Introduction

As with other crops, insects and other pests affect common or dry bean production before and after harvest. Many species have been listed as pests of common beans (King and Saunders, 1984; Mancia and Cortez, 1975; Ruppel and Idrobo, 1962). The few that are recognized as economically important pests are listed in Table 1 according to their main feeding habits. The given division cannot be maintained strictly because the Mexican bean beetle and chrysolomelids may also attack young pods while pod borers such as *Epinotia* and *Heliotis*, may also feed on leaves and buds. Slugs and spider mites are not insects but are listed because of their economic importance in certain areas.

This chapter updates pertinent literature available on bean pests in Latin America, with emphasis on bean-pest ecology and non-chemical control methods. Emphasis is also given to those insects or pest situations for which valuable, new information has been published since 1980 (van Schoonhoven and Cardona, 1980).

Geographical Distribution of Important Bean Pests

A simplified distribution of the principal bean pests in Latin America is shown in Figure A. Documentation on the bean-pest complex has improved since 1980. New authoritative descriptive reviews have been published. Table 2 lists general references on the insect fauna registered on beans in Latin America.

* Entomologist, Centro Internacional de Agricultura Tropical (CIAT), Cali, Colombia.
<table>
<thead>
<tr>
<th>Feeding norm and common name</th>
<th>Scientific name</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Seedling-attacking insects</strong></td>
<td></td>
</tr>
<tr>
<td>Seedcorn maggot</td>
<td><em>Delia platura</em> (Meigen)</td>
</tr>
<tr>
<td>Cutworms</td>
<td><em>Agrotis ipsilon</em>, <em>Spodoptera exigua</em> (Hübner)</td>
</tr>
<tr>
<td>White grubs, crickets</td>
<td><em>Phyllaphaga mentresi</em> (Blanchard), <em>Gryllus assimilis</em> F.</td>
</tr>
<tr>
<td>Lesser cornstalk borer</td>
<td><em>Elasmopalpus lignosellus</em> (Zeller)</td>
</tr>
<tr>
<td><strong>Leaf-feeding insects</strong></td>
<td></td>
</tr>
<tr>
<td>Chrysomelids</td>
<td><em>Diabrotica</em> spp., <em>Cerotoma</em> spp.</td>
</tr>
<tr>
<td>Saltmarsh caterpillar</td>
<td><em>Estigmene acrea</em> (Drury)</td>
</tr>
<tr>
<td>Bean leafroller</td>
<td><em>Urbanus proteus</em> (L.)</td>
</tr>
<tr>
<td>Webworm (Hedylepta)</td>
<td><em>Omiodes indicata</em> (F.)</td>
</tr>
<tr>
<td>Mexican bean beetle</td>
<td><em>Epilachna varivestis</em> Mulsant</td>
</tr>
<tr>
<td>Leafminers</td>
<td><em>Liriomyza</em> spp.</td>
</tr>
<tr>
<td><strong>Piercing and sucking insects</strong></td>
<td></td>
</tr>
<tr>
<td>Leafhopper</td>
<td><em>Empoasca kraemeri</em> Ross &amp; Moore</td>
</tr>
<tr>
<td>Common whitefly</td>
<td><em>Bemisia tabaci</em> (Gennadius)</td>
</tr>
<tr>
<td>Aphids</td>
<td><em>Aphis</em> spp., and others</td>
</tr>
<tr>
<td>Thrips</td>
<td><em>Caliothrips braziliensis</em> (Morgan)</td>
</tr>
<tr>
<td>Stink bugs</td>
<td><em>Acrosternum marginatum</em> (Palisot de Beauvois), and others</td>
</tr>
<tr>
<td><strong>Pod-attacking insects</strong></td>
<td></td>
</tr>
<tr>
<td>Bean-pod weevil</td>
<td><em>Apion godmani</em> Wagner</td>
</tr>
<tr>
<td>Pod borers</td>
<td><em>Heliothis</em> spp., <em>Epinotia opposita</em> Hein., <em>E. aoprema</em> (Walsingham), <em>Etiella zinckenella</em> (Treitschke), <em>Maruca testulalis</em> (Geyer)</td>
</tr>
<tr>
<td><strong>Storage insects</strong></td>
<td></td>
</tr>
<tr>
<td>Bruchids</td>
<td><em>Acanthoscelides obtectus</em> (Say), <em>Zabrotes subfasciatus</em> (Boheman)</td>
</tr>
<tr>
<td><strong>Other pests</strong></td>
<td></td>
</tr>
<tr>
<td>Spider mites</td>
<td><em>Tetranychus desertorum</em> Banks, <em>Tetranychus urticae</em> Koch</td>
</tr>
<tr>
<td>Tropical spider mites</td>
<td><em>Polyphagotarsonemus latus</em> (Banks)</td>
</tr>
<tr>
<td>Slugs</td>
<td><em>Sarasinula plebeia</em> (Fisher)(^a)</td>
</tr>
</tbody>
</table>

a. Identification needs further confirmation (K. L. Andrews, personal communication).
Figure A. Geographic distribution of bean pests in Latin America.
Table 2. Selected general references on bean pests in Latin America.

<table>
<thead>
<tr>
<th>Country or region</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Argentina</td>
<td>Costilla (1983)</td>
</tr>
<tr>
<td>Brazil</td>
<td>Costa and Rossetto (1972); de Carvalho et al. (1982)</td>
</tr>
<tr>
<td>Central America</td>
<td>Bonnefil (1965); King and Saunders (1984); Andrews (1984)</td>
</tr>
<tr>
<td>Chile</td>
<td>Olalquiaga-Fauré (1953); Ripa-Schaul (1981)</td>
</tr>
<tr>
<td>Colombia</td>
<td>Posada-O. et al. (1970); Posada-O. and García (1976)</td>
</tr>
<tr>
<td>Cuba</td>
<td>Pendás-Martínez (1983)</td>
</tr>
<tr>
<td>Guatemala</td>
<td>Salguero (1981)</td>
</tr>
<tr>
<td>Haiti</td>
<td>Kaiser and Meléndez (1976)</td>
</tr>
<tr>
<td>Honduras</td>
<td>Peairs (1980); Passoa (1983); Andrews (1984)</td>
</tr>
<tr>
<td>Latin America</td>
<td>Ruppel and Idrobo (1962); van Schoonhoven and Cardona (1980); Cardona et al. (1982b)</td>
</tr>
<tr>
<td>Nicaragua</td>
<td>Sequeira et al. (1978)</td>
</tr>
<tr>
<td>Peru</td>
<td>Wille-T. (1943); Avalos-Q. (1977); Avalos-Q. (1982)</td>
</tr>
<tr>
<td>El Salvador</td>
<td>Mancía and Cortez (1972); Mancía and Cortez (1975)</td>
</tr>
<tr>
<td>Caribbean region</td>
<td>Parasram (1973)</td>
</tr>
</tbody>
</table>

Leafhoppers, chrysomelids, cutworms, spider mites, leaf-feeding caterpillars, and storage insects (bruchids) are the most widely distributed pests of beans in Latin America. Of regional importance in Mexico and parts of Central America are the bean-pod weevil, the common whitefly, and, to a lesser extent, the Mexican bean beetle. The seedcorn maggot is more common and important in Mexico and Chile than elsewhere, while *Epinotia* species (pod borers) continue to be major pests in Chile and Peru.

The most important recent change in pest status is the rise of the slug (*Sarasinula plebeia* (Fisher)) to a key pest position in Central America.
America. This phenomenon has been well documented (Andrews, 1983a; Andrews and Dundee, 1986). Interestingly, leafminers (*Liriomyza* species) have become more troublesome in Peru and Ecuador than before, possibly as a result of insecticide abuse and other factors.

**Economic Losses**

Insect losses vary widely between and within regions. Estimates based upon yield reductions in insecticidal trials tend to overestimate the importance of insects. Thus, yield losses resulting from leafhopper damage during dry seasons are estimated as high as 80%, while losses during wet seasons averaged 22% (CIAT, 1975). A more realistic estimate of the economic importance of the leaf-hopper was obtained by Pinstrup-Andersen et al. (1976) who calculated an 11% crop loss in commercial fields in Colombia.

Losses from the bean-pod weevil (*Apion* spp.) in Central America are variable. Sifuentes-A. (1981) estimated 50% losses occurred in Mexico, while Guevara-Calderón (1961) reported as much as 80% damage. Salguero (1983b) found an average of 17% damage in central, and 9%-60% damage in southeastern, Guatemala.

Losses can be expressed in other terms and not necessarily as percentage of yield reductions. In Central America, slugs affect half a million farmers’ crops per year (Andrews, 1983a). Since there are few crop alternatives for the subsistence farmer to grow, the pest becomes a serious socioeconomic problem. Bruchid damage is another example of a pest problem which affects small farmers’ economies. Fear of bruchid damage forces farmers to sell their produce as soon as possible, even when supply is high and prices are low (van Schoonhoven, 1976).

A recent survey of bean scientists (CIAT, 1984b) revealed that, at least in qualitative terms, the leafhopper is regarded as the most important insect pest of beans in Latin America (Table 3), followed by chrysomelids, bruchids, whitefly, and soil insects. *Apion godmani* Wagner and slugs were not considered as important, possibly because the sample size among Central American scientists was small. Chrysomelids, leafhoppers, whitefly, and soil insects were
Table 3. Insect pests of beans in Latin America, ranked by 35 bean scientists, according to their importance in terms of incidence and need to be controlled by chemical means.

