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BIOLOGICAL CONTROL OF INSECT PESTS OF CRUCIFERS IN SELECTED WEST INDIAN ISLANDS

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ABSTRACT

In the Caribbean, cole crops are attacked by many insects and other pests, most of which are controlled by insecticides. This paper provides data on the potentials for biological control of diamondback moth, *Plutella xylostella*, cabbage looper, *Trichoplusia ni*, Armyworms, *Spodoptera* spp., Cabbage white butterfly, *Ascia monuste monuste*, Cabbage budworm, *Hellula phidilealis*, and Cabbage aphid, *Brevicoryne brassicae*.

RESUMEN

En la region del caribe las cruciferas son atacadas por muchos insectos y otras plagas, las cuales son controladas por insecticidas. Este trabajo muestra informacion sobre el potencial del control biologico de los lepidopteros, *Plutella xylostella, Trichoplusia ni, Spodoptera* spp., *Ascia monuste, Hellula phidilealis*, y el afido, *Brevicoryne brassicae.*

Cabbage (*Brassica oleracea* var. *capitata*), cauliflower (*B. oleracea* var. *botritis*), pak choi (*B. oleracea* ssp. *chinensis*), chinese cabbage (*B. campestris* var. *pekinensis*) and radish (*Raphanus sativus*) are important cole crops of the Caribbean growing year-round and occupying large acreages. With the growing tourist industry in the region, demand for these crops has increased considerably. During 1988 and 1989 the acreage of crucifers in Jamaica was over 1,000ha and cabbage production alone was around 16,000 tons. In Barbados, the acreage of cabbage cultivation increased from 24ha in 1968-69 to 144ha in 1979-80 (Ministry of Agriculture, unpublished reports, 1969 and 1980). Despite the great potential demand for these crops, insect pests limit their production.

In the Caribbean cole crops are attacked by many insects and other pests, most of which are controlled by insecticides. This paper provides data on the potential of biological control of certain cruciferous pests in the region.

The common pests of economic importance and their distribution in the Caribbean are presented in Table 1.

DIAMOND-BACK MOTH (*Plutella xylostella*)

The diamond-back moth is a cosmopolitan pest, causing serious losses throughout the region. In Jamaica cabbage losses due to the combined feeding of diamondback moth, cabbage looper and armyworms, range from 74 to 100% and average 79% (Alam 1992). Diamondback moth comprises more than 89% of the pest population and up to 95% crop damage (Figs. 1a-c). When *Plutella* population was reduced, the incidence of other pests, particularly of cabbage looper increased (Alam 1992). In a study of four

TABLE 1. COMMON CRUCIFER PESTS OF ECONOMIC IMPORTANCE IN THE CARIBBEAN.

Common name	Scientific name	Distribution
The diamondback moth	*Plutella xylostella*	Caribbean
Cabbage white butterfly	*Ascia monuste monuste*	Caribbean
Cabbage budworm	*Hellula phidilealis*	Caribbean (Serious in Trinidad)
Cabbage looper	*Trichoplusia ni*	Caribbean
Armyworms	*Spodoptera frugiperda*	Caribbean
	S. latifascia	Caribbean
	S. sunia	Barbados & the Windward Islands
	S. eridania	Barbados & the Windward Islands
Cross-striped cabbageworm	*Evergestis remosalis*	Jamaica (Blue Mountains)
Cabbage aphid	*Brevicoryne brassicae*	Caribbean

