Insects and their Natural Enemies Associated with Vegetables and Soybean in Southeast Asia

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FRONT COVER - *Chrysodeixis chalcites* is one of a complex of loopers that feed on vegetables and soybean crops in Southeast Asia. However, loopers (upper left) rarely reach damaging levels in the field because of the action of natural enemies. Looper populations are kept in check by insect diseases, such as the fungus, *Pandora gammae* (upper right), parasitoids, such as braconids, (braconid parasitoid coccoon shown beneath larva -- center), and predators, such as the jumping spider, *Siler* sp. (bottom). These are only a few examples of the rich communities of natural enemies that impact pest populations in vegetables and soybeans.

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Dedicated to the vegetable and soybean farmers of Southeast Asia

Contents

Introduction

This book is intended to acquaint those interested in the arthropod fauna of vegetables and soybean with the more common forms of plant-feeding insects (and mites) and their natural enemies in Southeast Asia. Clearly, the coverage is not complete and a species list that makes up the rich communities of insects, spiders and mites associated with these crops in Southeast Asia will grow as more in depth surveys of the region are made. We have intentionally kept the narrative to a minimum but for most of the species, not much is known. We hope that readers realize that images shown here are not meant to replace actual field observations. On the contrary, an illustrated introduction to the insects, spiders and mites may arouse curiosity and a desire to visit the field and discover the dynamics that make up the vegetable/soybean ecosystems.

Most of the species that inhabit these crops are not pests. Even those insects and mites that feed directly on the plants seldom reach levels that affect yields of vegetables and soybean. Our experience has been that low population levels of plant feeders are actually useful as they provide food sources for beneficial species (predators, parasitoids and insect pathogens) which, in turn, keep many potential pest species in check. Thus, any attempt to keep a crop entirely insect free through the use of chemical insecticides will ultimately fail because the insecticides remove natural enemies, resulting in pest resurgence. This is a common phenomenon because plant feeders recolonize fields faster than natural enemies after chemical treatment.

Parasitoids are particularly susceptible to chemical insecticides and understanding their role in the ecosystem is very important for implementing integrated pest management. The species of parasitoids, predators and diseases of insects presented in this book are a result of field observations and collections of thousands of immature insects from farmers' fields in Southeast Asia. Field-collected insects were either placed on artificial diet or reared on host plant material and held in the laboratory until parasitoids emerged, or diseases killed the host insects. In other instances, the prey enrichment method was used whereby insect eggs were placed in the field, collected after a few days and held in the laboratory until parasitoids emerged. Most of the species photographed resulted from direct field observations.

This book contains more than 250 species of arthropods, many of them natural enemies. Many of these were either new records or known only to the genus level. We hope that this will encourage study of the lesser known species. Often, species in the vegetable ecosystems were common to soybean. This was particularly true for the natural enemies. However, abundance and species composition of major plant feeders and natural enemies varied according to location, season, crop type and history of insecticide use.

Predators

Because of the behavior and nature of generalist predators, it is difficult to determine the most important ones. While we saw many predation events during the day, many predators are active only at night. The most common predators were ladybeetles, which were found most often associated with aphids. Predatory crickets and grasshoppers also were abundant. These prey on eggs and young, soft-bodied insects. Syrphid larvae also were present in these situations. Many of the small mirid predators, such as *Nisiodiocoris tenuis* (Reuter), feed on plant juices as well as prey on eggs and small soft-bodied insects. Several species of wasps were frequently seen searching the canopies for caterpillars. It was not uncommon to see a large *Polistes* wasp feeding on a cadaver of a caterpillar that had died of a virus. We hope that further studies can be conducted to determine if these wasps and other insects help in the spread of insect diseases, thereby providing an additional biocontrol function.

The most significant shortcoming in our records of predators is the lack of representation by ants, spiders and predatory mites. These groups will require more in depth studies to assess their impact on potential pest species.

Parasitoids

Chemical insecticides adversely impact this diverse and abundant group of natural enemies. The list of parasitoids by Shepard and Barrion (1998) contained only 85 species from collections carried out mainly in Indonesia but this is probably a small representation of the total species to be found in the region. It is clear that some plant-feeders, such as *Omiodes* and *Plutella,* were being held in check by parasitoids. However, because most parasitoids are small and they usually develop inside of their hosts, farmers fail to recognize them as important natural enemies. The pictures contained herein should be helpful for recognizing some of the more common species. By recognizing them, we hope that farmers will want to know more about them.

Insect diseases

In some areas, insect disease outbreaks were keeping pest populations in check. For example, in carrots, the presence of a nuclear polyhedrosis virus (NPV) and the fungus, *Nomuraea rileyi,* kept loopers under control in almost every field we surveyed. Populations of the diamondback moth were being controlled by *Zoopthora radicans* in some cabbage fields in Batu (East Java) and in North Sulawesi. Likewise, *Hirsutella* was abundant on diamondback moth in cabbage in North Sulawesi. An outbreak of a NPV was found infecting *Spodoptera exigua* in shallots in Probolinggo, East Java. This virus is currently the subject of study by farmers who produce it on live hosts and use it to control *S. litura* in shallots on Java, Sumatra and Sulawesi, Indonesia.

We hope that sharing these images with scientists, researchers, extension workers, rural development officers, agricultural trainers and farmers, will open the door for a better understanding of the vegetable and soybean ecosystems, leading to better implementation of IPM to achieve sustainable food security.

Plant-Feeding Arthropods

Figure 1

Name: *Phyllotreta sp.* (Figure 1)
Family: Chrysomelidae
Order: Coleoptera
Common name: Flea beetle
Life cycle: While actual life cycle information is not known, the life cycle of similar species of *Phyllotreta* suggests that eggs are laid in the soil up to a depth of 2-3 cm. Larvae feed on roots and subterranean stems. Pupation takes place in a small cocoon in the soil. Total life cycle from egg to adult lasts about 3-4 weeks. Adult beetles are 2 mm long.
Damage symptoms: Adults feed on leaves, scraping away leaf tissues and making characteristic perforations.
Status as pest: When large populations of flea beetles occur, such perforations make the vegetable unmarketable. The most common vegetables damaged are those belonging to Cruciferae, although some species have been recorded on eggplant (Figure 2).
Important natural enemies: Little is known about natural enemies of this insect.
Other remarks: Several species of flea beetles are recorded and the genus needs revision.

Figure 2

Figure 3

Name: *Aulacophora similis* (Olivier) (Figure 3)
Family: Chrysomelidae
Order: Coleoptera
Common name: Pumpkin beetle
Life cycle: The life life cycle of a similar species suggests that eggs are laid in the soil and larvae feed on the roots (usually cucurbit). Pupation occurs in the soil. Adults are 7 mm long. Complete life cycle from egg to adult of a similar species varies from 45 to 60 days.
Damage symptoms: Adults make characteristic circular feeding marks on the leaves before making holes in them. Larval feeding on the roots often further weaken the plant.
Status as pest: When the pumpkin beetles occur in large numbers, severe defoliation may result.
Important natural enemies: Little is known about natural enemies of the pumpkin beetle.
Other remarks: There may be some confusion about the different species of *Aulacophora,* such as A. *flavomarginata* Duvalier (Figure 4). Often, more than one species occur together.

Figure 4

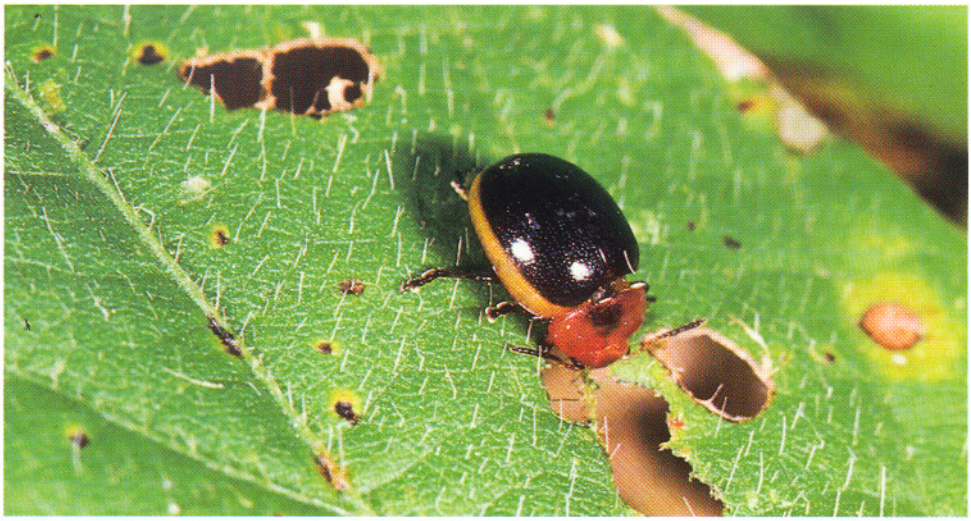
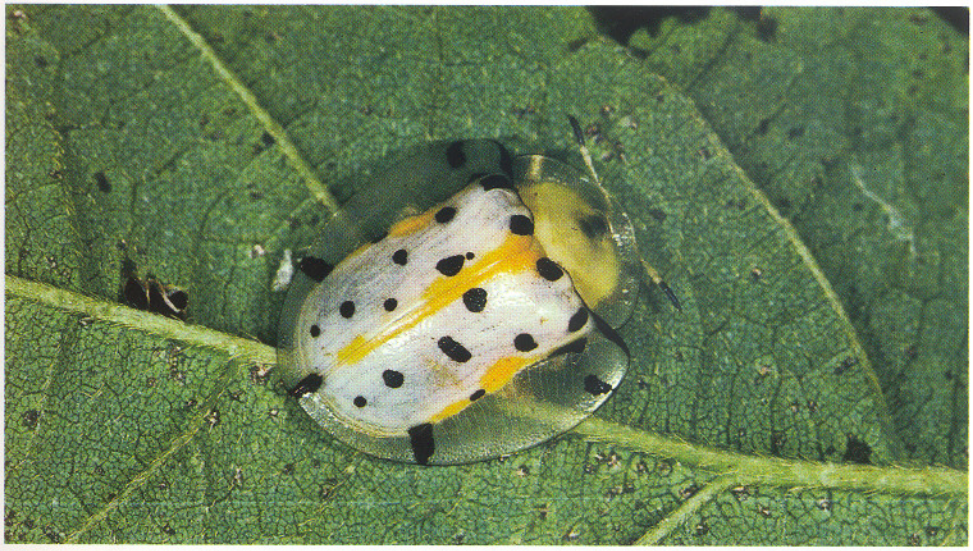


Figure 5

Name: *Phaedonia inclusa* (Stål) (Figure 5)
Family: Chrysomelidae
Order: Coleoptera
Common name: Soybean leaf beetle
Life cycle: Eggs are laid in groups on the under surface of soybean leaves and the egg stage lasts about 4 days. Larvae (Figure 6) pass through 5 developmental stages which last 8 days. Pupation takes place in the soil and adults emerge in about a week. Adults are 4-5 mm in length.
Damage symptoms: Although adults feed on older leaves, the grey colored, slow moving larvae feed on young leaves, flowers and young pods.
Status as pest: Heavy defoliation by this beetle has been reported occasionally, especially in central and eastern Java. Yield losses were attributed to this defoliation.
Important natural enemies: Little information exists on natural enemies of this beetle.
Other remarks: An attempt at importing a pteromalid wasp, *Schizonotus latus* (Walker), did not result in establishment in Indonesia.

Figure 6



Name: *Aspidomorpha miliaris* (F.) (Figure 7)
Family: Chrysomelidae
Order: Coleoptera
Common name: Tortoise beetle

Figure 7

Life cycle: Adults are 9-14 mm in length and often have spotted markings. Eggs are laid in clusters of about 20 within a paper-like substance (ootheca). Larvae hide by carrying remains of their cast skins and fecal matter on their backs. Young larvae cluster together, feeding on the under-surface of older leaves. Larger larvae disperse over the plant. Pupation occurs on the leaf. The total development time varies from 4-6 weeks.
Damage symptoms: Feeding by larvae causes round holes in the leaves, but these beetles are not considered major pests
Status as pest: The insect is commonly associated with plants in the family Convolvulaceae. Figure 8 shows another species on sweet potato.
Important natural enemies: Egg parasitoids appear to be common and probably help to keep the population low. In addition, a larval parasitoid is known from Indonesia and India.
Other remarks: Many species of tortoise beetles are shiny metallic or gold-colored.

Figure 8

Name: *Dactylispa sp.* (Figure 9) **Figure 9**
Family: Chrysomelidae
Order: Coleoptera
Common name: Hispa beetles, spiny chrysomelids, hedgehog beetles
Life cycle: Hispa beetles are small (5 mm), dark beetles covered with spines. The species shown is found in soybean but normally does not cause important damage.
Damage symptoms: Larvae mine leaves and are concealed within the leaves where they also pupate.
Status as pest: Not important
Other remarks: Mining of leaves may cause farmers to use chemical insecticides.

Name: *Hypomeces squamosus* (F.) (Figure 10) **Figure 10**
Family: Curculionidae
Order: Coleoptera
Common name: Gold dust weevil
Life cycle: Eggs of this weevil are laid singly in the soil. Larvae develop on roots of weeds or crop plants. Pupation occurs in the soil. Adults are about 14 mm long. Exact life cycle is still unknown.
Damage symptoms: Adult weevils feed on foliage and may cause considerable defoliation.
Status as pest: Often a minor problem in tree crops such as mango.
Important natural enemies: Little is known about its natural biological control. A tachinid fly has been reported to attack the larval stage.
Other remarks: Often found mating on foliage.

Figure 11

Name: *Cylas formicarius* (F.) (Figure 11)
Family: Apionidae
Order: Coleoptera
Common name: Sweet potato weevil
Life cycle: Eggs are laid in cavities made on the vines and tubers. The egg stage lasts 3 - 7 days. Larvae (Figure12) feed on vines and tubers of sweet potato and larval stages are completed in 21-26 days. Pupation takes place inside the tuber and the pupal stage is completed in 7 - 11 days. Adult weevils are about 7 mm long.
Damage symptoms: Weevils feed on leaves, vines and tubers of sweet potato. Larvae bore into tender vines and tubers making the latter unmarketable.
Status as pest: This insect can be a serious problem, especially when sweet potato tubers are being stored.
Important natural enemies: Little is known about natural enemies of this insect but the fungus, *Beauveria bassiana,* has been found infecting adults (Figure 256).
Other remarks: This weevil also attacks other plants related to potatoes (Solanaceae).

Figure 12

Name: *Epilachna vigintioctopunctata* (F.) (Figures 13-15)
Family: Coccinellidae
Order: Coleoptera
Common name: Leaf-feeding ladybird beetle
Life cycle: Yellow spindle-shaped eggs are laid in clusters of 15-50, usually on the upper surface of leaves. Egg stage lasts 2-4 days and development of four larval instars (Figure 14) is completed in 16-18 days. Pupation occurs on the plant (Figure 15) and adults emerge about 4-6 days later.
Damage symptoms: Adults and larvae feed on leaves of plants belonging to the family Cucurbitaceae and Solanaceae. Skeletonized leaves (Figure 16) usually dry out.
Status as pest: Usually not an important pest although high populations have been observed in potato in West Sumatra, Indonesia.
Important natural enemies: Besides heavy rains that reduce field populations of the beetle, natural enemies are important in keeping this insect in check. Egg parasitoids belonging to the genus *Tetrastichus* have been reported to kill 70% of the eggs while 30-55% of larvae and pupae are attacked by another eulophid, *Pediobius* sp. Several other parasitoids, predators and pathogens are known to attack this beetle.
Other remarks: Larvae have a characteristic feeding pattern on the under surfaces of leaves, scraping away the green tissue and leaving behind windows with leaf veins showing. This genus of coccinellid is the only one in the family whose members are plant feeders. The insect is differentiated from aphid-feeding ladybeetles of similar size by the covering of fine hairs on the wings, giving them a dull appearance. A similar species, *Epilachna sparsa 28-punctata,* was reported on soybean (Figure 17) and its larvae feed on soybean leaves.

Figure 13

Figure 14

Figure 15

Figure 16

Figure 17

Figure 18

Name: Cockchafers (Figures 18-20)
Family: Scarabaeidae
Order: Coleoptera
Common name: Cockchafers
A number of scarabaeid beetles are found in soybean and vegetable crops. The adults are active only at night. Damage to the leaves is characteristic with large holes and skeletonized patterns. Larvae live in the soil where they feed on organic matter but sometimes on plant roots. An *Anomala* sp. (Figure 18) is common on eggplant and another unknown species (Figure 19) has been found on cabbage.

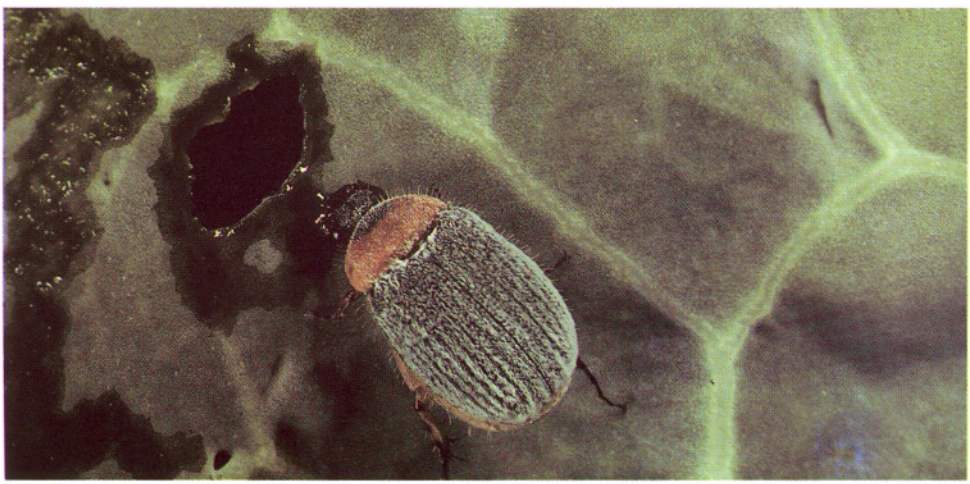


Figure 19

Figure 20

Name: *Adoretus compressus* (Weber) (Figure 20)
Family: Scarabaeidae
Order: Coleoptera
Common name: Brown cockchafer
Damage symptoms: Feeding on leaves at night can be extensive.
Other remarks: Because of the habit of feeding at night, farmers are often puzzled as to what is causing the damage because the adults hide during the day.

Figure 21

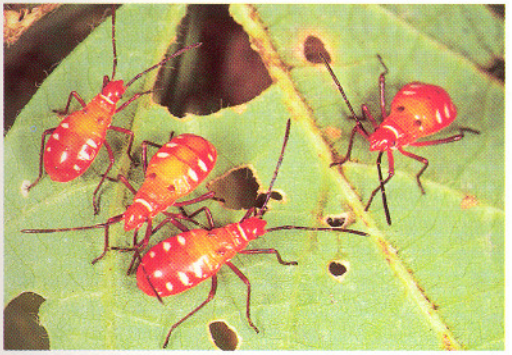


Figure 22

Name: *Dysdercus cingulatus* (F.) (Figures 21-22)
Family: Pyrrhocoridae
Order: Hemiptera
Common name: Cotton stainer
Life cycle: Eggs are laid in clusters of 100 in the soil under the food plant, in small superficial holes. High humidity is essential for egg development. The egg stage lasts 6 days. The five nymphal stages (Figure 22) are completed in 25-27 days. Adults are 11-17 mm long.
Damage symptoms: Older nymphs and adults suck sap from pods and seeds mainly from plants belonging to the family Malvaceae and Bombacaceae. Pyrrhocorids pictured here were found on soybean.
Status as pest: Can develop into a serious pest under suitable conditions.
Important natural enemies: Natural enemies of *Dysdercus* spp. include soil dwelling predators such as carabid beetles and reduviid bugs. Tachinid parasitoids are known to attack this insect.
Other remarks: Better known as a pest of cotton, it attacks vegetables in the hibiscus (Malvaceae) family, such as okra.