<table>
<thead>
<tr>
<th>Pest</th>
<th>Times insect mentioned as:</th>
<th>Weighted rank for importance</th>
<th>Chemical control required</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Severe</td>
<td>Moderate</td>
<td>Occasional</td>
</tr>
<tr>
<td>Leafhoppers</td>
<td>13</td>
<td>14</td>
<td>7</td>
</tr>
<tr>
<td>Chrysomelids</td>
<td>10</td>
<td>19</td>
<td>6</td>
</tr>
<tr>
<td>Bruchids</td>
<td>13</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>Whiteflies</td>
<td>9</td>
<td>11</td>
<td>2</td>
</tr>
<tr>
<td>Soil insects</td>
<td>6</td>
<td>9</td>
<td>14</td>
</tr>
<tr>
<td>Aphids</td>
<td>1</td>
<td>9</td>
<td>14</td>
</tr>
<tr>
<td>Slugs</td>
<td>6</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Spider mites</td>
<td>1</td>
<td>7</td>
<td>11</td>
</tr>
<tr>
<td>Heliotris spp.</td>
<td>3</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>Leaf-feeding caterpillars</td>
<td>0</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>Other pod borers</td>
<td>0</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>Stink bugs</td>
<td>2</td>
<td>1</td>
<td>13</td>
</tr>
<tr>
<td>Apion spp.</td>
<td>2</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Epilachna sp.</td>
<td>1</td>
<td>1</td>
<td>3</td>
</tr>
</tbody>
</table>

SOURCE: CIAT, 1984b.

regarded as those pests for which chemical controls were more frequently needed.

Progress has been made in establishing initial action thresholds and/or economic injury levels for controlling identified pests (Table 4). These may change as research on new or refined techniques continues.
Table 4. Action thresholds for some bean pests, according to their economic injury level.

<table>
<thead>
<tr>
<th>Pest</th>
<th>Country</th>
<th>Economic injury level</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Apion</em> spp.</td>
<td>Guatemala</td>
<td>4-6 adults/4 m of row</td>
<td>Salguero (1983b)</td>
</tr>
<tr>
<td><em>Acrosternum</em> spp.</td>
<td>Colombia</td>
<td>1 late-instar nymph/0.6 m&lt;sup&gt;2&lt;/sup&gt;</td>
<td>Hallman et al. (1986)</td>
</tr>
<tr>
<td>Chrysomelids</td>
<td>Colombia</td>
<td>2-4 adults/plant</td>
<td>Cardona et al. (1982a)</td>
</tr>
<tr>
<td>Cutworms</td>
<td>General</td>
<td>10% of plants cut</td>
<td>Hallman (1985)</td>
</tr>
<tr>
<td></td>
<td>USA</td>
<td>1-1.5 larvae/plant</td>
<td>Michels and Burckhardt (1981)</td>
</tr>
<tr>
<td><em>Heliothis</em> spp.</td>
<td>Colombia</td>
<td>8 larvae/m&lt;sup&gt;2&lt;/sup&gt;</td>
<td>Hallman (1985)</td>
</tr>
<tr>
<td>Leafhoppers</td>
<td>Colombia</td>
<td>2-3 nymphs/leaf</td>
<td>CIAT (1976)</td>
</tr>
<tr>
<td></td>
<td>Honduras</td>
<td>2 nymphs/leaf or 2 adults/plant</td>
<td>Andrews (1984)</td>
</tr>
<tr>
<td>Leafrollers</td>
<td>USA</td>
<td>26 fourth-instar or 4-5 fifth-instar larvae/plant</td>
<td>Greene(1971a)</td>
</tr>
<tr>
<td><em>Omiodes</em> sp.</td>
<td>Brazil</td>
<td>33% defoliation</td>
<td>de Bortoli (1980)</td>
</tr>
<tr>
<td>Slugs</td>
<td>El Salvador</td>
<td>0.2 active slugs/m&lt;sup&gt;2&lt;/sup&gt; or 0.4 slugs/traps/night</td>
<td>Andrews and Huezo de Mira (1983)</td>
</tr>
<tr>
<td></td>
<td>Honduras</td>
<td>1 slug/m&lt;sup&gt;2&lt;/sup&gt; or 1 slug/trap/night</td>
<td>Andrews and Barletta (1985)</td>
</tr>
</tbody>
</table>

Control Methods

Bean-cropping systems in Latin America are variable. So are bean-pest control tactics. These vary from sophisticated, large-scale applications of granular insecticides (to control whiteflies in
Argentina) to occasional insecticidal applications by small farmers, or even to complete reliance on natural mortality factors to suppress insect populations.

The short growing season of beans and frequent fallow periods reduce the effectiveness of biological control. Apart from the introduction of larval parasites of Mexican bean beetle in Mexico, there have been no attempts to mass-rear, mass-release, or manipulate parasites or predators of bean pests in Latin America. However, research in this area and in the potential use of pathogenic fungi or bacteria, must continue, if only to know which beneficial organisms must be preserved.

Cultural control practices are important in some cases. Shifting the planting date can reduce pressure from leafhoppers, bean-pod weevils, and seedcorn maggots. However, it has limited applications where rainfall distributions govern planting dates. Common agronomic practices such as weeding, land preparation, and burning of residues, are useful for controlling slugs, cutworms, white grubs, and other soil pests. The common practice of planting associated crops must not be discouraged among small farmers. Research has shown that this system regulates populations of leafhoppers, Mexican bean beetles, *Apion* spp., and chrysomelids.

Host-plant resistance studies have identified cultivars with genetic resistance to leafhoppers, bruchids, bean-pod weevil, Mexican bean beetle, and pod borers. Such studies must continue as a major objective in research, together with studies on minimizing pesticide applications. A decision to spray must not only be based upon expected yield losses, but also upon treatment costs and upon the consequences this spray will have on later pest development. Most national programs have updated their chemical control recommendations. Recently, valuable information has been obtained on action threshold populations and critical crop-growth periods for control of several species. Progress in establishing action thresholds (Table 4) will help formulate recommendations to meet the objective of pest management. Pohronezny et al. (1981) and Andrews (1984) provide recent examples of how to carry out integrated pest management programs.
Seedling-attacking Insects

White grubs, cutworms, and crickets

White grubs, cutworms, and crickets are minor pests of beans in Latin America. Damage from these insects is usually confined to small scattered areas of bean-producing regions and plant losses are not high. Outbreaks, however, can be locally devastating.

Common names frequently used for white grubs in Latin America include “gallinas ciegas,” “chizas,” “mayates,” and “mojojoys.” Cutworms are called “tierberos,” “trozadores,” “cortadores,” “nocheros,” “rosquillas,” “lagarta militar,” and “lagarta rosca.” Common names for crickets and mole crickets are “grillos” and “grillotopos,” respectively.

White grubs (Figure 187) feed on roots and show a characteristic patchy distribution. Damaged plants wilt and exhibit yellowing of leaves. Plant losses from white-grub attack usually occur in crops that follow pasture. Losses can be reduced by proper land preparation and weed control or, if there is a history of previous attacks, by incorporation of granular insecticides. Phyllophaga menetriesi (Blanchard) is described by King and Saunders (1984) as an important species in Central and South America.

Cutworms damage beans by cutting stems of young seedlings (Figure 188). Older plants can be damaged by stem girdling, although this damage is less common. Agrotis, Feltia, and Spodoptera are common cutworm genera and Agrotis ipsilon (Hufnagel) is the most important species. The biology and control of cutworms are discussed by Metcalf et al. (1962).

Cutworm attacks in beans are sporadic and difficult to predict. Therefore, it is better to control cutworms with baits placed, in late afternoon, near plants rather than with preventive insecticide treatments such as granular formulations of various insecticides. A mixture of sawdust, molasses, and trichlorfon or carbaryl is effective, and controls crickets and millipedes as well.

Cricket attacks on beans are sporadic and difficult to predict. Therefore, it is better to control crickets with baits placed, in late afternoon, near plants rather than with preventive insecticide treatments such as granular formulations of various insecticides. A mixture of sawdust, molasses, and trichlorfon or carbaryl is effective, and controls crickets and millipedes as well.

Crickets and mole crickets have been listed as bean pests in some areas (Posada-O. et al., 1970). However, they seldom cause significant economic losses (Figure 189).
Seedcorn maggot (Diptera: Anthomyiidae)

The seedcorn maggot, *Delia platura* (Meigen) (syn. *Hylemya cilicrura* Rond.), is a bean pest in Chile, Mexico, and parts of United States and Canada. It has also been reported from Central America (King and Saunders, 1984) and Brazil (Hohmann, 1980). There has been some confusion about the taxonomy of this group: the genus has been named *Delia, Phorbia, and Hylemya*. McLeod (1965) separated species on the basis of their nutritional requirements and infertility of interspecific hybrids. Maize, beans, potatoes, beets, tobacco, vegetables, and peas have been listed as host plants. Damage is more serious in Mexico and Chile than elsewhere in Latin America.

Common names for the seedcorn maggot in Latin America are “mosca de la semilla,” “mosca de la raíz,” “gusano de la semilla,” and “mosca de semente.” The biology of this species has been studied by Harris et al. (1966), Hohmann (1980), and Miller and McClanahan (1960). Adults resemble houseflies and females lay eggs near seeds or plants in the soil. Larvae feed on bean seeds (Figure 190) or seedlings (Figure 191), and pupate in the soil. Eggs are white and hatch in two (Harris et al., 1966) or four to eight days, depending on the temperature (Sandsted et al., 1971). The pupal stage lasts 9-12 days and there can be as many as three generations per crop. The first generation is the most damaging.

Leaf damage by *D. platura* ranges from a few holes in the first true leaves to complete destruction of the growing point. In laboratory experiments, 5-10 maggots per seed were required to significantly reduce stands of kidney, lima, and snap beans (Vea et al., 1975). Subsequently, Vea and Eckenrode (1976b) determined that a 25% loss of the first pair of unifoliate leaves significantly reduced yield in snap beans by 11%-48%. In common beans, a loss as large as 70% of the first pair of unifoliate leaves did not affect final yields. When the maggot feeds on the growing point, the resulting damaged plant is stunted, incurring the name “baldhead.” Most of such plants shrivel and die, resulting in high plant stand losses.

Cultural practices help reduce seedcorn maggot damage. Shallow planting in warm, moist soil can hasten emergence and thus reduce
the susceptible period (Sandsted et al., 1971). Montecinos-Urbina
(1982) recommended late planting, especially in areas with soils rich
in organic matter which may attract ovipositing females. Biological
control was not effective (Miller and McClanahan, 1960).

Resistance to seedcorn maggot was found by Vea and Eckenrode
(1976a) in two breeding lines which had significantly lower levels of
stand losses than did susceptible commercial cultivars. White-
seeded beans were more susceptible. Hagel et al. (1981) found some
variability for seedcorn maggot resistance in 160 common bean
accessions, but concluded that resistant materials benefited from
the additional protection provided by treatment with chlorpyrifos.
Black, pink, and dark Red Kidney types were less susceptible.
Guevara-Calderón (1969) in Mexico also found less damage in
black-seeded cultivars than in yellow.

