# UNPLANNED FACTORS AFFECTING POPULATION SIZE IN LABORATORY POPULATIONS OF THE ALMOND MOTH *EPHESTIA CAUTELLA* (WALKER)

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Abstract

Fourteen genetically different populations of the almond moth Ephestia cautella (Walker) were maintained for 12 months with a regular weekly replacement of the old food cups by fresh ones. Population size was measured by weekly counts of live and dead adults. Our intentin was to establish continuous populatins which would maintain a more or less stable population size over a long period of time. Instead, population size decreased steadily in the first 3 months,then increased steadily in the following 5 months and decreased sharply in the final 3 months of the experiment. The temporal pattern of population size was similar for all the populations regardless of strain, suggesting external causative factors. Two unplanned factors affected population size: 1) Low humidity caused it to decrease. The populations recovered when humidity was increased. 2) Infestation by two parasitoids. Nemeritis canescens co-existed with the moths and did not affect population size significantly; Bracon hebetor spread to all populations and within 3 months reduced them to extinction. However, in one population infested with both parasitoids, the numbers of N. canescens exceeded those of B. hebetor. The implications for almond moth control were considered.

## Introduction

The almond moth Ephestia cautella (Walker) is a serious pest of a variety of stored products, such as cereals, corn, peanuts, beans, peas and dried fruit (Abreu & Williams, 1978, 1982; Brower & Tilton, 1975). The short-lived (5-7 days) adults do not feed. Considerable damage is caused by larval feeding, debris and webbing.

The regulation of population size by food, parasites and predators, in the closely-related moth Anagasta (=Ephestia) kuehniella was studied by Flanders & Badgley (1963), Flanders (1968), Hassell & Huffaker (1969), and White & Huffaker (1969a,b).

The impact of two parasitoid wasps, Bracon hebetor Say and Nemeritis canescens Gravenhorst on Ephestia cautella populations, as possible biological control agents was studied by Press, Flaherty & Arbogast (1977), Press and Flaherty (1981) and Press et al., (1981).

In this paper, we present data on the influence of two unplanned external factors affecting population size, namely: a) low humidity and, b) parasitoid infestation, on 14 Ephestia cautella populations, maintained for 12 months by a regular weekly food supply.



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## Materials and methods

### Strains

A list of the almond moth strains used in this study is given in Table 1.

Table 1: Strains of *Ephestia cautella* used to establish continuous populations.

| Code | Replicates | Full name | Origin | Collected from | Additional information |
|---|---|---|---|---|---|
| V | 3 | Volcani | Israel | cereals | |
| BMR | 4 | Douglas | Georgia,USA | peanuts | |
| BW | 5 | Black wing | Florida,USA | citrus pulp | Homozygous for the recessive mutant (black wing)* |
| Mixed | 2 | | | | Made up of equal parts of the three strains |

* Hagstrum, 1974

### Rearing conditions

The standard rearing medium was ground wheat supplemented with 12% glycerol, (Gonen & Donahaye, 1973; Navarro & Gonen, 1970; Wool & Kamin-Belsky, 1983, 1984). The populations were housed in plastic cages (40x20x20 cm) at 28±1°C with a light cycle of 15L:9D. Ambient relative humidity (r.h.) during the first 4 months of the study was not controlled and reached as low as 30%. Later, a humidifier was installed and r.h. was controlled at 60±5% for the rest of the study period.

### Experimental procedures

The study was carried out on three single-strains and two mixed populations with the number of replicates indicated in Table 1. The populations were established by placing in each cage 7 sets of pairs of plastic food cups containing 25 gr medium each. Six sets contained developing larvae of approximately 100 eggs per cup, collected at different oviposition dates, spanning one month. One food cup set was egg-free. Thus, the first adults emerged from the oldest pair of cups soon after introduction, and subsequently adult emergence was continuous. The seventh pair of food cups, containing fresh medium served as oviposition site for the emerging adults. The oldest pair of food cups was replaced weekly by a pair containing fresh food. Each pair of cups thus remained in the cage for 7 weeks.

Population size was measured weekly by counting and removing all dead adults that accumulated during the week. This same measurement has been used by others (Flanders, 1968; White & Huffaker, 1968a,b).