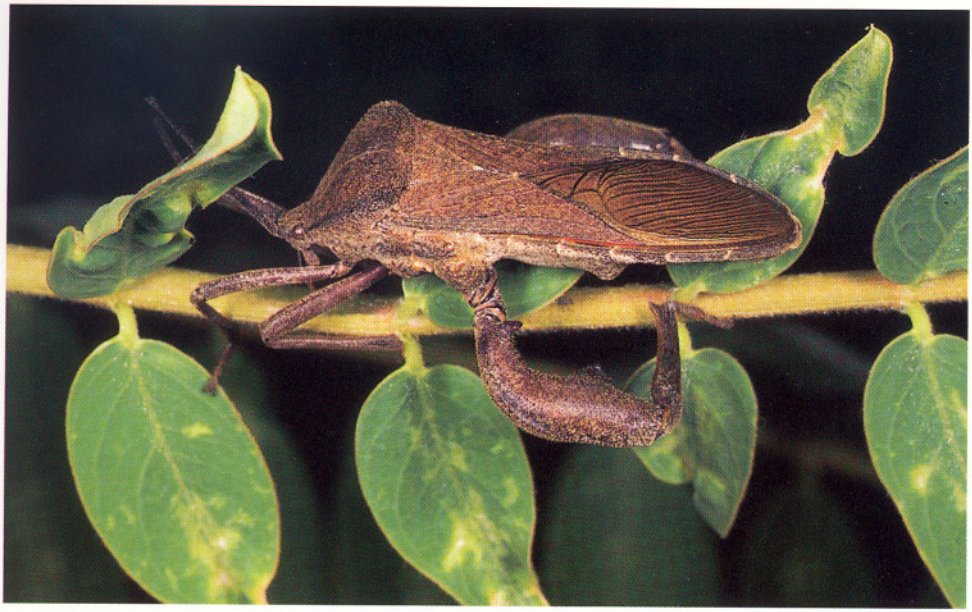


Figure 23

Figure 24

Name: *Anoplocnemis phasiana* (F.) (Figures 23-24)
Family: Coreidae
Order: Hemiptera
Common name: Legume pod bug
Life cycle: A. *phasiana* is a large (20-25mm) brownish to brownish black coried bug. Eggs are laid in clusters. The small nymphs cluster together and gradually disperse as they mature. The bug is associated with a wide variety of plants.
Damage symptoms: It occasionally feeds on terminals of soybean, mungbean, longbean and other legumes.
Status as a pest: Populations do not normally build up to large numbers.
Important natural enemies: Not well studied.
Other remarks: The male (Figure 23), is easily distinguished from the female (Figure 24) by the enlarged femur (upper leg) of the hind legs.

Name: *Physomerus grossipes* (F.) (Figure 25)
Family: Coreidae
Order: Hemiptera
Common name: Red-striped bug
Life cycle: Adults are 19-22 mm long. Eggs are deposited in clusters and take about 17 days to hatch. There are 5 nymphal instars lasting 61 days.
Damage symptoms: Feeding on young parts of plants in the family Convolvulaceae results in wilting and eventual drying up.
Status as pest: Not considered a serious pest.
Important natural enemies: Like many other coreids, this insect has natural enemies attacking it in the egg, nymphal and adult stages.
Other remarks: Females often position themselves over their egg clusters to protect them from predators and parasitoids. Because of this behavior, often only eggs along the edge of the cluster are parasitized.

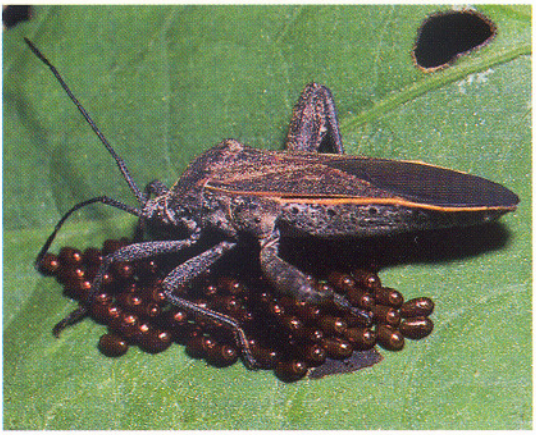


Figure 25

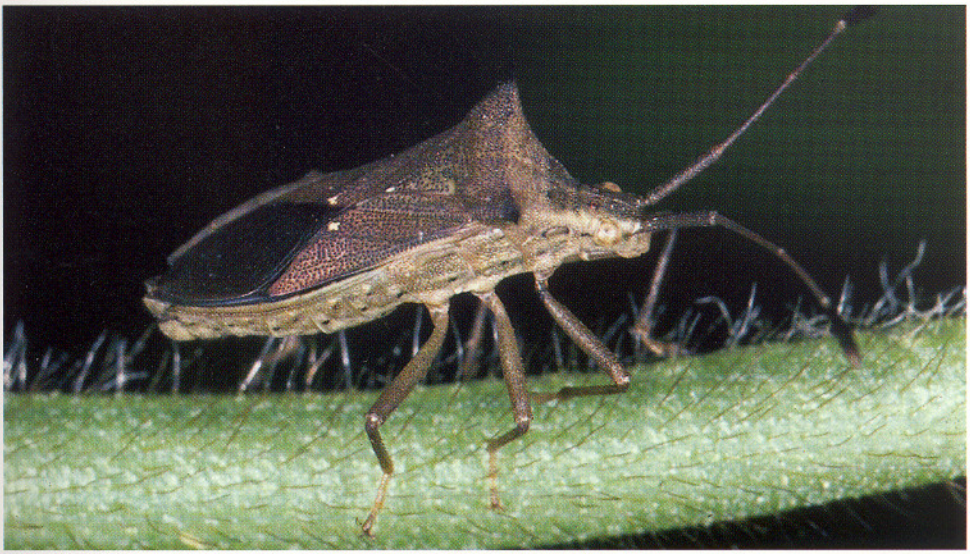
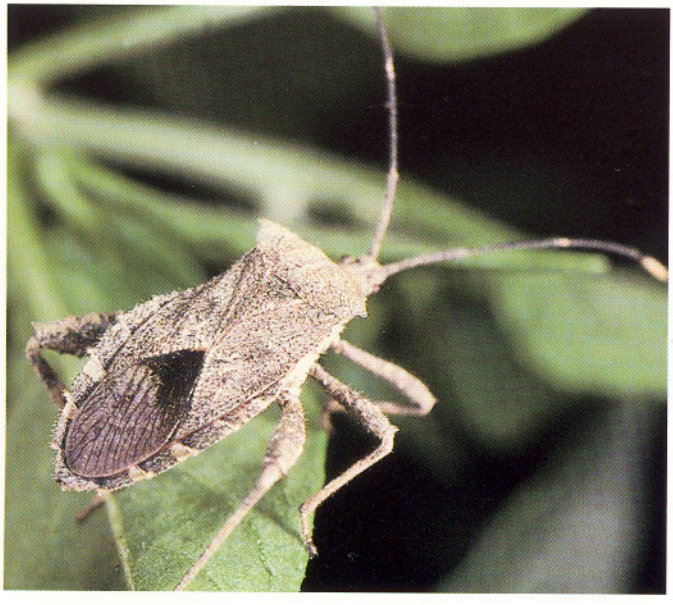


Figure 26

Name: *Cletus bipunctatus* (Westwood) (Figure 26)
Family: Coreidae
Order: Hemiptera
Common name: Spined legume bug
Life cycle: Adults are 9-10 mm. Little is known about the life cycle of this species. In related *Cletus* spp., eggs are laid singly on flowers. The egg stage lasts about 8 days. There are usually 5 nymphal stages which are completed in 18-28 days.
Damage symptoms: This bug feeds on young seedlings and pods of soybean and mungbean but does not cause visible damage.
Status as pest: Although common in legumes, it is not a pest.
Important natural enemies: Little is known about its natural enemies.
Other remarks: Found on many kinds of weeds.

Name: *Leptoglossus gonagra* (F.) (Figure 27) **Figure 27**
Family: Coreidae
Order: Hemiptera
Common name: Leaf-footed plant bug
Life cycle: Life cycle is completed in about 40 days on fruits of Cucurbitaceae, including bitter gourd *(Momordica charantia).* Eggs are laid in strings of varying numbers. The egg stage lasts 4-8 days. There are 5 nymphal stages completed in about 30 days. Adults are 17-20 mm long.
Damage symptoms: High populations have been observed in cucumbers in Indonesia. Feeding on the young fruit causes distortion as fruit matures.
Status as pest: Populations build up only in localized situations.
Important natural enemies: Little is known about its natural enemies.
Other remarks: The underside of the bug is brilliantly-colored with reddish spots.



Name: *Acanthocoris scabrator* (F.) (Figure 28)
Family: Coreidae
Order: Hemiptera
Common name: Plant bug.
Adults (12 - 15 mm) occur in groups and are mostly found feeding on non-crop host plants such as *Ipomea* and nightshades. They feed only occasionally on crops such as pepper and are not considered pests. Little is known about this insect.

Figure 28

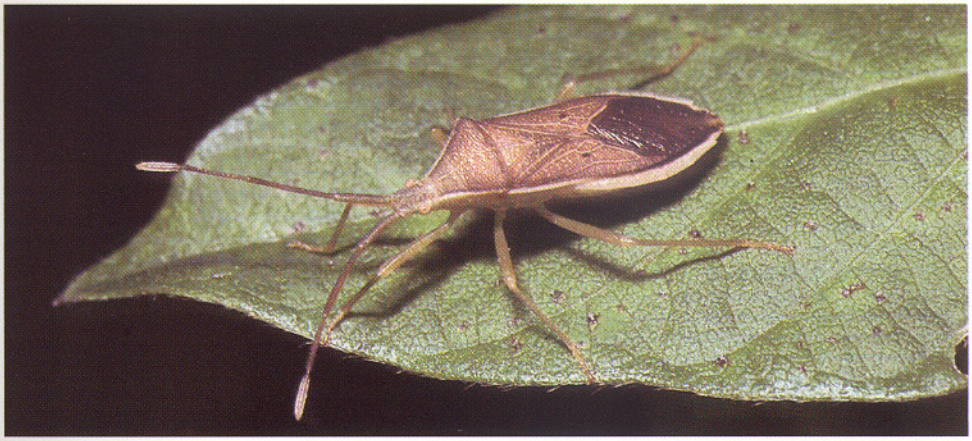


Figure 29

Name: *Homoeocerus marginellus* (Herrich-Schaeffer) (Figure 29)
Family: Coreidae
Order: Hemiptera
Common name: Margined legume bug
H. marginellus is a brownish green bug (11 - 14 mm) with a small black dot on each of the forewings. It feeds on legumes and cabbage but does not appear to cause extensive damage. Little is known about the biology and ecology of this species.

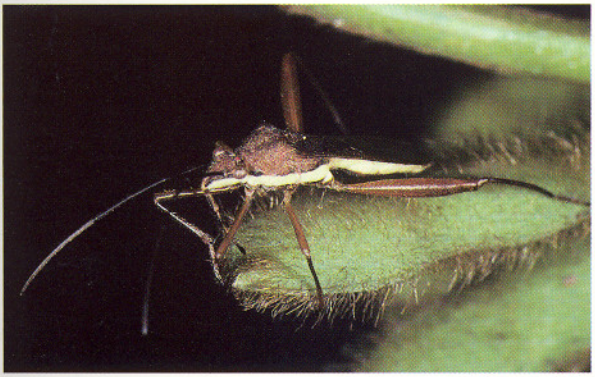


Figure 30

Figure 31

Name: *Riptortus linearis* (L.) (Figures 30-31)
Family: Alydidae
Order: Hemiptera
Common name: Soybean pod bug
Life cycle: Eggs are deposited singly on the under surface of leaves and pods of food plants such as soybean, other members of the bean family, and several Solanaceae and Convolvulaceae. Nymphs feed on pods (Figure 31) and the total development stage from egg to adult takes about 29 days.
Damage symptoms: Damage to developing pods is significant in soybean when populations of the insect are high.
Status as pest: An important pod-sucking pest which can cause damage when present in combination with other pod-sucking bugs.
Important natural enemies: Egg parasitoids are known in Java, but little is known about other natural enemies.

Figure 32

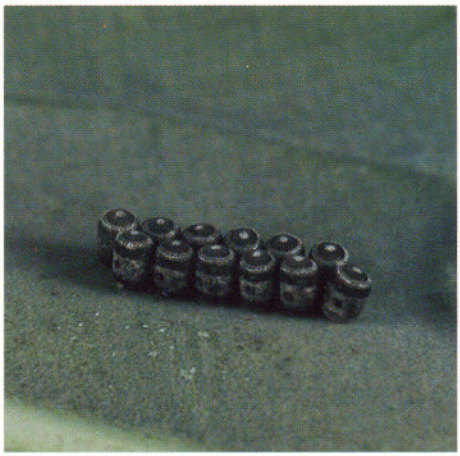


Figure 33

Figure 34

Figure 35

Name: *Eurydema pulchrum* (Westwood) (Figures 32-34)
Family: Pentatomidae
Order: Hemiptera
Common name: Cabbage shield bug
Life cycle: Egg-masses are laid in two rows of about 12 cylindrical eggs (Figure 33). The egg stage lasts about 6 days. There are 5 instars lasting about 28 days (Figure 34). Adults (7 mm) are colorful with orange, black and white markings.
Damage symptoms: Feeding by nymphs and adults causes white necrotic spots (Figure 34) on the leaves of crucifer crops such as cabbage and cauliflower. Damage is localized and confined to the older, outer leaves.
Status as pest: Rarely a serious pest.
Important natural enemies: Little is known about its natural enemies.
Other remarks: Besides crucifers, this insect is found on flowering weeds. A related *Eurydema* species (Figure 35) has been observed on peppers.

Name: *Plautia affinis* Dallas (Figure 36)
Family: Pentatomidae
Order: Hemiptera
Common name: Brown-winged stinkbug.
Damage symptoms: Feeds on the pods of chillies.
Other remarks: Little is known about the biology and ecology of this insect.

Figure 36

Figure 37

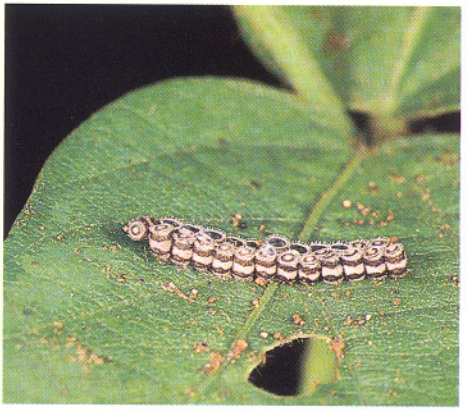


Figure 38

Figure 39

Name: *Piezodorus hybneri* Gmelin (Figures 37-39)
Family: Pentatomidae
Order: Hemiptera
Common name: Legume shield bug
Life cycle: Eggs are laid in clusters of two rows on leaves, stems or pods. Each egg cluster contains 9-42 eggs. The egg stage (Figure 38) lasts about 4 days. Initially, nymphs stay together after hatching but disperse as they mature. There are 5 nymphal stages lasting 14-22 days (Figure 39). Adults are about 10 mm long.
Damage symptoms: Both adults and nymphs feed on pods of legumes.
Status as pest: Damage is sometimes caused in soybean and mungbean.
Important natural enemies: Egg parasitoids and predators are important control factors if chemical insecticides are avoided.
Other remarks: Feeding symptoms on soybean pods are similar to those caused by other pod-sucking insects such as *Nezara viridula* and *Riptortus linearis*. *P. hybneri* usually occurs together with *N. viridula* and *R. linearis*.

Name: *Nezara viridula* (L.) (Figures 40-46)
Family: Pentatomidae
Order: Hemiptera
Common name: Green stink bug
Life cycle: Eggs are laid in clusters of 10-90 on undersides of leaves. The eggs (Figure 41) turn reddish a few days before the nymphs hatch. The egg stage lasts 5-7 days. The brightly colored nymphs pass through 5 instars in 21-28 days (Figures 42, 43, 44). Adults are about 16 mm long.
Damage symptoms: A wide range of plants is attacked, especially legumes. Feeding on pods results in damaged seeds.
Status as pest: An occasional pest.
Important natural enemies: Three species of egg parasitoids have been reported in Java, namely: *Ooencyrtus malayensis* Ferriere, *Trissolcus basalis* (Gahan) and *Telenomus sp.* Other natural enemies, particularly predators, impact this bug and often keep its populations low. Eggs and first instar nymphs are favored by generalist predators.
Other remarks: The green stink bug is as common as *Piezodorus* in soybean fields but is larger and brighter green. Adults may occur in different color morphs, e.g., this yellow form, *Nezara viridula torquata* (F.) (Figure 45) and green adults with yellow shoulders (Figure 46).

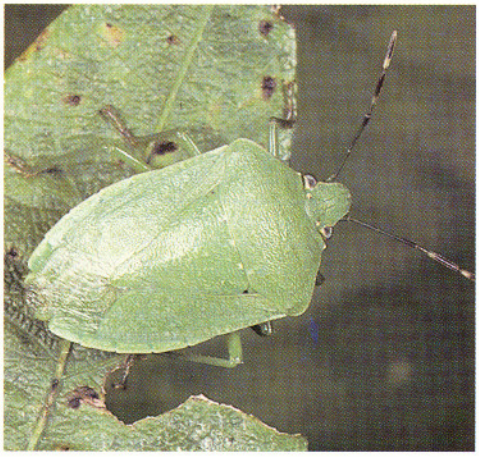


Figure 40

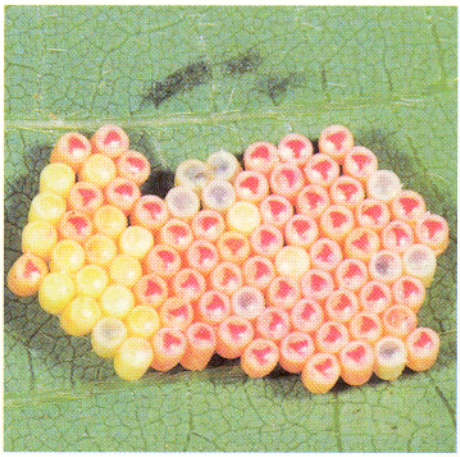


Figure 41

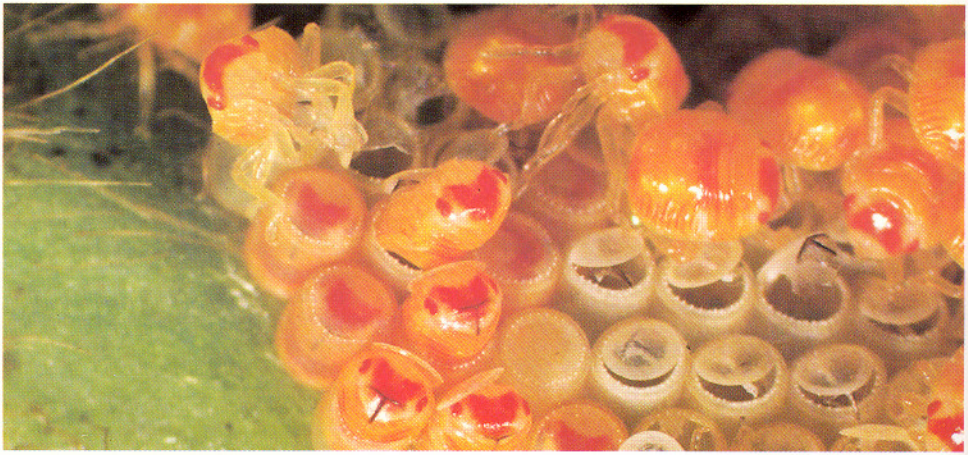


Figure 42

Figure 43

Figure 44

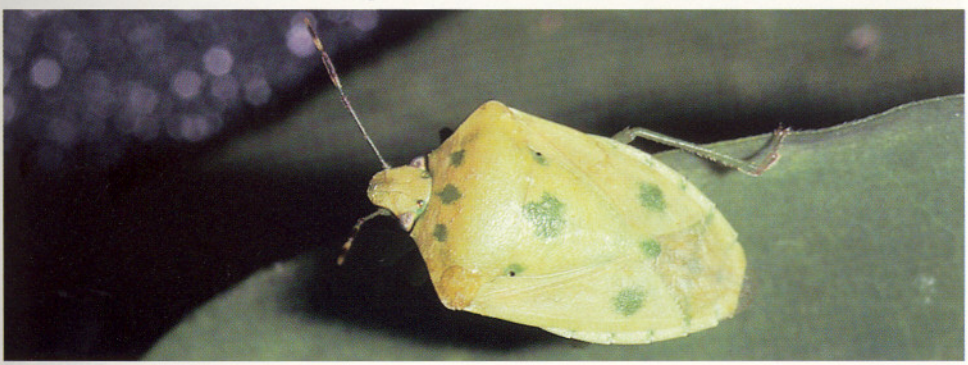


Figure 45

Figure 46

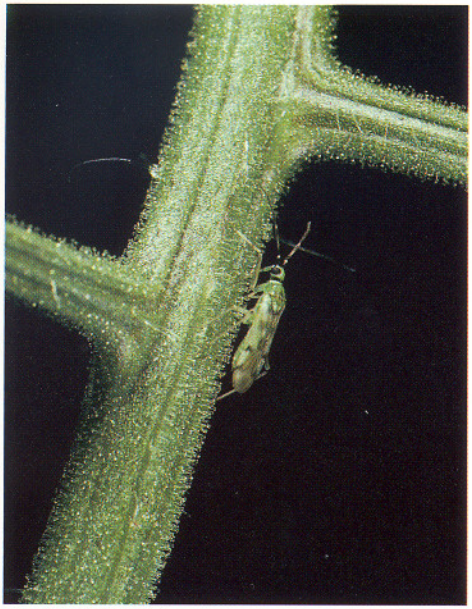


Figure 47

Name: *Nisiodiocoris tenuis* (Reuter) (Figure 47)
Family: Miridae
Order: Hemiptera
Common name: Green tobacco capsid
Life cycle: Adults are 2.5-3.5 mm long. Eggs are laid on the under surface of leaves or inserted into leaf veins. Nymphs feed at the site of hatching. The total development from egg to adult lasts 26-33 days.
Damage symptoms: This insect feeds on the stems of tomato blooms causing a girdling effect that results in flower drop. Leaf damage has been reported in tobacco.
Status as pest: The impact of bloom drop on yield is not known.
Important natural enemies: Little is known about the natural enemies of this insect.
Other remarks: Like many mirids, this insect has dual feeding habits as a plant feeder and predator, feeding occasionally on small insects, eggs and young caterpillars or nymphs of whiteflies.

