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OCCURRENCE OF DIAMONDBACK MOTH AND ITS PARASITOIDS WITHIN CABBAGE HEADS

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Keywords: Diamondback moth, *Plutella xylostella* (L.), *Apanteles plutellae* Kurdj., *Diadegma eucerophaga* Horstm.

RINGKASAN

Dua kajian telah dijalankan untuk mengkaji kemungkinan kejadian dan kehidupan rama-rama *Plutella* (diamondback moth) serta parasitoidnya di dalam kubis-kubis yang baru dipungut untuk pasaran. Kubis-kubis ini disimpan secara berasingan selama dua minggu di dalam keadaan makmal untuk meneliti spesies rama-rama yang keluar dari kubis-kubis tersebut. Akhirnya, daun-daun kubis dikopak untuk menentukan peringkat spesies-spesies yang masih ada dalam kubis tersebut.

Hasil kajian menunjukkan walaupun keadaan kubis ini agak ketat dan tertutup, masih terdapat rama-rama pada peringkat larva dan pupa, dan parasitoidnya pada peringkat kepompong di antara daun kubis. Kebanyakannya didapati di bahagian luar daun pertama hingga ke 15 sementara sedikit sahaja didapati jauh ke dalam hingga daun ke 27. Di ladang yang tidak disembur dengan racun serangga, 46.7% daripada kubis yang ditanam diserang oleh rama-rama ini sementara di ladang yang disembur pula sebanyak 80.0% mendapat serangan.

Rama-rama yang pada mulanya didapati jauh ke dalam gagal untuk keluar, kalau adapun hanya pada peratus yang rendah. Kebanyakan daripadanya disyaki diserang penyakit kalau dilihat daripada tanda berair, berbau busuk dan keadaan reputnya.

Keupayaan rama-rama ini hidup dalam daun kubis dalam jangka masa yang panjang mempunyai implikasi yang menggalakkan. Perkara ini telah dibincangkan berdasar kepada 'carry-over' antara tanaman-tanaman yang berlainan, penggunaan dan kerintangan racun-racun serangga serta penyebaran rama-rama dan parasitoidnya.

INTRODUCTION

Like most other insects, the occurrence and spatial distribution of the diamondback moth (DBM) [*Plutella xylostella* (L.) (Lepidoptera: Yponomeutidae)] over its host plant are not uniform. Frequently, certain parts or surfaces are preferred over others. Likewise, the occurrence and distribution of its parasitoids may be largely governed by the presence of the host(s).

Since previous studies on the occurrence of DBM and its parasitoids on brassicas involved transplanted crops (HARCOURT, 1960; CHUA and LIM, 1977; 1979; LIM, 1982), investigation was thus made to clarify their possible presence within the cabbage heads. In part, these were also prompted from encounters of live *P. xylostella* larvae in fresh cabbages purchased for family consumption. An understanding concerning this aspect would not only prove useful in the rational and more efficient use of chemical insecticides against the moth, but also a better comprehension on its dispersal ecology.

MATERIALS AND METHODS

Investigation on the occurrence of DBM, its parasitoids and other arthropod species within the cabbage heads covered three aspects. The first aimed to determine if any of the species could be found within the heads, and if so, their respective positions. In this study, freshly harvested cabbages ready for market were used; 30 heads taken randomly from crops cultivated successively at MARDI research station without any insecticidal treatment and 15 heads from a farmer's crop at Tanah Rata

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where insecticides (decamethrin, permethrin or quinalphos) were regularly applied every two to three days. Beginning from the outermost of each head, all the leaves were peeled individually and examined for the presence of any arthropod species.

The second study also used freshly harvested cabbage heads but these were obtained from three different localities; 24 heads from an unsprayed crop at MARDI research station while 15 heads and 25 heads from sprayed farmers' fields at Brinchang and Kampung Raja respectively. These were individually enclosed for two weeks under laboratory conditions in wooden frame cages (38.1 cm^3) overlaid with white nylon netting. All arthropods emerging from the heads were determined. Subsequently, the cabbage heads from Brinchang and Kampung Raja were peeled to determine the stages of those still remaining within. This determination constituted the third aspect of investigation on the cabbage heads.