Total number of larval counts from August 1989 to August 1990

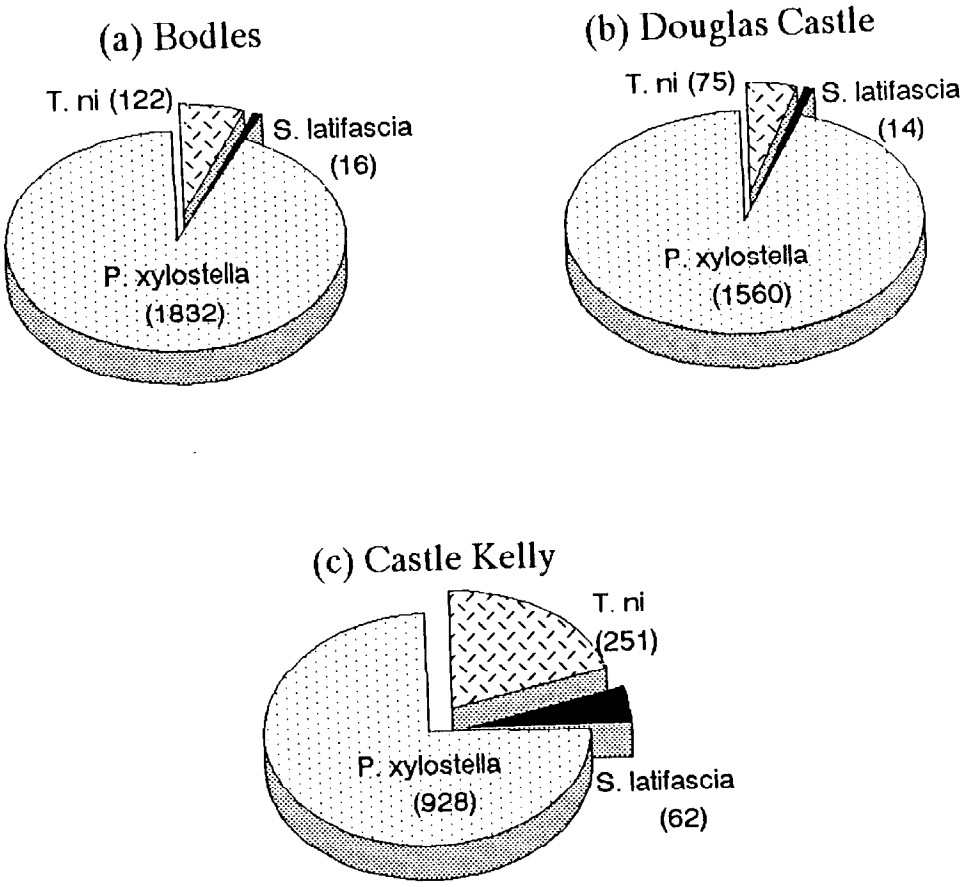

Fig. 1. Leaf defoliators of cabbage. Total number of larval counts from August 1989 to August 1990.

areas in Jamaica, the populations of diamondback moth were highest (95%) at Bodles Agricultural Experimental Station and Douglas Castle and the lowest (76%) at Castle Kelly (Figs. 1a-c). Monthly populations of diamondback moth, cabbage looper and armyworms recorded at these sites are shown in Figs. 2a-c. During 1989 data on the pest-parasite complex in the Blue Mountains of Jamaica were also collected, but due to the ecological damage caused by Hurricane Gilbert further observations were not possible. Alam (1992) reported a complex of parasites, predators and pathogens attacking diamondback moth in Jamaica. Parasites and pathogens of economic importance are discussed in this paper.

Indigenous Parasites

Diadegma insulare (Cresson), a larval parasite is the most common species attacking diamondback moth. Densities of *D. insulare* recorded at different sites are presented in Table 2, along with those of its hyperparasite, *Spilochalcis* sp.