For many years, a dieldrin seed-dressing was used to control D.
platura. As this product is prohibited in many countries, and as the
insect developed resistance to chlorinated hydrocarbons, recent
research has focused on identifying alternatives. Chlorpyrifos was
recommended by Gould and Mayor (1975), Crowell (1976), and
Ruppel (1982) who also recommended seed-dressing with diazinon.
Granular formulations of carbofuran, fonofos, and phorate have
also been effective (Eckenrode et al., 1973; Ruppel, 1982).

**Lesser cornstalk borer (Lepidoptera: Pyralidae)**

The lesser cornstalk borer (Elasmopalpus lignosellus (Zeller)) is a
widespread pest of beans in Central and South America, but is most
serious in Brazil (Costa and Rossetto, 1972) and Peru (Avalos-Q.
and Lozano-V., 1976). This polyphagous insect attacks beans,
sugarcane, cotton, sorghum, rice, peanuts, cowpea, and several
graminaceous weeds. Common names are “coralillo,” “barrenador
menor del tallo,” “gusano saltarín,” and “elasmo.”

Females lay eggs singly on leaves, stems, or in the soil. The larval
stage lasts 13-26 days, and there are six instars. Pupation occurs in
the soil (Leuck, 1966). Dupree (1965) found little evidence of stem-
boring activity before the third larval instar.

Damage is caused by the larvae (Figure 192) which enter the stem
just below the soil surface and tunnel upwards (Figure 193). Attacks
usually occur when plants are 10-12 cm high with two leaves. Damaged plants look flaccid and wilt or lodge. Attacks usually occur in irregular patterns (Salinas, 1976). These symptoms are similar to those caused by the scolytid Hypothenemus sp. and the root borer Conotrachelus phaseoli Marshall (Calil and Chandler, 1982; Calil et al., 1982).

Avalos-Q. and Lozano-V. (1976) evaluated 93 bean cultivars for lesser cornstalk borer resistance but did not find variability. Some species of Braconidae, Ichneumonidae, and Tachinidae have been identified as larval parasites (Leuck and Dupree, 1965; Salinas, 1976). However, their efficacy in suppressing lesser cornstalk borer populations has not yet been evaluated.

Seed dressings with insecticides were evaluated by Campos-P. (1972) with variable results. Granular insecticides placed near the seeds must be applied before planting. Campos-P. (1972) and Wille-T. (1943) recommend clean fallowing for prolonged periods and heavy irrigation to achieve control.

**Leaf-Feeding Insects**

**Chrysolomelids (Coleoptera: Chrysolomelidae)**

Chrysolomid beetles are among the most widely distributed pests of beans in Latin America (Bonnefil, 1965; King and Saunders, 1984; Passoa, 1983; Ruppel and Idrobo, 1962). Prevalent genera are Diabrotica, Neobrotica, and Cerotoma. Other genera listed by Grillo-Ravelo (1979), Popov et al. (1975), Ruppel and Idrobo (1962), Valverde et al. (1978), and Yépez-Gil and Montagire-A. (1985) include Epitrix, Systena, Colaspis, Gynandrobrotica, Chalepus, Nodonota, Chaetocnema, and Maecolaspis. Cerotoma and Diabrotica are the most important, and this review will concentrate on the banded cucumber beetle (Diabrotica balteata LeConte) (Figure 194) and the bean beetle (Cerotoma facialis Erickson) (Figure 195).

Some common names for chrysolomids in Latin America are “crisomelidos,”“doradillas,”“diabrotica,”“tortuguillas,”“mayas,”“vaquitas,”“vaquinhas,” and “cucarroncitos de las hojas.”
Chrysomelids can affect beans in three ways: larvae damage roots and root nodules; adults feed on foliage at all stages of crop growth; and adults act as vectors of important viral diseases (Gámez, 1972). Sometimes adults also feed on flowers and young pods.

The biology of the banded cucumber beetle (*D. balteata*) as a polyphagous species was studied by Pulido-F. and López de Pulido (1973). They listed 32 host plants for this species. Of these, beans and maize were hosts for larvae and adults. González et al. (1982) demonstrated that *D. balteata* does not survive on bean roots and the bean beetle (*C. facialis*) does not feed on maize roots. This confirmed previous findings by Young and Candia (1962) that *D. balteata* adults have a feeding preference for young bean plants and oviposition preference for soil in which young maize plants are growing.

Females undergo a preoviposition period which varies from 5-12 days in Colombia (González et al., 1982) to 4-8 days in Mexico (Young and Candia, 1962). Oviposition takes place singly or in clusters of as many as 12 eggs in soil cracks or beneath plant debris. A female can lay as many as 800 eggs and has an average life cycle of 37 days. Eggs hatch in five to six days, and the three larval instars together last 14 days. Pupation takes place in a cell in the ground (Pitre and Kantack, 1962) and lasts six to seven days. The sex ratio is usually 1:1. Pulido-F. and López de Pulido (1973) found that nutrition has a significant effect on female fecundity. Females fed with soybean leaves laid an average of 326 eggs, while those fed with soybean leaves, flowers, and young pods laid 975 eggs. Maximum egg production by females fed with bean leaves was 144 per individual.

The biology of *C. facialis* is similar. Females live 52 days, undergo a 5-12 day preoviposition period, and lay an average of 532 eggs per female. The egg stage lasts six days, there are three larval instars which together last 10-11 days, and pupation lasts six to seven days. The sex ratio is 1:1 (González et al., 1982).

Most damage by chrysomelids occurs during the seedling stage. Adult (Figure 196) and larval (Figure 197) damage at different population levels and crop-growth stages was evaluated by Cardona et al. (1982b). Second- and third-instar larvae were more damaging than first instars and could cause as much as 100% loss under
greenhouse conditions. Significant damage and reduction in leaf area were detected when plants were infested one, four, and seven days after planting. Fourteen-day-old and older plants did not show a significant reduction in leaf area. Under field conditions, mixed and pure populations of *C. facialis* and *D. balteata* caused yield losses when infestation levels were two to four adults per plant during early growth stages and, to a lesser extent, during flowering. No significant damage occurred at other growth stages.

Intercropping of beans with banana in Costa Rica significantly reduced populations of *D. balteata* and *C. ruficoris* (Olivier) (Risch, 1982). Predation of adults by reduviids has been observed (Hallman, 1985). Young and Candia (1962) identified a tachinid adult parasite. When natural control is not effective and populations reach critical levels, sprays with carbaryl, methomyl, or malathion are useful. Insecticide applications are usually not justified when average natural populations are 0.6-1.0 adults per plant. Cardona et al. (1982b) recommend limiting sprays to early growth stages or the initial flowering period when populations are higher than two adults per plant.

**Mexican bean beetle (Coleoptera: Coccinellidae)**

The Mexican bean beetle, *Epilachna varivestis* Mulsant, called “conchuela” in Latin America, is basically a pest of soybeans (Turnipseed and Kogan, 1976). However, it attacks common beans in United States, Mexico, parts of Guatemala, Honduras, and El Salvador. It is also a pest of cowpea and lima beans in El Salvador (Mancia and Román-Cortez, 1973). Beggarweed, scarlet runner bean (*Phaseolus coccineus* L.), and *Lablab purpureus* (L.) Sweet are also host plants (Turner, 1932). Augustine et al. (1964) and Wolfen-barger and Sleesman (1961c) found that mung bean (*Vigna radiata* (L.) Wilczek) and urd bean (*V. mungo* (L.) Hepper) were less preferred hosts than common bean (*Phaseolus vulgaris* L.).

Damage is caused by both larvae (Figure 198) and adults (Figure 199) which feed on leaves. Stems and pods can also be damaged when populations are high. Larvae do not chew leaves but scrape the tissue, compress it, and then swallow the juices. Damage is more
serious at early crop-growth stages and mature larvae are more damaging than adults (Turner, 1935).

The preoviposition period lasts 7-15 days. Females lay yellow to orange-colored eggs on the undersurface of leaves. The eggs are laid in groups of 36-54 per batch with an average of 43 (Mancía and Román-Cortez, 1973). Hatching occurs six days later and the four larval instars are completed in 15-16 days. The prepupal stage lasts two days and the pupal stage six to seven days. Pupation occurs on leaves and pupae attach to the lower leaf surface. Adults are copper-colored, with 16 black spots on the elytra, and live four to six weeks. In United States, adults hibernate, often gregariously, in woodlands and bean debris (Elmore, 1949). In El Salvador, the beetle passes through four generations from May to November (Mancía and Román-Cortez, 1973).

Mellors and Bassow (1983) compared the life cycles on beans and soybeans and did not find differences in developmental periods. Hammond (1984) later reported that development on common beans took 16% less time than on soybeans.

There have been several studies on host-plant resistance to the Mexican bean beetle, with varying results. For example, Wolfenbarger and Slessman (1961c) did not observe resistance in the *P. vulgaris* accessions they investigated. They rated the cultivars Idaho Refugee and Wade as very susceptible. However, Campbell and Brett (1966) reported them as resistant. These authors found more variability among *P. vulgaris* cultivars. They also showed that egg number, egg masses, and adult weights were significantly reduced when beetles were reared on resistant cultivars. In Mexico, Montalvo and Sosa (1973) classified the cultivars Guanajuato 18 and Zacatecas 48 (*P. vulgaris*) and Puebla 86 (*P. coccineus*) as resistant. Egg numbers and adult weights were reduced—nonpreference and antibiosis were the mechanisms apparently responsible. More recently, cultivars Regal (snap beans) and Baby Fordhook and Baby White (lima beans) were reported as resistant (Raina et al., 1978).

