

# Diamondback Moth in Indonesia

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## Abstract

Investigations into diamondback moth in Indonesia were started during colonial times by Dutch entomologists. In the early 1950s there was renewed interest in research into control of this pest by the introduction of parasites, and Vos's classical publication gives the details of this work. In 1968 there was a large scale outbreak of this insect which gave further impetus to the investigation of diamondback moth. The author reviews the research carried out so far on the biology, ecology, population monitoring, biological control, and chemical control of diamondback moth.

## Introduction

Although diamondback moth (DBM) (*Plutella xylostella* L) (Lepidoptera: Yponomeutidae) has been reported to be a pest of crucifers in Indonesia since the beginning of this century (Vos 1953), our research group became interested in it only in 1968 when there was a severe outbreak of the pest in Lembang, the major vegetable growing highland area of West Java. Until then DBM was under control and was considered as a secondary pest of many crucifers. The renewed interest in this insect led to the initiation of several basic studies, specifically related to its control. This paper reviews the research work conducted on DBM since 1968.

## Population Studies

### Monitoring

The purpose of this study was to determine the seasons when diamondback moth causes damage to crucifers. This work was similar to and partly inspired by Robertson's studies in New Zealand (Robertson 1939). Data of this nature gives valuable information about specific local importance. After 1968, weekly monitoring of DBM populations was carried out in the Lembang area in order to study the causes of the insect outbreak. Besides monitoring of DBM populations, observations were also recorded on crop damage, the level of parasitism, local weather, possible alternate hosts, and insecticide application by local growers. In the first three years of monitoring, the results showed that the DBM population was at epidemic level. The level of parasitism of *Diadegma eucerophaga* Horstm (Hymenoptera: Ichneumonidae) was below 30%. During the years of monitoring, two dry months—September and October—appear to trigger the outbreaks. This was corroborated by further work by Sudarwohadi (1974) which revealed that rainfall is a major limiting factor for DBM populations.

### Crop stages and population trend

In a further population study, Yuwono (1975) studied the correlation between crop growth stage and population trend, especially the proportion of various immature stages

of the insect. Within a crop season of 70 days data were recorded at 10, 16, 21, 26, 31, 36, 52, 63 and 65 days after transplanting, on the total number of insects per plant and on the composition of the population at larval instars and pupa stages. The study indicated that within the 70-day growing period, the DBM population peaks at 45 days after transplanting. The distribution of immature stages revealed that there were two generations and considerable overlapping of these generations (Figure 1). Given the continuous availability of the host, the insect is likely to continue breeding throughout the year.

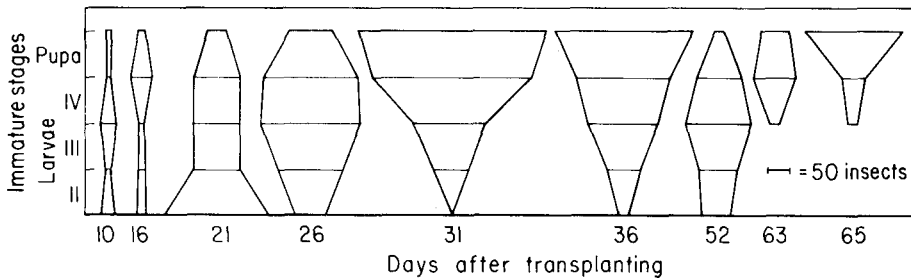


Figure 1 Age composition of DBM population in a cabbage field within a growing season at Bandung, West Java (Yuwono 1975)

### Insect pest community

After the initial few years of observations, it was deduced that DBM is not the only pest that attacks crucifers in Java. Weires and Chiang (1973) investigated the relative abundance of *Spodoptera* sp, *Hellula undalis*, *Heliothis armigera*, *Plusia orichalcea*, *Agrotis ypsilon*, *Crocidolomia binotalis* and DBM to decide the status of various pests and the position of DBM in the pest community. The number of insects of each species was recorded per unit sampled plants for up to 16 weeks in an insecticide-free field near Bandung. Among seven locations with relatively small distance between them, DBM was found to be dominant at only three locations. Other insects such as *C. binotalis*, *H. armigera*, *A. ypsilon* and *P. orichalcea* were much more dominant at other locations.

