

INFLUENCE OF LARVAL DENSITY ON BIOLOGICAL FITNESS OF *EPHESTIA KUEHNIELLA* ZELLER (LEPIDOPTERA: PYRALIDAE)

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ABSTRACT

Mediterranean flour moth, *Ephestia kuehniella*, is a cosmopolitan pest of stored products, and its eggs are widely used to rear parasitoids and predators for biological control programmes. This experiment investigated how larval population density affected the survival rate and reproductive output of this species under four rearing densities (1 larva per 2 g food per vial; or 100, 500 or 1000 larvae per 50 g food per jar). The survival rate and reproductive output significantly decreased ($P < 0.0001$) with increased larval density. On average 91, 73, 50 and 10% of neonate larvae survived to adults, and each resultant adult produced an average of 339, 321, 253 and 183 viable offspring, at densities of 1, 100, 500 and 1000 larvae, respectively. When the cost of labour is taken into consideration, a rearing density of 100 neonate larvae per 50 g food per jar is recommended to produce satisfactory quantity and quality of *E. kuehniella* adults and eggs.

Keywords: *Ephestia kuehniella*, larval density, survival, reproductive potential.

INTRODUCTION

The Mediterranean flour moth (*Ephestia kuehniella* Zeller) is a serious cosmopolitan pest of stored grain products, particularly flour (Rees 2003). Its eggs and larvae are widely utilised to rear parasitoids and predators for biological control and research into behaviour, biochemistry and molecular biology (Corbet 1973; Rahman et al. 2004). The economical production of large number of high quality *E. kuehniella* is, therefore, a pre-requisite for these purposes.

Previous studies showed that crowding affected biological fitness of the insects (Peters & Barbosa 1977). In *E. kuehniella*, larval crowding has impacts upon mortality (Bell 1976; Cerutti et al. 1992), adult size (Ullyett & Merwe 1947; Cerutti et al. 1992) and fecundity (Ullyett & Merwe 1947; Cerutti et al. 1992). However, the comparison of biological parameters of the New Zealand strain of *E. kuehniella* reared in different densities has not been reported, making it difficult to determine the optimal rearing density for research and mass production of biological control agents. In this study, experiments were carried out to determine the overall performance of this insect in four larval densities.

MATERIALS AND METHODS

Insects

Laboratory colonies were maintained in glass jars (9 cm diameter × 17 cm height), each filled with 100 g of a standard diet (43.5% wholemeal wheat flour, 43.5% maize meal, 3.0% yeast and 10% glycerine) (Lima et al. 2001), in the Entomology and IPM Laboratory of Massey University (Palmerston North) at 25±1°C and 70±10% relative humidity, with 14:10 h (light:dark). The jars were covered with two layers of nylon mesh. Adults were given neither food nor water because this is unnecessary (Calvert &

Corbet 1973; Karalius & Buda 1995). All experiments were carried out under the above environmental conditions. To start the colonies, three pairs of moths were introduced into each jar to lay eggs, which were deposited onto the standard diet (Karalius & Buda 1995). Two crumpled paper towels (25×25 cm) were placed in each jar for pupation.

Rearing densities

Eggs were collected from 20 pairs of moths in a plastic container (20×16×10 cm) lined with two porous plastic sheets (20×5 cm) as an oviposition surface. A preliminary study showed that the hatch rate of this colony was 86.4% (J. Xu, unpubl. data). To make densities of 100, 500, and 1000 neonate larvae, 116, 578 and 1157 newly laid eggs (< 24 h old) were inoculated on to 50 g of the standard diet in a plastic jar (8 cm diameter × 10 cm height). Each jar was provided with two crumpled paper towels (25×25 cm) for pupation and considered to be a replicate. The jar was covered with two layers of nylon mesh. Ten replicates were performed for densities of 100 and 1000 larvae and eight replicates for the 500 larvae density.

For the density of 1 neonate larva (individually reared), a newly laid egg (< 24 h old) was inoculated on to 2 g standard diet in each of 580 glass vials (2 cm diameter × 7.5 cm height). A crumpled paper towel (6×6 cm) was placed in each vial for pupation, and the vial was covered with a layer of nylon mesh. These vials were divided into groups of 116 vials, giving 5 replicates.

The final larvae densities of the 4 treatments were 1 larva per 2 g food per vial; or 100, 500 or 1000 larvae per 50 g food per jar.

Survival rate and reproductive output

The emerged moths were collected and sexed daily and the pupation rate (number of pupae/number of neonate larvae), emergence rate (number of emerged moths/number of pupae) and survival rate (number of emerged moths/number of neonate larvae) were recorded.