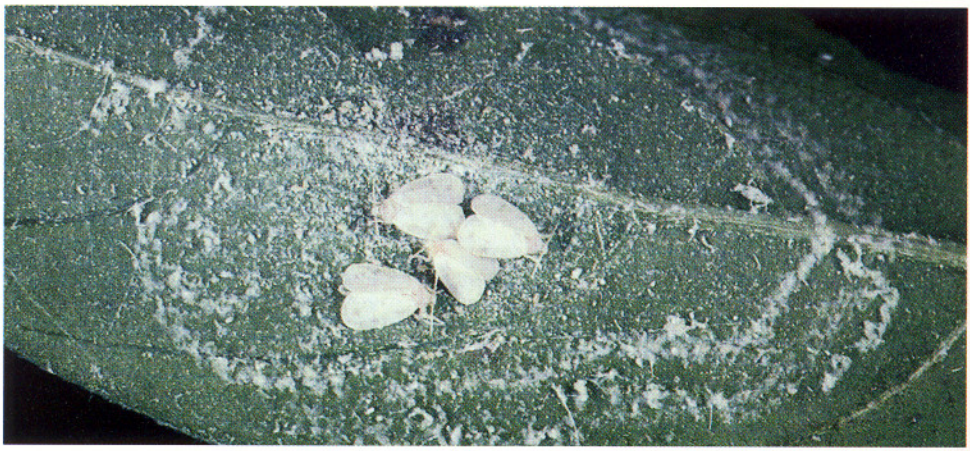


Figure 48

Name: *Aleurodicus dispersus* Russell (Figure 48)
Family: Aleyrodidae
Order: Homoptera
Common name: Spiraling whitefly
Life cycle: Adults (2 mm) lay eggs in circular patterns of waxy secretions, usually on the under surfaces of leaves. The egg stage takes about 7 days. The larval stages involve 4 instars which are completed in about 30 days. Although the first instar is mobile, the other larval instars do not move.
Damage symptoms: Besides dehydrating the plant from feeding by large populations, whiteflies produce honeydew which encourages growth of sooty mold. This blocks light necessary for normal plant growth.
Status as pest: This insect feeds on many different plants. In Indonesia, its pest status has declined following adaptation of local natural enemies as well as those that were introduced along with the pest. Introduced parasitoids also are effective in some countries.
Important natural enemies: Effective parasitoids such as *Encarsia* nr. *haitiensis* Dozier may have arrived with the whitefly.

Figure 49

Figure 50

Figure 51

Name: *Trialeurodes vaporariorum* (Westwood) (Figures 49-50)
Family: Aleyrodidae
Order: Homoptera
Common name: Common whitefly
Life cycle: Eggs are laid upright, attached to the leaf by a pedicel. Egg stage lasts about 7 days. Nymphs (Figure 50) take up to 14 days to complete their development. Adults are often covered with white powdery substance and measure 1-1.5 mm.
Damage symptoms: Besides direct damage from large numbers of whiteflies feeding, this insect is a vector of several plant diseases.
Status as pest: Occasionally an important pest of vegetables and soybean.
Important natural enemies: In Java, two species of parasitic wasps and a small coccinellid *(Scymnus sp.)* are recorded as natural enemies. An Entomophthorales (Figure 248) fungus is commonly found infecting whiteflies in beans and tomatoes.
Other remarks: There are other whiteflies that resemble *T. vaporariorum* in morphology and damage caused. One of them is *Bemisia tabaci* (Figure 51).

Figure 52

Name: *Stenocranus bakeri* (Muir) (Figure 52)
Family: Delphacidae
Order: Homoptera
Common name: Maize planthopper
Damage symptoms: Brown necrotic spots on leaves are caused by feeding by nymphs and adults.
Status as pest: No clear relationship has been shown between populations of the planthoppers and yield.
Important natural enemies: A fungus, *Hirsutella* sp., (Figure 255) was observed causing extensive mortality in planthopper populations. Spiders and other predators also may be important in regulating planthopper populations.

Figure 53

Name: *Empoasca* sp. (Figure 53)
Family: Cicadellidae
Order: Homoptera
Common name: Green jassid
Damage symptoms: Adults are about 2.5 mm long. They are often found on the under surface of leaves. Feeding by nymphs (Figure 54) and adults on the leaves results in whitish, yellowish or reddish spots and large numbers of these jassids may cause leaves to curl and dry up.
Status as pest: This insect is only an occasional pest on vegetables and soybean.
Important natural enemies: It is likely that predators are important in controlling nymphs of this pest. Also, a fungus, (Entomophthorales) has been found infecting adult jassids.
Other remarks: Several species of jassids occur on vegetables and soybean.

Figure 54

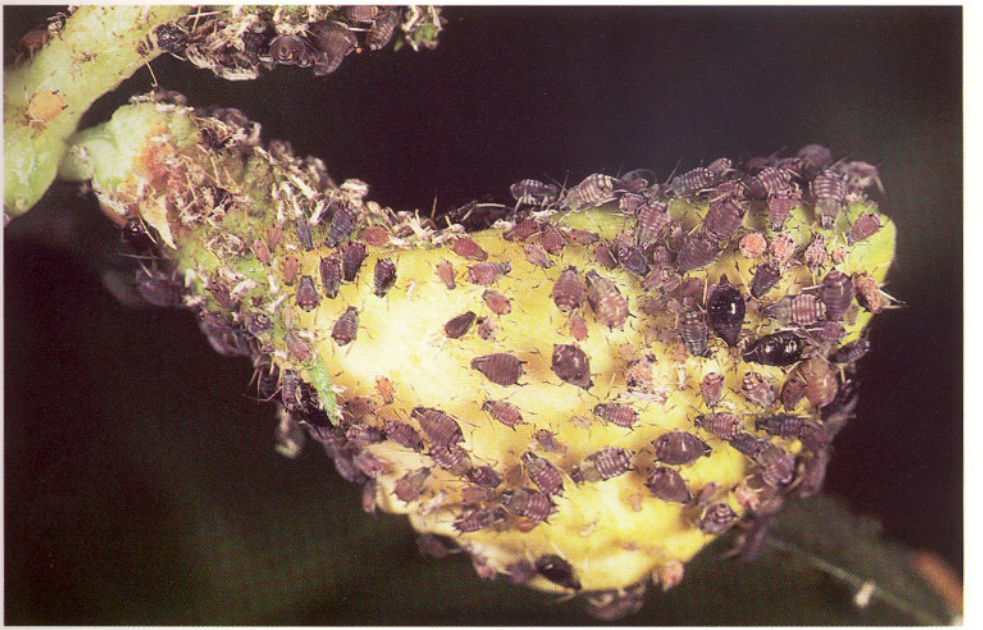


Figure 55

Name: *Aphis craccivora* Koch (Figure 55)
Family: Aphididae
Order: Homoptera
Common name: Legume aphid
Life cycle: Like many tropical aphids, *A. craccivora* can reproduce without mating. Young nymphs pass through 4 molts to become adults in 5-8 days. Adults are1.4-1.9 mm long.
Damage symptoms: Besides direct removal of plant sap, this aphid is known to transmit about 30 plant viruses including viruses of beans, cucurbits and crucifers. It is also reported to transmit groundnut viruses. Indirect damage from the build-up of sooty mold, which grows on the sugary secretions, also can affect plant growth.
Status as pest: Year-round suitable climate promotes build-up of populations on several crops especially longbean.
Important natural enemies: Ladybeetles and syrphid larvae are voracious predators of this aphid but often fail to control populations. A beneficial fungus, Entomophthorales, has been found infecting these aphids in Indonesia.
Other remarks: This aphid feeds on many plant species, with a marked preference for legumes.

Name: *Aphis glycines* Matsumura (Figure 56)
Family: Aphididae
Order: Homoptera
Common name: Soybean aphid
Life cycle: Adult aphids are 1-1.6 mm in length. Adults do not lay eggs, but bear live young.
Damage symptoms: This small yellow-green species feeds on developing shoots, stems and pods of soybean. This aphid may affect yields if plants are attacked when they are young. It transmits several viruses in soybeans.
Important natural enemies: Although high populations of this aphid can occur in young soybean, natural enemies, especially ladybeetles and syrphids usually keep aphid populations in check as the crop matures.
Other remarks: The picture shows several immature stages and winged adults together with numerous white cast skins that were shed as the aphids molted to the next stage of development.

Figure 56

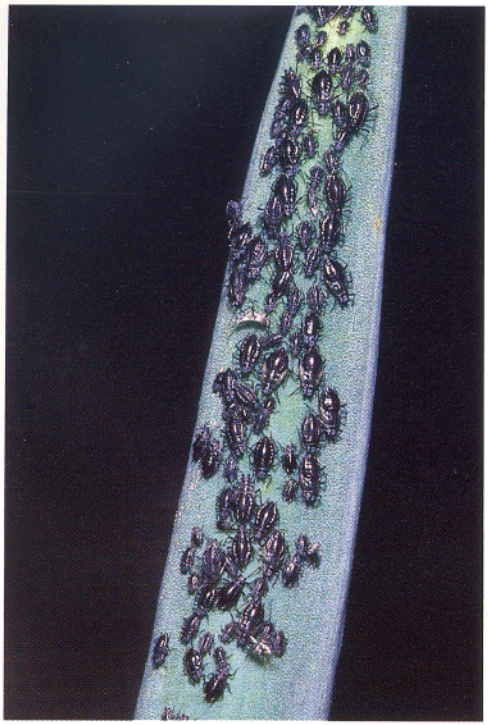


Figure 57

Name: *Neotoxoptera formosana* (Takahashi) (Figure 57)
Family: Aphididae
Order: Homoptera
Common name: Black onion aphid
Damage symptoms: These aphids (1.6 - 2.3 mm as adults) form dense colonies and can reduce the value of the crop due to feeding and because of the physical presence of the aphids, especially on leaf onions.
Status as pest: *N. formosana* is a common aphid on shallots and leaf onions especially in upland areas. It prefers shaded areas, such as covered seedbeds and shade from trees.
Other remarks: *N. formosana* is difficult to separate from a closely related black aphid, *N. oliveri* (Essig).

Name: *Aphis gossypii* Glover (Figure 58)
Family: Aphididae
Order: Homoptera
Common name: Cotton aphid
Damage symptoms: Adults (0.9 - 1.8mm) and nymphs feed on shoots and leaves. Although localized populations may cause direct damage to the plant, transmission of viruses is much more important.
Status as pest: A. *gossypii* is found on a wide variety of vegetable crops, including chilli peppers. It is considered a serious pest because even low populations are capable of extensive transmission of plant viruses.
Important natural enemies: As with other aphids, ladybeetles and syrphids are associated with A. *gossypii.*
Other remarks: This aphid is similar to the green peach aphid, *Myzus persicae* (Sulzer), which also is a serious pest of chilli peppers due to its ability to transmit viruses.

Figure 58

Figure 59

Name: *Rhopalosiphum maidis* (Fitch) (Figure 59)
Family: Aphididae
Order: Homoptera
Common name: Maize aphid
Life cycle: Adults are 0.9 - 2.4 mm and females produce from 1 - 9 nymphs per day.
Damage symptoms: Populations can be dense but localized. Production of honeydew excreted by the aphids may cause sooty mold to form on the leaves. This aphid may transmit viruses.
Status as pest: Little is known about the pest status of this insect.
Other remarks: Colonies of this aphid attract predatory insects such as syrphids, coccinellids, and fungi, including *Verticillium* (Figure 258) and Entomophthorales.

Figure 60

Name: *Macrosiphum euphorbiae* (Thomas) (Figure 60)
Family: Aphididae
Order: Homoptera
Common name: Potato aphid
Damage symptoms: This aphid vectors more than 45 plant viruses, including potato leaf roll virus. In addition, dense colonies can cause severe defoliation.
Status as pest: Localized dense populations and virus vectoring ability make this insect important.
Other remarks: In some areas, reproduction can occur without mating.

Figure 61

Name: *Planococcus* sp. (Figure 61)
Family: Pseudococcidae
Order: Homoptera
Common name: True mealybug
Damage symptoms: Pseudococcidae are often referred to as true mealybugs because of the white wax covering the body. Wingless females are 1.2-5 mm long. Both adults and larvae feed on plant sap and excrete large quantities of honeydew, which may encourage growth of sooty mold on the leaves.
Status as pest: Not generally considered an important pest.
Other remarks: This mealybug occurs commonly on soybean. Little is known about its natural enemies. Several species occur in the region.

Name: *Crocidolomia binotalis* Zeller (Figures 62-65)
Family: Pyralidae
Order: Lepidoptera
Common name: Cabbage heart caterpillar, cabbage webworm
Life cycle: Eggs are laid in clusters arranged like roof tiles in an overlapping manner (Figure 63) and hatch in 4-5 days. Upon hatching, larvae feed together (Figure 64) on leaves and complete 5 instars in about 12 days. When full grown (16-19 mm long), larvae (Figure 65) move to pupate in the soil. The pupal stage lasts about 10 days.
Damage symptoms: Feeding by large numbers of larvae in the growing point of cabbages results in unmarketable cabbage heads (Figure 66).
Status as pest: In areas where this pest is established, it is a major pest of cabbage, causing important yield losses; indigenous biocontrol agents may not be able to keep it in check.
Important natural enemies: Two species of tachinids, three species of ichneumonids and a braconid have been reported as parasitoids of this insect. Also, two fungi, *Nomuraea rileyi* and *Erynia* sp. (Figure 242), have been observed infecting larvae.
Other remarks: In small fields, regular handpicking of egg masses in combination with spot applications of *Bacillus thuringiensis* has been found to be effective in reducing damage by C. *binotalis*.

Figure 62

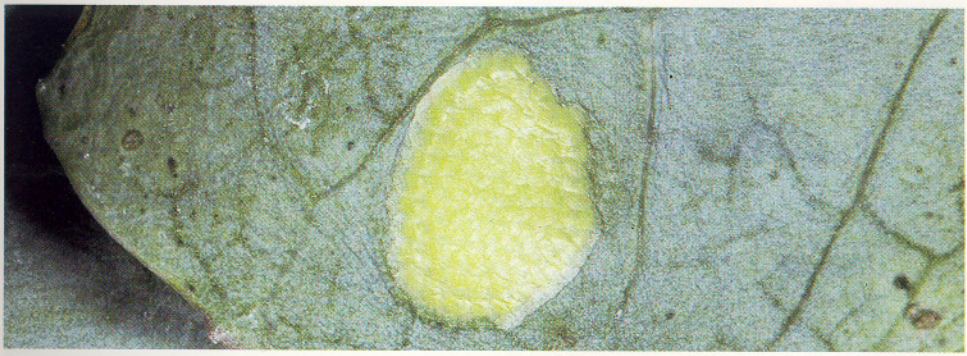


Figure 63

Figure 64

Figure 65

Figure 66

Figure 67

Name: *Hellula undalis* (F.) (Figure 67)
Family: Pyralidae
Order: Lepidoptera
Common name: Cabbage webworm
Life cycle: Eggs are laid singly or in a row on cabbage plants. Larvae (up to 14 mm long) can be recognized by several dark stripes along the back and sides of the body. Larvae mine the leaf midribs or feed inside the cabbage heart under protective silken webs. Pupation occurs inside a cocoon made of soil just below the soil surface. Total development time from egg to adult is 23-25 days.
Damage symptoms: Feeding is concentrated in the heart of young cabbage plants, unlike *C. binotalis*, which can affect the cabbage plant at any growth stage.
Status as pest: Feeding on young cabbage plants may result in loss of marketable cabbage heads. This insect is often considered a serious pest in lowland crucifers, but is less serious in upland areas.
Important natural enemies: Little is known about natural enemies of this insect.

Name: *Etiella zinckenella* (Treitschke) (Figures 68-71)
Family: Pyralidae
Order: Lepidoptera
Common name: Soybean podborer
Life cycle: Eggs, which can hardly be seen with the naked eye, are laid singly or in small groups at the under surface of calyx and sepals of well-grown pods (Figure 69). Upon hatching, larvae bore into the pods and feed on the seeds (Figure 70). There are 3 instars which are completed in 13-18 days. When full grown, larvae emerge from pods and pupate in the soil (Figure 71). Complete development from egg to adult takes about 40 days.
Damage symptoms: Feeding by larvae reduces the number of harvestable pods. Infested pods may look normal from the outside so the damage is often overlooked until harvest.
Status as pest: A major pest of soybean and other legumes in most parts of Southeast Asia.
Important natural enemies: Feeding within the pod helps to protect larvae from predators but larvae are parasitized by several species of ichneumonid and braconid wasps.
Other remarks: The most common host in the wild is *Crotalaria.* A second species of *Etiella* from Indonesia is *E. hobsoni* Butler (Figure 72). It is more common on Sumatra, and West and Central Java. Often both species occur together. In staggered plantings of soybean, the latest planted crop suffers substantially more damage than earlier planted ones.

Figure 68

Figure 70

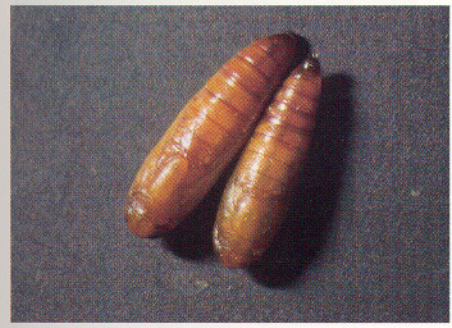


Figure 71

Figure 69

Figure 72

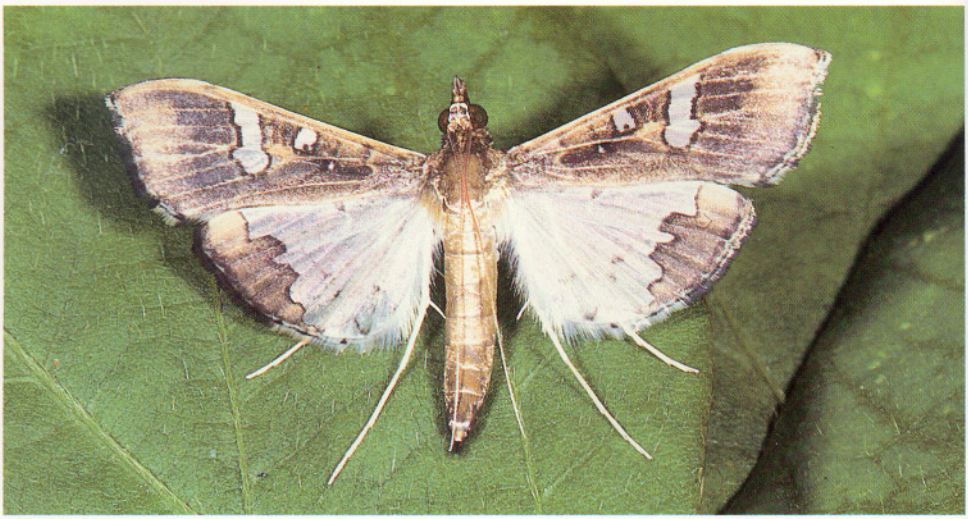


Figure 73

Figure 74

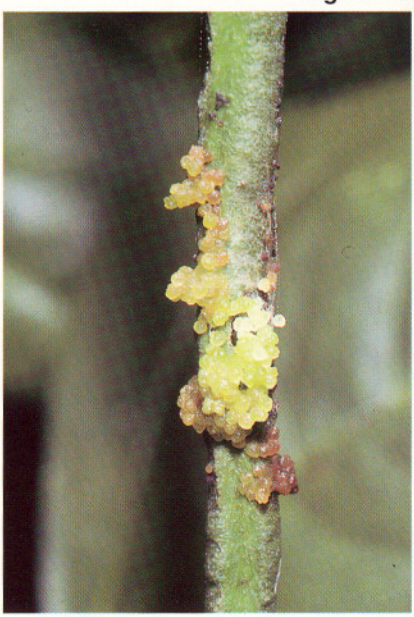


Figure 75

Name: *Maruca vitrata (= testulalis)* (Geyer) (Figures 73-74)
Family: Pyralidae
Order: Lepidoptera
Common name: Legume podborer
Life cycle: Eggs are deposited on flower buds, flowers and young pods. Egg stage lasts 2-3 days. There are 5 larval instars lasting around 13 days. Full-grown caterpillars (Figure 74) may grow up to 16 mm in length. Pupation occurs within a silken cocoon in the pod, webbed leaves or in the soil. Pupal period varies from 6-9 days.
Damage symptoms: Larvae feed on floral buds, young pods, leaves and shoots of legumes. Frass on the outside of the pod (Figure 75) is characteristic of *Maruca* - infested pods.
Status as pest: Often considered an important pest of leguminous vegetables in some countries. However, this may be true only in specific cases.
Important natural enemies: *Baeognatha* sp. and *Cotesia* sp. commonly parasitize the larvae.