### Biological Control

The introduction of a parasite, *Diadegma eucerothaga* by Vos (1953) from New Zealand for DBM control in Java was the continuation of Dutch entomologists' efforts to control important agricultural pests in Indonesia by parasitoids and predators (Eveleens 1976). Since then the research in this field has been confined to monitoring of the level of DBM parasitism by *D. eucerothaga* (Sastrodihardjo 1970, Sudarwohadi 1977, Janarti 1982). Sudarwohadi (1981) has also attempted mass rearing of the parasitoid and release in cabbage fields in other parts of the country.

Apparently *D. eucerothaga* has well adapted to an environment increasingly treated with insecticides. Data obtained from the laboratory and field study indicated that *D. eucerothaga* may have developed low levels of resistance to commonly used chemicals. In a laboratory study, Santoso (1979) treated DBM larvae and *D. eucerothaga* adults with commonly used insecticides and mortality counts were recorded at intervals over a one-week period. The results of the mortality counts are summarized in Figure 2.

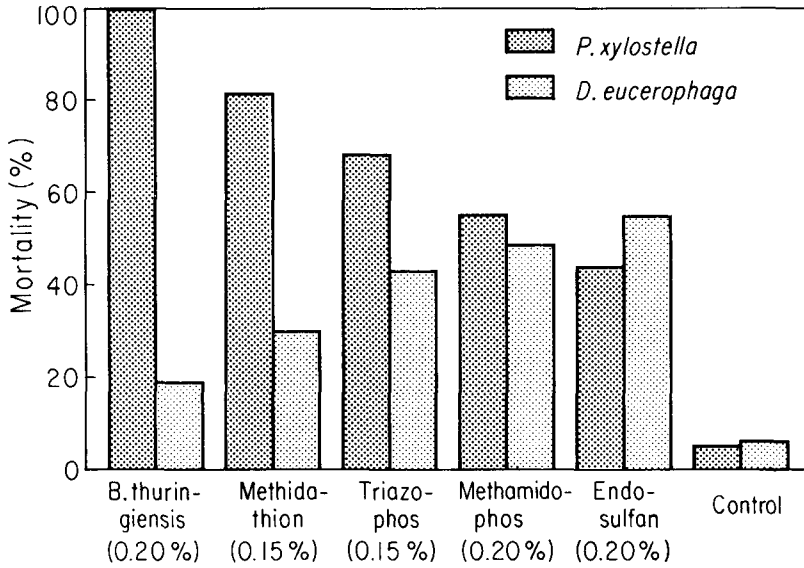


Figure 2. Toxicity of selected insecticides to DBM and its parasite, *Diadegma eucero-phaga*, seven days after treatment, laboratory study (Santoso 1979)

In general, parasites and predators tend to be more susceptible to insecticides than do the host insects. In Santoso's study, however, mortality of *D. eucero-phaga* was equal to or less than that of DBM. Dipel, a *Bacillus thuringiensis* formulation, was especially selective against DBM. Endosulfan caused slightly greater mortality in *D. eucero-phaga* than in DBM. Janarti (1982) surveyed DBM and *D. eucero-phaga* populations in untreated and insecticide treated plots. His survey (Figure 3) indicated a similar pattern in population changes in both untreated and treated field, indicating that these insecticides are not excessively harmful to *D. eucero-phaga*. Conversely, as indicated by laboratory studies, it can be deduced that *D. eucero-phaga* has developed a degree of resistance to insecticides.

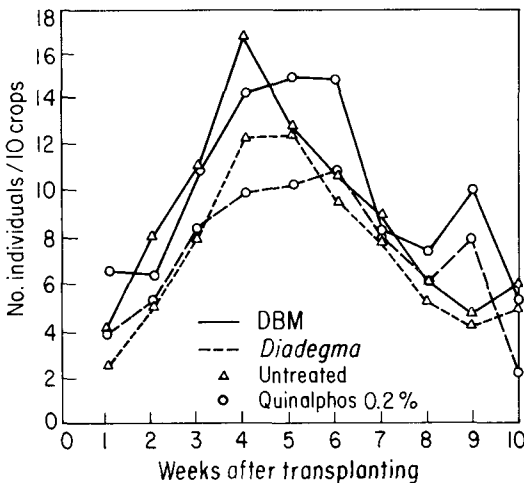


Figure 3. Population trends of DBM and its parasite, *Diadegma eucero-phaga*, in untreated and insecticide-treated plots (Janarti 1982)

Various strains of *Bacillus thuringiensis* imported from Japan have been screened against DBM by Sjamsuriputra et al (1976). His results showed that among 20 strains belonging to various serotypes, all strains of variety *aizawai* namely aizawai IH-A, aizawai HA-3, and aizawai T36-L4, were superior to others in effectiveness against DBM. Investigations on the preference of cabbage foliage by DBM indicated that DBM larvae always preferred younger leaves even if they were covered with *B. thuringiensis* (Sukarman 1982).

