RELATIONSHIP BETWEEN PHEROMONE TRAP CAPTURE AND EMERGENCE OF ADULT ORIENTAL FRUIT MOTHS, *GRAPHOLITHA MOLESTA* (LEPIDOPTERA: TORTRICIDAE)[1]

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Abstract

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Pheromone trap capture of feral male Oriental fruit moths was highly correlated with capture of males emerging from ground litter in the spring of 1977 and 1978. The correlation between pheromone trap capture of males and female emergence was also good in 1978 but poor in 1977. It is concluded that pheromone monitoring traps are an accurate measure of the actual spring adult emergence pattern of this species.

Introduction

Pheromone traps are widely used for monitoring populations of economically important lepidopterous insects. At present, aside from detecting the presence or absence of a pest, the most sophisticated use of pheromone traps is in predicting the temporal occurrence of life history events through heat summation for most effective timing of insecticide sprays (Batiste *et al.* 1973; Minks and de Jong 1975; Reidl *et al.* 1976). An extensive life-history forecasting system for an integrated orchard pest management program has been developed in Michigan (Welch *et al.* 1978), and it relies heavily upon pheromone trap data. For several species pheromone trap catch of male moths is presumed to be correlated with adult emergence, whereas in reality only a few studies have tried to verify this relationship (Reidl *et al.* 1976). Crucial to the accuracy of phenological models is the correlation between female emergence and pheromone trap catch. We investigated these relationships with the Oriental fruit moth, *Grapholitha molesta* (Busck), for first generation adults in Michigan in 1977 and 1978.

Material and Methods

Experiments in both years were deployed at Fennville, Michigan in a 1 ha block of semi-dwarf apple trees maintained for at least 3 years on an insecticide-free, fungicides-only spray program. The *G. molesta* population appeared quite dense in this location, which was adjacent to blocks of peaches.

In 1977 our initial attempt at obtaining overwintering larvae by banding trees with corrugated cardboard failed due to 97% larval (*G. molesta* plus codling moth) mortality from woodpecker predation, despite the bands' envelopment by steel screening throughout the winter. Of the 14 surviving larvae, only four were *G. molesta*, and so in a new attempt to obtain larvae, mummified apples and litter beneath five trees were raked into 10 shallow piles on 16 April. Over each pile was placed a 1 m high, 0.7 m basal diameter cone-shaped screen emergence trap (Reidl *et al.* 1976). The traps were ca. 1.5 m from the trunk, one each on a tree's east and west side. Ground litter appeared to be a major *G. molesta* overwintering site, possibly because trunks in this block had smooth bark lacking protective flaps and cracks, and so the procedure was repeated in 1978. On 24 April, the north and south side litter from beneath 19 trees was raked into 38 shallow piles each 1.5 m from the trunks, and the emergence traps placed over each pile. In both years, one Pherocon-II pheromone trap was hung ca. 1.5 m from the ground in each tree having

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emergence traps. Trap-trees were ca. 14 m apart. The pheromone was 100 μg (*Z*)-8-dodecenyl acetate [5.1% (*E*)], 1 μg (*Z*)-8-dodecen-1-ol, and 300 μg dodecanol on a rubber septum (Cardé *et al.* 1979; Baker and Cardé, in press). As checked by gas-liquid chromatography, all compounds were greater than 99% pure, except dodecanol which was greater than 98% pure. The (*Z*)-(*E*) acetate mixture contained no detectable quantities of any 12-carbon alcohols or other 12-carbon acetates, and the (*Z*)-8-dodecenyl alcohol contained no detectable amounts of any 12-carbon acetates or other 12-carbon alcohols. The dodecanol contained no detectable amounts of other 12-carbon alcohols or acetates. Pheromone traps and septa were changed about every 10 days. All traps were checked between 0900 and 1200 h, 2–3 times per week.