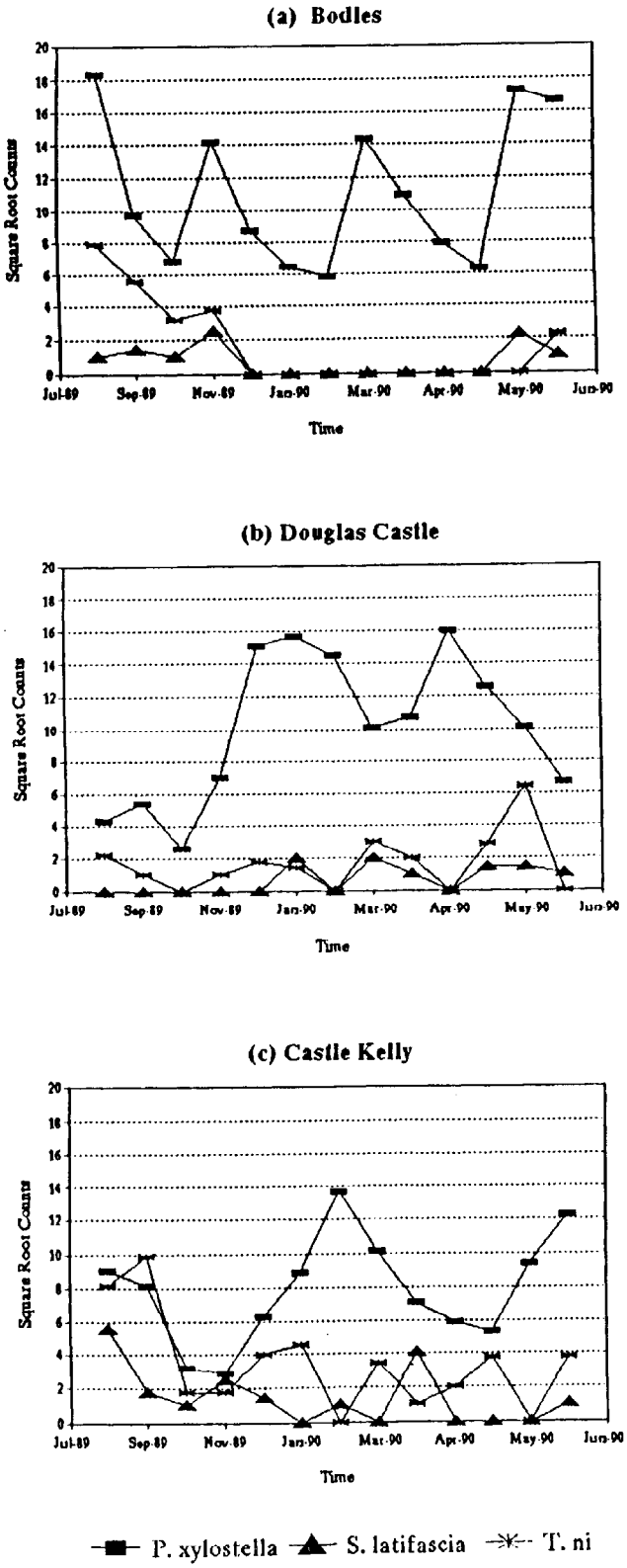

Fig. 2. Leaf defoliators of cabbage.

TABLE 2. PERCENTAGE LARVAL PARASITISM OF *PLUTELLA XYLOSTELLA* BY *DIADEGMA INSULARE*, AND PERCENT *D. INSULARE* COCOONS ATTACKED BY THE HYPERPARASITE *SPILOCHALCIS* SP. DURING 1988-90, IN JAMAICA.

Percent parasitism by *D. insulare*	Percent *D. insulare* cocoons attacked by *Spilochalcis* sp.	Sampling period	Sampling site
9.4-45.5	8.3-68.6	March-November 1988	Castle Kelly
0.0-41.8	0.0-25	February-December 1989	Castle Kelly
12.5-57.5	0.0-100	January-August 1990	Castle Kelly
12.0-28.5	0.0-67.3	April-December 1988	Douglas Castle
6.1-75.8	0.0-50	February-December 1989	Douglas Castle
7.9-46.4	0.0	January-July 1990	Douglas Castle
1.1-57.4	1.6-83.3	April-November 1989	Blue Mountains
2.6	Not Recorded	July 1989	Bodles Agric. Exp. Sta.
1.6	Not Recorded	March 1990	Bodles Agric. Exp. Sta.

At Bodles Agricultural Experimental Station *D. insulare* was rarely found and *Spilochalcis* sp. was not recorded. Forbes & Mansingh (1990) reported up to 62% parasitism by *D. insulare* at Douglas Castle and up to 60% in the Sandy River area.

Oomyzus sokolowskii, a gregarious, larval-pupal parasite of diamondback moth is well distributed in the Greater and Lesser Antilles. The parasite is indigenous to Jamaica and present in all cabbage growing areas. Data on field parasitism recorded at different sites between 1988 and 1990 are presented in Table 3. In Barbados, the parasite was introduced from India and Montserrat (Lesser Antilles) during 1977-80 (Alam 1982).

Cotesia sp. (*glomeratus* group), an indigenous larval parasite was recorded at all observation sites. Generally the parasite was rare, attacking 4.5% larvae in May and 5% in August 1988 at Castle Kelly; 1.5% at Douglas Castle and 3.7% in the Blue Mountains in June 1988.

