, and fruit peduncles of several plant species (Puzzi, 1966; Bastos, 1985; Teixeira *et al*., 1996). *Trigona spinipes* causes malformation of foliage and dropping of flowers, resulting in a reduction in the number of fruits produced per plant. It also attacks developing flowering buds (Fancelli and Mesquita, 1998). The parasitism of larvae of *T. spinipes* by *Pseudohypocera nigrofascipes* Borgn. & Schn (Phoridae) is reported by Silva *et al*. (1968).

Natural Enemies

The most important natural enemy of the larvae of *T. spinipes* is Pseudohypocera nigrofascipes (Silva et al. 1968). They are included in the family Phoridae

Control

To prevent honeybees from robbing passion fruit flowers, more attractive plant species such as eucalyptus and basil can be planted in adjacent areas to passion fruit. Collection of wild swarms is also recommended (Boaretto *et al*., 1994). The control strategies recommended for *T. spinipes* include the destruction of nests near the crop and weekly inspections to verify the occurrence of this pest on flowers. In exceptional cases, chemical control is recommended.

Registered/Suitable pesticides

Nematicide: Carbosulfan 6G, 17 kg/ha, soil application

Insecticides: Chlorpyriphos (Hilban 20EC, 2.5 ml/l)
Imidacloprid (Tatamida 200SL, 0.3 ml/l)
Quinalphos (Ekalux 25EC, 2 ml/l)

Miticide: Dicofol 4 ml/l

Note: Use 500 l/ha for foliar spray and 1 l/m^2 for soil drenching

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