The mechanisms of resistance to the Mexican bean beetle need further clarification. Augustine et al. (1964) suggested that high sucrose concentrations act as an arrestant. This hypothesis is
contrary to findings by Jones et al. (1981) and LaPidus et al. (1963) who concluded that sugar acts as a phagostimulant and that phenolic compounds reduce feeding rates. Experimental data by Arévalo-Aponte (1977) supports the hypothesis of the importance of sugar concentration as a phagostimulant. Resistant cultivars Puebla 84 and Zacatecas 48 had lower concentrations of saccharose, fructose, and galactose than susceptible cultivars. An earlier hypothesis on the importance of phaseolunatin (a cyanogenic glycoside) as an attractant (Nayar and Fraenkel, 1963) also needs further experimental support.

Recent work on resistance to Mexican bean beetle has concentrated on improving screening methodologies and knowledge of host plant-insect interactions (Raina et al., 1980; Wilson, 1981).

The role of natural enemies in suppressing beetle populations is an active area of research. Predators of eggs and first-instar larvae include Coleomegilla maculata De Geer and Hippodamia convergens Guérin-Méneville. Other predators are the pentatomids Podisus maculiventris (Say) and Stiretrus anchorago (F.) (Waddill and Shepard, 1975). The mite Coccipolipus epilachnae Smiley has been observed attacking adults in El Salvador (Smiley, 1974) and United States (Schroder, 1979). Possibly the best-known natural enemy of the Mexican bean beetle is the eulophid larval parasite Pediobius foveolatus (Crawford) which was effectively used on soybeans in United States (Stevens et al., 1975). This parasite was introduced into Mexico and became established within three years (Carrillo-Sánchez, 1977). Carrillo also reports that the tachinid Aplomyiopsis epilachnae (Aldrich) can parasitize as many as 70% of larvae. The bacteria Bacillus thuringiensis Berliner controlled larvae under laboratory and field conditions (Cantwell and Cantelo, 1982).

Removal of plant debris and deep plowing are cultural practices that control the insect. Turner (1935) indicated that damage by beetles is decreased when plant densities are reduced. Crop associations (maize-beans) also reduce beetle populations (Martínez-Rodríguez, 1978; Sánchez-Preciado, 1977). The effect of companion plantings was studied by Latheef and Irwin (1980). Fewer beetles were found on beans bordered by french marigold,
but the beneficial effect was overshadowed by allelopathic effects of French marigold on beans.

Carbaryl, malathion, and methyl parathion effectively control this insect (Cadena-L. and Sifuentes-A., 1969). The first application is made when there are 25 adults per hectare present, a second spray may be combined with Apion control, and a third application is made only if necessary. In United States, farmers are advised to spray when one beetle or egg mass is found per 1.8 m of row. The beetles are counted on the ground after shaking the plant. In Wyoming, USA, Michels and Burkhardt (1981) established an economic threshold level of 1-1.5 larvae per plant. Hagen (1974) obtained an effective 10-week control with granular formulations of disulfoton, carbofuran, phorate, aldicarb, and fensulfothion which were applied at planting. The effectiveness of pyrethroids was reported by McClanahan (1981). Zungoli et al. (1983) found that the chitin inhibitor, diflubenzuron, gave adequate control with no apparent effect on the main parasite, *P. foveolatus*.

**Bean leafroller (Lepidoptera: Hesperiidae)**

The bean leafroller, (*Urbanus* (syn. *Eudamus*) *proteus* (L.)), is called “gusano fósforo” and “gusano cabezon” in Latin America. This insect is widely distributed from United States (Quaintance, 1898) to Brazil (Freitas, 1960) and Chile (Díaz-P., 1976).

In general, the bean leafroller is a minor pest of beans. In Florida, USA, Greene (1971a) calculated that economic damage occurs when more than 725 cm² of leaf area per plant is destroyed. Yield reduction occurs when there are more than 26 fourth-instar larvae per plant. More than 4 fifth-instar larvae per plant would also be of economic significance. However, these population levels were seldom observed, possibly because only 4% of individuals reach the fifth instar.

The adult butterfly lays one to six eggs per leaf on the lower surface. Larvae fold the leaf margin (Figure 200) and feed and pupate within the fold. Larvae are recognized by their three dorsal longitudinal lines and large red-brown head capsules (Figure 201). In Florida, eggs hatch in three days (Greene, 1971b) and larval and
pupal stages last 15 and nine days, respectively. In Colombia, van Dam and Wilde (1977) found that the egg stage lasts an average of four days, while larval and pupal stages develop in 23 and 11 days, respectively. The duration of immature stages is longer in Chile (Díaz-P., 1976).

Chemical control is seldom required. Effective natural control (21%-40% larval parasitism) was observed in Colombia (van Dam and Wilde, 1977).

**Saltmarsh caterpillar (Lepidoptera: Arctiidae)**

The common Latin American name for the saltmarsh caterpillar, *Estigmene acrea* (Drury) is “gusano peludo.” *Estigmene acrea* is a cosmopolitan species and is basically a cotton pest. It also attacks lettuce and sugar beets and, although commonly found on beans, is not regarded as a major pest of this crop. Other host plants include maize, horticultural crops, soybean, sesame, tobacco, and several weeds (Young and Sifuentes-A., 1959).

Biological studies of this species were made by Stevenson et al. (1957) and Young and Sifuentes-A. (1959). Adult moths lay egg masses with as many as 1000 eggs. Larvae develop in 17-19 days. Young larvae remain aggregated (Figure 202) and can skeletonize isolated bean plants. Older larvae are solitary. Their bodies are covered with setae (Figure 203). Pupation takes place on the soil in plant debris.

Good levels of natural control were detected by Young and Sifuentes-A. (1959) in Mexico and by Rodas (1973) in Colombia. Economic levels are seldom reached and chemical control is rarely needed.

**Hedylepta (Lepidoptera: Pyralidae)**

Before the name of the genus was changed, the common name frequently used for this insect was “hedylepta.” *Omiodes* (syn. *Hedylepta*; syn. *Lamprosema*) *indicata* (Fabricius) is also known as “pega-pega” in some areas of Latin America. *Omiodes indicata* is a
pest of beans, soybeans, and other legumes in Central (King and Saunders, 1984) and South America (Ruppel and Idrobo, 1962).

Adult moths oviposit on the lower surface of leaves. A female lays an average of 330 eggs. Hatching occurs in four days and green larvae (Figures 204 and 205) develop in 11 days. They pupate (Figure 206) and emerge five days later as an adult (Kappor et al., 1972). Larvae weave leaves together (hence, the alternative name, webworm) and feed on the parenchyma (Figure 207), safe from insecticides.

The level of natural control is high (García, 1975; Lenis-Lozano and Arias-Sánchez, 1976) and the insect does not usually become a serious pest. Chemical control is seldom needed and is recommended only if 33% or more defoliation occurs at flowering (de Bortoli, 1980).

**Leafminers (Diptera: Agromyzidae)**

Several species of leafminers (Figure 208) occur on beans in Latin America, including the cosmopolitan species *Liriomyza huidobrensis* (Blanchard) and *L. sativae* Blanchard which are polyphagous and widely distributed (Spencer, 1973). Other species include *Melanagromyza phaseolivora* Spencer in Ecuador and *Japanagromyza* species in coastal areas of Peru. Common names for leafminers in Latin America include “minadores,” “tostones,” and “moscas minadoras.”

*Liriomyza sativae* has a short life cycle of 24-28 days and several generations occur per year. This species is particularly important in Venezuela as a pest of common beans, especially when young plants are attacked. The insect is usually regulated by natural enemies such as braconids, eulophids, and pteromalids (Spencer, 1973).

*Lyriomyza huidobrensis* is an important pest in certain areas of Ecuador such as the Catamayo and Lambayeque Valleys. The life cycle (17-25 days) was studied by Espinosa-G. and Sánchez-V. (1982). The egg stage lasts two to three days. The larval stage requires seven to nine days, and pupae five to seven days, to develop. Adults live three to six days. There are several generations per year.

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Chemical control is difficult. Insecticides can provoke high populations and outbreaks, resulting in severe defoliation and significantly reduced yields (Spencer, 1973). Omethoate, permethrin, and cypermethrin are recommended (Espinosa-G. and Sánchez-V., 1982; Torres-B. and Delgado-A., 1967). The use of plastic sheets lined with adhesive and passed through the field at canopy height has been suggested by Soto-P. (1982) for reducing adult populations. An economic injury level of one to two larvae per leaf was established by Espinosa-G. and Sánchez-V. (1982).

Piercing and Sucking Insects

Leafhoppers (Homoptera: Cicadellidae)

*Empoasca kraemeri* Ross and Moore is the most important insect pest of beans in Latin America. It occurs in Florida, Central America, Colombia, Ecuador, Peru, and Brazil (de Oliveira et al., 1981; Ross and Moore, 1957). *Empoasca fabae* (Harris) is a closely related species and is a pest of beans in Central America (King and Saunders, 1984). However, workers question its presence south of the United States (Ross and Moore, 1957; van Schoonhoven et al., 1985). Other minor species of *Empoasca* in Latin America are listed by Bonnefil (1965), Langlitz (1964), Ruppel and DeLong (1956), and van Schoonhoven et al. (1985).

Leafhoppers are highly polyphagous (DeLong, 1971). Nymphs of *Empoasca* spp. have been collected from more than 80 cultivated and noncultivated host plants in Colombia. Common names frequently used for leafhoppers in Latin America include “empoasca,” “chicharrita,” “lorito verde,” “cigarra,” “saltahojas,” and “cigarrinha verde.”

The biology of *E. kraemeri* was studied by Wilde et al. (1976). Eggs are inserted singly into leaf blades, petioles, leaf tissues, or stems, with 50%-82% of the eggs located in petioles (Gómez-Laverde and van Schoonhoven, 1977).

Eggs hatch in eight to nine days and the five nymphaal instars (Figure 209) are completed in 8-11 days. Adults are green (Figure 210) and have an adult life span, on average, of 62 days. Thirteen to
168 eggs with an average of 107 eggs per female are laid. The sex ratio is usually 1:1 and there is no parthenogenesis. In Brazil, Leite-Filho and Ramalho (1979) observed a three-day previposition period and a shorter adult life-span.

Damage (Figure 211) is caused by nymphs and adults feeding in phloem tissue which results in leaf curling and chlorosis, stunted growth, and severely reduced yields or complete crop loss. A toxin may be involved in plant damage but this has not been demonstrated. This species, unlike other species, does not transmit bean viruses. Damage is more severe when high populations occur at early crop-growth stages and flowering. Damage occurring after pod set does not have a significant effect on yields (van Schoonhoven et al., 1978a).