Exotic Parasites

The indigenous natural enemies of diamondback moth do not provide sufficient control of the pest. As a result, parasites were introduced from India, Pakistan and some of the Caribbean islands to supplement the existing mortality levels of diamondback moth. Alam (1975) reported the introduction of five species into Barbados in 1969 against diamondback moth, of which *C. plutellae* from India and *O. sokolowskii* from India, Montserrat and St. Vincent became established. Between 1971 and 1985, the annual average parasitism by *C. plutellae* ranged from 17.9 to 52.5% (Alam 1982, 1986). *C. plutellae* was also introduced into the Eastern Caribbean islands with similar success (Alam 1989a).

In Jamaica, earlier introductions of *C. plutellae* and *O. sokolowskii* were unsuccessful. They were re-introduced from Barbados in March 1989 and soon after *C. plutellae* was recovered from all four release sites (Table 4). The percent parasitism increased to 90% at Bodles Agricultural Experimental Station, but stayed below 4% in the other three areas. Four species of hyperparasites attacking *C. plutellae* cocoons were reported in Jamaica (Alam 1992).

Trichospilus diatraeae Cherian and Margabandhu, a pupal parasite of graminaceous stalk borers and some other lepidopterous pests, was introduced into Barbados from

TABLE 3. PERCENTAGE PARASITISM OF DIAMONDBACK MOTH PUPAE, BY *OOMYZUS SOKOLOWSKII*, DURING 1988-90, IN JAMAICA.

Range percent parasitism	Sampling Period	Sampling Site
0.0- 4.7	April-December 1988	Douglas Castle
0.0- 2.6	February-December 1989	Douglas Castle
6.8	July 1990	Douglas Castle
0.0-19.5	March-November 1988	Castle Kelly
0.0-15.9	February-December 1989	Castle Kelly
2 and 4.1	January & August 1990, respectively	Castle Kelly
0.5-12.8	April-December 1989	Bodles Agric. Exp. Sta.
0.0-18.5	January-August 1990	Bodles Agric. Exp. Sta.
0.0- 2.9	April-November 1989	Blue Mountains

India in 1972 against armyworms (Alam & Gibbs 1984). The parasite was recovered from the field collected pupae of *T. ni*, *Pseudoplusia includens* Walker, *Diaphanea hyalinata* (L.) and *Stemmorrhages flagia* (Cramer) (Bennett & Alam 1985). Later, the parasite was introduced in other Caribbean islands (Alam 1978, Alam & Gibbs 1984), and was recovered from field collected pupae of *D. hyalinata* and *P. xylostella* in St. Vincent (Alam 1992). In Jamaica, the parasite was recovered only once from a field collected pupa of diamondback moth. The presence of the parasite in Trinidad and in Florida was reported by Bennett et al. (1987).

Fungi

During the rainy season in Jamaica (July to November) 5 to 10% of *Plutella* larvae and pupae are infected by indigenous fungi. Between 1988-90, three parasitic fungi, *Beauveria bassiana* and *Hirsutella* sp. infecting diamondback moth larvae and *Paecilomyces* sp. infecting pupae, were recorded in the Douglas Castle and Castle Kelly areas. *B. bassiana* cultured in the laboratory at Silwood Park, London, was applied against diamondback moth at Bodles Agricultural Experimental Station in July 1990. During the second half of July 1990, 12.5-54.5% of the *Plutella* population was infected (Alam 1992).

Predators

In Douglas Castle, Castle Kelly and Blue Mountains, the predator population per plant was 0.38, 0.37 and 0.4, respectively. The population of Syrphids: *Pseudodoros*

TABLE 4. PERCENT LARVAL PARASITISM OF *PLUTELLA XYLOSTELLA* BY *COTESIA PLUTELLAE*, DURING 1989 AND 1990 AT DIFFERENT RELEASE SITES IN JAMAICA.

Percent larval parasitism by *C. plutellae*	Sampling Period	Sampling Site
5.4-88.7	March 1989 to July 1990	Bodles Agric. Exp. Sta.
<1.0	1989	Douglas Castle
2.8	February 1989	Castle Kelly
0.7- 3.8	June & September 1989	Blue Mountains

clavatus (F.), *Toxomerus dispar* (F.) and *Toxomerus watsoni* (Curran) was the highest, ranging from 77.8-99.6% of the total predator population, followed by Staphylinid, *Belonuchus gagatus* Erichson, 4.1% in Douglas Castle and 22.2% in Blue Mountain; and Coccinellids, *Coleomegilla maculata* DeGeer, *Cycloneda sanguinea* L. and *Hippodamia convergens* (Guer), 0.4% in Castle Kelly and 1.8% in Douglas Castle. *Chrysopid, Ceraeochrysa claveri* Navas was occasionally recorded feeding on young larvae and pupae.

