INFECTION OF PUPAE OF *HELIOTHIS ARMIGERA* BY *PAECILOMYCES FARINOSUS*

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ABSTRACT

Epizootics of **Paecilomyces farinosus** (Dicks ex Fr.) Brown and Smith on overwintering populations of **Heliothis armigera** Hübner pupae in 1969 and 1970 are described. In the study area the disease patterns were similar in both years. 50% of the pupae were killed before the ends of the winters.

It was concluded that it was unlikely to have a significant effect on the numbers of caterpillars in subsequent generations.

INTRODUCTION

Several outbreaks of *Heliothis* (= *Helicoverpa*) *armigera* Hübner (Lepidoptera: Noctuidae) have occurred on young pines in central North Island forests. During studies of an outbreak near Tokoroa it was noted that overwintering pupae were infected with a fungus (Alma, 1971). The fungus was isolated from pupae and cultured in the laboratory. It was identified as *Paecilomyces farinosus* (Dicks ex Fr.) Brown and Smith (Moniliales) by the Commonwealth Mycological Institute. The progress of the disease in overwintering pupae was followed in the field in 1969 and 1970.

OBSERVATIONS

The observations on the fungus were carried out in a small sample area (2 ha) of pine forest near Tokoroa, planted in 1967 with one-year-old nursery stock of *Pinus radiata* D. Don. Approximately 60% of the trees had more than 50% of their foliage eaten by caterpillars of *Heliothis armigera* in late February 1969.

There were two successful and a partial third generation of larvae each summer at Tokoroa; 60% of the first generation larvae and over 99% of the second generation larvae produced diapausing pupae (Alma, 1971). The overwintering population resulted from an unknown proportion of first and second generation larvae pupating in November to January and February to March respectively. In 1970 a larger proportion of pupae would have been produced by the first generation as the second generation was much reduced by a virus epizootic (Moore & Alma, 1974). The overwintering pupal populations in the study area were estimated to be 19 per m^2 in 1969 and 16 per m^2 in 1970 (Alma, unpublished data).

Pupae were collected by searching with a hand trowel the top 10 cm of soil in randomly selected quadrats of 0.5 by 0.5 m. Frequent, at least monthly, visits were made and 10 to 15 quadrats were examined at every visit. Sieving of the examined soil indicated that all pupae within the quadrats could be found by careful searching with the trowel. The method became slightly less reliable after late August owing to the break-down and decay of some of the older infected pupae, although some remains, particularly of the cuticle, could still be detected. It was possible to separate the remains of previous year's infected pupae by the degree of decay of the pupa and its integument, and the appearance of the fungal hyphal mat.

The percentage of fungus-infected pupae in the population and the progress of the disease in individual pupae was noted throughout the winters.

Healthy diapausing pupae were filled with an undifferentiated green fluid and moved when held. The first gross symptom of the disease was immobilisation of the pupae. The contents of the body cavity hardened and turned yellow-brown in colour as the mycelium invaded the haemocoel. The first external appearance of the fungus was usually as white spots at the spiracles. The mycelium spread over the surface of the pupa from the spiracles and the intersegmental membranes of the abdomen. Eventually the whole pupa was enveloped in a thin (less than 0.5 mm) sheet of white mycelium. Hyphae then grew up to the soil surface (pupae were usually found about 5 cm below surface level) and produced coremia above the surface. The fungus was never found on larvae, on pupae that had developed beyond the diapause state, or on adults.

The percentages of fungal-infected pupae at different times through the winters of 1969 and 1970 are shown in Fig. 1. In both years the percentages of infected pupae at a given time were very similar. The disease spread slowly and eventually 50% of the pupae were infected.

DISCUSSION

When considering the effect of fungal infection on insects, it is often difficult to determine whether the fungus is acting as a primary pathogen or saprophytically

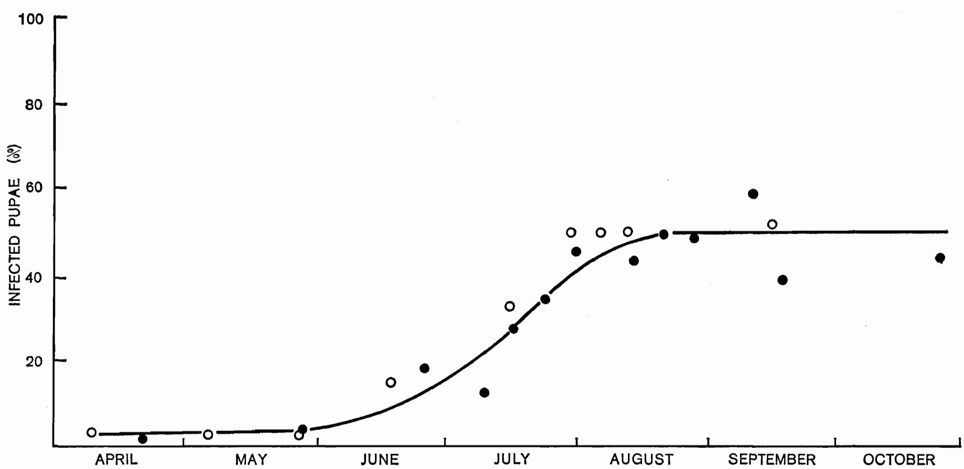

FIG. 1—The spread of infection of **Paecilomyces farinosus** in pupal populations of **Heliothis armigera** in 1969 (solid circles) and 1970 (open circles). The graph represents the mean of both years.

utilising an already dead carcase. As a group the hyphomycetous fungi are facultative parasites (Madelin, 1963). The species isolated from *H. armigera* was not an exception and grew well on artificial media. *P. farinosus,* however, is a well-known entomophagous fungus (Brown & Smith, 1957; Madelin, 1963). Pupae reared from larvae kept in isolation in the laboratory could be readily infected by brushing the surface with either coremia from infected pupae or spores from cultures.

Infection in the field may result from either fungal penetration of the spiracles or intersegmental membranes, or by infection from the gut. The high relative humidity of the pupal chamber would be conducive to spore germination and mycelial growth. It was noted that the gut contents of *H. armigera* are not voided prior to pupation, thus it is possible that infection may occur from the intestine. The possibility of transmission and introduction of the fungus by parasites, as noted by Voukassovitch (1925), is unlikely in this case. At Tokoroa parasitism of *Heliothis* was rare; less than 1% of the pupal population was parasitised by *Pterocormus promissorius* Ericson (Hymenoptera: Ichnuemonidae) (Alma, 1970), and no signs of parasite attack were ever found in pupae infected with fungus.

Although the fungus considerably reduced the initial population of adults present in spring, it is thought that the potential numbers of eggs (up to approx. 4,000 per female, Hardwick, 1968) and subsequent larvae produced by the remaining healthy females were probably well in excess of the available food material. It is likely that factors other than the fungus are responsible for limiting population expansion.

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