Statistical analysis

Monthly averages of the weekly counts of dead adults of each population were subjected to a 2-way analysis of variance. Temporal trends in population size were tested by regression analysis (Sokal & Rohlf, 1981).

Results

The temporal pattern of population size is illustrated in Fig. 1 for several populations. This pattern was common to all populations. The features of this pattern are: decline (July-November, 1983); increase (December 1983-April 1984); steep decline (April-July 1984). The similarity of the temporal patterns in 14 genetically different populations suggests external causative factors. The first decline was caused by low ambient humidity. The second, steep decline was the result of invasion of the populations by parasitoids.

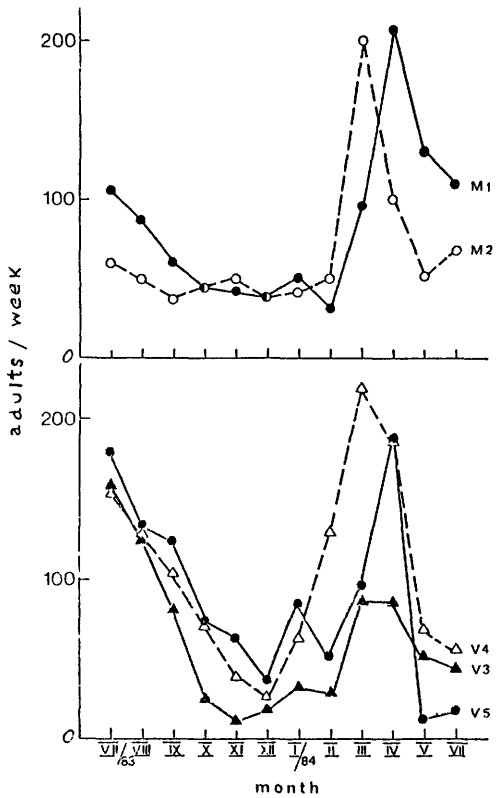


Fig. 1. Temporal trends of population size in 5 of the experimental populations during the 12 months study period. M1, M2 are repeats of mixed-strains populations (equal parts of 3 strains in each). V3-V5 are repeats of single-strain populations of Volcani strain.

Two events of parasitoid invasion were recorded. The first infestation by Nemeritis canescens was found in 3 populations during the summer of 1983, and was confined to them only. The number of wasps was relatively small throughout the experiment and did not affect population size significantly. The second infestation, in March 1984, was by Bracon hebetor. The wasps spread swiftly to all cages, drastically reducing population size to the point of extinction and at this point the experiment was terminated. During the final 3 months of the experiment (April-July, 1984), all adult wasps were removed daily, counted and destroyed. Table 2 lists the frequency distribution of the number of wasps removed from the population per week, as well as the number of adult moths removed from the populations in each wasp frequency class. The number of moths recorded was negatively correlated with wasp abundance ($r = -0.431$, $df = 40$, $p < 0.01$). One population contained both parasitoids in the last 3 months of the experiment. The number of N. canescens exceeded B. hebetor in this cage.

Table 2. Frequency distribution of the monthly mean numbers of B. hebetor removed per week, and the mean numbers of adult Ephestia cautella produced in populations of each parasite frequency class (mean ± S.E.). All populations and moths pooled (14 x 3 = 42 observations).

| Range of mean no. wasps/week | 0-25 | 26-50 | 51-75 | 76-100 | 101-125* |
|---|---|---|---|---|---|
| Number of observations | 12 | 10 | 10 | 5 | 5 |
| Mean no. moths per week | 138.9 | 81.8 | 31.6 | 55.7 | 73.9 |
| ± S.E. | ± 19.99 | 21.83 | 10.60 | 17.34 | 22.10 |

* 2 cases in which more than 150 wasps were collected per week are included.

## Discussion

The optimal r.h. for E. cautella at 30°C is 70-80%. The lower limit of r.h. for the moth development is 20% (Burges & Haskins, 1965). Very low humidity results in increased larval mortality, a 2-fold increase in developmental time, reduction of adult longevity by half and reduction of adult body size. Consequently, it leads to reduced reproductive activity including fecundity (Burges & Haskins, 1965; Bell, 1975; Imura, 1981; Lum, 1983). Therefore the observed decrease in population size, when r.h. in our experiment was 30%, close to the lower limit (July-November, 1983), was of no surprise. When ambient humidity was increased to 60%, population size increased (Fig. 1).

