

Epizootics of *Pandora blunckii* and *Zoophthora radicans* (Entomophthoraceae: Zygomycotina) in Diamondback Moth Populations in the Philippines

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Abstract

Entomophthoralean fungi cause natural epizootics in populations of the diamondback moth, *Plutella xylostella* (L.), in the Philippines. Natural epizootics of *Pandora (Erynia) blunckii* (Lakon ex Zimm.) Humber and *Zoophthora radicans* (Bref.) Batko were observed. The fungi can infect over 95% of the larvae and over 70% of the pupae on cabbage (*Brassica oleracea*); on petchai (*B. campestris*) the DBM density and the fungus infection levels were lower, i.e. only 20% of the larvae and 30% of the pupae were infected. There was no correlation between climatic data, i.e. relative humidity, rainfall, and temperature and the occurrence of the epizootics. The epizootics occurred after the DBM populations had reached their highest numbers. Insect density is probably an important factor for the initiation of the fungal epizootics in Philippine DBM populations.

Introduction

Insect fungi

Entomopathogenic fungi are specific natural enemies of insects and mites. The fungi are predominantly found in the Hyphomycetes (Deuteromycotina, with teleomorphs in the Ascomycotina) and the Entomophthoraceae (Zygomycotina). They infect their hosts by penetration through the cuticle and growth of hyphae in the host cavity. The fungi occur worldwide on crop pests such as those of soybeans (Ignoffo 1981) and citrus (McCoy 1981), on insects of medical importance such as mosquito larvae (Jaronski 1990) and on insects in forests, particularly in tropical rain forests (Evans 1982; Rombach and Roberts 1989).

Insect fungi can cause epizootics (epidemics) that decimate insect populations. They often control pest populations when: (a) the environmental conditions, in particular relative humidity and temperature, favor fungal development, and (b) the insect host is present in sufficient numbers to sustain such an epizootic. Lately increased efforts are being made to use fungi for the control of various insect and mite pests such as the citrus rust mite in Florida (McCoy 1981), vine weevils (*Otiorhynchus sulcatus* L.) on ornamentals in Europe (Zimmermann 1984) and the brown planthopper (*Nilaparvata lugens* (Stahl)) on rice in Asia (Rombach et al. 1987).

Novel mass production methods, such as the marcescent process (Soper and Ward 1981) and improved growth media (Trinci et al. 1990), were developed to produce large amounts of relatively inexpensive fungus inoculum to be used in field trials.

Fungi on DBM

Entomophthoralean fungi were collected from diamondback moth (DBM), *Plutella xylostella* (L.) (Lepidoptera: Yponomeutidae), around the world (Wilding 1986). Velasco (1983) found *Zoophthora radicans* (Bref.) Batko (Entomophthoraceae: Zygomycotina) on larvae of DBM in the Philippines.

Recently we collected *Pandora blunckii* (Lakon ex Zimm.) Humber (Entomophthoraceae: Zygomycotina) (Riethmacher and Kranz 1991), *Z. radicans* and a hitherto undescribed *Conidiobolus* species (Entomophthoraceae: Zygomycotina) from DBM larvae and pupae in the Philippines (Riethmacher et al. 1990). The development of epizootics of entomophthoralean fungi in DBM populations as well as fungus mass production and field trials were investigated. Results of the epizootiology studies are partly reported here.

Materials and Methods

Survey methods

Field sites. Surveys were carried out on (a) cabbage plants, *Brassica oleracea* L. (cv. 'Scorpio') as well as on (b) a local nonheading cabbage ('Petchai'; *B. campestris* L.). The survey fields (about 150 each) were adjacent and on the grounds of the Benguet State University (BSU), La Trinidad, Baguio City. The fields received normal maintenance (i.e. weeding, low level fertilization, adequate irrigation), but were not treated with insecticides or fungicides. The surveys were made during the dry season (November 1989-January 1990).

Survey techniques. Sixty randomly selected cabbage plants and 240 petchai plants were marked at the start of the surveys. On these plants the living and infected DBM larvae and pupae were counted weekly (but not collected). A total of 10 surveys on cabbage and five surveys on petchai were made. The numbers of living and infected larvae and pupae were added separately. The petchai field survey data were recalculated to represent numbers per 60 plants to be able to compare insect populations on petchai with the populations on cabbage.