Leafhopper attack and damage is more severe during hot, dry weather and is aggravated by poor soil conditions or insufficient soil moisture. Planting date affects leafhopper populations and resulting damage. In El Salvador, Miranda (1967) obtained yields of 1182 kg/ha when common beans were planted on December 21 (end of wet season), but only 121 kg/ha when beans were planted on January 21 (middle of dry season). At the Centro Internacional de Agricultura Tropical (CIAT) in Colombia, very high populations develop during dry or semidry seasons.

Besides planting dates, various cultural practices reduce leafhopper populations and damage. Associated cropping affects leafhopper populations: smaller *E. kraemerii* populations were found on common beans planted in association with maize that was planted 15-20 days earlier. However, populations were larger when both crops were planted on the same date (CIAT, 1977; Hernández-Romero et al., 1984). Similar results were obtained by García et al. (1979) who evaluated the effect of a sugarcane-bean association. Nymphs per leaf and adults per meter row were 44% and 55% lower, respectively, in association (when beans were planted 45 days after sugarcane) than in monoculture.

Preliminary studies showed that leafhopper adult and nymphal populations decreased 43% and 70%, respectively, in bean plots which had nearly 100% weed cover (CIAT, 1976). Altieri et al. (1977) suggested that *E. kraemerii* populations were reduced, not by
increased parasite or predator activity, but by a possible chemical repellent effect of two weed species (*Leptochloa filiformis* (Lam.) Beauv. and *Eleusine indica* L.) Gaertn. The role of weed cover in reducing leafhopper infestations was further studied by van Schoonhoven et al. (1981). They found that mixtures of these grassy weeds effectively reduced nympha1 and adult populations on leafhopper-susceptible and resistant cultivars. *Eleusine indica* was more competitive with the susceptible cultivars than *L. filiformis*. Both weeds competed with the resistant cultivars, preventing yield advantage. Similar results were obtained in United States by Andow (1983).

Mulching with aluminum foil and rice straw significantly reduced adult leafhopper colonization, possibly as a result of increased light reflection. Yields were greater compared to beans without mulches (Cardona et al., 1981; Wells et al., 1984). This method of control, however, has serious economical and practical limitations. Andrews et al. (1985) showed that plastic mulches can be economically viable in production of green beans, but advised against their use for common beans.

The egg parasite *Anagrus* sp. (Hymenoptera: Mymaridae) is the best known natural enemy of *E. kraemeri* in Latin America. This parasite has a functional response of two days to the presence of host eggs (CIAT, 1980). Although it parasitizes between 60% and 80% of leafhopper eggs under field conditions, it cannot keep leafhopper populations below economically damaging levels (Gómez-Laverde and van Schoonhoven, 1977). *Anagrus flaveolus* Waterhouse is present in Brazil (Pizzamiglio, 1979).

Other natural enemies include the trichogrammatid *Aphelinoidea plutella* (Girault) (Pizzamiglio, 1979), the mymarid egg parasite *Polynema* sp., and the dryinid *Agonatopus* sp. The parasitic fungi *Hirsutella guyana* and *Erynia radicans* (Brefeld) were found in Brazil (Ghaderi, 1984). *Erynia radicans* has also been observed infecting *E. kraemeri* during rainy periods in Colombia (van Schoonhoven et al., 1985) and Honduras (Caballero and Andrews, 1985).

Varietal resistance to *E. fabae* has been studied in the United States. McFarlane and Rieman (1943) classified several materials as
resistant and discussed the possibility of using them to suppress leafhopper populations. Wolfenbarger and Sleesman (1961a and 1961b) later screened 1619 lines and found significant variability in plant damage and nympha l counts. A significant correlation between nympha l counts and damage scores was detected. Epidermal hairs did not correlate with nympha l populations, whereas plant height, resistance to bean common mosaic virus (BCMV), and seed color were related to various levels of resistance. Higher levels of resistance were detected more among Phaseolus lunatus L. and Vigna radiata materials than among P. vulgaris (Wolfenbarger and Sleesman, 1961d). Chalfant (1965) found a 50% yield difference between protected and unprotected plots, regardless of their variability.

Resistance to E. kraemer i has been extensively studied at CIAT (Figure 212) by evaluating more than 18,000 bean accessions. Mass screenings are based solely on visual damage scores (leaf distortion and yellowing) that are recorded 25, 35, and 45 days after planting to avoid maturity and other late-season effects. Intermediate and resistant materials are rescreened in replicated nurseries in which a visual estimate of pod number per plant is also made. More indepth evaluations of bean accessions are made, calculating the yield difference between insecticide-protected and unprotected plots.

No high levels of resistance have been found in P. vulgaris. To date, 3%-4% of the 18,000 P. vulgaris accessions evaluated are classified as resistant. Most of these are small-seeded, black or cream-colored, indeterminate bush beans (Gawley, 1983). Black-seeded, late materials appear less susceptible than large-seeded red or white accessions. At high infestation levels, nympha l counts do not correlate with visual damage scores (Eskafi and van Schoonhoven, 1978; Murguido and Beltrán, 1983). Hooked trichomes are a major factor responsible for resistance of P. vulgaris to E. fabae (Pillem er and Tingey, 1976). As resistant mechanisms to E. kraemer i they are also important in P. lunatus (Lyman and Cardona, 1982), but not in P. vulgaris (CIA T, 1974).

Mechanisms of resistance to E. kraemer i have been the subject of several studies. Wilde and van Schoonhoven (1976) did not find antibiosis or definitive signs of nonpreference (antixenosis). Additional research suggested that tolerance was manifested by
reduced damage, expressed as less stunting, higher leaf area index, and more pods (CIAT, 1983). Additionally, in both free- and no-choice tests, ovipositional antixenosis was detected in the cultivars EMP 89, EMP 94, and EMP 97 (Kornegay, 1985; Kornegay et al., 1986). According to Kornegay and Temple (1986) an additive-dominance genetic model explained the inheritance of tolerance and antixenosis defense mechanisms.

Breeding for resistance to *E. kraemerii* has been complicated by the lack of adequate levels of resistance in *P. vulgaris*, lack of diversity in resistance responses, quantitative nature of inheritance (Galwey and Evans, 1982a), and strong interactions between genotype and environment (Galwey and Evans, 1982b; Kornegay et al., 1986; van Schoonhoven et al., 1985). Nevertheless, a recurrent selection program has successfully diversified mechanisms of resistance (Kornegay et al., 1986) and some lines have been consistently outstanding (van Schoonhoven et al., 1985). Some of the CIAT-developed EMP lines that yield well under high insect pressure have wide adaptation in various Latin American countries. For example, EMP 92 has been multiplied in Argentina for commercial production (Costilla, 1983) and EMP 84 is a potential new cultivar for Cuba.

In addition to *P. vulgaris*, resistance to *E. fabae* has been found among *P. lunatus*, *P. acutifolius* A. Gray, and *P. coccineus* materials (Wolfenbarger and Sleesman, 1961d). When barriers to interspecific crossing are overcome, more rapid breeding progress may be possible (Galwey et al., 1985).

Chemical control of *E. kraemerii* is effective with monocrotophos, methamidophos, dimethoate, and granular carbofuran (CIAT, 1974 and 1976; Murguido, 1983). The economic injury level is two to three nymphs per leaf and is higher for resistant cultivars (CIAT, 1976 and 1983). In Central America, Andrews (1984) recommends that sprays be made when one adult per plant is found at the seedling stage. Two nymphs per leaf or two adults per plant are critical population sizes between the two-leaf stage and pod set. As many as three nymphs per leaf or three adults per plant can be tolerated during pod fill.
Whiteflies (Hemiptera-Homoptera: Aleyrodidae)

The sweetpotato or common whitefly, *Bemisia tabaci* (Gennadius), is the most important aleyrodid affecting beans in Latin America. Other species are *B. tuberculata* Bandar, *Tetrakeurodes acaciae* (Quaintance), *Trialeurodes abutiloneus* (Haldeman), and *Trialeurodes vaporariorum* (Westwood). These species have other leguminous and nonleguminous host plants (Russell, 1975). Common names for whiteflies in Latin America are “mosca blanca” and “mosca branca.”

*Bemisia tabaci* is a vector of such important bean viruses as bean golden mosaic and bean chlorotic mottle (Gámez, 1971). Direct feeding does not damage bean plants and the insect becomes important only in areas where virus transmission occurs such as Central America, parts of Mexico, the Caribbean, Brazil, and Argentina (Blanco-Sánchez and Bencomo-Pérez, 1981; Cárdenas-Alonso, 1982; Costa, 1965; Gámez, 1971).

The systematics of the group has been complicated by the occurrence of host-correlated variation (Mound, 1963). Immature stages of *B. tabaci* occur in a variety of morphological forms associated with definitive types of host leaves. Races also occur (Bird and Maramorosch, 1978). This is important, especially when breeding plants for resistance to whiteflies.

Russell (1975) summarized the biology of *B. tabaci*: females lay 25-32 eggs singly or in groups on the undersurface of bean leaves where the egg pedicel is inserted into the epidermis. The immature stages (Figures 213 and 214) also occur on the undersurface of leaves. The egg to adult (Figure 215) cycle is completed in about three weeks and is similar on cotton seedlings (Butler et al., 1983).

In Brazil and other countries, soybeans act as a transitional host for whitefly infestations which then move in large numbers to beans (Costa, 1975). Wide planting periods favor population buildup and breeding of successive generations. Alonzo (1975) reported a significant effect of late planting dates on whitefly infestations in Guatemala.

Resistance to BGMV is an economic method of control, particularly as little is known about resistance mechanisms of bean
cultivars to B. tabaci. Hohmann and de Carvalho (1982) found that B. tabaci preferred Porrillo Sintético but did not report resistance in four cultivars tested. Studies in Guatemala demonstrated that the resistant cultivar ICTA Jutiapán, without chemical protection against the vector, outyielded the protected susceptible check, Rabia de Gato (Aldana-De León et al., 1981). In Mexico, line D 145, without protection, outyielded the protected susceptible cultivars Jamapa and Criollo Regional (Rodríguez-Rodríguez, 1983).