RESULTS

Location of DBM and its Parasitoid, *Apanteles plutellae* Kurdj. (Hymenoptera: Braconidae), within Marketable Cabbage Heads

In spite of the tight and closed conditions of the cabbage heads, both DBM and its parasitoid were found in between the leaves *(Tables 1* and *2)*. The stages observed included larvae and pupae of DBM, and cocoons of the parasitoids. Although most were recorded from the first 15 outer leaves, some were found as far in as the 27th leaf. These were trapped within as the younger leaves folded over to become compacted to form the head. In unsprayed heads, 46.7% had infestations within while that of sprayed heads 80 per cent. The vast difference was probably because of differing levels of natural infestations initially. Nevertheless, it was evident that the insecticides applied could not reach within the heads to kill the larvae.

Table 1. Location of *Plutella xylostella* (L.) and its parasitoid, *Apanteles plutellae* Kurdj., within marketable cabbage heads obtained from sprayed and unsprayed fields in Tanah Rata, Cameron Highlands

Leaf no.+	No. of *P. xylostella* and *A. plutellae*					
	Within 15 sprayed heads			Within 30 unsprayed heads		
	L	P	C	L	P	C
1	0	1	1	0	3	0
2	1	1	1	0	1	2
3	1	0	0	3	0	2
4	1	0	1	3	1	1
5	3	0	0	3	0	0
6	3	0	0	2	0	0
7	1	0	0	0	0	0
8	2	1	0	3	0	1
9	1	1	0	1	0	0
10	2	0	0	2	0	0
11	0	0	0	0	1	0
12	2	0	0	1	0	0
13	2	0	0	0	1	0
14	0	0	0	0	0	0
15	1	0	0	0	0	0
16	0	0	0	1	0	0
17	1	0	0	0	0	0
18	1	0	0	0	0	0
19–26	0	0	0	0	0	0
27	0	0	0	1	0	0
28–39	0	0	0	0	0	0

+Beginning from the outermost on a marketable head.
L = Larva of *P. xylostella*
P = Pupa of *P. xylostella*
C = Cocoon of *A. plutellae*

Insects Emerging from Harvested and Cleaned Marketable Cabbage Heads

Both DBM and its parasitoids [*A. plutellae* and *Diadegma eucerophaga* Horstm. (Hymenoptera: Ichneumonidae)] could survive to crawl out of the heads *(Table 2)*. In some heads, the adult DBM and parasitoids would first emerge within and later crawl out of the heads. Some larvae of DBM might move out to pupate, and if parasitized, the parasitoids then emerged to pupate. Generally, by the 12th day all would have completely emerged.

Table 2. Insects emerging from cabbage heads purchased from Brinchang and Kampung Raja, and others harvested from MARDI Research Station, Cameron Highlands

Nature of emergence	Total no. of heads	No. of insects emerging at various days after harvest														Total
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	
Cabbage sprayed with insecticides																
Brinchang	15															
Pl		–	2	4	–	–	4	2	–	1	–	–	–	–	–	13
Ap		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Da		–	–	–	–	–	2	1	–	–	–	–	3	–	–	6
Hp		–	–	–	–	–	–	2	–	–	–	–	–	–	–	2
Others		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Kampung Raja	25															
Pl		–	–	–	4	–	–	2	–	–	–	–	1	–	–	7
Ap		–	–	–	–	–	–	–	–	2	–	–	1	–	–	3
Aa		–	–	–	–	–	–	2	–	1	–	–	1	–	–	4
Ha		–	–	–	2	–	–	1	–	1	–	–	–	–	–	4
Others		–	–	–	–	–	–	–	–	–	–	–	–	–	1^{+}	1
Unsprayed cabbage	24															
Pl		–	–	4	–	6	2	–	1	–	–	1	1	–	–	15
Ap		–	–	1	–	–	–	–	–	–	–	–	2	–	–	3
Aa		–	–	–	–	1	–	–	1	–	–	–	–	–	–	2
Hp		–	–	–	–	1	2	–	–	–	–	–	–	–	–	3
Others		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Pl = *Plutella xylostella* larvae emerging to the outer leaves to pupate.
Ap = *P. xylostella* emerging as adults.
Aa = *Apanteles plutellae* emerging as adults.
Ha = Host larvae emerging to outer leaves, followed by emergence of the parasitoid *(A. plutellae)* larvae.
Da = *Diadegma eucerophaga* emerging as adults.
Hp = Host larvae emerging to outer leaves, followed by emergence of the parasitoid, *D. eucerophaga.*
$^{+}$Dipteran adult (*Atherigona* sp.).