A preliminary study by Subiana (1973) on mating behavior of DBM indicated the possible existence of a sex pheromone. However, no further research has been done into this.

## Chemical Control

Use of insecticides is the most common method of DBM control in Indonesia. Before the introduction of synthetic organic insecticides, arsenates were used for insect pest control. Arsenates were later replaced by Derris powder which gave effective control of this pest (van der Vecht 1936). After the Second World War, DDT was the chemical most frequently used by growers to control cabbage pests. Probably the first report of any agricultural pest becoming resistant to organic insecticides involved DBM to DDT in Java (Angkersmit 1953). Ever since that report, insecticide resistance in DBM has become a routine phenomenon. In recent years organophosphorus and carbamate insecticides have replaced organochlorines practically all over Indonesia (Sudarwohadi 1974). In the early 80s synthetic pyrethroids were introduced and became popular because of their quick action, but DBM developed resistance to these chemicals more quickly than expected. Very little basic work on the physiological effect of insecticides on DBM and on the mechanism of insecticide resistance has been done. Laksana (1974) and Suradinata (1979) studied the effects of organophosphorus insecticides on the development and respiration of DBM larvae. Treatment with 10 ppm quinalphos reduced the relative growth rate by 60, 50, and 30% respectively of 1st, 2nd, and 3rd instar larvae. Oxygen consumption in 3rd instar larvae increased by 20% half an hour after treatment with 0.1% quinalphos, and this was followed by a 50% reduction thereafter.

## Resistant Cultivars

Very little research effort is devoted to searching for DBM resistance in crucifer species, or to breeding of resistance in horticulturally desirable cultivars. In one study at the Bandung Institute of Technology, Gunawan (1975) studied the resistance of six commercial cutlivars: RvE-37, Oseno, Yoshin 1, Yoshin 2, KY Cross and KK Cross. Plants were grown for seven weeks and observations on the number of DBM larvae present on each cutlivar were recorded at weekly intervals. In general KK Cross was less infested than the others and RvE-37 was the most heavily infested, especially in later growth stages.

## Sterile Insect Technique

The severity of the DBM problem has attracted the attention of the National Atomic Energy Agency. A special committee was formed in 1972 which decided to explore the possibility of using the sterile male technique to control several agricultural pests, including DBM. Several basic and applied investigations were carried out with a view to controlling DBM.

In order to raise large numbers of pupae for irradiation and eventual release in the field, several mass rearing techniques, including use of synthetic diets as well as various host plants, were tried (Subiana 1973, Sugiyanto 1973, Sutomo 1974). Comparisons were made in respect of percentage survival, duration of each immature stage, pupal weight, adult longevity and sex ratio between the insects raised on synthetic or semi-synthetic diets and those raised on natural host plants. Natural host plant, cabbage, proved to be better than other diets. Laksana (1974) explored the use of  $^{32}\text{P}$  and  $^{35}\text{S}$  radioisotope tagging to study the dispersal of DBM in the field. She was able to detect quite high level of radioactivity in the larvae of which had been fed on a diet containing  $^{32}\text{P}$  and  $^{35}\text{S}$ . This basic information was useful in deciding upon the release of sterile males. In other radiation-related basic studies, Hutabarat (1976) observed a direct relationship between gamma radiation dosage and ovarian damage in DBM. Ovarioles of adults emerging from pupae that had been treated with 15 to 20 krad were 2 mm shorter than the ovarioles of normal adults. The effect of the irradiation was more marked during vitellogenesis, wherein large vacuoles were observed at the alpha oocyte stage (Figure 4). A quite intensive study on mass sterilization ( $^{60}\text{Co}$  source) and release of sterile males in a small scale field was carried out by Hudaya (1976, 1983). A dose of 30 krad applied to pupae was able to induce optimal sterility in adults without impairing adult emergence (Figure 5). In a cage experiment where plants were intentionally infested with DBM, release of sterile males (9 sterile: 1 normal) reduced DBM populations by 61% by the next generation. However, further research is still necessary to make this technique practical for the control of DBM in the field.