Chemical control is possible with foliar applications of methamidophos 15 and 30 days after planting or applying, before planting, granular phorate or carbofuran (Mancia et al., 1973). Aldicarb also provides good protection (de Bortoli and Giacomini, 1981). Triazophos and mephosfolan were not effective in Brazil (Hohmann, 1982).

**Aphids (Homoptera: Aphidae)**

Several aphid species attack common beans. Their direct damage is not important but their ability to transmit bean common mosaic virus makes them important economic pests. Common names in Latin America include “áfidos,” “pulgones,” “afidios,” and “pulgaro do feijoeiro.” Species common on beans are *Aphis gossypii* Glover, *A. craccivora* Koch, *A. spiraecola* Patch, *A. fabae* Scopoli, *Tetranura nigriabdominalis* (Sasaki), *Myzus persicae* (Sulzer), and *Brevicoryne brassicae* (L.) (Bécquer-Hernández and Ferrándiz-Puga, 1981; Costa and Rossetto, 1972; Zaumeyer and Thomas, 1957).

High aphid mortality occurs when aphids are captured by hooked hairs on bean leaves (McKinney, 1938). Control of bean common mosaic has been achieved by incorporating resistance genes so that chemical control of aphids is not needed.

**Thrips (Thysanoptera: Thripidae)**

Thrips are pests of beans in several Latin American countries, but their attacks are usually of little economic importance. *Frankliniella* sp., *Sericothrips* sp., and *Caliothrips braziliensis* (Morgan) have occurred in Brazil (Rossetto et al., 1974) and Colombia (Posada-O.
et al., 1970). In Colombia, *C. braziliensis* is the most abundant species. *Calothrips fasciatus* (Pergande), *C. phaseola* (Hood), *Frankliniella insularis* (Franklin), and *F. williamsi* (Hood) are pests of beans in Central America (King and Saunders, 1984). Common names in Latin America include “trips” and “bicho candela.”

Females insert their eggs into leaves, petioles, and stems. In laboratory studies at CIAT, eggs of *C. braziliensis* hatched in five to six days. First-instar larvae developed in one to two days and the second lasted four to five days. Pupation occurred in the soil and debris and lasted two to three days. Longevity and fecundity of adults were not studied.

Larvae and adults feed on the undersurface of cotyledonary leaves. In older plants they can also be found feeding on leaves, flowers, and petioles. When populations are high, thrips cause leaf cupping and reduction in the size and development of young plants (Figure 216). In general, they seldom become an economic pest. Most attacks occur in field borders and usually during hot, dry weather.

Chemical control of thrips is rarely needed. Adults and nymphs of *Orius tristicolor* (White) prey on *Sericothrips* sp. and *C. braziliensis*.

**Stink bugs (Hemiptera: Pentatomidae)**

Several species of pentatomids have occurred as pests of beans in Latin America. *Acrosternum marginatum* (Palisot de Beauvois), the green bean stink bug, is found in Central America, Mexico, the Caribbean (King and Saunders, 1984), and Colombia. The cosmopolitan and polyphagous bugs *Nezara viridula* (L.) and *Piezodorus guildinii* (Westwood) are not economically important in common beans (Costa et al., 1980 and 1981). Other pentatomids recorded on beans in Latin America are *Edessa rufomarginata* De Geer, *Euschistus bifibulus* (Palisot de Beauvois), *Padaeus trivittatus* Stål, and *Thyanta perditor* (F.). None of these are economically important (King and Saunders, 1984). Common names for these insects are “chinches,” “chinches apostosos,” and “chinches hediondos.”
The biology of *A. marginatum* was studied by Hallman et al. (1985 and 1986). The total cycle from egg to adult takes 42 days. There are five nympha1 instars. The first-instar nymphs are foliar feeders, while later nymphs are pod feeders. After a 10-day preoviposition period, females lay an average of 96 eggs in masses of 3-28 eggs (average 13). The insect (Figure 217) is not commonly found in commercial fields but sometimes appear in large populations when it becomes economically important. Hallman (1985) estimated that significant yield losses occurs at infestation levels of one late-instar nymph/0.6 m² of beans.

*Telenomus* sp. (Hymenoptera: Scelionidae) is an important egg parasite of pentatomids in Brazil (Link et al., 1980). No other control measures are reported.

**Pod-attacking Insects**

**Bean-pod weevil (Coleoptera: Curculionidae)**

The bean-pod weevil, *Apion godmani* Wagner, is an important insect pest of common beans in Mexico and parts of Central America (Salguero, 1983a; Sifuentes-A., 1981). *Apion aurichalceum* Wagner is also important in the highlands of Mexico (McKelvey et al., 1951) and Guatemala (Salguero, 1983a). In Central America, *A. godmani* occurs in Guatemala, El Salvador, Honduras, and northern Nicaragua. It does not occur in coastal areas and is more serious at higher altitudes. Reports on the presence of this insect in Colombia have not been confirmed. Other less important species of *Apion* on beans are listed by McKelvey et al. (1947) and Mancia (1972). Host plants for *A. godmani* include *Dalea, Desmodium, Rhynchosis*, and *Tephrosia* species (McKelvey et al., 1947). Common names for these insects are “apion,” “picudo de la vaina,” and “picudo del ejote.”

The economic importance of *A. godmani* varies. In Mexico, Sifuentes-A. (1981) estimated 50% yield losses while Guevara-Calderón (1961) reported as much as 80% damage. Salguero (1983b) found 17% average damage in the central-western plateau of Guatemala and 9%-60% damage in the southeastern plateau.
Mancía et al. (1972) observed as much as 94% bean loss in El Salvador, especially during the rainy season. In germplasm screening nurseries in Honduras, seed damage has ranged from 1% in resistant to 80%-85% in susceptible materials. *Apion aurichalceum* is less important, possibly as a result of its ovipositional behavior: the female lays about 35 eggs only in the distal portion of a pod, and the remaining seeds of the pod therefore escape attack (McKelvey et al., 1951).

The adult bean-pod weevil (Figure 218) is black and about 3 mm long. During the wet season, two generations may form, with a possible third generation occurring during the dry season. Survival sites could not be located in Mexico (McKelvey et al., 1951) or in Guatemala (Salguero, 1983b).

In the laboratory (21 °C and 75% r.h.), Mancía (1972) found that the egg stage lasted five days, the three larval instars six days, while the prepupal and pupal stages lasted two and nine days, respectively. Adults sometimes remained in the pupal chamber for three or four days but usually emerged immediately after pupation. Adults lived from 10 days to nearly a year, and mated several times. A maximum of 392 eggs per female were recorded (Mancía, 1972). The pre-oviposition period lasted 10 days.

McKelvey et al. (1951) reported a longer larval period of three weeks and four larval instars. The egg-to-adult period in Mexico lasted 6-8 weeks and adults lived an average of three months. A shorter egg-to-adult cycle of 28-30 days was calculated by Salguero (1983b) in Guatemala. The insect has not been observed during the dry season.

Adults usually appear before flowering and cause light feeding damage to leaves, pods, and flowers which is not economically important. Oviposition takes place on newly formed pods during the daytime. The female adult chews a small hole in the mesocarps of one- to four-cm-long pods, usually above the developing seed, and deposits a white, semitranslucent egg. These spots are visible as white hyperplastic deformations (Figure 219) (McKelvey et al., 1947 and 1951). Those young pods which are attacked may abort (Enkerlin-S., 1951).
Second-instar larvae bore into the mesocarp of the pod wall and feed on developing seeds (Figure 220), leaving the hilum intact. *Apion* damage is somewhat similar to that of *Asphondylia* sp., a cecidomyiid common in El Salvador and Honduras (Espinoza-R., 1985). One larva per seed is normal, but three to five per seed have been found during heavy infestations with a maximum of seven per seed and 28 per pod (Mancia, 1972; McKelvey et al., 1947). Larvae do not feed on mature seed.

*Triaspis* sp., a braconid larval parasite was recorded by McKelvey et al. (1951) in Mexico and by Mancía (1972) in El Salvador. The fungus *Metarrhizium* sp. was observed attacking *Apion* adults in Guatemala (Salguero, 1983a). The efficiency of these natural enemies has not been evaluated. Bean-maize crop associations reduce *Apion* populations (Martínez-Rodríguez, 1978).

Host-plant resistance to *A. godmani* has been studied by several authors. McKelvey et al. (1951) identified bean accessions Puebla 2 and 32, and Hidalgo 6 and 24 as resistant. Guevara-Calderón (1961) identified lines derived from Hidalgo and Puebla 32 as most resistant, together with cultivars Amarillo 155 and Amarillo 156. Other Mexican resistant cultivars were selected by Ramírez-Genel et al. (1959), Guevara-Calderón et al. (1960), Guevara-Calderón (1969), and Medina-Martínez and Guerra-Sobrevilla (1973). From these studies and the intensive screening conducted in El Salvador by Mancia (1973c) and in Guatemala by Yoshii (1978), high levels of resistance (expressed as percentage of seed damage) were detected in accessions Mexico 1290, Amarillo 154, Negro 150, Puebla 152, Línea 12 Salvador, and Línea 17 Salvador.

These and other sources of resistance were used in a breeding project which identified highly resistant lines with less than 10% of pods damaged and less than 2% of seeds damaged (CIAT, 1983). Resistant lines with better adaptation to Mexican and Central American conditions have since been used in crosses to recover resistance through transgressive segregation (Beebe, 1983). Some of these parents were APN 18, APN 92, APN 64, Línea 17 (derived from Mexico 1290), and BAT 340. Simultaneously, new parents of Mexican origin were identified. Some of these are Aguas Calientes 40, Puebla 22, Puebla 36, Puebla 36-1, Puebla 49, Puebla 416, Amarillo 169, Hidalgo 46-A, and Veracruz 155. A good correlation
between percentage of pods damaged and percentage of seeds damaged has been obtained. A sequential sampling plan for resistance nurseries has been proposed by Hallman (1983).