Cabbage Looper (*T. ni*)

Generally, the cabbage looper is a minor pest in the Caribbean, but occasional large populations cause serious defoliation (Alam 1982). In Jamaica, it is the second most important pest representing 4-20% of the population (Fig. 1a-c). In the Douglas Castle area, the highest population (42 larvae from five randomly examined cabbage heads) was recorded in July 1990. In other months the numbers varied from zero to eight. At Castle Kelly, the pest was more abundant and, except in February and July 1990, was recorded throughout the year. The peak populations of 66 and 97 larvae per observation were recorded in August and September 1989. At Bodles Agricultural Experimental Station, it was recorded between August and November 1989 and in August 1990, with 62, 31, 10, 14, and 15 larvae per month, respectively (Fig. 2a-c).

Natural Enemies

The natural enemies of cabbage looper in Jamaica and Barbados was usually low (Table 5). *C. plutellae*, a larval parasite of diamondback moth introduced from India for control of its original host, became an important parasite of young larvae of *T. ni* (and of *P. includens*) in Barbados (Alam 1982) and in Jamaica.

A large number of predatory arthropods including coccinellids, chrysopids, staphylinids, ground beetles and syrphids feeding on cabbage looper (as well as diamondback moth, armyworms and other crucifer pests) in Barbados, the Eastern Caribbean islands and Jamaica are reported by Alam (1982, 1985, 1992). These play an important role in regulating the populations of cabbage looper (and other pests).

Armyworms (*Spodoptera* spp.)

Two armyworm species, *S. latifascia* and *S. frugiperda*, feed on cole crops in Jamaica. From 1988 to 1990, the pest populations were low. The overall population at Bodles Agricultural Experimental Station, Douglas Castle and Castle Kelly was 0.4, 1 and 4%, respectively (Fig. 1a-c).

In Barbados, the armyworm species recorded on cabbage and cauliflower were *S. eridania*, *S. frugiperda*, *S. latifascia* and *S. sunia*. The populations of these insects were also low. The number of egg-masses per infested plant ranged from 1 to 7. Regular pesticide applications against diamondback moth and other leaf feeders killed the armyworm larvae before they damaged the crop.

Natural Enemies

At the Bodles Agricultural Experimental Station in Jamaica, larval parasitism by *E. platyhypenae* was 50%. At Castle Kelly 50% of the caterpillars were parasitized by *Enicospilus* sp. (December 1989) while 8% of the larvae were parasitized by a tachinid, *Archytas incertus* Giglio-Tos (April 1990).

TABLE 5. PARASITES AND A FUNGUS ATTACKING *T. NI* IN JAMAICA, BARBADOS AND ST. KITTS.

Natural enemy	Percent parasitism	Months recorded
JAMAICA		
Parasites		
Brachymeria sp.	2.4	July 1990
Copidosoma sp.	12.5	June 1990
Cotesia sp. (*glomeratus* group)	20.0	November 1990
[1]*C. plutellae*	29.6, 34.5 & 70	August, September, & October 1989 (Bodles Agric. Sta.)
Euplectrus platyhypenae	4.2	June 1989
Winthemia sp.	From one pupa	May 1990
Unidentified tachinid	From one larva	May 1990
Fungus		
Entomophthoralis	58.5, 80 and 9.5 (medium to full-grown larvae)	July 1989, March, & June 1990
BARBADOS		
Months of record for Barbados cited in Alam (1982)		
Parasites		
C. plutellae	3-50	
Glyptapanteles sp. (*vitripennis* group)	0.5-2	
E. platyhypenae	4.3-50	
Copidosoma floridanum (indigenous)	0.5-5	
[2]*Copidosoma* sp. (*truncatellum* group)	25.8	
Brachymeria ovata	0.5	
Winthemia sp. nr. *pinguis* F. and *Winthemia* sp. nr. *pyrrhopyga*	20.0-35.8	

[1]Introduced against diamondback moth in March 1989, from Barbados.
[2]Introduced against cabbage looper from India. According to Noyes 1988, this material is also *C. floridanum*

From 75-90% of the egg-masses of *S. latifascia* collected on citrus leaves in the Bog Walk area of Jamaica during 1989-90 were parasitized by *T. remus*. This egg parasite was introduced from India into the Caribbean, first into Barbados. Between July and November 1990, up to 70% egg-masses were infected by a fungus, *Sporodiniella umbellata*.