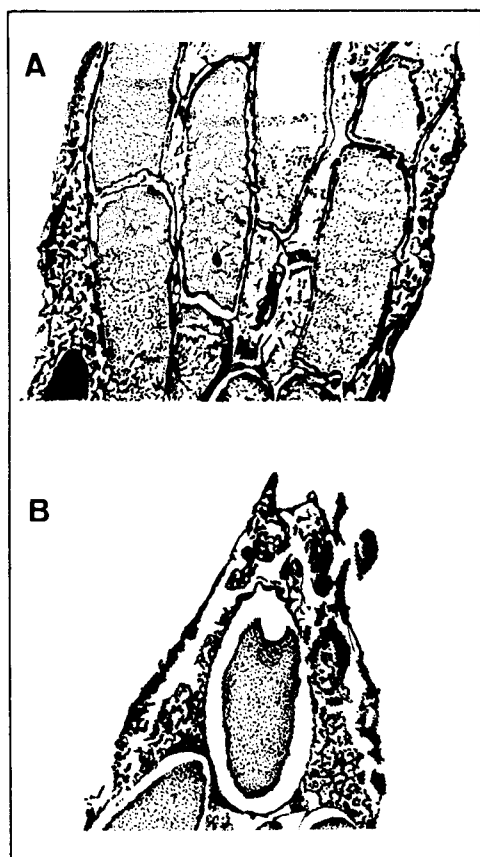
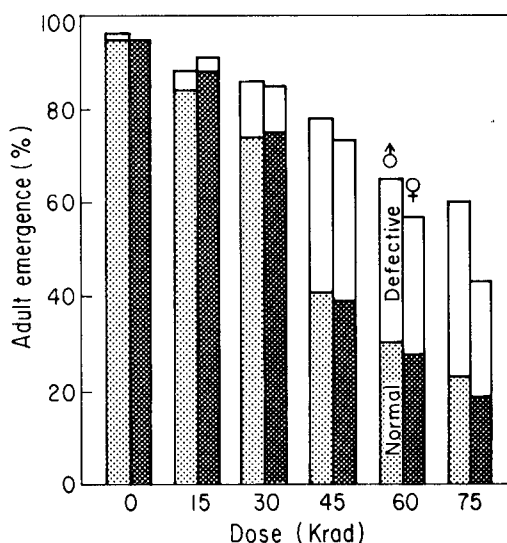


Figure 4.  
(A) Ovarioles of normal DBM female (255X) and (B) of female whose pupa was exposed to 17.5 Krad of gamma rays (85X) (Hutabarat 1976)

Figure 5.  
Influence of gamma ray irradiation on emergence of DBM adults from irradiated pupae (Hudaya 1983)