Table 3. Insect species found remaining within the cabbage heads purchased from Brinchang and Kampung Raja

Insect species	Leaf no.+		Total no. of insects
	Brinchang	Kg. Raja	
Diadegma eucerophaga			
Empty pupal case	2nd, 4th, 5th(x2), 6th, 7th(x2), 9th, 10th, 12th	–	10
Dead adult	4th, 5th.	–	2
Dead flea beetle	4th, 5th(x3), 6th(x3), 7th(x3), 8th(x2), 9th, 10th, 12th, 13th(x2)	–	17
Plutella xylostella			
Dead larva	2nd(x3), 3rd(x22), 12th(x4)	–	29
Dead pupa	9th	–	1
Empty pupal case	6th	–	1
Dead adult	3rd, 4th, 7th, 12th	3rd	5
Spodoptera litura			
Dead larva	–	6th	1

+The outermost leaf on a head is the first leaf.
Figures in ( ) indicate more than one specimens recorded on a particular leaf.

From one of the heads, however, a non-parasitic dipteran, *Atherigona* sp. (Muscidae), also emerged on the 14th day.

When cabbage heads were peeled open at the end of the observational period in Kampung Raja, there was found only a dead larva of *Spodoptera litura* (F.) (Lepidoptera : Noctuidae) under the sixth leaf of one of the heads, as well as, a dead adult DBM under the third leaf of another *(Table 3). Diadegma eucerophaga* was not recorded from these cabbages largely because the parasitoid had yet to spread into Kampung Raja area (LIM, 1982).

DISCUSSION

In general, only a small percentage of the insects initially trapped within the cabbage heads failed to emerge. Most of the insects were able to survive and find their way out in spite of the tight conditions within the heads, perhaps moving out as the leaves tightened up.

Most DBM died during the larval stages. Although not confirmed from pathogen isolates, many were suspected to have succumbed to diseases as indicated by their watery, foul and disintegrated appearance. This was expected as hearted brassica plants can promote conditions which encourage diseases (WAY, SMITH and HOPKINS, 1951). Largely, this occurred through the compact leaves holding wet insect faeces in pockets of stagnant air which favour diseases (GUNN, 1917; SMITH, 1931; WAY *et al.*, 1951; LIM, 1982).

A number of DBM and its parasitoids survived within the cabbage heads until crop harvest, indicating that the present farm practice of insecticidal control is providing only partial control. Protection within the cabbage heads evidently afforded a survival advantage to the species concerned. Unless particular attention is given to overcome this, management of the moth through chemicals alone is unlikely to succeed. Moreover, over a long-term period, this would facilitate more extensive insecticide resistance build-up since sublethally-exposed individuals are also afforded protection and could disperse *via* the heads. Perhaps the current severe problem of rapid development of resistance to almost all the insecticides and over a wide area by DBM in the Cameron Highlands is in part a result of such a situation.

With respect to management of DBM, the findings that the moth may survive for extended period within cabbbage heads have notable implications. Among adjoining cabbage farms, pest survival within the heads between croppings will obviously constitute a contributory factor in maintaining its presence in succeeding crops. A possible source would include cabbages retained by farmers for family consumption since these are usually left uncovered in the homes. However, its relative importance with respect to other carry-over factors, such as, left-over crop residues and the survival on cruciferous weeds host (ULLYETT, 1947) is not known. Evidently, this merits further investigation.

The presence of DBM protected within the heads constitutes a reservoir of pest population which could be dispersed *via* the marketing system. HO (1965) suggested that DBM probably came into Malaysia through importation of cruciferous vegetables *via* Thailand, Sumatra or Singapore. This can well happen since cabbage heads need to be despatched rapidly to avoid deterioration, particularly when it occurs within the emergent period (*ca* two weeks) of the moth from the time of crop harvest. However, for DBM, such a dispersal mechanism is probably important only over time since the moth can migrate over long distances (LIST, 1937; HARDY, 1938; FRENCH and WHITE, 1960; FRENCH, 1965; JOHNSON, 1969). For its parasitoids, dispersal within cabbage heads is perhaps less important. Otherwise, parasitoid species in the region would be less diverse and more common.