Each of the two parasitoids affected population size differently: N. canescens was able to coexist with its host while B. hebetor reduced host population size to extinction. This difference in response may be due to the different biologies of the parasitoids.

B. hebetor paralyzes the moth caterpillar by stinging it several times, and then deposits several eggs externally on the paralyzed caterpillar (Anonymous, 1979). More host larvae are paralyzed than actually parasitized by B. hebetor (Hagstrum, 1983; Press et al., 1977).

N. canescens does not paralyze the host, but lays its eggs internally. Only one parasite emerges from a host larva (Flanders & Badgley, 1963;

Takahashi, 1968; Press et al., 1977).

The life cycle of B. hebetor is about 2 weeks (Anonymous, 1979), while that of N. canescens may be as long as 33 days at 27°C (Flanders & Badgley, 1963). Under favorable conditions B. hebetor develops from egg to adult in less than 2 weeks (Anonymous, 1979; Press et al., 1981). The heterogeneity in larval developmental time within a single generation of E. cautella makes available host larvae for at least two generations of B. hebetor. In a comparison of the efficiency of N. canescens with B. hebetor as bio-control agents for stored product moths - B. hebetor was considered the more efficient of the two (Press et al., 1977). At favored host density N. canescens parasitized 30% of the hosts (Takahashi, 1962, 1968), while B. hebetor was 2-3 times more effective (Hagstrum, 1983). Press & Flaherty (1981) suggested that B. hebetor would quickly increase in numbers in a large population of E. cautella and that the numbers of hosts killed per parasite would also increase.

Our data agree with this suggestion. The overlapping generations of the hosts in our cages, as well as in natural habitats of E. cautella (stored-products warehouses) further favors the spread of B. hebetor in the host populations. Press et al. (1977) found that when both parasitoids were present, N. canescens was depressed by B. hebetor due to the ability of B. hebetor to develop on host larvae previously parasitized by N. canescens, while N. canescens cannot survive on hosts parasitized by the other wasp. They predicted that if the two species were introduced into a warehouse, N. canescens will eventually become extinct. In our one cage infested continually by both parasitoids, however, both species were recovered for the duration of the host population and N. canescens was more numerous than B. hebetor. Several possible explanations for the discrepancy may be considered: 1) The host/parasite ratio at that time, may have been favorable for N. canescens (Takahashi, 1962); 2) Competition between parasitoid species may have been too small to be effective. 3) The availability of larvae at different developmental stages. N. canescens may have been provided with larvae at favorable physiological states for parasitization, due to overlapping generations in our continuous populations, thus giving this species some advantage. We have no proof so far of these assumptions.

The presence of the parasitoids in our cultures was unplanned and may simulate natural infestations which occur in storage facilities. Our data support the suggestions of Press et al., (1977) that B. hebetor is a promising biological control agent for E. cautella.

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References

Abreu, J.M., and R.N. Williams. 1978. A bibliography of the almond moth Ephestia cautella (Walker) (Lepidoptera:Pyralidae). Res. Circ. 237 Ohio Agr. Res. & Dev. Center. 42p.

Abreu, J.M., R.N. Williams, and P.A. Rude. 1982. Revised bibliography of the almond moth (Tropical warehouse moth) Ephestia cautella (Walker) (Lepidoptera:Pyralidae). Trop. Stored Prod. Inf. 44:15-36.

Anonymous. 1979. Stored Grain Pests. USDA Agr. Handbook No. 500. 57p.

Bell, C.H. 1975. Effect of temperature and humidity on development of four pyralid moth pests of stored products. J. Stored Prod. Res. 11:167-175.

Brower, J.H., and E.W. Tilton. 1975. Potential for control of Cadra cautella (Walker) by release of fully or partially sterile males. Intern. J. App. Rad. & Isotopes 26:720-725.

Burges, H.D., and K.P.F. Haskins. 1965. Life cycle of the tropical warehouse moth Cadra cautella (Walker) at controlled temperatures and humidities. Bull. Entom. Res. 55:775-789.

Flanders, S.E. 1968. Mechanisms of population homeostosis in Anagasta ecosystems. Hilgardia 39:367-404.