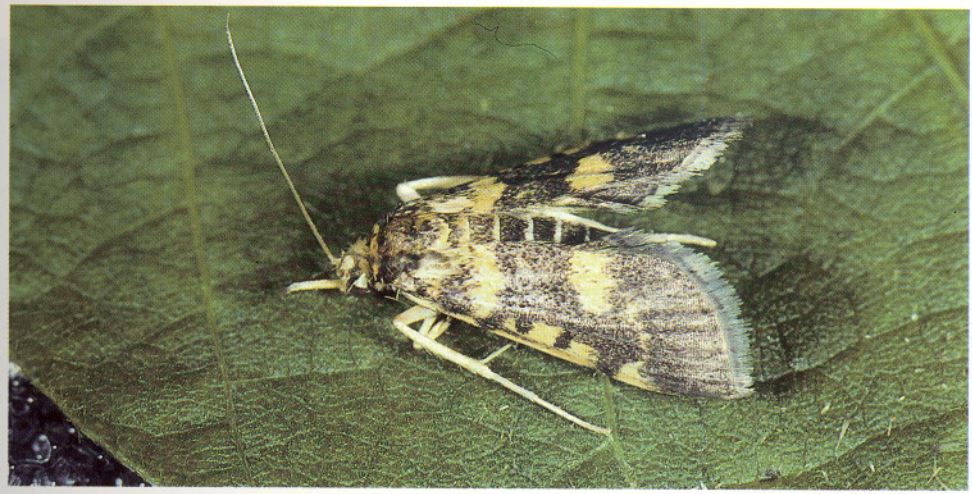


Figure 76

Figure 77

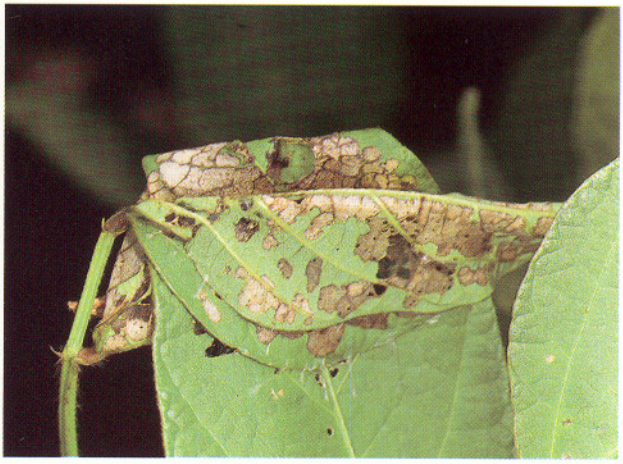


Figure 78

Name: *Omiodes indicata* (F.) (Figures 76-77)
Family: Pyralidae
Order: Lepidoptera
Common name: Soybean leaffolder
Damage symptoms: Larvae (Figure 77) web leaves together, especially those at the top of the plant and skeletonize the leaves from the inside (Figure 78). Full-grown larvae are about 20 mm.
Status as pest: Although damage to leaves is often perceived as severe, populations of *O. indicata* rarely reach levels that cause yield losses when chemical sprays are not used.
Important natural enemies: The larvae are attacked by a rich complex of parasitoids and predators. In Indonesia, at least 15 species of parasitoids attack *O. indicata.*
Other remarks: This leaf feeder also is known as the soybean leafroller and previous names include *Lamprosema* and *Hedylepta.* The insect is found on several leguminous plants.

Name: *Leucinodes orbonalis* Guenee (Figures 79-81)
Family: Pyralidae
Order: Lepidoptera
Common name: Brinjal fruit borer
Life cycle: Eggs are usually laid singly on young shoots, flower buds and calyces of developing fruits. The egg stages lasts 3 - 5 days. Upon hatching, the larvae bore into the shoots (Figure 80), flower buds or fruits, the latter being preferred. There are five larval instars which are completed in 11- 13 days. Full-grown larvae (Figure 81) are about 18mm and emerge from the damaged fruit to pupate in the soil, often in leaf litter. Pupal stage lasts 6 - 8 days.
Damage symptoms: Feeding within the fruit causes the most serious damage (Figure 82) while boring in the shoot causes wilting and eventual death of the shoot (Figure 83). Attack on the fruit normally occurs when populations are high.
Status as pest: In some areas, the insect is the limiting factor to brinjal (eggplant) production. This is exacerbated by the regular use of insecticides that has a negative impact on natural enemies.
Important natural enemies: There are a number of parasitoids associated with the larvae of this insect but most of these are not present in areas where the pest has recently invaded.

Figure 79

Figure 80

Figure 81

Figure 82

Figure 83

Name: *Chrysodeixis (=Plusia) chalcites* (Esper) (Figures 84-85)
Family: Noctuidae
Order: Lepidoptera
Common name: Green looper
Life cycle: Eggs are laid singly on leaves. The egg stage lasts 3-4 days. There are 5 larval instars lasting about 13 days. Full-grown larvae (Figure 85) are about 40 mm. Pupation occurs in a silken cocoon on leaves. The pupal period takes about 7 days.
Damage symptoms: Larvae feed on leaves and occasionally may cause defoliation serious enough to reduce yields.
Status as pest: Green loopers are found in a wide range of cultivated crops, most notably, in crucifers, potatoes, beans, carrots and soybeans. They seldom reach high populations due to a rich complex of natural enemies.
Important natural enemies: Many larval parasitoids have been reared from field-collected loopers. In addition, there are carabid and pentatomid predators as well as solitary wasps that attack loopers. Insect pathogens play a major role in regulation of looper populations, notably, fungal and viral pathogens such as *Pandora gammae* (Figure 244), *Nomuraea rileyi*, and a nuclear polyhedrosis virus (Figure 261). Because of the combined action of these natural enemies, loopers rarely cause economic damage.
Other remarks: There are also two other species of loopers which may occur together with *C. chalcites* namely, *Thysanoplusia orichalcea* (F.) (Figure 86) and *Argyrogramma cf. signata* (F.) (Figure 87, 88).

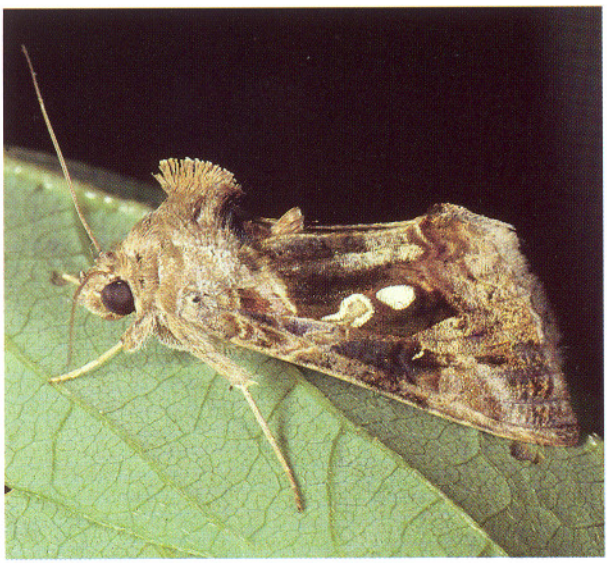


Figure 84

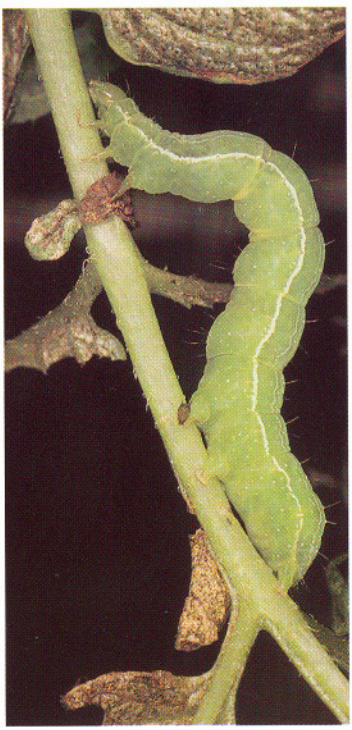


Figure 85

Figure 86

Figure 87

Figure 88

Name: *Spodoptera exigua* (Hübner) (Figures 89-93)
Family: Noctuidae
Order: Lepidoptera
Common name: Onion armyworm
Life cycle: Clusters of eggs are laid on leaves and covered with white felt-like scales (Figure 90). Eggs hatch in about 3 days. Initially, larvae feed together after hatching, but soon disperse. There are usually six larval instars and larvae complete their development in 9-14 days. Pupation occurs in a firm cocoon in the soil and the pupal period lasts for about 10 days .
Damage symptoms: Damage is caused by larvae feeding on the leaves (Figure 91). In onions and shallots, the larvae enter the leaves as early instars and feed from inside the leaves, causing characteristic "window paning," leaving only the outer cuticular portion of the leaf.
Status as pest: This insect is the most serious problem in low-altitude onion production in Indonesia. Heavy infestations can reduce yields significantly or totally destroy the crop (Figure 91). Larvae damage foliage of a number of crops, including cabbage, tomato, peppers, sugarbeet, groundnut and cotton. Onions are particularly susceptible.
Important natural enemies: While several parasitoids have been recorded (a braconid, an ichneumonid and a tachinid), the most effective natural enemy, when present, is a nuclear polyhedrosis virus (NPV). A solution containing NPV (Figure 264) may be applied to plants using a standard backpack sprayer. This helps to reduce dependence on chemical insecticides. Other pathogens found on this pest in Indonesia include *Nomuraea rileyi* (Figure 250) and a microsporidian (protozoan) (Figure 265). Predators also may be important.
Other remarks: There are several larval color phases, ranging from green (Figure 92, 93) to nearly black. Sometimes the dark colored larvae are confused with other armyworm species. Due to heavy use of insecticides, especially on shallots, this pest has become resistant to chemical insecticides.

Figure 89

Figure 90

Figure 91

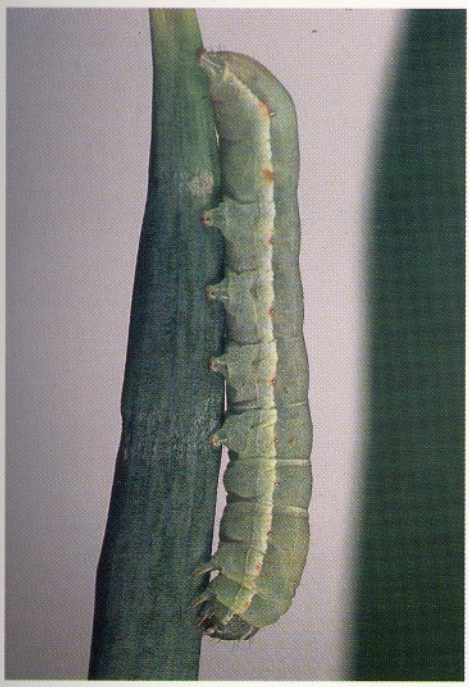


Figure 92

Figure 93

Name: *Spodoptera litura* (F.) (Figures 94-96)
Family: Noctuidae
Order: Lepidoptera
Common name: Cluster caterpillar or armyworm
Life cycle: Eggs (Figure 95) are laid in clusters on leaves and covered with hair scales for protection. Each egg cluster contains 100-300 eggs. Egg stage lasts 3-6 days. Upon hatching, larvae feed together and disperse as they mature. There are 6 larval instars and depending on the food plant and temperature, development to pupation takes 15-21 days. A full-grown larva (Figure 96) is about 50 mm in length. Pupation occurs in an earthen cell in the ground and the pupal stage lasts about 12 days.
Damage symptoms: The most conspicuous damage is caused by early larval instars as hundreds of caterpillars feed in clusters and quickly skeletonize leaves.
Status as pest: *S. litura* attacks a wide range of crops, including soybean and other legumes, pepper, shallot, potato, and crucifers. In most crops, the caterpillar clusters appear early in the season. However, it has been shown that due to plant compensation and the presence of many natural enemies, this insect has been overrated as a pest.
Important natural enemies: *S. litura* attracts many predators due to its clumping behavior. These include ants, earwigs, pentatomid bugs and predaceous beetles (Figure 178). Egg parasitoids, e.g. *Telenomus spodopterae* Dodd and *Telenomus remus* Nixon, can be important in reducing of *S. litura* populations. Nuclear polyhedrosis virus and *Nomuraea rileyi* also are important natural enemies.
Other remarks: *S. litura* usually does not reduce crop yields.

Figure 94

Figure 95

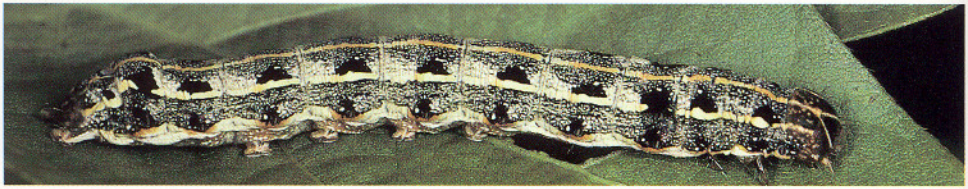


Figure 96

Name: *Helicoverpa armigera* (Hübner) (Figures 97-99)
Family: Noctuidae
Order: Lepidoptera
Common name: Bollworm or corn earworm
Life cycle: Eggs are laid singly on the upper parts of host plants. In maize, eggs may be laid on silks of ears. Egg stage lasts about 3 days. Upon hatching, larvae bore into the ears of maize or into fruits of other crops. The larval stage takes about 25 days and there are 6 larval instars. Larvae may occur in different color forms (Figure 98, 99). Pupation occurs in the soil and the pupal stage lasts about 13 days.
Damage symptoms: Larvae feed on leaves, flowers, fruit and pods of a wide range of host plants. Larvae often feed on fruiting structures which makes this species a serious pest in some areas.
Status as pest: Often considered a serious pest of tomato, peppers, maize, soybean, cotton and in some areas, cabbage.
Important natural enemies: Few parasitoids of *H. armigera* are known in Indonesia. These include *Trichogrammatoidea nana* (Zehntner), *Eriborus argenteopilosa* (Cameron) and some tachinids. *Nomuraea rileyi* and a nuclear polyhedrosis virus have been recorded from caterpillars. Predators are probably the most important natural enemies of this pest, feeding on the vulnerable eggs and young larvae.
Other remarks: It has been suggested that heavy rains destroy many eggs and newly hatched larvae. In addition, the high humidity favors mortality due to fungi.

Figure 97

Figure 99

Figure 98

Name: *Agrotis ipsilon* (Hufnagel) (Figures 100-103)
Family: Noctuidae
Order: Lepidoptera
Common name: Black (greasy) cutworm
Life cycle: This species is better studied than the closely-related, *Agrotis segetum* (Denis & Schiffermüller) (Figure 101). Both are cutworms and their life cycles and behavior are similar. Eggs are laid in clusters of about 30 on the under surface of leaves or in the soil at the base of the plant. Egg stage lasts 3 - 4 days. Initially, larvae feed on leaves but eventually burrow into the soil and come out only at night to feed on the plant. Larval stage (Figure 102) is completed in about 30 days, depending upon temperature. Pupation occurs in the soil and the pupal stage (Figure 103) lasts about 10 days.
Damage symptoms: Caterpillars often cut young stems and drag these into the soil to feed on them. Stand loss results from heavy infestations of this caterpillar.
Status as pest: Could be occasionally a serious pest in the early stages of growth of the crop.
Important natural enemies: Little is known about the natural enemies of this insect. However, we have observed a fungal pathogen, *Entomophaga* sp. (Figure 249).
Other remarks: Often *A. ipsilon* and *A. segetum* occur together in the field on a variety of host plants.

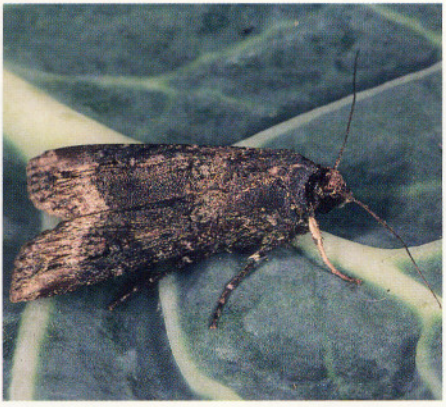


Figure 100

Figure 101

Figure 102

Figure 103

Name: *Mythimna sp.* (Figure 104)
Family: Noctuidae
Order: Lepidoptera
Common name: Armyworm
Life cycle: The pale brown moths lay their eggs in batches of about 100 on leaves of plants. Eggs hatch in 4 - 13 days. Development takes 30-40 days. Larvae may reach a size of 35 - 40 mm after about 18 days. Pupation takes place in the soil.
Damage symptoms: Caterpillars feed on leaves of host plants, particularly maize and other plants belonging to the family Gramineae.
Status as pest: Only occasionally considered a pest in maize and sugar cane.
Important natural enemies: Little is known about its natural enemies.
Other remarks: Older caterpillars are gregarious and may eat entire leaves or whole plants during the night. Caterpillar color is highly variable from green to pink.

Figure 104

Name: *Homona coffearia* (Nietner) (Figure 105-106)
Family: Tortricidae
Order: Lepidoptera
Common name: Tea tortrix
Life cycle: Development time is about 40 days. Larvae, common on soybeans, can grow up to 26mm. Moths are nocturnal and lay many eggs.
Damage symptoms: Larvae (Figure 106) web young parts of plants, resulting in leaves being rolled up. Besides leaves, these larvae feed also on fruits, shoots and flowers.
Status as pest: Although leaf-folding is common in soybean, it is not likely that this insect causes reduction in yield.
Other remarks: Many parasitoids are known to attack this insect on Java, Indonesia. Introduction of *Macrocentrus homonae* Nixon in 1936 resulted in a successful biological control program in tea in Sri Lanka.

Figure 105

Figure 106

Name: *Adoxophyes privatana* (Walker) (Figures 107-108)
Family: Tortricidae
Order: Lepidoptera
Common name: Soybean tortrix, webworm, leafroller
Life cycle: Eggs are laid on young leaves and development time is from 32 - 42 days. The larvae feed on a range of plants, including legumes. On soybean, the active larvae live within a number of leaves spun together. Larvae may grow to a length of 18-26 mm.
Damage symptoms: As with the tea tortrix, larvae fold leaves together and feed from inside the folded leaves.
Status as pest: Not usually serious but common. Leaf-feeding activity often induces farmers to spray insecticides.
Important natural enemies: Parasitoids cause major mortality.
Other remarks: Adult males (Figure 107) have different wing coloration than females (Figure 108).