### Literature Cited

- Angkersmit, G. W. 1953. D.D.T. resistance in *Plutella maculipennis* (Curt) (Lepidoptera) in Java. Bull. Entomol. Res. 44:421-425.
- Eveleens, K. G. 1976. Agricultural entomology in Indonesia during colonial period and its relevance to current pest research. Countr. Centr. Res. Inst. Agri. Bogor 6, 26 pp.
- Gunawan, B. 1975. Susceptibility of several cabbage varieties toward *Plutella maculipennis* Curt. (= *Plutella xylostella* Linn) (in Indonesian). Thesis, Department of Biology, Bandung Institute of Technology, Bandung, West Java, Indonesia, 70 pp.
- Hutabarat, D. 1976. Histological observation of *Plutella maculipennis* ovaries after gamma-ray irradiation (in Indonesian) Meeting, Pest Control by Irradiation. National Atomic Energy, Jakarta, Indonesia, 12 pp.
- Hudaya, M. S. 1976. Progress on *Plutella maculipennis* Curtis Research on its control by radiation techniques (in Indonesian). Meeting, Pest Control by Irradiation. National Atomic Energy, Jakarta, Indonesia, 20 pp.
- Hudaya, M. S. 1983. The application of SIT on cabbage pest *Plutella maculipennis* Curtis (in Indonesian). Nuclear Technique Application in Agriculture and Biology, National Atomic Energy, Jakarta, Indonesia, 10 pp.
- Janarti, P. L. 1982. Monitoring of parasites and predators of cabbage pests on cabbage communities treated with insecticides (in Indonesian). Thesis, Department of Biology, Bandung Institute of Technology, Bandung, West Java, Indonesia, 65 pp.
- Laksana, L. 1974. Tagging of *Plutella maculipennis* Curtis with <sup>32</sup>P and <sup>35</sup>S (in Indonesian). Thesis, Department of Biology, Bandung Institute of Technology, Bandung, West Java, Indonesia, 35 pp.
- Robertson, P. L. 1939. Diamondback moth investigation in New Zealand. N. Z. J. Sci. Technol. 20:1-35.
- Santoso, P. 1979. Effectivities of several insecticides on *Plutella xylostella* L. and its parasite, *Diadegma eucerophaga* Horstm (in Indonesian). Thesis, Department of Biology Bandung Institute of Technology, Bandung West Java, Indonesia, 70 pp.
- Sastrodihardjo, S. 1970. Census on *Plutella maculipennis* Curtis and *Angitia cerophaga* Grav. and the application of insecticides (in Indonesian) Res. Rep. Department of Biology, Bandung Institute of Technology, Bandung, West Java, Indonesia, 15 pp.
- Sjamsuriputra, A. A., T. Sugijanto, I. Sastramihardja, and S. Sastrodihardjo. 1976. Laboratory evaluation of several strains of *B. thuringiensis* on *Plutella maculipennis* larvae. Res. Rep. Bandung Institute of Technology, Bandung, West Java, Indonesia, 50 pp.
- Subiana, I. 1973. Rearing, life cycle and mating behaviour of *Plutella maculipennis* (in Indonesian). Thesis, Department of Biology, Bandung Institute of Technology, Bandung, West Java, Indonesia, 40 pp.
- Sudarwohadi, S. and H. A. M. van der Oever 1974. Leaf eating caterpillars of cabbage (*Plutella maculipennis* and *Crociodomia binotalis*): Population fluctuations and chemical control. pp 385-392. In Agricultural Cooperation Indonesia—The Netherlands Research Reports. Bogor, Indonesia.
- Sudarwohadi, S., A. H. Dibyantoro, Soenarso, and K. G. Eveleens. 1977. Evaluation of *Bacillus thuringiensis* var *alesti* Berliner alone and in mixture with insecticides, for control of *Plutella xylostella* and *Crociodomia binotalis* on cabbage. Bull. Penel. Hort. 5:11-21.
- Sudarwohadi, S. 1981. The latest development in biological control of *Plutella xylostella* L in Indonesia (in Indonesian) National Congress of Horticulture, Malang, Indonesia, 20 pp.
- Sugiyanto, T. 1973. Rearing of *Plutella maculipennis* Curt. on *Brassica olerasia* and *Brassica chinensis* (in Indonesian). Thesis, Bandung Institute of Technology, Bandung,

- West Java, Indonesia, 55 pp.
- Sukarman, F. F. 1982. Leaves selection of *Plutella xylostella* larvae on young cabbage sprayed with *B. thuringiensis* Berliner (in Indonesian). Thesis, Department of Biology, Bandung Institute of Technology, Bandung, West Java, Indonesia, 50 pp.
- Suradinata, T. S. 1979. Measurement of insecticide toxicity on *Plutella maculipennis* respiration (in Indonesian). Thesis, Department of Biology, Bandung Institute of Technology, Bandung, West Java, Indonesia, 45 pp.
- Sutomo, F. X. 1974. Rearing of *Plutella maculipennis* on synthetic diets (in Indonesian). Thesis, Department of Biology, Bandung Institute of Technology, Bandung, West Java, Indonesia, 50 pp.
- van der Vecht, J. 1936. Experiments with Derris for control of insect pests in Nederland Indies (in Dutch). Korte Med. van het Inst. van Plantenziekten, No. 21. 25 pp.
- Vos, H. C. C. A. A. 1953. Introduction in Indonesia of *Angitia cerophaga* Grav., a parasite of *Plutella maculipennis* Curt. Contrib. Gen. Agri. Res. Sta. Bogor 134, 32 pp.
- Weires, R. W. and H. C. Chiang. 1973. Integrated control prospects of major cabbage insect pests in Minnesota based on fannistic, host varietal and trophic relationships. Tech. Bull. Univ. Minnesota, Agri. Exp. Sta. No. 291, 42 pp.
- Yuwono, S. 1975. Effects of pesticides on cabbage pests *Plutella maculipennis* Curt. and its parasites *Angitia cerophaga* Grav (in Indonesian). Thesis, Department of Biology, Bandung Institute of Technology, Bandung West Java, Indonesia, 45 pp.