Collection and incubation

Field site. The field was situated adjacent to the fields used for the surveys. It was transplanted to cabbage at the same time as the survey fields and received the same maintenance treatment. The collections were carried out during the same period as the surveys.

Collection. The collection fields were visited weekly. Each week 15 plants were selected randomly and 15 DBM larvae (second and third instar) were collected from these plants and transferred to separate plastic containers.

Incubation. In the laboratory the larvae were transferred to small 'Bellaplast' containers (9 cm diam) on a cabbage leaf disc. The leaf discs were washed before the incubation to prevent possible infection of the larvae by fungi present on the leaves. A wet cotton plug was added to the container to ensure maximum relative humidity. The temperature remained at about 20°C for the incubation period.

Evaluation. The larvae were examined daily for the development of fungus diseases. Larvae which developed a fungus disease were removed and the fungus was identified. A percentage infection of the 225 larvae collected per sampling date was calculated.

Weather data

The weather data were provided by the PAGASA weather station (Benguet State University); the station is situated directly at the border of the experimental fields. Only data on temperature, rainfall, and relative humidity are presented here.

Results

Survey results

Cabbage. At the first counting date (11 November 1989) only a very few DBM larvae (about 100 larvae/60 plants) were present (Fig. 1). The population increased to about 4000 larvae/60 plants after 7 weeks, but close to harvesting (10 weeks after transplanting) the larval population decreased dramatically. The pupal population peaked at 7 weeks after transplanting at about 250 pupae/60 plants (Fig. 2).

Fungus infections first occurred at 6 weeks in the larval and at 7 weeks in the pupal population. Infection levels increased up to 95% in the larva population (Fig. 1) and up to 70% in the population of pupae (Fig. 2).

Petchai. DBM infestations on the petchai were considerably lower compared with the cabbage (Fig. 3 and 4). In the petchai field larvae and pupae were found after 3 weeks. The population increased to approximately 220 larvae/60 plants (Fig. 3) and 12 pupae/60 plants (Fig. 4). Seven weeks after transplanting, fungus infections had increased to about 20% in the larval population and 30% in the pupal population.

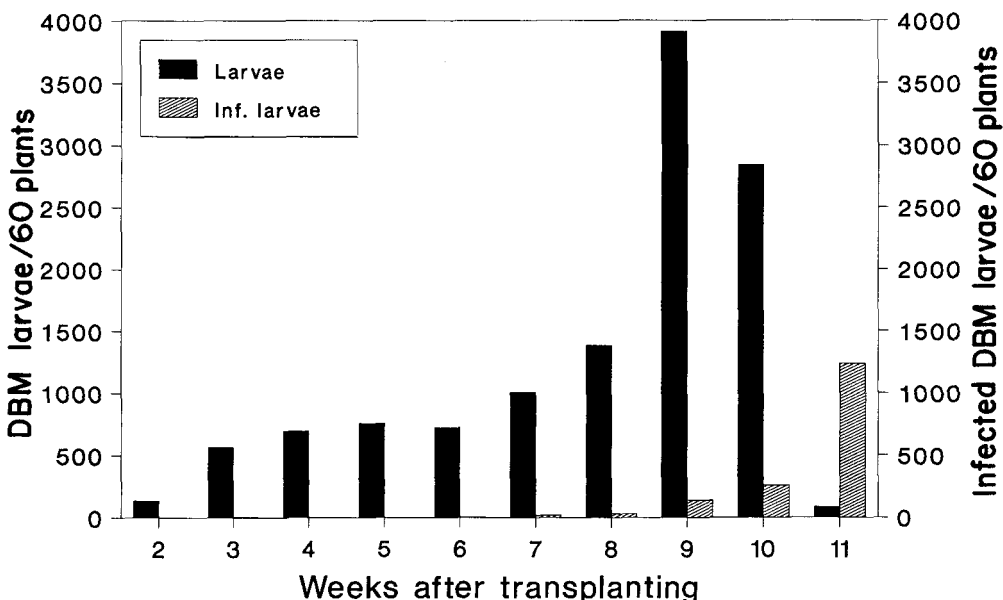


Fig. 1. Numbers of healthy and fungus-infected DBM larvae on cabbage at different observation dates.