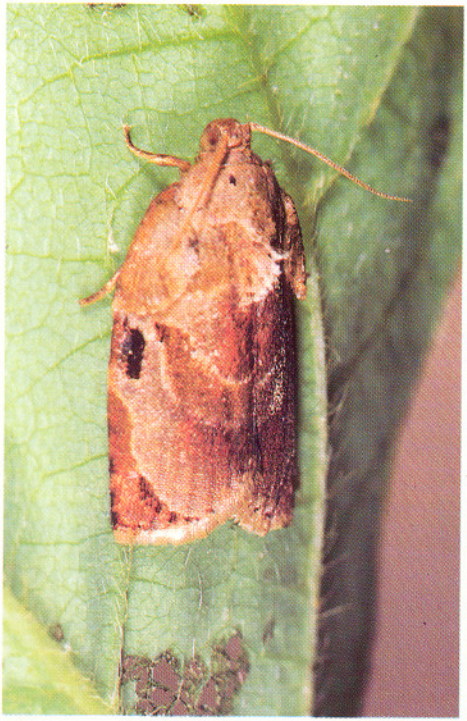


Figure 107

Figure 108

Name: *Hyposidra talaca* (Walker) (Figure 109)
Family: Geometridae
Order: Lepidoptera
Common name: Soybean geometrid
Life cycle: Development takes place in about 2 months in high altitudes. Pupation takes place in the soil.
Damage symptoms: Caterpillars feed on the leaves of a wide range of food plants.
Status as pest: Polyphagous but not a serious defoliator.
Important natural enemies: Little is known about its natural enemies and ecology.

Figure 109

Name: *Spilosoma sp.* (Figure 110)
Family: Arctiidae
Order: Lepidoptera
Common name: Wooly bear caterpillar
Life cycle: The larvae grow up to 40 mm in length.
Damage symptoms: These hairy caterpillars feed on leaves of a wide range of food plants, including weed hosts.
Status as pest: These large conspicuous caterpillars are quite common but have not been shown to cause yield losses.
Other remarks: Several species have been found. But little is known about their natural enemies and ecology.

Figure 110

Name: *Acherontia* spp. (Figures 111-115)
Family: Sphingidae
Order: Lepidoptera
Common name: Hornworm, hawk moth
Life cycle: Eggs (Figure 112) are laid singly and caterpillars (Figure 113, 114) grow to a maximum of 130 mm. Pupation takes place in the soil (Figure 115)
Damage symptoms: Caterpillars feed on leaves.
Status as pest: Populations rarely reach levels that cause significant damage.
Important natural enemies: Eggs are often attacked by *Trichogramma* spp. and *Sycanus* sp. bugs prey upon the caterpillars. Tachinid flies commonly attack the larvae.
Other remarks: These caterpillars are differentiated from other similar sphingids by the slightly bent tail covered with tiny horns. Two species are common in Indonesia and neighbouring countries: *A. lachesis* (Fabricius) and *A. styx* (Westwood). *A. lachesis* (Figure 113), reaches a full grown length of 100-130 mm while caterpillars of *A. styx* (Figure 114) usually attain a maximum length of 80 mm. The life cycles of both species are usually more than 3 months.

Figure 111

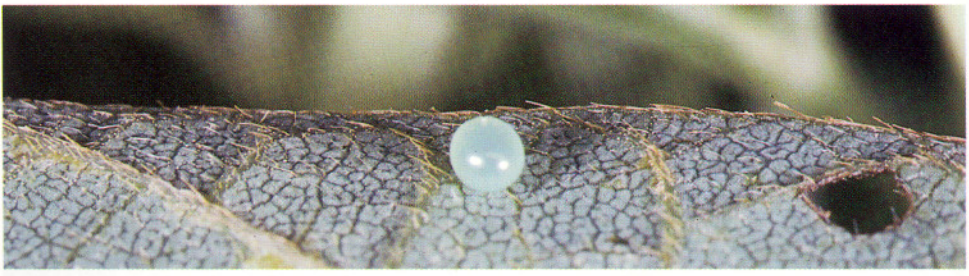


Figure 112

Figure 113

Figure 114

Figure 115

Name: *Agrius convolvuli* (L.) (Figures 116-117)
Family: Sphingidae
Order: Lepidoptera
Common name: Hornworm, hawk moth
Life cycle: The life cycle and behavior are essentially the same as for *Acherontia* spp. Larvae grow to a maximum length of 90 mm and can be separated from *Acherontia* spp. by the characteristic "trunk" on the pupae (Figure 117).
Damage symptoms: Caterpillars feed on leaves of sweet potato. This may delay harvest when populations are heavy and increase the likelihood of attack by the sweet potato weevil.
Status as pest: Populations usually are not dense due to the action of natural enemies.
Important natural enemies: *Trichogramma* spp. are important egg parasites. Tachinid flies and a large reduviid, *Sycanus* sp. (Figure 192), attack the larvae.
Other remarks: This insect is believed to be kept in check by natural enemies but more research is needed. There are more than one species of *Agrius* (Figure 118).

Figure 116

Figure 117

Figure 118

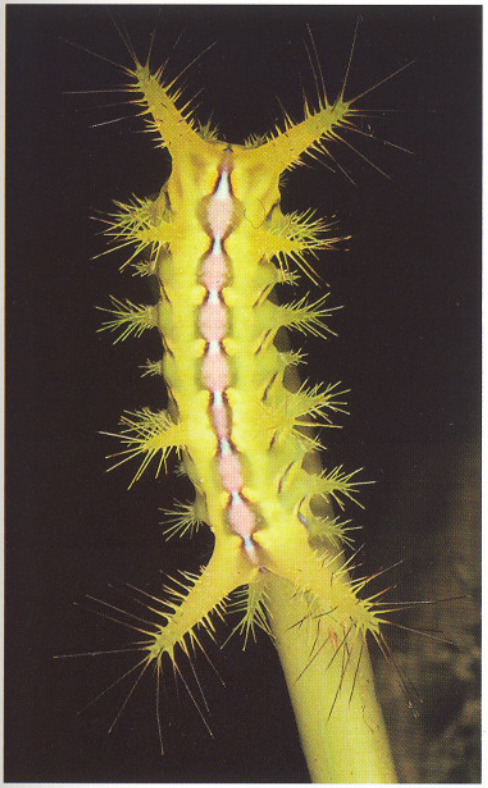


Figure 119

Name: *Parasa lepida* (Cramer) (Figure 119)
Family: Limacodidae
Order: Lepidoptera
Common name: Nettle caterpillar
Life cycle: Eggs are laid on leaves which hatch in 3-5 days. Young larvae feed on the leaf epidermis and as they grow, chew up leaves. There are 7 larval instars (often 8 instars for females) which are completed in 35-42 days. Pupation occurs in cocoons often attached to stem or bark and the pupal stage lasts 21-24 days. The complete life cycle recorded on coconut is 65-68 days while it takes about 70 days on coffee.
Damage symptoms: Caterpillars of this insect feed on leaves of beans and other plants.
Status as pest: Not an important pest on vegetables and soybean. More often recorded on perennial crops such as palms and coffee.
Important natural enemies: A specific parasitoid, *Apanteles parasae* Rohwer, is an important mortality factor. Another larval parasitoid is *Chrysis shanghaiensis* Smith. *Cordyceps coccinea,* a fungal pathogen, is known to kill the larvae. As with most limacodid caterpillars, *P. lepida* is susceptible to virus diseases.

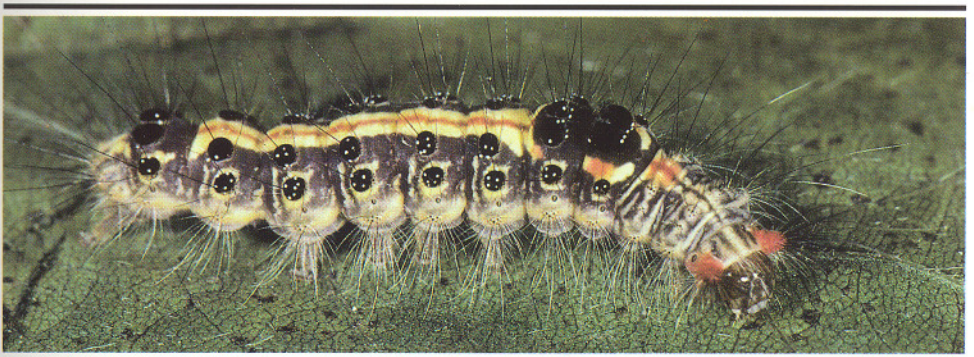


Figure 120

Name: *Euproctis* sp. (Figure 120)
Family: Lymantriidae
Order: Lepidoptera
Common name: Tussock moth
Life cycle: Development takes place between 30 - 40 days. Pupation occurs within a cocoon attached to the plants.
Damage symptoms: Besides feeding on leaves, some members of this genus are known to feed on flowers of beans and crucifers.
Status as pest: Rarely reaches dense populations.
Important natural enemies: Fungal diseases are common as are larval parasitoids, such as braconids, eulophids and tachinids. These keep populations of caterpillars in check.
Other remarks: Larvae of *Euproctis* and *Parasa* (Figure 119) are very hairy and these hairs are poisonous, causing irritation when handled.

Name: *Orgyia* spp. (Figures 121-122)
Family: Lymantriidae
Order: Lepidoptera
Common name: Tussock moth
Life cycle: Females are wingless (Figure 121) and move only a short distance from the cocoon before mating. Development takes place in about 4 weeks.
Damage symptoms: Larvae (Figure 122) are polyphagous, feeding on leaves.
Status as pest: Occasionally, numbers are high enough to cause defoliation.
Important natural enemies: Natural enemies are believed to be responsible for keeping this insect in check. A rich complex of natural enemies is known from *O. postica* Walker, ranging from parasitoids, predators, and viral and fungal pathogens.
Other remarks: Stinging hairs may cause irritation. Adult coloration allows them to blend into their background making it difficult to see them.

Figure 121

Figure 122

Name: *Dasychira* spp. (Figures 123-125)
Family: Lymantriidae
Order: Lepidoptera
Common name: Tussock moth
Life cycle: Larvae grow to a maximum of 50 mm.
Damage symptoms: Caterpillars feed on leaves of a wide range of plants.
Status as pest: Same as lymantriids described above.
Important natural enemies: Many natural enemies, particularly parasitoids, are known from these hairy caterpillars and these probably keep the populations low.
Other remarks: There are several species, but the two common species are *D. inclusa* Walker (Figure 124) and *D. mendosa* Hübner (Figure 125).

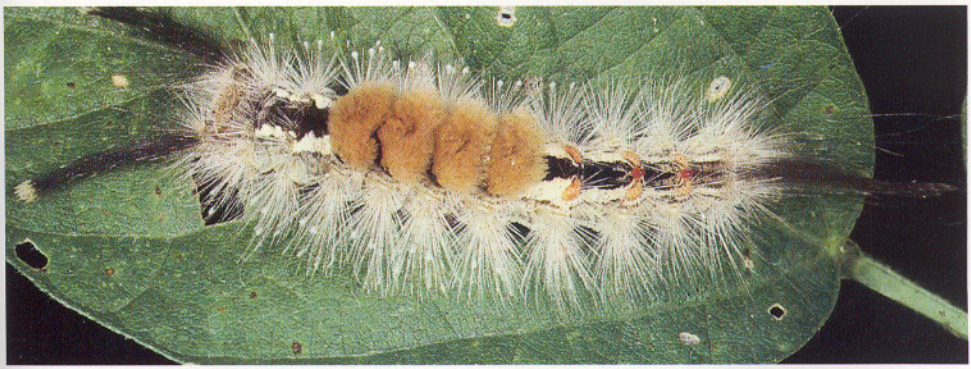


Figure 123

Figure 124

Figure 125

Name: *Phthorimaea operculella* (Zeller) (Figures 126-128)
Family: Gelechiidae
Order: Lepidoptera
Common name: Potato tuber moth
Life cycle: Eggs are laid singly on the under surface of leaves or on exposed tubers and hatch in about 7 days. Larvae first mine the leaves making blotch mines and then move to the stems and tubers. Larval stage (Figure 127) lasts 14-21 days. Pupation (Figure 128) occurs in a silken cocoon on the soil surface. Pupal period lasts 7-10 days.
Damage symptoms: Larvae feed on leaves but the most important damage is to the potato tubers. Tunnelling in the tubers make them unmarketable. Besides the direct damage, the tunnels provide entry for secondary infection.
Status as pest: Can be a serious pest in storage and in the field where potatoes are produced commercially.
Important natural enemies: Parasitoids have been recorded and a granulosis virus has been isolated from larvae.
Other remarks: This insect originated from South America.

Figure 126

Figure 127

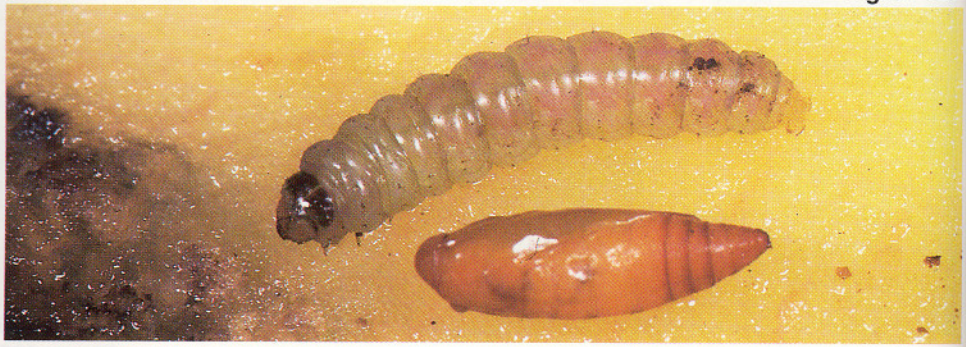


Figure 128

Name: *Brachmia* sp. (Figure 129)
Family: Gelechiidae
Order: Lepidoptera
Common name: Sweet potato leaf roller
Life cycle: Not known.
Damage symptoms: Larvae roll and feed within the rolled leaves of sweet potato.
Status as pest: Does not reach populations high enough to cause problems.
Important natural enemies: Earwigs, ants, spiders and parasitoids have been observed attacking the larvae.
Other remarks: Little is known about this insect. Larvae wriggle violently when disturbed.

Figure 129

Name: *Euchrysops cnejus* (F.) (Figures 130-132)
Family: Lycaenidae
Order: Lepidoptera
Common name: Bean lycaenid
Life cycle: Eggs are laid singly on young beans or flower buds. The larval stage (Figure 131) lasts 11-14 days. Larvae grow up to 18 mm in length. Pupal stage (Figure 132) lasts 6-7 days.
Damage symptoms: Larvae feed on pods of longbean and other beans. Damage is characterized by round holes in pods.
Status as pest: Feeding on pods occurs but heavy damage is prevented by natural enemies.
Important natural enemies: Several species of parasitoids have been recorded.
Other remarks: Often, the larvae are found in association with the ant, *Camponotus compressus* (F.).

Figure 130

Figure 132

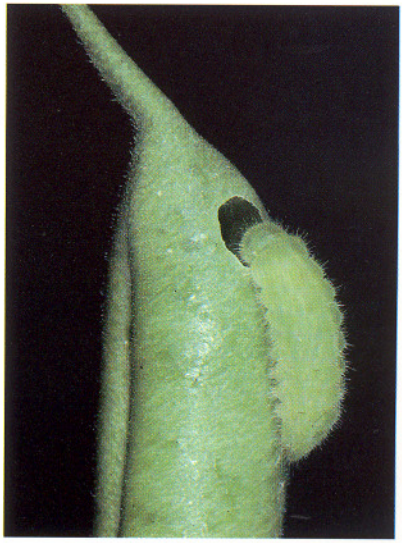


Figure 131

Name: *Plutella xylostella* (L.) (Figures 133-135)
Family: Yponomeutidae
Order: Lepidoptera
Common name: Diamondback moth
Life cycle: Development depends highly on temperature. In warmer climates the life cycle may be half of that in cooler areas. Eggs are laid singly on the lower surface of crucifer leaves. In the highlands, the egg stage lasts about 6 days. There are 4 larval instars which are completed in about 14 days. The full-grown caterpillar (Figure 134) is about 8 mm in length. Pupation occurs on the leaves in a silken cocoon (Figure 135). Adults emerge about 7 days after pupation.
Damage symptoms: Caterpillars feed on leaves and when populations are high, damage to leaves is severe.
Status as pest: In areas where there are no effective natural enemies and farmers rely completely on chemical insecticides, outbreaks occur.
Important natural enemies: In the highlands of Indonesia and neighboring countries, effective parasitoids such as *Diadegma semiclausum* (Hellen) (Figure 214, 215) and *Diadromus collaris* (Gravenhorst) (Figure 216) help keep the insect in check. However, these are minimized when farmers spray chemical insecticides. Besides these parasitoids, *Cotesia plutellae* (Kurdjumov) (Figure 234) can reach high levels. Other important natural enemies include two fungi, *Zoophthora radicans* (Brefeld) Batko (Figure 246) and *Hirsutella* sp. (Figure 253).
Other remarks: In almost all countries with a diamondback moth problem, the insect has acquired multiple resistance to a wide range of insecticides. Hence, it is recommended that an ecological approach be adopted to help farmers understand biological control in order to establish effective parasitoids.

Figure 133

Figure 134

Figure 135

Name: *Pieris rapae* (L.) (Figures 136-139)
Family: Pieridae
Order: Lepidoptera
Common name: Imported cabbageworm
Life cycle: Adults deposit single eggs (Figure 137) that hatch in 3 - 4 days depending upon temperature. Larvae (Figure 138) undergo 5 developmental stages and pupation (Figure 139) takes place on the plant. Mature larvae can reach a length of about 30 mm.
Damage symptoms: Larval feeding on leaves of crucifers can cause serious damage.
Status as pest: This species is widely distributed throughout the world and can be serious.
Important natural enemies: Little is know about natural enemies of this insect in Asia.
Other remarks: In some parts of the world, larval and pupal parasites, (especially *Apanteles spp.* and *Cotesia spp.*) and a granulosis virus are important mortality factors.

Figure 136

Figure 137

Figure 138

Figure 139

Name: *Sphenarches caffer* (Zeller) (Figure 140)
Family: Pterophoridae
Order: Lepidoptera
Common name: White plume moth
Life cycle: Little is known about this insect.
Damage symptoms: Larvae feed on leaves flowers and fruits of numerous plants, including sweet potato.
Status as pest: Damage is usually not important.
Important natural enemies: Nothing is known about its natural enemies.

Figure 140

Name: *Asphondylia capsici* Barnes (Figure 141-142)
Family: Cecidomyidae
Order: Diptera
Common name: Gall fly
Life cycle: Life history is not well known. Eggs are deposited in pepper pods and larvae develop therein. Often, part of the pupae (Figure 142) can be seen protruding from the pepper pods.
Damage symptoms: Larvae (Figure 141) feed inside fruit of peppers. Attacks on pepper pods also cause small, deformed pods (Figure 143) if the attack occurs when pods are young. When older pods are attacked they become twisted and distorted.
Status as pest: Damage is more severe early in the season when parasitism rates are lowest. As the season progresses, this fly becomes less important because of the action of hymenopterous parasitoids.
Important natural enemies: Larval parasitoids (Figure 211) are important in regulating populations of this fly.

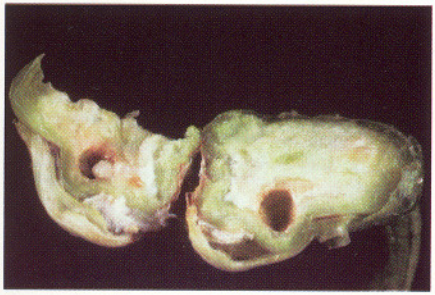


Figure 141

Figure 143

Figure 142

Name: *Liriomyza huidobrensis* (Blanchard) (Figures 144-146)
Family: Agromyzidae
Order: Diptera
Common name: Leafminer
Life cycle: Eggs are laid into leaf tissue. Larvae mine leaves and full-grown larvae (Figure 145) are about 3.3 mm in length. When mature, the larva leaves its mine and may drop to the soil to pupate or it may pupate on the leaf (Figure 146).
Damage symptoms: Larvae feed primarily by mining leaves of a wide variety of crops including shallots (Figure 147), potato (Figure 148), beans and tomato.
Status as pest: After its arrival in Indonesia, the insect has caused severe damage to potato. Other vegetable crops are attacked but the damage is usually not as severe.
Important natural enemies: In Indonesia, *Hemiptarsenus varicornis* (Girault) was found to be the most important parasitoid although it is unable to control *L. huidobrensis* populations in potato.
Other remarks: This pest has only recently invaded Southeast Asia. As an introduced pest, a classical biological control program is appropriate.