Although some 16 parasite species attacking eggs, larvae and pupae of various *Spodoptera* spp. were recorded in Barbados (and other species in the Eastern Caribbean islands), control was inadequate. Twelve parasite species (four egg-parasites, three larval, two egg-larval, two larval-pupal and one pupal parasite) were imported from India, Pakistan, Uruguay and Trinidad (Alam 1975) and released against these pests in the field. Since then, some have established permanently, while others were recorded

for only a short period. The most important establishments were of the egg-parasites, *T. remus* and *Trichogramma chilotraeae* Nagaraja and Nagarkatti from India. Two larval parasites, *Campoletis flavicincta* (Ashmead) from Uruguay and *Campoletis chlorideae* Uchida from India and Pakistan, were recovered after releases, but later disappeared. Since its establishment, *T. remus* has played a significant role in the control of armyworms. Over the years, the average parasitism on different host plants has exceeded 70%. On crucifers, the range of parasitism recorded was 37.5-64.3% (average 53.3%) during 1978; 33.3-75% (average 52.2%) in 1979; and 16.7-100% (average 41%) in 1980 (Alam 1982).

T. remus was successfully introduced from Barbados into St. Kitts, against *Spodoptera ornithogalli* (Guenee) and *S. latifascia* during 1980-81. At present it attacks over 50% egg-masses in the field, and has reduced the pest populations considerably (Alam et al. 1991).

The following predatory insects were recorded in Barbados: *C. sanguinea*, *Pullus* sp.; *Ceraeochrysa valida* (Banks), *Chrysopa* sp. and *Chrysoperla lanata* (Banks) (Bennett & Alam 1985).

Cabbage White Butterfly (*Ascia monuste monuste*)

During 1989-90, cabbage white butterfly was not recorded in any appreciable numbers on cole crops in Jamaica, because most of the fields were sprayed at short intervals against diamondback moth and cabbage looper, and because the crop remains were removed from the field soon after harvest. Since the insect breeds in large numbers on weeds like *Cleome viscosa*, *C. spinosa* and *Gynandropsis gynandra*, which are common around cabbage fields and in citrus growing areas, full grown larvae and pupae were found on various cultivated and wild plants.

In Barbados, cabbage white butterfly remains active throughout the year at low densities. During the rainy season (i.e. early July to late October) it may reach outbreak proportions. The number of larvae per plant range from 20 to 100 causing complete defoliation (Alam 1982).

Natural Enemies

In the St. Elizabeth area of Jamaica, some pupae collected on escallion (*Allium cepa* var.) were parasitized by a pteromalid, *Catolaccus* sp. Also in Jamaica at United Estates Ltd., Bog Walk, almost 95% of the larvae and pupae were infected by a fungus, *S. umbellata*; some pupae also were parasitized by *Brachymeria* sp.

Three indigenous natural enemies were recorded in Barbados. *Trichogramma* sp. which was recorded only from the eggs laid on *C. viscosa*, where parasitism was about 0.5%. A tachinid, *Phorocera* sp.? *parviteres* Alders parasitized 14% of the larvae on cabbage and 8% of the larvae on *C. viscosa* in 1973 (Alam 1982). A chalcid, *B. ovata*, was the most common pupal parasite, parasitized 24.5-61.3% (average 36.4%) of the pupae on cabbage between April and December 1979; 33.3-83.9% (average 50.3%) on *C. spinosa* between December 1979 and October 1980; and 22.2-52.5% (Average 35.2%) on *C. viscosa* between April and October 1980. In the rainy season, About 20% of full-grown larvae and 95% of pupae, some of which were parasitized by *B. ovata*, were killed by a polyhedrosis virus. Alam (1982) reported coccinellids, chrysopids, carabids, jack spaniard wasps, formicids and a black bird feeding on the pest.

In St. Kitts a larval parasite, *Lespesia aletiae* (Riley), attacked 50% of larvae, and *Brachymeria innulata* F. attacked over 50% of pupae in the field. These are potential candidates for introduction into those countries where they are absent (Alam 1985).