Chemical control of *A. godmani* is still important. Monocrotophos, methamidophos, methomyl, methyl parathion, and carbaryl are effective (Mancia et al., 1972). Carbofuran is effective at a high dosage of 2.5 kg (Mancia, 1973a), but not at 1.5 kg a.i./ha (Salguero, 1983a). Sprays are more effective when made six days after flower initiation and again seven days later (Mancia et al., 1974). A tentative economic threshold of 4-6 adults/40 m of row was established by Salguero (1983b). This economic threshold appears too low and further field testing is needed.

**Lepidopterous Pod Borers**

**Corn earworm and tobacco budworm (Lepidoptera: Noctuidae)**

Damage by the *Heliothis* complex, *H. zea* (Boddie) and *H. virescens* (F.) (Figure 221), is sporadic but can be severe. Common Latin American names include “heliothis,” “bellotero,” “elotero,” “ejotero,” and “yojota.”

Females oviposit on leaves. The larvae (Figure 222) undergo six larval instars during 18-30 days. Larvae attack pods, and feed on seeds after perforating the pod wall above the seeds. Pupation occurs in the soil.

At high population levels, attacks can be devastating (Turner, 1979). Several seeds per pod may be destroyed and secondary rotting may destroy any remaining seeds. Because of the sporadic nature of attacks, the *Heliothis* complex has not been well studied in beans. *Heliothis virescens* seems to be more abundant than *H. zea*.

High levels of parasitism occur. Posada-O. and García (1976) listed 26 different parasite or predator species of *Heliothis* in Colombia. As much as 89% larval parasitism has been recorded at CIAT. The egg parasites *Trichogramma* spp., the tachinid larval parasites *Eucelatoria* sp., and *Archytas piliventris* Wulp are common. Others include the braconid larval parasites *Bracon hebetor*
Say, *Chelonus antillarum* Marsh, *C. insularis* Cress., and *Apanteles marginiventris* (Cress.) (King and Saunders, 1984). *Orius* sp. and *Geocoris punctipes* (Say) are predators of eggs and first-instar larvae.

Chemical control of older larvae is difficult. Pyrethroids are widely recommended. The nuclear polyhedrosis virus (Elcar) was tested on beans in Australia (Rogers et al., 1983) and compared favorably with fenvalerate.

**Epinotia pod borer (Lepidoptera: Olethreutidae)**

*Epinotia aporema* (Walsm.) is widely distributed throughout Latin America. It is an important insect pest in Peru (Wille-T., 1943) and Chile (Brücher-E., 1941). The insect has also attacked faba beans, chickpeas, soybeans, alfalfa, and lentils (Alomia, 1974; Wille-T., 1943). Common names frequently used for this species in Latin America include “polilla del frijol,” “epinotia,” “polilla del brote,” and “barrenador de la vaina.”

Females lay an average of 100 eggs in four to eight masses during one to two weeks. The egg stage lasts four to seven days in Peru (Wille-T., 1943), Chile (Ripa-Schaul, 1981), and Colombia (Alomia, 1974). There are five larval instars which together are completed in 14-22 days. Pupation occurs in a cocoon on leaves or the ground (Wille-T., 1943) during 14-16 days. Adults live 15-22 days and are active at night.

Larvae damage beans by feeding on or in terminal buds, stems, and pods. Larvae weave their excrements together and push them out of the feeding canals. The insect may also cause flower damage and abortion. Stems and buds can be deformed (Figure 223) and pod damage can result in rotting by secondary organisms (Alomia, 1974).

The egg parasite *Trichogramma* sp. has been recorded in Chile (Ripa-Schaul, 1981). Wille-T. (1943) observed a tachinid larval parasite, *Eucelatoria* sp., in Peru. Some work on resistance to *E. aporema* has been done in Peru (Avalos-Q., 1982). In a screening of 968 bean materials, five had significantly lower levels of damaged stems and seeds than the local commercial cultivar. Adequate
chemical control is available with aminocarb, parathion, and omethoate (Torres-B., 1968). Fenvalerate or carbaryl applied 30 days after planting are also effective (Avalos-Q., 1977). Fenvalerate has a 15-day residual effect.

Lima bean pod borer (Lepidoptera: Pyralidae)

The lima bean pod borer (*Etiella zinckenella* (Treitschke)) has occurred in the United States (Stone, 1965), Puerto Rico (Scott, 1940), Mexico, parts of Central America and the Caribbean (King and Saunders, 1984), and Brazil (Ramalho et al., 1978). Little is known about the economic importance of this species in Latin America. According to King and Saunders (1984), it is more important in the Caribbean than in Central America. Attacks are sporadic and only occasionally does the insect become a serious pest. Common names for this insect in Latin America are “barrenador del ejote,” “polilla de las vainas,” and “medidor de las vainas.”

Eggs are laid on flowers or pods. Larvae are yellow, green, or pinkish with red-brown dorsal lines. It can feed on flowers or the exterior of pods, but prefers to act as a pod borer, feeding on developing seeds. Pupation can take place inside pods or the ground. Damaged flowers and small pods can abort (Stone, 1965). *Etiella zinckenella* leaves almost no outside evidence of its presence in pods, while maruca pod borer, *M. testulalis* (Geyer), keeps exit holes open in the sides of infested pods. Larvae force feces and other waste material outside through these holes.

Chemical control of the lima bean pod borer is difficult and is best directed against small larvae before they perforate pods (King and Saunders, 1984). Some work on the resistance of bean cultivars to this insect has been carried out in Brazil by Ramalho et al. (1978) who observed variability in percentage of infested pods and seed damage.

Maruca (Lepidoptera: Pyralidae)

*Maruca testulalis* Geyer is an important pest of legumes in Africa and Asia (Singh and van Emden, 1979; Taylor, 1978), but is not
usually an important pest of common beans in Latin America (King and Saunders, 1984). Occasional attacks, though, can be serious. *Maruca testulalis* has occurred in Brazil (Ruppel and Idrobo, 1962), Colombia (Posada-O. et al., 1970), the Caribbean (Leonard and Mills, 1931), and Central America (King and Saunders, 1984). Common names include “maruca,” “barrenador de la vaina,” and “perforador de la vaina.”

Like most pod borers, *M. testulalis* oviposits near or on flower buds, flowers, young leaves, and pods. There are five larval instars which together last 8-13 days (Broadley, 1977). Larvae have four black or dark gray spots on each segment (Figure 224). Larvae penetrate the pod, feed on developing seeds, and expel frass and feces. Some damage to leaves and flowers occurs before pod feeding (Scott, 1940). Pupation occurs in a cocoon woven between two pods in debris on the soil or in the soil itself.

According to King and Saunders (1984) chemical sprays may be justified when one damaged pod per two plants is found.

### Storage Insects

#### Bruchids (Coleoptera: Bruchidae)

van Schoonhoven (1976) has listed 28 insect species occurring on stored beans. However, most are of minor importance or only accidentally found on beans. By far the most important pests of stored beans in Latin America are the Mexican bean weevil, *Zabrotes subfasciatus* (Bohemian) (Figure 225) and the bean weevil, *Acanthoscelides obtectus* (Say) (Figure 226). Both are cosmopolitan (Chapter 21, this volume). Literature on the economic importance of bruchids is scarce. McGuire and Crandall (1967) estimated 35% of losses occurred during storage (Figure 227) in Mexico and Central America but did not specify if these losses resulted from insects or other factors. In Brazil, 13% losses have been estimated. van Schoonhoven (1976) calculated that in Colombia 7.4% losses were caused by bruchids. Damage was not higher because storage periods were short, averaging 44 days. Common names for these insects are “gorgojos,” “gorgojo pintado,” or “gorgulho de feijão”
(Z. subfasciatus); and "gorgojo común" or "caruncho" (A. obtectus).

The main difference between these bruchids is in their oviposition behavior. Zabrotes subfasciatus attaches the egg to the seed (Figure 225). After hatching, the young larvae bore through their egg shell and the seed coat in one process (Howe and Currie, 1964). Zabrotes subfasciatus does not attack in the field. In contrast, A. obtectus females do not glue eggs to the testa but scatter them among stored seeds or infest beans in the field by ovipositing on growing pods. The newly hatched larvae will later penetrate the seed.

Another important difference lies in their ecological adaptation. Zabrotes subfasciatus is a tropical species and is found predominantly in warmer areas. Acanthoscelides obtectus occurs at higher latitudes and altitudes, in subtropical regions, or in the cooler environment of the highlands of tropical America. In a study in Nicaragua (Peter H. Giles, personal communication), beans were infested initially with A. obtectus (99.7%) and Z. subfasciatus (0.3%) at different elevations above sea level. After 16 weeks, the percent ratios became 0:100 at 56 m; 5:95 at 450 m; and 27:73 at 680 m. Temperatures decreased as elevation increased. These data suggest that A. obtectus becomes a stronger competitor at lower temperatures.

In storage, the life history of Z. subfasciatus and A. obtectus is similar (Howe and Currie, 1964). Larvae of both species molt four times before pupating. During the last larval instar, the feeding and pupation cell (Figure 228) becomes externally visible as a circular window in the seed where larvae feed on the lower testa surface. After pupation the adult may remain in the cell for several days before pushing or biting out the window with its mandibles. Adults normally do not eat but may consume water or nectar. Adults are short lived, and mate and oviposit soon after emergence.

Zabrotes subfasciatus adults exhibit strong sexual dimorphism. Females are large and have four characteristic cream-colored spots on the elytra. The male is entirely brown. At 28 °C and 75%-80% r.h., females lay an average of 36 eggs and live 13 days. The egg stage lasts five to six days, larval development takes 14 days, and the pupal stage takes six to seven days. Usually the sex ratio is 1:1.
At 26 °C and 75%-80% r.h., females of *A. obtectus* live 14 days and lay an average of 45 eggs. Eggs hatch in six to seven days and the larval-pupal development takes 23 days. Sex ratios tend to be 1:1. Mortality during development occurs mainly as larvae penetrate the seed or when the exit hole is not large enough for adult emergence.

Farmers have used various traditional methods to control bruchids. Among these are mixtures of grain with inert materials such as sand, crystalline silica, bentonite, and magnesium carbonate which effectively kill weevils. Ashes from fireplaces are also used as an effective physical barrier to adults (CIAT, 1975). Black pepper has been successfully used to control *A. obtectus* (Lathrop and Keirstead, 1946).