Figure 144

Figure 145

Figure 146

Figure 147

Figure 148

Name: *Melanagromyza sojae* (Zehntner) (Figures 149-151)
Family: Agromyzidae
Order: Diptera
Common name: Soybean stemfly
Life cycle: Eggs are inserted on the upper surface of leaves, under the epidermis. Usually, the egg stage lasts 2-3 days. Three larval instars (Figure 150) are completed in 9-11 days. Pupation occurs in the center of the bean stem (Figure 151), often at the level of the unifoliate leaves of younger plants. An exit hole (Figure 152) is formed before pupation occurs. The pupal stage lasts 6-9 days.
Damage symptoms: *M. sojae* is a pith feeder. However, larvae feed first in the leaf tissue, and tunnel through leaf veins and petioles before entering the stem.
Status as pest: In areas where soybean follows rice, yield reduction by this insect may not be detectable. However, there are reports of yield losses in soybean where the crop is grown under ideal agronomic conditions.
Important natural enemies: Several parasitoids of this insect have been recorded and these parasitoids and other natural enemies may be important in suppressing stemfly populations.
Other remarks: *M. sojae* attacks a few plant species but soybean is preferred in most areas. *M. dolichostigma* de Meijere, the top borer, attacks soybean but is less common than *M. sojae.* It feeds inside the stem near the top and damaged tops can easily be recognized in the field.

Figure 149

Figure 150

Figure 151

Figure 152

Name: *Ophiomyia phaseoli* (Tryon) (Figure 153)
Family: Agromyzidae
Order: Diptera
Common name: Legume seedling fly
Life cycle: Eggs (Figure 154) are laid singly into the leaf epidermis of beans, soybeans and other legumes. The egg stage lasts 2-4 days. Larvae pass through 3 instars which are completed in about 10 days at lower elevations. In cooler areas, development time is extended to 17-22 days. Larval feeding and pupation occurs mainly in the center of the stem near the soil surface but in older plants, pupation occurs at the junction of the leaf and stem. The pupal stage lasts 7-13 days in warmer areas and 13-20 days in higher elevations.
Damage symptoms: The main damage is caused by larvae as they mine the central core of the stem down to the root-shoot junction. When attack occurs during the seedling stage, plants normally wilt and die (Figure 155).
Status as pest: In some areas, heavy infestations reduce stands to levels where replanting is required.
Important natural enemies: Larval-pupal parasitoids, *Plutarchia* sp. and *Biosteres* sp., are considered important natural enemies of the fly. Little is known about predators and other natural enemies.
Other remarks: Importation of natural enemies for the fly has been carried out in some countries but the impact is not well documented. Rice straw applied as mulch at the time of planting of soybean reduces attack by seedling fly.

Figure 153

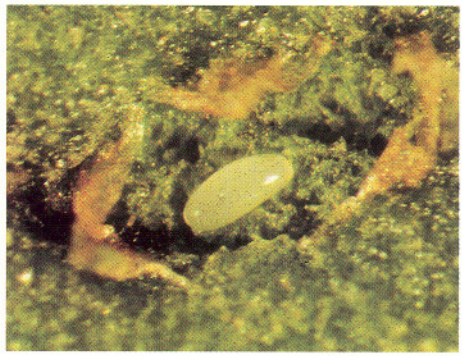


Figure 154

Figure 155

Name: *Phytomyza horticola* (Goureau) damage (Figures 156-158)
Family: Agromyzidae
Order: Diptera
Common name: Pea leafminer
Life cycle: Eggs are inserted singly into the epidermis of young leaves. The egg stage lasts 2-4 days. Larvae mine the leaves of peas (*Pisum sativum* L.) (Figure 157) and crucifers (Figure 158) making irregular linear mines. Larval stage lasts about 6 days. Pupation occurs within the leaf mine and the pupal stage (Figure 156) takes 7-15 days.
Damage symptoms: Leaf mining by the larvae may result in withering and premature dropping of the leaves, resulting in yield loss.
Status as pest: Often cited as an important pest of peas.
Important natural enemies: Numerous parasitoids have been recorded from this leafminer. However, little is known of these in Southeast Asia.
Other remarks: Like other agromyzids, this is an introduced species and ecological studies will help in understanding the role of natural enemies in controlling this pest.

Figure 156

Figure 157

Figure 158

Name: *Bactrocera cucurbitae* (Coquillett) (Figure 159)
Family: Tephritidae
Order: Diptera
Common name: Cucumber fruit fly or melon fly
Life cycle: Eggs are laid in clusters of about 12 per cluster into ripe fruits belonging to the family Cucurbitaceae. Egg stage lasts 2-3 days. Larvae bore into the fruit and pass through 3 instars which are completed in 5-7 days. Full-grown larvae (about 10 mm long) leave the rotting fruit and pupate in the soil or occasionally in the fruit. Pupal stage lasts about 10 days.
Damage symptoms: Feeding by the larvae causes fruits to rot.
Status as pest: The melon fly is a serious problem in some areas.
Important natural enemies: Several larval-pupal parasitoids are recorded from this fruit fly. However, their role is not clear. Little information exists about other natural enemies.

Figure 159

Name: *Bactrocera dorsalis* (Hendel) (Figure 160)
Family: Tephritidae
Order: Diptera
Common name: Oriental fruit fly
Life cycle: Eggs are laid in clusters inside punctures made in ripe fruits. The egg stage lasts 2-3 days. Larvae pass through 3 instars inside the fruit and the larval stages last 8-9 days. Full-grown larvae leave the rotting fruit and pupate in the soil. Pupal period lasts about 10 days.
Damage symptoms: Feeding by larvae causes the fruit to rot.
Status as pest: In some areas, fruit production may be limited by this insect. This pest is especially important in chillies.
Important natural enemies: Many parasitoids of this insect are known as a result of an extensive biological control program. However, little is known about the role of predators and other natural enemies.

Figure 160

Name: *Athalia* sp. (Figure 161)
Family: Tenthredinidae
Order: Hymenoptera
Common name: Cabbage sawfly
Life cycle: Eggs are deposited into plant tissue with a saw-like ovipositor. Larvae feed on leaves of cruciferous plants and drop to the soil surface and pupate in the soil.
Damage symptoms: Feeds on leaves of cabbage and other crucifers.
Status as pest: Although it has a wide distribution, populations are usually not abundant.
Important natural enemies: Unknown
Other remarks: This sawfly can be confused with caterpillars or larvae of moths and butterflies

Figure 161

Name: *Thrips palmi* Karny (Figure 162)
Family: Thripidae
Order: Thysanoptera
Common name: Palm thrips
Life cycle: The life cycle of *T. palmi* is not well documented. The egg stage lasts about 3 days. Immature stages include two active larval instars, prepupa and pupa. The total life cycle from egg to adult takes about 11 days.
Damage symptoms: Adults and larvae feed by scraping the surface cells of a wide range of plants, including cucurbits, eggplant, potato, beans, and other legumes.
Status as pest: In some instances, this thrips can be a serious pest.
Important natural enemies: Studies of natural enemies in the Southeast Asian region suggest that the eulophid parasitoid, *Ceranisus* sp., is important in keeping thrips populations down.
Other remarks: Despite its name, *T. palmi* has not been recorded on any palm. Thrips are very small and difficult to see with the naked eye.

Figure 162

Figure 163

Name: *Thrips tabaci* Lindeman (Figure 163)
Family: Thripidae
Order: Thysanoptera
Common name: Onion thrips
Life cycle: Eggs are laid in leaves and stems of young plants. Eggs hatch in 4 - 10 days. Nymphs undergo two molts in about 5 days. Pupation occurs in the soil and the pupal stage lasts 4 - 7 days.
Damage symptoms: Leaves of onion, tomato, brassicae, peas, and other plants are attacked. Leaves are rasped by both nymphs and adults which suck the sap, causing leaf mottling, flecking and wilting of plants.
Status as pest: A polyphagous pest on many crops. Heavy populations can cause severe damage from direct feeding.
Important natural enemies: Little is known about natural enemies of this pest.
Other remarks: This pest also may transmit plant viruses.

Figure 164

Figure 165

Name: *Tetranychus cinnabarinus* (Boisduval) (Figure 164)
Family: Tetranychidae
Order: Acari
Common name: Red spider mite
Life cycle: Adults are 0.5 mm in length. Eggs are laid on the under surfaces of leaves. The larval stage has six legs. There are two nymphal stages (with eight legs). Total development time from egg to adult is about 15 days (on cassava). A wide range of wild and cultivated plants are attacked.
Damage symptoms: Feeding by adults and immatures may cause clusters of whitish-yellow (Figure 165) spots which are visable on the upper surface of the leaves. Heavy damage can cause leaves to wither and drop.
Status as pest: Severe infestations may result in considerable yield loss of crops such as soybean.
Important natural enemies: Predaceous phytoseiid mites are believed to be responsible for keeping the red spider mite population in check in some areas. A fungal pathogen, *Neozygites floridana*, is an important mortality factor when populations reach high levels.
Other remarks: Applications of insecticides may cause mites to become a problem.

Name: *Polyphagotarsonemus latus* (Banks) damage (Figure 166)
Family: Tarsonemidae
Order: Acari
Common name: Broad mite
Life cycle: Oval, flattened eggs are laid on the under surface of young leaves. These are laid singly and hatch in 2-3 days. Initially, larvae are white and pear shaped, feeding on cell sap. Males hatch earlier than females. The larval/nymphal stage lasts 2 - 5 days.
Damage symptoms: Direct feeding on leaves of peppers (Figure 166) causes the leaves to become distorted and curled downwards.
Status as pest: Occasionally a serious pest of peppers, tomato, potato, and beans.
Important natural enemies: Little is known about the natural enemies of this mite but there are reports that predatory phytoseiid mites may keep this pest in check in some areas.
Other remarks: Damage caused by *P. latus* is often confused with leaf-curl virus symptoms in peppers.

Figure 166

Predatory Arthropods

Arthropod predators make up the most numerous and widely diverse group of natural enemies of insects associated with vegetable and soybean. Many species of predators are active only at night. Others actively search the foliage of crops during the day. Most predators feed on a wide variety of insects but some are quite specific. Generalist predators make up the most important group of natural enemies in most cultivated crops and are seriously affected by chemical insecticides.

Name: *Paederus fuscipes* Curtis (Figure 167)
Family: Staphylinidae
Order: Coleoptera
This small (10 mm) red and black beetle is common in all cultivated ecosystems in the tropics. It feeds on eggs and other soft-bodied insects. It moves quickly over the foliage and often drops from the plant when disturbed.

Figure 167

Name: *Philonthus* sp. (Figure 168)
Family: Staphylinidae
Order: Coleoptera
This staphylinid is larger (12 - 14 mm) than *Paederus fuscipes* and less abundant. Also, it is less colorful and not as well known as *P. fuscipes.* This one was found on cabbage in West Java, Indonesia.

Figure 168

Ladybeetles are abundant members of a community of predatory insects that are common to vegetable and soybean fields in Southeast Asia. With few exceptions, adults and larvae are predaceous. There are a number of species that can be identified by their distinct color patterns. However, color patterns may be quite variable in some groups. Ladybeetles feed on aphids, eggs of lepidopterans and other small soft-bodied insects. They also may use pollen and nectar as sources of energy.

Figure 169

Name: *Micraspis lineata* (Thunberg) (Figure 169)
Family: Coccinellidae
Order: Coleoptera

This brightly colored orange and black ladybeetle (5 mm) can be abundant in soybean and mungbean. They are often seen feeding on nectaries of mungbean.

Name: *Coccinella transversalis* F. (Figure 170)
Family: Coccinellidae
Order: Coleoptera

One of the most abundant coccinellids. The larvae within this group are brightly colored yellow and black (Figure 171). Members of this group are larger than *Micraspis.* However, the behavior and biology of both genera are quite similar. Figure 172 shows another common species in the genus *Coccinella.* Color patterns may be somewhat variable as with many other ladybeetles.

Figure 170

Figure 171

Figure 172

Name: *Cheilomenes sexmaculatus* (F.) (Figures 173-175)
Family: Coccinellidae
Order: Coleoptera

These coccinellids are pink and black in color. The adults (Figure 173) and larvae (Figure 174) feed voraciously on aphids, especially *Aphis glycines* in soybean. As with most coccinellids, pupation (Figure 175) takes place on the plant, usually on the under-sides of leaves.

Figure 173

Figure 174

Figure 175

Figure 176

Name: *Harmonia octomaculata* F. (Figure 176)
Family: Coccinellidae
Order: Coleoptera

As with many ladybeetles, this species may have more than one color pattern.

Name: *Coleophora inequalis* (Thunberg) (Figure 177)
Family: Coccinellidae
Order: Coleoptera

This is another representative of the large and diverse group of ladybeetles that inhabit vegetable and soybean fields. Little is known about its biology and behavior.

Figure 177

Name: *Calleida* sp. (Figures 178-179)
Family: Carabidae
Order: Coleoptera

Ground beetles are members of the family Carabidae. They are swift runners and move rapidly over the plants and soil surface, especially at night, in search of suitable prey. Often, these predatory beetles attack prey items much larger than themselves. Figure 178 shows *Calleida* sp. feeding on a larva of *Spodoptera litura.* Both larvae (Figure 179) and adults are predatory. *Chlaenius bimaculatus* Dejean (Figure 180) is shown feeding on a larva of *Spodoptera exigua.* Figure 181 shows another *Chlaenius* sp. and Figure 182 is *Pheropsophus javanus* Dejean, a major predator of soil-inhabiting insects such as cutworm larvae and pupae. Lepidopteran larvae and eggs plus eggs of sucking bugs make up a large part of the diet of carabid beetles. Because many of the Lepidoptera do not exist in numbers high enough to cause yield or quality losses, they are often valuable sources of food for supporting populations of carabid beetles and other predators, which may later attack more important pest species.

Figure 178

Figure 179

Figure 180

Figure 181

Figure 182

Figure 183

Name: *Ophionea interstitialis* Schmidt-Goebel (Figure 183)
Family: Carabidae
Order: Coleoptera

This brightly colored carabid is one of the most abundant species in vegetables and soybean. It attacks a range of prey and moves rapidly about the foliage during daylight hours. Its prey is similar to that of other small carabids, e.g., small soft-bodied insects and their eggs.

Name: *Formicornus* sp. or ant beetle (Figure 184)
Family: Anthicidae
Order: Coleoptera

This tiny black beetle could easily be mistaken for an ant. It is like an "ant mimic" but the reason for this mimicry is not clear. It feeds on small soft-bodied insects and eggs of several moths. Little is known about the biology and behavior of this beetle.

Figure 184

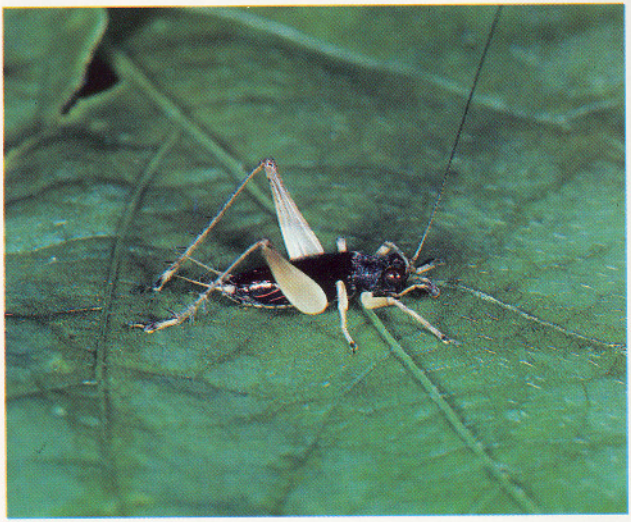


Figure 185

Name: *Metioche* sp. Predatory cricket, (Figure 185)
Family: Gryllidae
Order: Orthoptera

Metioche is one of the most common cricket predators in vegetables and soybean. It also thrives in rice planted in rotation with the above crops. It is an excellent egg predator and often is not recognized as a beneficial insect.

Name: Preying mantis (Figure 186)
Family: Mantidae
Order: Mantodea

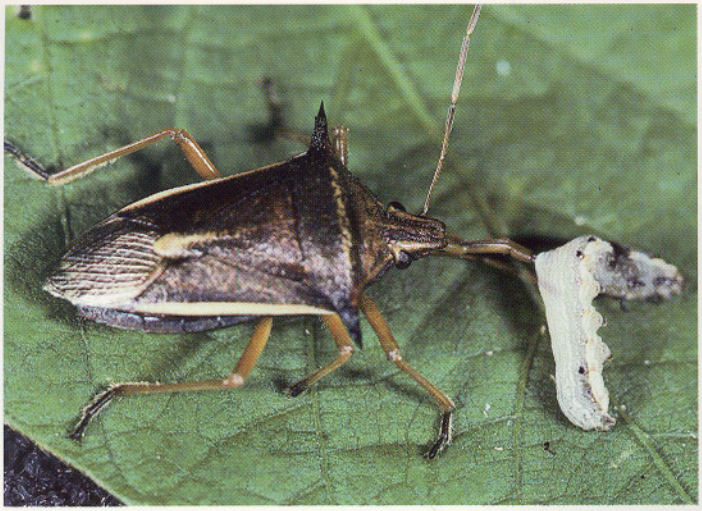
Several species of preying mantids are found in vegetables and soybean. They do not normally actively search for their prey but remain stationary until suitable prey comes near enough to be attacked and captured. Mantids are not generally considered to be important in regulating insect pest populations.

Figure 186

Name: *Chrysoperla* sp. (Figure 187)
Family: Chrysopidae
Order: Neuroptera

Eggs of this predator are laid on stalks on the upper surface of the leaves. The larvae have well-developed mouth parts for catching and consuming prey. Adults are light green in color and have net-like wings folded like a tent over the body. When disturbed, the adults produce a strong odor. Larval development takes only about 2 weeks.

Figure 187



Name: *Andrallus spinidens* (F.) (Figure 188)
Family: Pentatomidae
Order: Hemiptera

Andrallus spinidens is an impressive predatory sucking bug that is capable of attacking and killing large caterpillars. The one shown here has killed and is sucking the juices from a *Spodoptera exigua* larva. The eggs of this predator often are parasitized by small wasps.

Figure 188

Name: *Eocanthecona furcellata* (Wolff) (Figure 189)
Family: Pentatomidae
Order: Hemiptera
This predatory stink bug is not as common as *A. spinidens* but occurs in low numbers in vegetables and soybean. It is more commonly found in soybean. Its prey capture behavior is similar to that of *A. spinidens.*

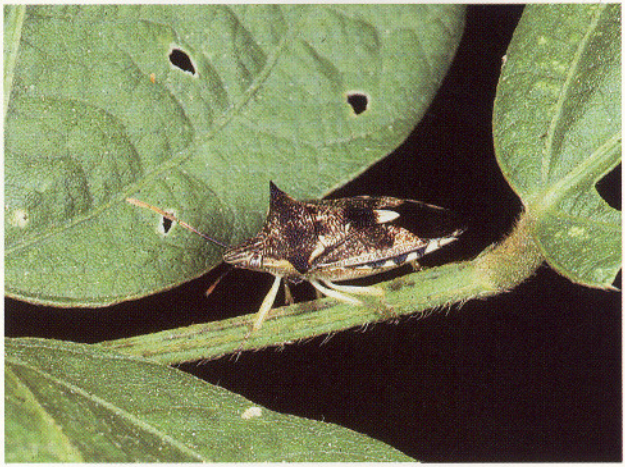
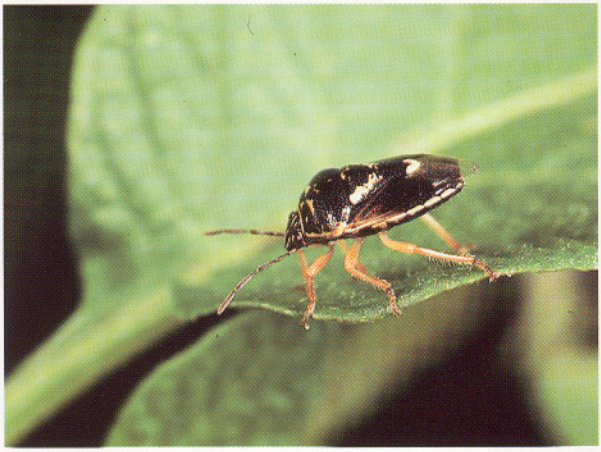
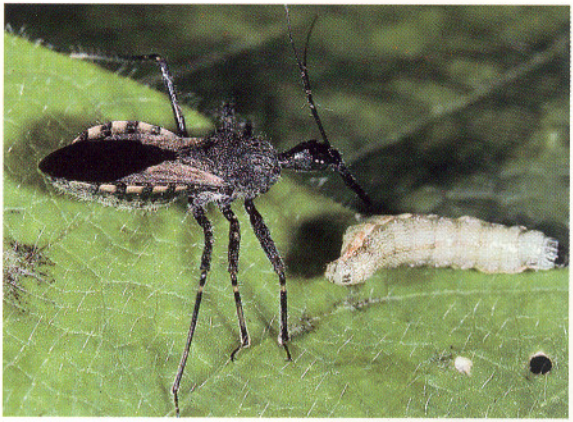


Figure 189



Name: *Pygomenida varipennis* (Westwood) (Figure 190)
Family: Pentatomidae
Order: Hemiptera
This small pentatomid acts mainly as a predator of eggs and young butterfly and moth larvae. It also may suck juices from plants. However, this does not damage the plant.