To determine the effect of larval density on fecundity and fertility, 51, 43, 43 and 47 pairs of newly emerged moths (<12 h old) were randomly collected from densities of 1, 100, 500 and 1000 larvae, respectively. These were individually caged for their lifespan in plastic jars (8 cm diameter × 10 cm height), internally lined with porous plastic sheets for oviposition, and covered with two layers of nylon mesh. Eggs were collected daily and incubated in Petri dishes (8.5 × 1.5 cm). Total eggs were counted for each pair, and those with black dots (larval heads) after 3 days (egg development period of this colony was 4-5 days) of incubation were recorded as fertile.

Statistics

A goodness-of-fit test was used to test the distribution of data before analysis. The fertility data were not normally distributed even after transformation and thus were analysed using the nonparametric Kruskal-Wallis test followed by Dunn's procedure for multiple comparisons (Zar 1999). Other data were normally distributed and analysed using ANOVA followed by a Tukey's studentized range test. The percentage data were arcsine transformed prior to analysis. Statistical significance was assessed at $P < 0.05$.

RESULTS AND DISCUSSION

With the increased larval density in *E. kuehniella* the emergence, pupation and survival rates significantly decreased ($P < 0.0001$) (Fig. 1). The survival rates were significantly different ($P < 0.001$) between density treatments, with 73% of neonate larvae surviving to adults in the density of 100, compared to 91% in individually reared larvae. When the larval density increased to 500 and 1000, only 50% and 10% larvae, respectively, became adults. The low survival rate at the high density may be due to food shortage (Cerutti et al. 1992; Sato et al. 2004), fecal and microbial contamination and cannibalism (Singh 1977; Stone & Sims 1992).

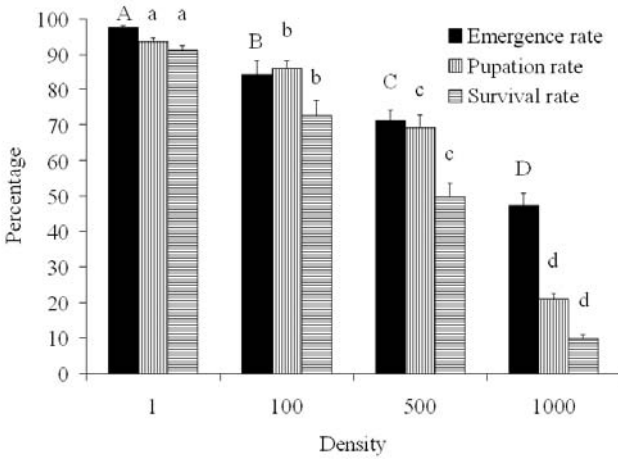


FIGURE 1: Mean emergence, pupation and survival rates at four larval densities in *E. kuehniella*. For each parameter, columns with the same letters are not significantly different ($P>0.05$).

The fecundity and fertility of resultant adults of *E. kuehniella* significantly decreased with the increasing larval density ($P<0.0001$) (Fig. 2). However, these parameters were not significantly different between the density of 1 and 100 larvae ($P>0.05$) (Fig. 2), indicating that the insects reared under the density of 100 larvae can still produce adults of the highest fecundity and fertility. To obtain 100 adults, the calculated time of individual rearing was > 2 h while that of the 100 larval density was < 10 min.

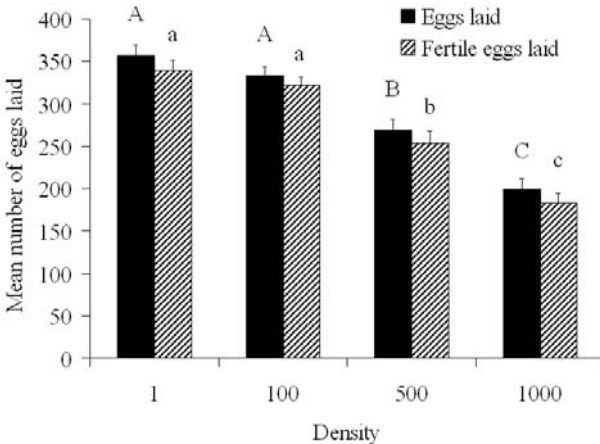


FIGURE 2: Mean number of eggs and fertile eggs laid at four larval densities in *E. kuehniella*. For each parameter, columns with the same letters are not significantly different ($P>0.05$).

This study suggests that although the overall performance of *E. kuehniella* decreased with the increase of larval density, a rearing density of 100 neonate larvae per 50 g food per jar is highly recommended to produce a satisfactory quantity and quality of *E. kuehniella*, particularly when the cost of labour is taken into consideration.

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