Nevertheless, dispersal in cabbage heads may be important within the country since cabbages are generally more actively distributed internally. For example, transportation of cabbage heads from Cameron Highlands to various parts of the country occurs daily. This may be the reason for *A. plutellae* being widespread in West Malaysia.

In general, an understanding of the occurrence and spatial distribution of DBM and its parasitoids within the cabbage heads is important, and these aspects merit consideration when developing guidelines for the management of the moth.

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ABSTRACT

In investigating the possible occurrence and survival of the diamondback moth (DBM) (*Plutella xylostella* L.) and its parasitoids (particularly *Apanteles plutellae* Kurdj.) within cabbage heads, two studies were carried out using freshly harvested cabbage heads ready for marketing. The cabbages were individually enclosed for two weeks for emergence of any infesting species and the leaves subsequently peeled to determine the stages of those still remaining within.

In spite of the tight and closed conditions of the cabbage heads, both DBM and its parasitoids were found within. The life stages included larvae and pupae of DBM, and cocoons of the parasitoids. Most was found on the first 15 outer leaves while a few as far in as the 27th leaf. In unsprayed fields 46.7% of the heads had infestations within while that of sprayed heads 80 per cent.

Only a very small percentage of the insects initially trapped within the heads failed to emerge. Many succumbed to diseases as indicated by their watery, foul and disintegrated appearance.

The fact that the moth may survive for extended period within cabbage heads has notable implications. This is discussed with respect to carry-over between different croppings, insecticidal usage and the associated problem of insecticide resistance development, and dispersal of the moth and its parasitoids.

REFERENCES

CHUA, T.H. and LIM, B.H. (1977). Effects of inter-plant distance on the distribution pattern of diamondback moth, *Plutella xylostella* (L.) among host plants. *Malays. Appl. Biol.* **6**, 19–23.

——— (1979). Distribution pattern of diamondback moth, *Plutella xylostella* (L.) (Lepidoptera : Plutellidae) on choy-sum plants. *Zeit. für angewandte Entomologie* **88**, 170–5.

FRENCH, R.A. (1965). Long range dispersal of insects in relation to synoptic meteorology. *Proc. XII Int. Congr. Ent.*, London, 1964, 419 pp.

FRENCH, R.A. and WHITE, J.H. (1960). The diamond back moth outbreak of 1958. *Pl. Path.* **9**, 77–84.

GUNN, D. (1917). The small cabbage moth (*Plutella maculipennis* Curtis). *Bull. Dept. Agr. S. Afr.* **8**, 1–10.

HARCOURT, D.G. (1960). Distribution of the immature stages of the diamondback moth, *Plutella maculipennis* (Curt.) (Lepidoptera : Plutellidae), on cabbage. *Can. Ent.* **92**, 517–21.

HARDY, J.E. (1938). *Plutella maculipennis* (Curt.), its natural and biological control in England. *Bull. ent. Res.* **29**, 343–72.

HO, T.H. (1965). The life-history and control of the diamondback moth in Malaysia. *Minis. Agric. & Co-operatives. Bull.* **118**, 26 pp.

JOHNSON, C.G. (1969). *Migration and Dispersal of Insects by Flight* 763 pp. London: Methuen and Co. Ltd.

LIM, G.S. (1982). The biology and effects of parasites on the diamondback moth, *Plutella xylostella* (L.). Ph.D. Thesis, University of London.

LIST, G.M. (1937). Possible migration of diamondback moth. *J. econ. Ent.* **30**, 676.

SMITH, K.M. (1931). *Textbook of Agricultural Entomology* Cambridge: University Press.

ULLYETT, G.C. (1947). Mortality factors in populations of *Plutella maculipennis* Curtis (Tineidae : Lep.), and their relation to the problem of control. *Entomol. Mem., Dept. Agric. & Forestry Union S. Africa* **2**, 177–202.

WAY, M.J., SMITH, P.M. and HOPKINS, B. (1951). The selection and rearing of leaf-eating insects for use as test subjects in the study of insecticides. *Bull. ent. Res.* **42**, 331–55.

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