CABBAGE BUDWORM (*Hellula phidilealis*)

In Barbados, the East Caribbean islands and in Jamaica, cabbage budworm is a minor pest, but in Trinidad it causes substantial damage to crucifers (Alam 1982, 1989a). The insect also breeds freely in the pods and terminal buds of *C. viscosa*, *C. spinosa* and *G. gynandra* in the Caribbean (Alam 1989b). On cabbage in Jamaica only one larva of *Hellula* was observed in November 1988 at Guys Hill, but 5-10% of the pods of *C. spinosa* were infested in citrus groves at United Estates Ltd. Bog Walk during 1988-89 (Alam 1989b).

In Barbados between 1969 and 1975, the population of cabbage budworm was very low. It increased steadily during 1976-80, infesting 44-75% of cabbage plants at different plantations. The possible reason for this increase was the greater reliance on permethrin (Ambush®) and some other non-systemic insecticides for the control of diamondback moth. These chemicals are not only ineffective against *Hellula* larvae feeding protected within plant tissue, but are detrimental to natural enemies. Crop damage was reduced significantly when farmers stopped using Ambush® (Alam 1982).

Natural Enemies

In Trinidad, four parasite species were reported attacking cabbage budworm (Herting 1965). In Barbados, the parasites attacking cabbage budworm on cabbage, *Cleome* spp. and *G. gynandra* are presented in Table 6 (Alam 1982).

There is information indicating that the parasite complex of cabbage budworm is richer and more consistent on *Cleome* spp. then crucifers (Alam 1982, F. D. Bennett, personal communication).

TABLE 6. THE PARASITES ATTACKING *H. PHIDILEALIS* LARVAE ON CABBAGE, *C. SPINOSA*, *C. VISCOSA* AND *G. GYNANDRA*, RECORDED DURING 1978-80, IN BARBADOS.

	Host plants and percent parasitism (mean)			
Parasite	*B. oleracea* var. *capitata*	*C. spinosa*	*C. viscosa*	*G. gynandra*
Braconidae:				
Apanteles spp. (2)		0.0-59.6 (9.7)		
Bracon sp.? *hebetor*	60.7 (May 1979)	(64.5)	55.1-89.2	
Chelonus sp. nr. *mexicanus*		11.3-61.9 (33.1)		0-69.6 (34.6)
Ichneumonidae:				
Eiphosoma annulatum		1.6-25.3 (9.8)		0-21.8 (12.9)
Bethylidae:				
Goniozus sp.	11.8 (April 1980)			
Tachinidae:				
Gen. et. sp. indet.		2.2		

Cross-striped Cabbageworm (*Evergestis remosalis*)

Cross-striped cabbageworm, *E. remosalis*, was recorded only in the Blue Mountain areas of Jamaica. The population was fairly high in the field ranging from 75 to 174 larvae on five randomly examined plants. During August 1988, only one larva was parasitized by *Eiphosoma* sp.

Cabbage Aphid (*Brevicoryne brassicae*)

Generally, the aphid is of little economic importance, although it may become abundant seasonally and cause heavy crop losses. Some cabbage varieties, especially Chinese cabbage, are more susceptible. A black aphid, *Myzus persicae* (Sulz.), was also recorded on cabbage in the Caribbean (Alam 1982).

In Jamaica, *B. brassicae* was recorded in small numbers at all observation sites, except at Bodles Agricultural Experimental Station. When crops were left unattended, the insect built up to high populations and caused substantial crop losses.

Natural Enemies

In Barbados and the Eastern Caribbean islands an aphidiid, *Lysiphlebus testaceipes* (Cresson), is the most important parasite. At high pest populations, the parasite attacks over 90% of the aphids. The parasite was also recorded in Jamaica, with similar parasitism levels.

Predatory insects reported by Alam (1982) included two species of coccinellids, three of chrysopids and a syrphid in Barbados. In Jamaica, the most common predators were *C. sanguinea*, *C. maculata*, *H. convergens*, *T. dispar*, *T. watsoni* and *P. clavatus*, and *C. claveri*.

Discussion

Diamondback moth, a cosmopolitan pest of crucifers, causes heavy economic losses to farmers in the Caribbean throughout the year. A temperature range of 17 to 25°C is considered optimum for the pest (Atwal 1955). In the Caribbean, where the temperatures fluctuate between 28 and 31°C during the year, the pest breeds continuously and probably completes up to 20 generations (Alam 1982). Similar observations were reported by Talekar et al. (1985) in Taiwan.