Flanders, S.E., and M.E. Badgley. 1963. Prey-predator interactions in self-balanced laboratory populations. Hilgardia 35:145-183.

Gonen, M., and E. Donahaye. 1973. An improved technique for rearing the tropical warehouse moth Ephestia cautella (Walker) (Lepidoptera: Phyticidae). Israel J. Entomol. 8:179-181.

Hagstrum, D.W. 1974. Four non-allelic, autosomal recessive eye-and-wing-color mutations of Cadra cautella (Lepidoptera:Pyralidae). J. Georgia Entom. Soc. 9:88-90.

Hagstrum, D.W. 1983. Self-provisioning with paralyzed hosts and age, density and concealment of hosts as factors influencing parasitation of Ephestia cautella (Walker) (Lepidoptera:Pyralidae) by Bracon hebetor Say (Hymenoptera:Braconidae). Environ. Entom. 12:1727-1732.

Hassell, M.P., and C.B. Huffaker. 1969. Regulatory processes and population cyclicity in laboratory populations of Anagasta kuehniella (Zeller) (Lepidoptera:Phyticidae). III. The development of population models. Res. Popul. Ecol. 11:186-210.

Imura, O. 1981. Effect of relative humidity on the development and oviposition of four phyticid moth pests. Rep. Natl. Food Res. Inst. (Tokyo) 38:106-114.

Lum, P.T.M. 1983. Oocyte degeneration in Plodia interpunctella (Hubner). Environ. Entom. 12:1539-1541.

Navarro, S., and M. Gonen. 1970. Some techniques for laboratory rearing and experimentation with Ephestia cautella (Walker) (Lepidoptera:Phyticidae). J. Stored Prod. Res. 6:187-189.

Press, J.W., B.R. Flaherty, and R.T. Arbogast. 1977. Interaction among Nemeritis canescens (Hymenoptera:Ichneumonidae), Bracon hebetor (Hymenoptera:Braconidae) and Ephestia cautella (Lepidoptera:Pyralidae). J. Kansas Entom. Soc. 50:259-262.

Press, J.W., and B.R. Flaherty. 1981. Reproductive potential of Bracon hebetor Say on three moth species Ephestia cautella (Walker, Achronia grisella and Galleria mellonella. J. Georgia Entom. Soc. 16:342-345.

Press, J.W., Flaherty, B.R., and L.L. McDonald. 1981. Survival and reproduction of Bracon hebetor on insecticide-treated Ephestia cautella larvae. J. Georgia Entom. Soc. 16:231-234.

Sokal, R.R., and F.J. Rohlf. 1981. Biometry (2nd Ed.). Freeman & Co. London. 859p.

Takahashi, F. 1962. Retardation of development and reproductive power of an Ichneumon fly Nemeritis canescens Gravenhorst (Hymenoptera) in relation to the parasitizing stage of its host. Jap. J. Appl. Entom. & Zool. 6:160-162.

Takahashi, F. 1968. Functional response to host density in a parastitic wasp, with reference to population regulation. Res. Pop. Ecol. 10:54-68.

White, E.G., and C.B. Huffaker. 1969a. Regulatory processes and population cyclicity in laboratory population of Anagasta kuehniella (Zeller) (Lepidoptera:Phyticidae). I. competition for food and predation. Res. Pop. Ecol. 11:57-83.

White, E.G., and C.B. Huffaker. 1969b. Regulatory processes and population cyclicity in laboratory populations of Anagasta kuehniella (Zeller) (Lepidoptera:Phyticidae). Parasitism, predation and protective cover. Res. Pop. Ecol. 11:150-185.

Wool, D., and N. Kamin-Belsky. 1983. Age-dependent resistance to malathion in adult almond moth Ephestia cautella (Walker). Z. Ang. Entom. 96:386-391.

Wool, D., and N. Kamin-Belsky. 1984. Effect of diet and larval density on adult sensitivity to malathion and on ecological parameters in Ephestia cautella (Walker) (Lepidoptera:Phyticidae). Z. Ang. Entom. 98:58-62.

Wool, D., Brower, J.H., and N. Kamin-Belsky. 1986. The relative importance of factors affecting the size of laboratory populations of the almond moth Ephestia cautella (Walker) (Lepidoptera:Pyralidae). (In preparation).