Figure 190

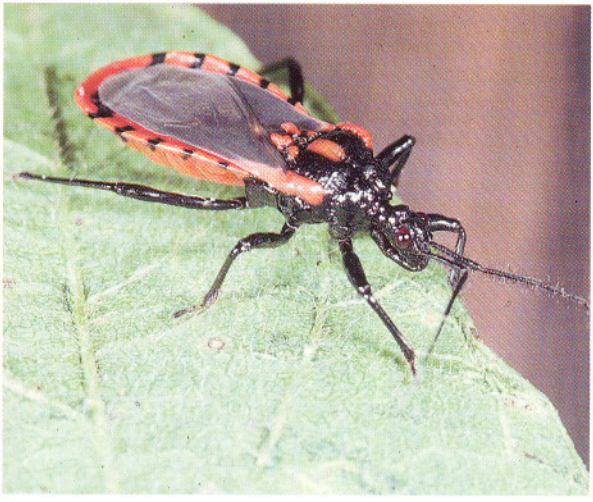


Name: *Rhynocoris* sp. (Figure 191)
Family: Reduviidae
Order: Hemiptera
This small to medium-size predator is not abundant but contributes to a group of predators that kill their prey by inserting their mouthpart and injecting a toxin into the prey. This paralyzes the prey and makes it easy for the predator to suck out the liquid contents of its victim.

Figure 191

Name: *Sycanus* sp. (Figure 192)
Family: Reduviidae
Order: Hemiptera
This large (18 - 20 mm) predator is capable of successfully attacking large larvae such as members of the hawk moth family Spingidae. It lays its eggs together in a mass held together by a sticky material. The hatching nymphs remain close together when they first hatch, then disperse as they mature.

Figure 192



Name: *Ectrychotes* sp. (Figure 193)
Family: Reduviidae
Order: Hemiptera
This colorful predatory bug is quite large (about 15mm) but not usually abundant. This one was found in soybean in the southern part of Sumatra, Indonesia.

Figure 193

Name: *Chrysosoma* sp. (Figure 194)
Family: *Dolichopodidae*
Order: Diptera
These predatory flies are referred to as long-legged flies or dance flies. Most are brightly colored, usually metallic green or gold. The adults are predatory on small insects such as whiteflies and leafhoppers.

Figure 194

Name: Robber fly (Figure 195)
Family: Asilidae
Order: Diptera
These fast flying predatory flies are capable of attacking a wide variety of insects. This one is feeding on a moth in the genus *Hymenia.*

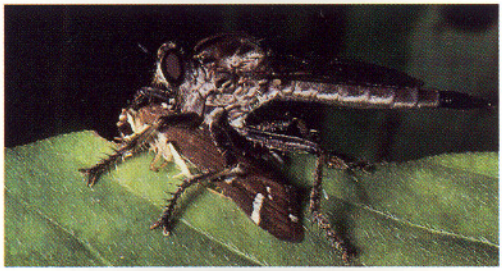


Figure 195

Name: *Ischiodon scutellaris* (F.) (Figures 196-197)
Family: Syrphidae
Order: Diptera
These insects are sometimes referred to as hover flies because of the way the adults hover or fly in one spot. The larval form of syrphids are predaceous. Figure 197 shows a syrphid larva feeding on an aphid.

Figure 196

Figure 197

Name: *Ropalidia* sp. (Figure 198)
Family: Vespidae
Order: Hymenoptera
This small predatory wasp constructs a nest that is often found attached to the undersides of soybean leaves. Because of this habit, it may be an important predator in this crop.

Figure 198

Figure 199

Name: *Polistes* sp. (Figure 199)
Family: Vespidae
Order: Hymenoptera
The wasp shown here is feeding on the larva of a lymantriid caterpillar, *Dasychira sp.* *Polistes* wasps attack a wide variety of caterpillars in almost all vegetable and soybean crops.

Name: *Vespa* sp. (Figure 200)
Family: Vespidae
Order: Hymenoptera
This vespid wasp is feeding on the remains of a looper, probably *Thysanoplusia orichalcea,* in carrots. This host was infected and killed by an insect virus. Studies have shown that predators can spread insect viruses by feeding on virus-infected hosts and later excreting the virus in other areas of the field.

Figure 200

Name: *Eumenes* sp. (Figure 201)
Family: Vespidae
Order: Hymenoptera
This predatory wasp is feeding on a captured *Helicoverpa armigera* larva. Caterpillars make up a large part of the diet of vespid wasps. Large caterpillars are chewed up and carried away piece by piece. Caterpillars also are fed to developing larvae of predatory wasps.

Figure 201

Figure 202

Name: *Euborellia* sp. (Figure 202)
Family: Carcinophoridae
Order: Dermaptera
Members of this order are commonly referred to as earwigs. Although some species are plant feeders, others are voracious predators. They hide in the soil or in plant parts until night time when they search plants for eggs, larvae and nymphs of smaller soft-bodied insects.

Spiders

This is a large and very diverse group of beneficial arthropods in vegetable crops and soybean. Their predatory habits and abundance make them very important in helping to keep populations of pests from reaching damaging levels. Their prey capture behavior varies with the species. Many are active at night, actively stalking their prey while others wait for prey to come close by before capturing it. Many build webs and wait for their prey to get caught before moving in for the kill. Even though the spider fauna is rich and diverse in Southeast Asia, only a few species are depicted herein.

Name: *Argiope trifasciata* (Forskal) (Figure 203)
Family: Araneidae
Order: Araneae
This adult female garden spider is securing her elongate and light brown egg cocoon in the center of the web. Like other garden spiders, *A. trifasciata* captures her prey using a web.

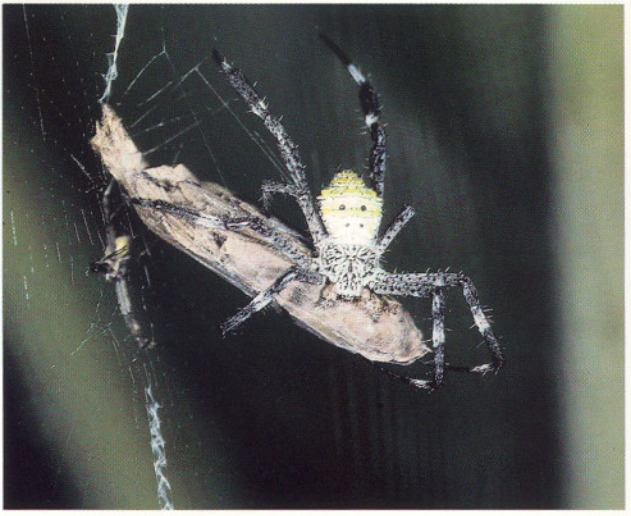


Figure 203

Name: *Leucauge decorata* (Blackwall) (Figure 204)
Family: Tetragnathidae
Order: Araneae
A female big-jawed spider resting on an onion leaf shoot. Tetragnathid spiders catch their prey in webs but may hunt their prey or they may lie in wait for a unsuspecting victim to pass nearby.

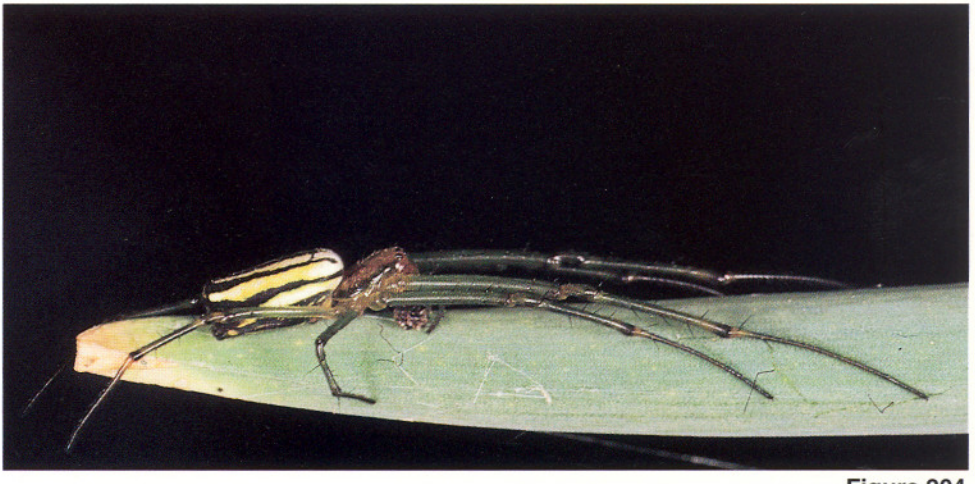


Figure 204

Name: *Marpissa* sp. (Figure 205)
Family: Salticidae
Order: Araneae
This immature stage of a jumping spider is feeding on a winged ant. It is not uncommon for predators to feed on other predators during periods when populations of plant-feeding insects are not available. This helps to maintain predator populations in the crop until potential pests arrive.

Figure 205

Name: *Carrhotus barbatus* (Karsch) (Figure 206)
Family: Salticidae
Order: Araneae
This female jumping spider is preying on a cabbage webworm larva, *Crocidolomia binotalis.* Jumping spiders actively stalk their prey and do not rely on web-building for prey capture.

Figure 206

Name: *Siler* sp. (Figure 207)
Family: Salticidae
Order: Araneae:
This figure shows a larva of a leaf-feeding looper in soybean being eaten by a female jumping spider. As a result of the action of natural enemies, looper larvae rarely reach population levels that cause losses in this crop.

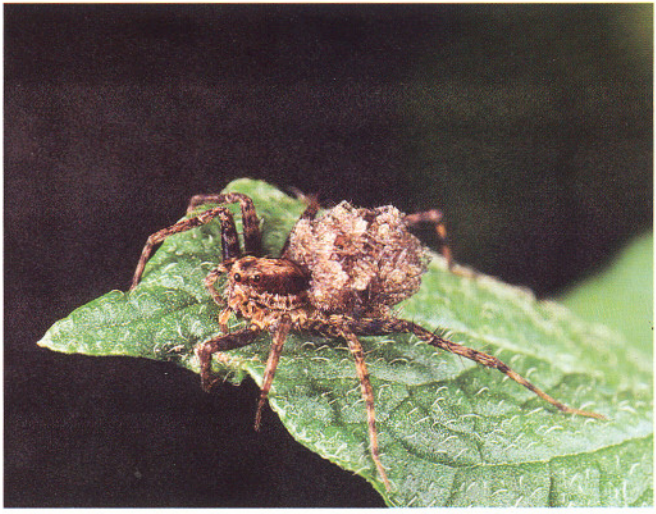
Figure 207

Name: *Crustulina* sp. (Figure 208)
Family: Theridiidae
Order: Araneae
This comb-footed spider is feeding on an adult leafminer fly, *Liriomyza* sp. (Diptera: Agromyzidae) captured earlier on bean leaves and held down by silken threads.

Figure 208

Name: *Oxyopes* sp. (Figure 209)
Family: Oxyopidae
Order: Araneae
This female lynx spider is devouring a young armyworm.

Figure 209



Name: *Pardosa* sp. (Figure 210)
Family: Lycosidae
Order: Araneae
These spiders are excellent hunters both on the ground and in the plant canopy. Each female produces about 100 eggs in one cocoon. As shown in the figure, females carry their young on their back. The females chew the cocoon to soften it, thereby providing food for nourishment of the newly hatched spiderlings.

Figure 210

Parasitoids

Parasitoids, as a group, are considered to be very important in helping to keep populations of potential insect pests from reaching pest status. They are more host specific than insect or spider predators and need only an individual host to complete their development to adulthood. Often, more than one parasitoid can develop and emerge from a single host. In general, parasitoids are much more sensitive to pesticides than are predators.

Figure 211

Name: *Eurytoma* sp. (Figure 211)
Family: Eurytomidae
Order: Hymenoptera
This eurytomid wasp, *Eurytoma* sp., is a common inhabitant of pepper pods. It is parasitic on *Asphondylia* sp., an occasional pest of chilli peppers.

Name: *Charops brachypterum* Gupta & Maheswary (Figure 212)
Family: Ichneumonidae
Order: Hymenoptera
This male ichneumonid wasp is resting on a leaf after emerging from its oblong cocoon. It is distinguished by the black and elongate abdomen, and yellow front and middle pair of legs. The pupal cocoon (Figure 213) is shown hanging from an onion leaf.

Figure 212

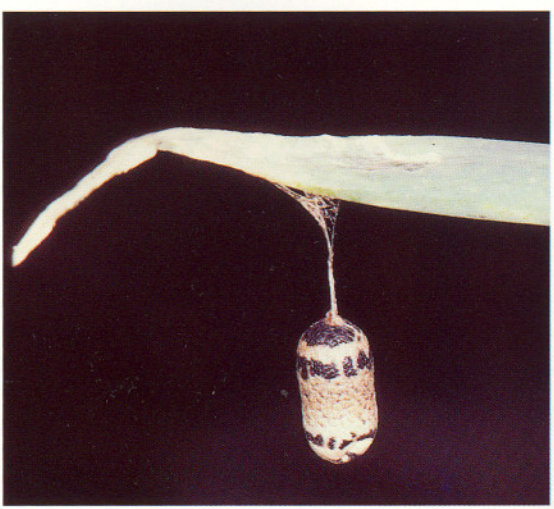


Figure 213

Name: *Diadegma semiclausum* (Hellen) (Figures 214-215)
Family: Ichneumonidae
Order: Hymenoptera

After its introduction into many areas of Southeast Asia, this parasitoid is playing a major role in suppressing populations of the diamondback moth in crucifers. Figure 215 shows a mating pair of *D. semiclausum.*

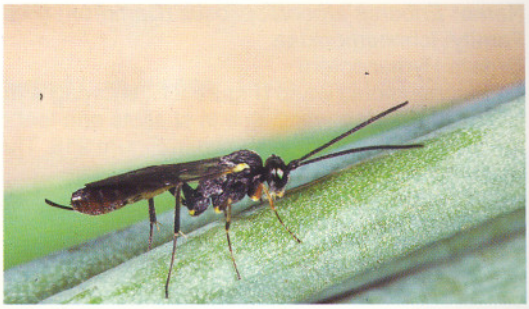


Figure 214

Figure 215

Name: *Diadromus collaris* (Gravenhorst) (Figure 216)
Family: Ichneumonidae
Order: Hymenoptera

This parasitoid attacks the pupae of the diamonback moth. It was originally from Europe and came to Asia via Australia. It complements the action of the larval parasitoid, *D. semiclausum.* Together with *D. semiclausum, Diadromus collaris* helps keep diamondback moth populations below damaging levels, especially when there is reduced use of insecticides.

Figure 216

Name: *Eriborus argenteopilosus* (Cameron) (Figures 217-218)
Family: Ichneumonidae
Order: Hymenoptera
This ichneumonid wasp (Figure 217 showing a male) is one of the most common parasitoids of *Spodoptera exigua* in shallots and leaf onion. An adult female of *Eriborus argenteopilosus* (Cameron) is shown in Figure 218. The parasitoid is characterized by the red posterior portion of abdomen, yellow base of antennae and black basal one-third to one-half of femur and tibia of hind legs. Populations of this parasitoid are often kept low by the heavy use of chemical pesticides.

Figure 217

Figure 218

Figure 219

Name: *Colpotrichia* sp. (Figure 219)
Family: Ichneumonidae
Order: Hymenoptera
The stout-legged wasp is a larval parasitoid of cabbage webworm, *Crocidolomia binotalis.* It is distinguished from related parasitoids by the presence of stout and uniformly yellow legs.

Name: *Temelucha etiellae* Kusegimati (Figure 220)
Family: Ichneumonidae
Order: Hymenoptera
This parasitoid is a common species that attacks the soybean pod borer, *Etiella* spp. The cocoon is brown and covered with silk. The level of parasitism, however, is usually low.

Figure 220

Name: *Enicospilus* sp. (Figure 221)
Family: Ichneumonidae
Order: Hymenoptera
This large (about 18mm) ichneunonid emerged from a looper, *Chrysodeixis* sp., on soybean.

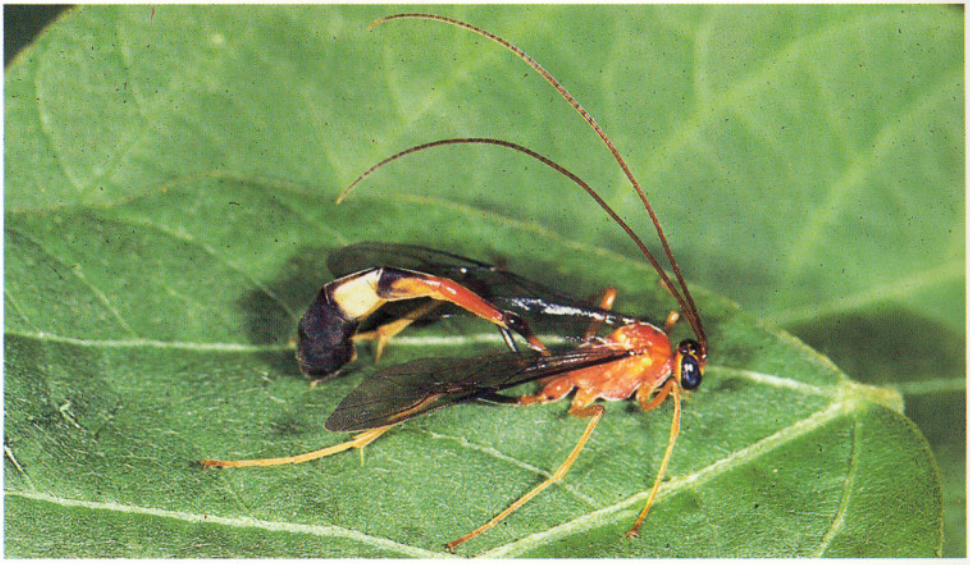


Figure 221

Name: *Baeognatha javana* Bhat & Gupta (Figure 222)
Family: Braconidae
Order: Hymenoptera
This female braconid parasitoid attacks larvae of *Etiella* spp., an important pest of soybean. The parasitoid is characterized by the red thorax and black abdomen with white on its sides.

Figure 222

Name: *Microplitis similis* Lyle (Figure 223-225)
Family: Braconidae
Order: Hymenoptera
This small black parasitic wasp is one of the most common species attacking *Spodoptera litura.* A mature larva of *M. similis* (Figure 225) is emerging from its host, *S. exigua,* and is ready to pupate after feeding internally in its host. An adult is shown on a soybean leaf after emerging from its light brown pupal cocoon (Figure 224) near its host, *S. litura.*

Figure 223

Figure 224

Figure 225

Name: *Euplectrus sp.* (Figure 226)
Family: Eulophidae
Order: Hymenoptera
These parasitoids are shown attached to a host larva, *Spodoptera litura.* The adult parasitoid lays its eggs on the outside of the host's body. Hatching larvae, attach themselves by mouth hooks to their hosts. They pupate in cocoons against the body of the dead host.

Figure 226

Name: *Glyptapanteles phytometrae* (Wilkinson) (Figures 227-229)
Family: Braconidae
Order: Hymenoptera
This braconid parasitoid is emerging from its looper host, *Chrysodeixis chalcites.* A pupal cocoon (Figure 228) is shown beside its dead host larva on a soybean leaf. Figure 229 shows a pupa of this parasitoid underneath its looper host, *Thysanoplusia orichalcea.*

Figure 227

Figure 228

Figure 229

Name: *Cotesia* spp. (Figures 230-233)
Family: Braconidae
Order: Hymenoptera
Parasitoids in this genus attack several host species. Figure 230 shows newly formed pupal cocoons around and underneath the dead host larva of the soybean leaffolder, *Omiodes indicata,* on a soybean leaf. *Chrysodeixis chalcites* also is a host for this group of parasitoids (Figure 231) as is *Thysanoplusia orichalcea* (Figure 232) and the lymantriid, *Orgyia* sp. (Figure 233).

Figure 230

Figure 231

Figure 232

Figure 233

Name: *Cotesia plutellae* Kurdjumov cocoon (Figure 234)
Family: Braconidae
Order: Hymenoptera
This parasitoid makes up an important component of the complex of parasitoids that attack the diamondback moth on crucifer crops. It is especially important in the lowlands where *Diadegema semiclausum* may not be as effective. A cocoon is shown here beside a dead larva.

Figure 234

Name: *Biosteres longicaudatus* Ashmead (Figure 235)
Family: Braconidae
Order: Hymenoptera
The adult female of this braconid wasp is ovipositing on its host larva of the oriental fruit fly, *Bactrocera dorsalis* (Hendel).