In the Caribbean, and particularly in Jamaica, the highest populations of diamondback moth were recorded during dry weather (January to June) and reduced to a minimum in the rainy season (July to December) (Fig. 2a-c). Pest populations in Taiwan are reduced significantly during the dry period when the crop is irrigated with overhead sprinklers (Talekar et al. 1985). Yaseen (1974) also reported that the pest populations were highest during periods of low rainfall in Trinidad.

In the Eastern Caribbean islands, there are very few indigenous parasites and as a result cabbage pest populations before 1970 were very high. During 1969, five parasite species were imported from India. Of these *C. plutellae* and *O. sokolowskii* became established in Barbados and were later introduced into the Eastern Caribbean islands and Jamaica. In spite of heavy applications of pesticides, *C. plutellae* has maintained high populations and provides significant control. As one of the important biocontrol agents, *C. plutellae* is being used in other parts of the world. Since its establishment in the Caribbean, the parasite has been supplied by the International Institute of Biological Control (IIBC) in Trinidad, to Ghana (1973), St. Helena (1975), Cape Verde Islands (1981), Seychelles (1972), Hawaii (1971-73), Brazil (1972), Fiji (1979) and Missouri, USA (1978). In the Cape Verde Islands, *C. plutellae* and *O. sokolowskii*, along with other pest management practices, has led to the satisfactory control of diamondback moth (Bennett et al. 1985).

In Jamaica, a complex of indigenous natural enemies of diamondback moth includes three parasite species (one each attacking eggs, larvae and pupae) and eight species of predators (including three species each of coccinellids and syrphids, and one each of a chrysopid and a syrphid). Three species of fungi infecting larvae and pupae were also recorded (Table 1).

For the control of armyworms, exotic parasites were introduced from Pakistan and India and some became established (Alam 1975). The most important of these were the egg-parasites, *T. remus* (in Barbados and the Eastern Caribbean Islands) and *T. chilotraeae* (in Barbados only). *T. remus* has also been established in Jamaica parasitizing 75-90% of egg-masses of *Spodoptera* spp. on different host plants (Alam et al. 1991).

An indigenous fungus, *S. umbellata* infects over 70% of *Spodoptera* egg masses laid on citrus. A complex of indigenous and exotic natural enemies now established in different Caribbean islands provides good control of these pests. Opportunities for the introduction of those parasites, predators and pathogens into those countries where they are absent are available. Similarly, a pupal parasite, *Catolaccus* sp., and a fungus, *S. umbellata*, infecting the larvae and pupae of cabbage white butterfly are potential candidates for introduction.

H. phidilealis and other members of this genus, usually regarded as the primary pests of crucifers, were observed feeding in greater numbers throughout the year in pods and terminal shoots of *Cleome* spp. and *G. gynandra* in Barbados, the Leeward and Windward islands, Guyana, Mexico and in Jamaica, (Alam 1989b). Compared to cole crops, the natural enemy complex also was richer on these hosts. Therefore *Cleome* spp. may be the main host plants of *Hellula* spp. and species in the genus may be expanding their host range to include crucifers. To further support this idea, it was noted that an Asian species, *Hellula undalis*, also was reported feeding in pods and terminal shoots of *C. viscosa* in Pakistan (Alam et al. 1961-62). Munroe (1972) also stated that *H. phidilealis* and *H. rogatalis* feed on host plant families, additional to the crucifers.

Although many parasites recorded from *Cleome* spp. may not readily switch to *H. phidilealis* on cabbage and cauliflower, there are a number of other parasites recorded from *Hellula* spp. on these crops. These parasites can be introduced into countries were cabbage budworm is a serious problem (Alam 1989b).

B. brassicae is a minor pest in well-managed cabbage fields. The insect becomes more abundant where crops are sprayed with pesticides frequently or are left unattended for a long time. Usually, when the pest builds up high populations, an aphid parasite, *L. testaceipes* attacks over 90% pest population and, along with coccinellids, syrphids and chrysopids, keeps the pest in check.

Acknowledgments

I wish to thank Mr. W. Fielding and Mr. Joe R. R. Suah for their valuable suggestions, and Dr. Don Walmsley who edited the paper. I also thank Miss Sharon McDonald for computing the graphs and Miss Diana Bailey for typing the manuscript.

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