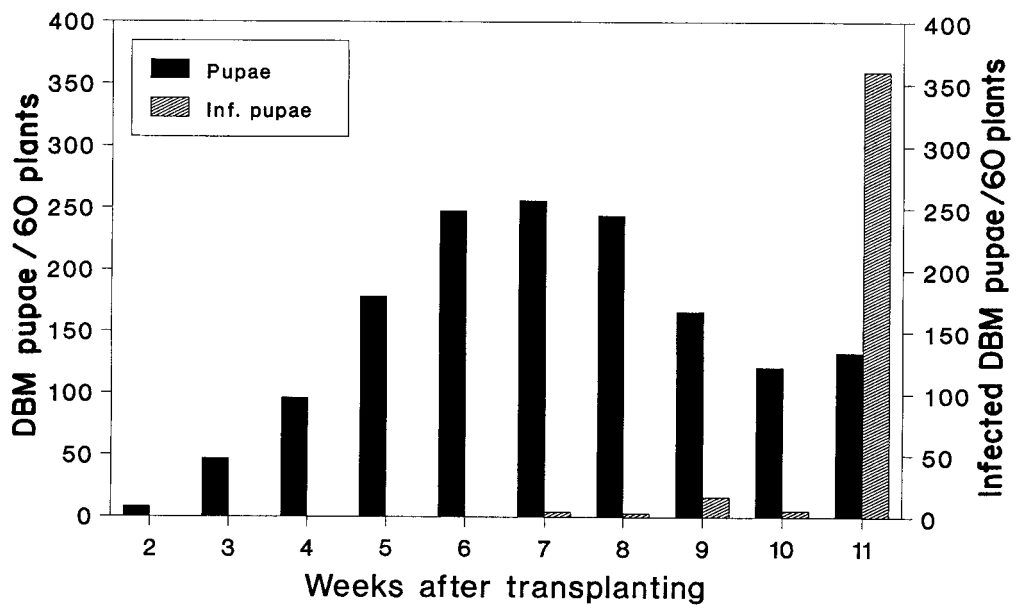


Fig. 2. Numbers of healthy and fungus-infected DBM pupae on cabbage at different observation dates.

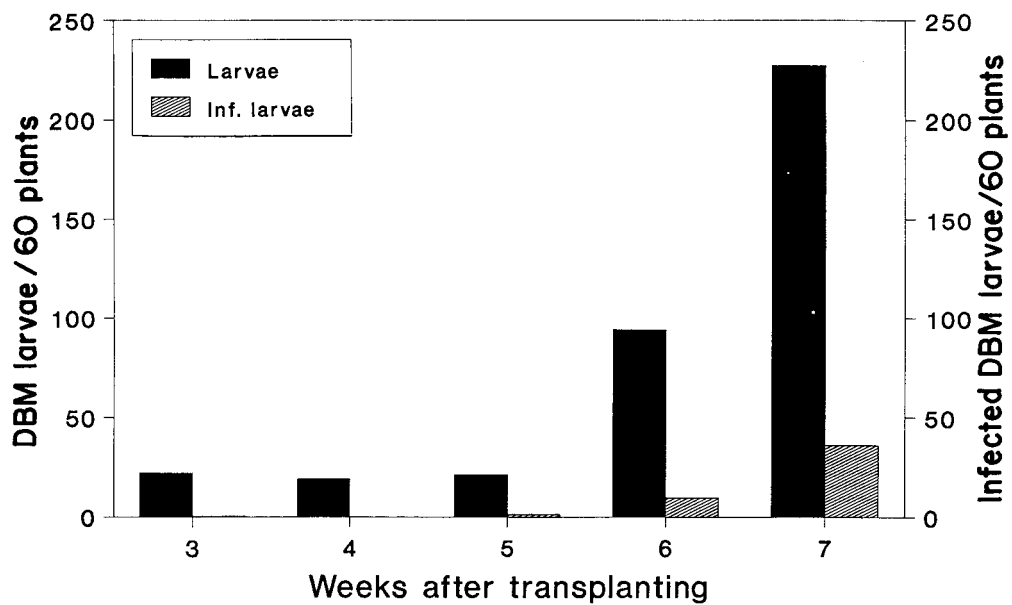


Fig. 3. Numbers of healthy and fungus-infected DBM larvae on petchai at different observation dates.