Storing beans in undamaged pods can reduce losses from *Z. subfasciatus*. Eggs deposited on pod walls hatch but larvae die inside the pods without penetrating seed. This method cannot, however, be used to control *A. obtectus* since this insect can attack beans in the pods. Labeyrie (1957) showed that storing beans unshelled or delaying the harvest considerably increases *A. obtectus* attack. This occurs because *A. obtectus* prefers to oviposit on mature pods (Labeyrie and Maison, 1954; Menten and Menten, 1984).

Vegetable oils are also effective against bruchids. van Schoonhoven (1978) found that cotton, peanut, soybean, and maize oils were equally efficient when applied at the rate of 5-10 ml per kg seed. Treated seed retained its germination ability (CIAT, 1977), while the oils caused adult mortality, reduced oviposition, and killed eggs. Unrefined oils can also be used (Hill and van Schoonhoven, 1981).

Chemical control of weevils is readily obtained with a variety of products such as malathion, pyrethrins, pirimiphos-methyl, and fenitrothion (CIAT, 1975; Salas and Ruppel, 1959). The pyrethroids, deltamethrin and permethrin, have also given excellent control. Some fungicides also protect seed (van Schoonhoven and van Dam, 1982). For large volumes of seed, the fumigants aluminum phosphide and methyl bromide are widely used in Latin America (van Schoonhoven, 1976).

Recent work on resistance to bruchids has been conducted at CIAT, Colombia, on a continuous basis (Menten and Menten, 1984).
1984; Oliveira et al., 1979; Ramalho et al., 1977). After screening more than 4000 cultivated bean accessions for resistance to Z. subfasciatus, van Schoonhoven and Cardona (1982) concluded that resistance levels were too low to be of economic value. Similarly, no satisfactory levels of resistance were identified when more than 10,000 genotypes were tested with A. obtectus.

However, very high levels of resistance to both bruchids were found in noncultivated, small-seeded wild forms of P. vulgaris of Mexican origin (CIAT, 1984a; van Schoonhoven et al., 1983). Resistance is expressed as reduced oviposition, longer larval development times, and reduced progeny weight. Antibiosis is the resistance mechanism. According to Osborn et al. (1986), the protein, arcelin, could be the factor responsible for resistance. Variants of this protein are present in accessions with the highest resistance levels: G 12866 (arcelin 2); G 12891, G 12895, and G 12942 (arcelin 3); and G 12949, G 12952, and G 12953 (arcelin 4).

Work is underway to genetically transfer the different arcelin types into cultivated beans and to determine the effect of arcelin on bruchid resistance and human nutrition (CIAT, 1988; Osborn et al., 1986). Evaluation of resistance sources and progenies for resistance to A. obtectus under field conditions is also in progress.

Other Pests

Snails and slugs

Snails are a minor pest in Africa and seldom cause damage to beans in Latin America.

Slugs (Figure 229), however, have become important pests of common beans in some parts of Central America (Andrews and Dundee, 1986). Slugs have also been reported as minor pests in Africa (Chapter 21, this volume), the Caribbean (King and Saunders, 1984) and certain areas in South America (CIAT, unpublished surveys). Common names for slugs in Latin America include “babosas,” “lesmas,” “ligosas,” “sanguijuelas,” “lipes,” and “chimíllias.”
The veronicellid which has been identified as *Sarasinula plebeia* (Fisher) (syn. *Vaginulus plebeius* (Fisher)) is the most important species (Andrews, 1983a). It was reported for the first time from Central America in El Salvador in 1967 by Mancia (1973b). According to Andrews and Dundee (1986), this species was accidentally introduced into El Salvador. It has superimposed its range of distribution on that of native veronicellids such as *Diplosolenodes occidentalis* (Guilding) and *D. olivaceus* (Stearns). Other species reported in Central America are *Leidyula* (syn. *Veronicella*), *moreleti* (Crosse and Fisher) and *Leidyula floridana* (Binney). It is not known whether *D. occidentalis* (syn. *Vaginulus occidentalis*) and *D. olivaceus* are separate species or simply ecotypes.

By 1976 *S. plebeia* was a serious pest of beans in El Salvador, Nicaragua, and Honduras. It was first reported in Guatemala and Costa Rica in 1971 and 1981, respectively. It is not known to occur in Panama, but attacks cassava in Colombia. *Sarasinula plebeia* is a minor pest of beans in Guatemala where it borders El Salvador and Honduras (Salguero, 1981). It is not clear whether this species occurs in Mexico. Andrews and Dundee (1986) report that damage by *S. plebeia* occurred in Chiapas, Veracruz, and Yucatán. However, the Mexican Quarantine Service (Dirección General de Sanidad Vegetal de México, 1982) lists *Leidyula* (syn. *Veronicella*), *moreleti* as the responsible species.

According to Andrews (1983a), crops of 500,000 Central American farmers are affected by this pest every year. The slug problem is more serious in Honduras and Nicaragua than elsewhere. In certain years, as much as 53% of the area planted with beans can be affected (Secretaría de Recursos Naturales de Honduras, 1981).

Slugs are hermaphroditic and self-fertilization in *S. plebeia* is common. Females lay as many as 80 eggs in masses under plant debris or in soil cracks. Eggs are oval, translucent, and hatch in 20-24 days at 27 °C. Under dry conditions, eggs may take six months to hatch. Young slugs resemble adults and reach maturity in two to five months (Mancia, 1973b). Slugs live 12-18 months and reach five to seven cm in length. According to Andrews and Lema (1986), one generation takes eight weeks and there may be two generations per year in Honduras. Slugs are inactive during dry periods. Higher slug
densities occur near streams, in heavy clay soils, and in weedy fields. Most damage occurs along the borders of fields and progresses inwards, especially if vegetation and debris provide ample protection for slugs during the day.

Young slug damage is apparent when whole leaves, except for veins, are consumed (Figure 230). Older slugs consume entire leaves. Entire seedlings may also be consumed, and pod damage can occur. Andrews and Huezo de Mira (1983) calculated that each active slug/m² can cause, in one night, a plant stand reduction of 20% and yield reduction of 16%. Andrews and Huezo de Mira (1983) used simple, inexpensive, pitfall traps that were baited with a mixture of bean, molasses, beer, and carbaryl (Andrews, 1983b). They determined that each captured slug represented a reduction of plant stands by 14% and yield by 11%. The authors established an economic injury level of 0.25 active slugs/m² or 0.4 slugs per trap each night. Honduran work has raised the levels to 1 slug/m² or 1 slug per trap each night (Andrews and Barletta, 1985).

At high population levels, slugs can become a health problem. They act as vectors of the nematode *Angiostrongylus costaricensis* Morera and Cespedes which is pathogenic to man, especially children (Morera, 1973).

Slugs show marked preferences for certain weeds and crops (Ramírez et al., 1985) and are repelled by several plant species. Extracts of *Canavalia* sp. and other plants may reduce slug damage (Coto-Alfaro and Saunders, 1985). Protozoans, brachylaemid flatworms, lungworms, lampirid beetles, and sciomyzid flies have been reported as natural enemies of slugs (Stephenson and Knutson, 1966). A review and a proposal for biological control of slugs in Central America were recently prepared by Bennett and Andrews (1985).

Control of slugs is most effectively achieved by ridding fields and field borders of weeds and plant debris. Burning crop residues, land preparation, and drainage of fields are recommended (Mancía, 1973b). Chemical control is obtained with baits prepared with carbaryl, methiocarb, phorate, aldicarb, thiocarboxime, or metaldehyde (Crowell, 1977). Metaldehyde is widely recommended (Mancía, 1973b; Navarro, 1980). Residual effects of this product are
short term, especially under wet conditions. Foliar sprays of common insecticides do not work (Wheeler and Peairs, 1980). Granular insecticides applied to the soil are also less efficient than baits (Durón-Andino et al., 1981).

Spider Mites

Tropical spider mites (Acarina: Tarsonemidae)

The tropical spider mite, *Polyphagotarsonemus latus* (Banks), causes postflowering foliar damage to beans, especially during humid and warm weather. It also attacks potato, tomato, cotton, pepper, and many weeds (Cromroy, 1958; Doreste, 1968). It is not a serious pest of beans but occasionally can become economically important (CIAT, 1975). According to van Schoonhoven et al. (1978b), the tropical mite occurs in Florida, the Caribbean, Central America, and parts of South America, and is a pest in Brazil (Costa, 1970) and in parts of Colombia. It also occurs in Africa (Chapter 21, this volume). Common names in Latin America include “ácaro blanco,” “ácaro tropical,” and “ácaro branco.”

The tropical mite is small and green, and has a short life cycle which passes through the stages of egg, larva, pseudopupa, and adult. In Brazil, the developmental stages together last six to seven days (Flechtmann, 1972). van Schoonhoven et al. (1978b) found a shorter life cycle in Colombia where the duration of egg, larva, and pseudopupa stages was two, one, and one day, respectively. Males lived for 12 days, while females lived 15 days and laid an average of 48 eggs.

Mite-damaged leaf edges roll upwards and have a shiny appearance (Figure 231). Lower leaf surfaces may turn purple. Young leaves may turn yellow to gold and be stunted. Pods can also be attacked, becoming covered with brown wound tissue (Figure 232). Symptoms can be confused with those induced by virus, mineral deficiencies, sunscald, or pollutants (Chapter 24, this volume).

Chemical control is possible with sulfur, endosulfan, dicofol, and omethoate (van Schoonhoven et al., 1978b). Dimethoate apparently stimulates *P. latus* populations (Harris, 1969).
Spider mites (Acarina: Tetranychidae)


Spider mites usually attack beans (Figure 233) near physiological maturity and are not regarded as important pests of the crop. Studies on the biology of *T. desertorum* were made by Nickel (1960) and Piedrahita-C. (1974). The resistance of bean cultivars to spider mites was studied at CIAT. Some variability was detected but the levels of resistance were not high enough to provide economic benefits (Jara et al., 1981). In Latin America, chemical control recommendations for spider mites on beans include sprays with omethoate or tetradifon (González-A., 1969).

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