Figure 235

Figure 236

Name: *Opius* sp. (Figure 236)
Family: Braconidae
Order: Hymenoptera
This is one of several species that attacks the soybean leaffolder, *Omiodes indicata* and the pod-borer, *Maruca vitrata*. Parasitism rates however, are not usually high.

Name: *Phanerotoma philippinensis* (Ashmead) (Figure 237)
Family: Braconidae
Order: Hymenoptera
This is one of several parasitoids that attack *Etiella* spp. in soybean. Also, it parasitizes *Maruca vitrata (=testulalis),* a pest of longbean.

Figure 237

Figure 238

Name: *Copidosomopsis truncatella* Dalman (Figure 238)
Family: Encyrtidae
Order: Hymenoptera
The egg stage of the host is attacked by this parasitoid. Several looper species are attacked including *Chrysodeixis* and *Thysanoplusia.* Even after being parasitized, the egg of the host hatches normally and the developing parasitoid egg divides many times as the host grows. Shortly before the host larva pupates, a mummified host larva is produced. Several hundred adult parasitoids emerge from a single mummified host larva.

Name: *Argyrophylax* sp (Figure 239)
Family: Tachinidae
Order: Diptera
This tachinid parasitoid is searching for its host on a leaf surface. Parasitism by tachinids is usually low.

Figure 239

Name: *Palexorista* sp. (Figure 240)
Family: Tachinidae
Order: Diptera
This tachinid fly is a common parasitoid of *Spodoptera* spp.

Figure 240

Name: Tachinid eggs (Figure 241)
Family: Tachinidae
Order: Diptera
This *Spodoptera exigua* larvae has been parasitized by a tachinid fly. The white tachinid eggs are clearly visible on the side of the host larva.

Figure 241

Insect Diseases

Fungi

In most locations in Southeast Asia, weather conditions are ideal for development of fungi, and insects and other arthropods are infected by a wide variety of fungal pathogens. Since most fungi produce extensive growth on the external surface of their hosts, symptoms of their infection are more striking and easily recognized. Fungi are probably reported as natural enemies more frequently than other pathogen groups such as viruses and protozoa.

Most fungal pathogens including all reported here, can be divided into two main groups, the Entomophthorales (Zygomycotina) and the Hyphomycetes (Deuteromycotina). The defining characteristic of the Entomophthorales is the production of conidia which are forcibly ejected from the host onto the surrounding substrate. The Hyphomycetes, also called imperfect fungi, usually form an extensive layer of vegetative growth (mycelium) on the outside of the host. Conidia are produced on the surface of this mycelium and are not forcibly ejected.

Entomophthorales

The Entomophthorales are a large group of fungi that are important regulating agents in insect populations. They are able to spread rapidly through a population and cause extensive mortality, especially when host insect populations are high. Some species are quite host specific and can be identified by their association with a certain host, but others have been reported from a wide range of hosts, even from different orders. There are about ten genera which are identified mainly by characteristics of the primary and secondary spores.

Name: *Erynia* sp. (Figure 242)
Order: Entomophthorales
Host pictured: *Crocidolomia binotalis*
Host range: Unknown

Description: External growth on the larva is white to light tan. Spores are produced in large numbers on the surface of this hyphal mat. Spores are white and oval and accumulate in sufficient numbers on the leaf surface surrounding the host so that they form a halo around the larva.

Other remarks: This is one of two fungi found on *Crocidolomia*. The other is *Nomuraea rileyi* which has green spores. *Erynia* sp. is found in moist upland areas and is only found in low incidence.

Figure 242

Name: *Pandora gammae* (Weiser) Humber (Figures 243-244)
Order: Entomophthorales
Host pictured: *Thysanoplusia orichalcea*
Host range: Loopers in the subfamily Plusiinae

Description: Infected larvae climb to the tops of plants and attach by their prolegs before they die. The larvae die in the late afternoon and sporulation occurs throughout the night. Spores are white and oval. A freshly-killed larva has a very fine growth of light tan colored hyphae over the entire surface with tufts of longer white hyphae emerging from the ventral surface (Figure 243). As sporulation progresses, the color changes to brown and then dark brown (Figure 244) and the cadaver becomes wrinkled and collapsed. At this stage the cadaver resembles that of a virus-killed larva, but can be distinguished by the masses of white spores clinging to the setae.

Other remarks: This fungus is an important regulating agent in looper populations. It can cause extensive mortality when larval populations are high.

Figure 243

Figure 244

Name: *Entomophaga grylli* (Fresenius) Batko (Figure 245)
Host pictured: grasshopper [*Ailophus thalassinus tamulus* (F.)]
Host range: Most grasshopper species

Description: Infected grasshoppers cling to upper portions of plants before they die. Clumps of spore-producing hyphae grow through intersegmental membranes. Spores are large, pear-shaped, and white.

Other remarks: *E. grylli* occasionally causes extensive mortality in grasshopper populations.

Figure 245

Name: *Zoophthora radicans* (Brefeld) Batko (Figure 246)
Host pictured: *Plutella xylostella*
Host range: Wide host range

Description: This fungus infects larvae, pupae, and adults of *P. xylostella.* It forms an extensive flat mat of external hyphae which grows out from both sides of the larva. Numerous white spores are formed on and ejected from this mat. Spores are elongate and spindle-shaped, with a cone-shaped point at the base and rounded at the top.

Other remarks: This fungus can cause dramatic epizootics in *P. xyllostella* populations, especially in moist upland areas. Infection can approach 100%. This is one of two fungi commonly found in *P. xylostella.* The other is *Hirsutella* sp. which forms prominent spiked structures.

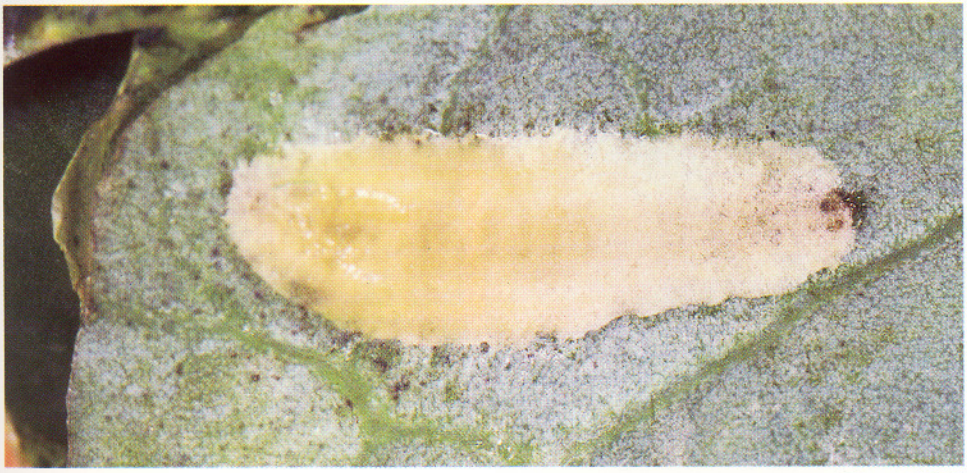


Figure 246

Name: *Zoophthora radicans* (Brefeld) Batko (Figure 247)
Host pictured: Cabbage aphid
Host range: Wide host range.

Description: *Z. radicans* is also a common pathogen in aphid populations. Dead aphids are attached to the leaf surface by many thin fungal structures that grow out from the lower surface of the aphid. The fungus forms a white to tan-colored hyphal mat over the top of the aphid on which numerous white spores are produced. Spores are elongate and spindle-shaped with a cone-shaped base and a rounded point.

Other remarks: This is a common fungus and is probably an important mortality factor in aphid populations. Because *Z. radicans* is found in such a wide range of hosts, it is suspected that this may actually be a complex of species, each with a more restricted host range.

Figure 247

Name: Unidentified Entomophthorales (Figure 248)
Host pictured: *Trialeurodes vaporariorum*
Host range: Unknown

Description: This fungus infects adult whiteflies. Dead whiteflies are attached to the leaf surface by fungal structures and their wings are spread apart, exposing the abdomen on which spores are produced. Spores and hyphae are white. It appears similar to a recently described species, *Orthomyces aleyrodis* Steinkraus, Humber and Oliver, which was found infecting the bandedwinged whitefly, *Trialeurodes abutilonea,* in North America.

Other remarks: This fungus was observed causing extensive mortality in whitefly populations in Indonesia, especially during the dry season when whitefly populations were high.

Figure 248

Name: *Entomophaga* sp. (Figure 249)
Host pictured: Cutworm
Host range: Unknown

Description: This fungus was found infecting late instar larvae of cutworms on cabbage in upland areas of Sumatra. Dead larvae were found attached to the outer edges of leaves. The fungus does not form an extensive growth on the outside of the larva. Freshly-killed larvae are brown and turn black and shrink after sporulation is complete. Spores are large, oval and white.

Other remarks: Infection levels by this fungus appear to be quite low.

Figure 249

Hyphomycetes

The Hyphomycetes or imperfect fungi are distinguished from the Entomophthorales by forming spores which are not forcibly ejected from the host. They usually form an extensive growth of hyphae on the outer surface of the host and sometimes form stalk-like structures which grow out from the host. Genera and species are usually distinguished by color, shape, and arrangement of the spores, and by presence or absence of stalk-like structures. Hyphomycetes can usually be cultured easily on artificial media.

Figure 250

Name: *Nomuraea rileyi* (Farlow) Sampson (Figures 250-252)
Hosts pictured: *Helicoverpa armigera, Spodoptera exigua, and S. litura*
Host range: Mostly larvae of Lepidoptera

Description: Before sporulation occurs, the dead host is covered by a thick growth of white mycelium (Figure 250 - on *Helicoverpa armigera*). When sporulation occurs the larva turns green due to a heavy accumulation of green spores (Figure 251 - on *Spodoptera exigua),* (Figure 252 - on *Spodoptera litura).* Spores are light green and oval.

Other remarks: This was the most common pathogen found during extensive surveys in Indonesia. With one exception, it was found entirely on larvae of Lepidoptera. It was the most common pathogen found on *Crocidolomia binotalis, Spodoptera litura,* and *Helicoverpa armigera* and was also found frequently on *Spodoptera exigua* and loopers. The only non-lepidopteran host recorded was a long-horned grasshopper.

Figure 251

Figure 252

Name: *Hirsutella* sp. (Figure 253)
Host pictured: *Plutella xylostella*
Host range: Unknown
Description: Freshly-killed cadavers have a thin layer of white mycelium with tufts forming at various locations. Eventually, these tufts develop into grey stalks (synnemata). Ten to 15 of these stalks form on a single larva. Spores are clear and spindle-shaped and are formed at the tip of slender spikes projecting out from the surface of the stalks.
Other remarks: This fungus is easily distinguished from the other fungi that infects *P. xylostella* by the presence of slender grey stalks. It was found quite frequently in upland cabbage-growing areas of Java, Sumatra and Sulawesi (Indonesia).

Figure 253

Name: *Hirsutella* sp. (Figure 254)
Host pictured: *Helicoverpa armigera*
Host range: Unknown
Description: The host larva is covered with tan-colored mycelium out of which several stalk-like structures (synnemata) develop. These stalks are dark grey with white tips. Spores are formed on the surface of these stalks. This *Hirsutella* can be distinguished by the tan mycelium and fewer and thicker stalks. This fungus is not common.

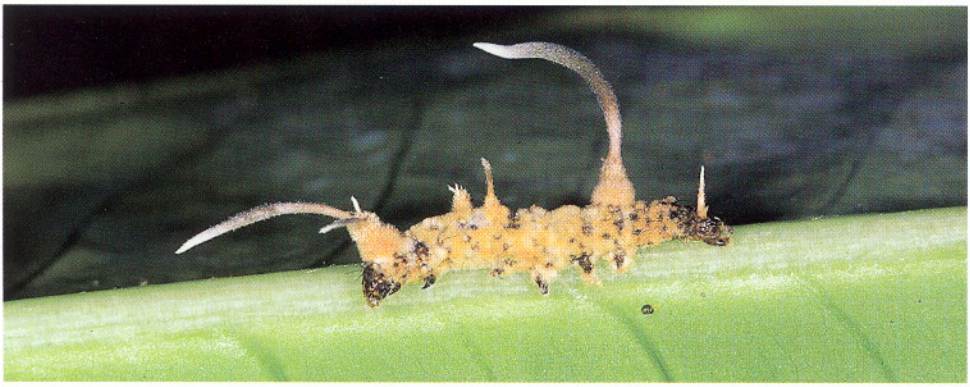


Figure 254

Name: *Hirsutella* sp. (Figure 255)
Host pictured: *Stenocranus bakeri*
Host range: Unknown
Description: This fungus is one of the *Hirsutella* species that do not form stalks. Infected hoppers are found attached to maize leaves by the white hypae which grow out of the dead host and across the leaf surface, forming a "halo" around the hopper. Clear spindle-shaped spores are formed along these hyphae.
Other remarks: This fungus was observed causing heavy mortality in a maize planthopper populations in West Sumatra.

Figure 255

Figure 256

Name: *Beauveria bassiana* (Balsamo) Vuillemin (Figures 256-257)
Host pictured: *Cylas formicarius*
Host range: Wide host range
Description: *B. bassiana* is characterized by having white hyphae and white spores. There is usually a dense white growth of hyphae on the outer surface of the host. The oval, white spores can be seen clumped together into spore balls under high magnification (Figure 257).
Other remarks: This fungus has been reported from a wide variety of hosts including beetles, moths, bugs and grasshoppers. It is commonly found infecting soil inhabiting insects.

Figure 257

Name: *Verticillium* sp. (Figure 258)
Host pictured: *Rhopalosiphum maidis*
Host range: Aphids, whiteflies, thrips and other insects
Description: Aphids are the most common host for this fungus which has white hyphae and white conidia. The aphids become completely covered by the hyphae and the white cylindrical spores accumulate into slime balls on the surface of this hyphal mat.
Other remarks: In Indonesia, this fungus was observed only on aphids.

Figure 258

Name: *Paecilomyces* sp. (Figure 259)
Host pictured: *Plutella xylostella*
Host range: unknown
Description: Hyphae are white and form a thick mat over the entire host. This fungus is characterized by having stalks (synnemata) which are clubbed or enlarged at the tips. White oval spores are formed in clumps on the surface of these clubbed structures.
Other remarks: *Paecilomyces* can be distinguished from *Hirsutella* by having clubbed stalks instead of slender tapering stalks. This fungus was found in very low incidence.

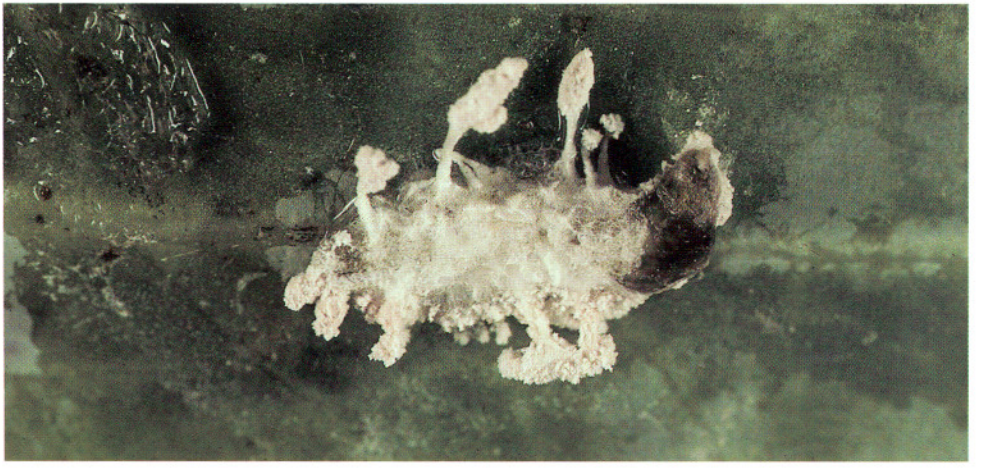


Figure 259

Viruses

Viruses have been isolated mostly from larvae of moths. All of the ones reported here are nuclear polyhedrosis viruses (NPVs). NPVs are very effective natural regulating agents, especially when larval populations are high. These viruses can spread rapidly through populations and cause dramatic epizootics.

Description: In late stages of infection, larvae infected with NPV turn white and become swollen and sluggish (Figure 260). Just before they die, the larvae climb to the tops of plants and attach to leaves by their prolegs (Figure 261). After death, the larvae quickly turn brown or black, the internal contents become liquified, and the integument becomes very fragile. The integument ruptures, releasing the liquid contents which contain millions of polyhedral bodies of the virus (Figure 262). If this liquid is examined with a compound microscope, the polyhedral bodies can be seen as bright refractile bodies. In the field, this virus-containing liquid is spread over the plant and is fed on by other larvae. Larvae die within 4 - 7 days after ingesting the virus.

Other remarks: NPVs for a number of caterpillar pests, including *Helicoverpa armigera* and *Spodoptera exigua,* have been developed and used successfully as microbial insecticides.

Name: *Thysanoplusia orichalcea* NPV (ThorNPV) (Figures 260-261)
Host pictured: *T. orichalcea*
Host range: Several species of Plusiinae (loopers)

There are two distinct NPVs of *T. orichalcea* that can be only distinguished by examining the polyhedral bodies (PIBs) with a compound microscope. One has small pyramid-shaped PIBs and the other has large, irregular-shaped PIBs. Both cause similar symptoms in the host. The pyramid-shaped NPV is the one found most frequently in the field. It is a very effective regulating agent in looper populations, especially in carrots and potatoes. Figure 260 shows a live looper in late stages of virus infection and Figure 261 show a recently-killed larva hanging by its prolegs.

Figure 260

Figure 261

Name: *Spodoptera litura* NPV (SlNPV) (Figure 262)
Host pictured: *S. litura*
Host range: Specific to *S. litura*
This is a typical NPV with large irregular-shaped polyhedra. It is not found frequently in the field under natural conditions, but it is quite effective in reducing larval populations when applied as a microbial agent. Figure 262 shows a virus-killed larva with the liquid contents leaking out through a break in the integument.

Figure 262

Figure 263

Figure 264

Name: *Spodoptera exigua* NPV (SeNPV) (Figures 263-264)
Host pictured: *S. exigua*
Host range: Specific for *S. exigua*
This is a typical NPV with large irregular-shaped polyhedra. Figure 263 shows a live larva in late stages of infection and Figure 264 shows a freshly-killed larva, both on shallots. This virus is not common as a natural regulating agent, but has been very effective as a microbial agent, especially in shallots in Indonesia.

Protozoa

Most protozoan pathogens reported from Lepidoptera are members of the microsporidia group. They are characterized by the production of larger numbers of spores which accumulate in the fat body and blood of the host larva. Spores in the blood can easily be seen with a compound microscope. They are oval and refractile. Externally, infected larvae turn white due to the accumulation of large numbers of spores in the tissues (Figure 265, Figure 266). At this stage, larvae appear similar to those infected by NPVs. However, microsporidian disease takes longer to kill the larvae than do viruses. A larva may remain alive for 7 - 10 days. An NPV-infected larva that has reached the white stage usually dies within 24 hours. Also, the integument of a microsporidian-infected larva does not become fragile as with NPV infection. Because of the chronic nature of microsporidian infections, these pathogens are often overlooked in surveys for natural enemies. However, they are quite common and probably play an important role in population suppression.

Name: Microsporidian of *Spodoptera exigua* (Figure 265)
Host pictured: *S. exigua*
Host range: Unknown
In extensive surveys in Indonesia for natural enemies of this pest, this was the most common pathogen. Infection levels by this protozoan pathogen were as high as 20% in some locations. Figure 265 shows an *S. exigua* larva heavily infected with this pathogen.

Figure 265

Figure 266

Name: Microsporidian of *Argyrogramma signata* (Figure 266)
Host pictured: *A. signata* (looper)
Host range: Unkown
Figure 266 shows a heavily-infected looper larva. Large numbers of spores in the fat body make the larva look whiter than normal. Microsporidian infections can be found in all three species of loopers (*A. signata, C. chalcites* and *T. orichalcea*) and it may be the same pathogen infecting all three looper species. Infection levels in all three species were low.

Nematodes

Name: Mermithid nematode (Figure 267)
Host pictured: *Helicoverpa armigera*
Host range: Unknown
Mermithids develop within their hosts until the last larval stage of the nematode is reached. They then kill their host by emerging through the cuticle. All the nematodes shown in Figure 267 emerged from a single *H. armigera* larva. They were collected from a tomato field in N. Sulawesi, Indonesia. Forty percent of the *H. armigera* collected from this field were parasitized by this nematode.

Figure 267

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