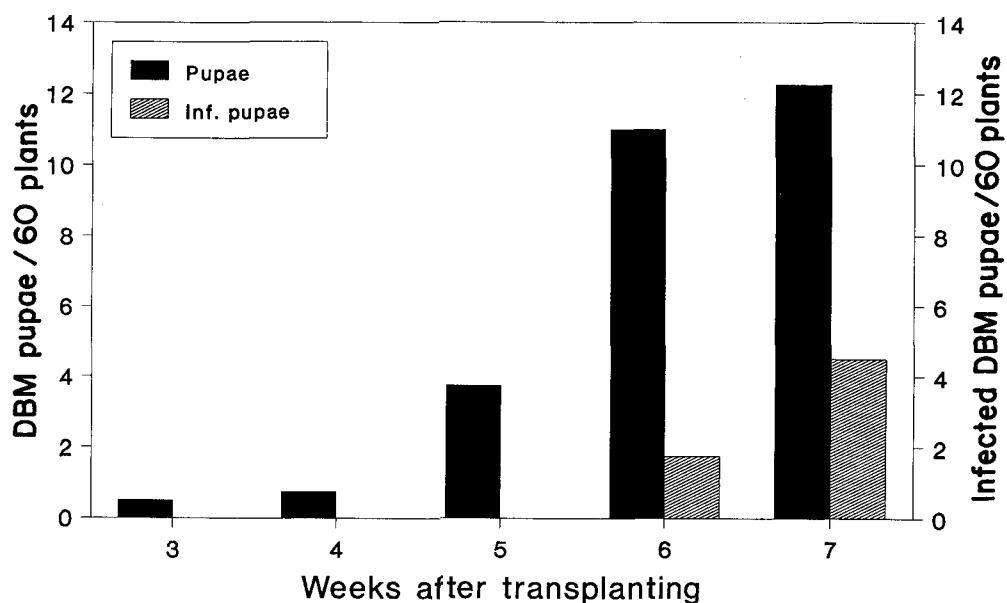


Fig. 4. Numbers of healthy and fungus-infected DBM pupae on petchai at different observation dates.

Weather data

The average maximum temperature was about 23°C, and the average minimum temperature was 12°C (Fig. 5). No apparent trends in temperatures were present. Only one strong rain-shower occurred during the studies.

The average relative humidity was high, and never below 65%; average nightly relative humidity mostly exceeded 85%. No apparent trends in relative humidity were present during the studies.

Collection and incubation

Pandora blunckii and *Z. radicans* were the only fungi identified from the field-collected and incubated larvae (Table 1). Infections with *P. blunckii* increased from 1 to 22% during the sampling period. *Z. radicans* occurred in the last collection, but only on 4% of the larvae.

Table 1. Infestation of field-collected DBM larvae by *Pandora blunckii* and *Zoophthora radicans* after incubation in the laboratory.

Sampling date	Larvae (%) infected with	
	<i>P. blunckii</i>	<i>Z. radicans</i>
13 November 1989	1	0
27 November 1989	5	0
11 December 1989	12	0
8 January 1990	12	0
19 January 1990	22	4

Conclusions

Entomophthoralean fungi clearly are important natural enemies of DBM on cabbage and petchai in the Philippines. *P. blunckii* is the dominant fungus in these surveys and collection

fields; *Z. radicans* was collected on 19 January 1990 (the last sampling date) and only infected 4% of the larvae. In all, the fungi infected up to 95% of the larvae on cabbage, and up to 20% of the larvae on petchai in the surveys.

The lower infection rates on the petchai plants might be caused by the lower insect density on the petchai (Fig. 3 and 4). The lower insect infestation probably reflects a preference for cabbage of the DBM adult, since the fields were adjacent and adults could easily move between them. Also, petchai plants are considerably smaller compared to cabbage, which affects population growth rates.

The fungi only occurred at a fairly late stage in the plant development, i.e. shortly before harvest and before the DBM populations decreased. However, from this survey we cannot determine whether the decline of the populations was due to the fungus infections or to other factors.

It might well be that high DBM populations have to be present to initiate the fungus epizootics. This is unfortunate because the damage often occurs before these epizootics. It should be investigated whether artificial dissemination of fungus material at lower insect densities can cause the epizootics to occur at an earlier stage of the DBM population development. Kelsey (1965) achieved infections of DBM larvae in New Zealand by field application of cadavers infected with *Z. radicans*.

Field trials to test the efficacy of mass-produced Entomophthoraceae to control DBM populations on cabbage are now being conducted in the Philippines. Mass-produced material of these fungi might well become a new tool for DBM management, but only if epizootics can be induced at lower DBM infestation levels.

Acknowledgments

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