Results

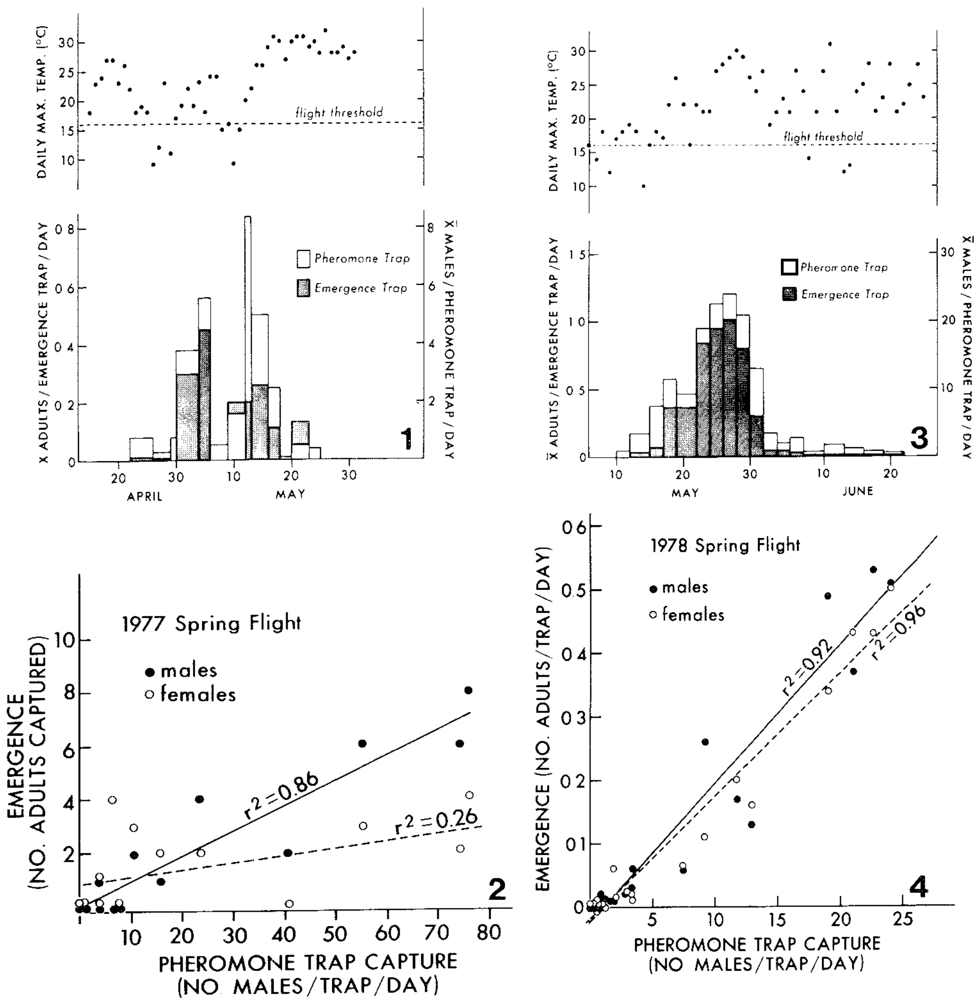
In 1977 spring adult emergence as measured by both emergence and pheromone traps appeared bimodal (Fig. 1). The two periods of reduced captures, 27–30 April and 6–12 May, appeared to coincide with days when the maximum temperature did not exceed the 15°–16°C flight threshold reported by several authors (Reichart and Bodor 1972; Armstrong 1929; Rothschild and Minks 1974). Pheromone trap capture of males was well correlated with male emergence (Fig. 2) (r^2 = 0.86), and more poorly correlated with female emergence (r^2 = 0.26). A total of 51 moths (30 males, 21 females) was captured in the emergence traps and 324 males in the pheromone traps over the entire flight period.

In 1978 the spring adult emergence pattern approximated a more normal distribution (Fig. 3). During spring this year, daily maximum temperature only occasionally failed to exceed the flight threshold. Pheromone trap catch of males again was well correlated with male emergence (Fig. 4) (r^2 = 0.92), but this year also with female emergence (r^2 = 0.96). Emergence of all adults occurred earlier on the trees' south sides than on the north (Fig. 5). A total of 369 moths (200 males, 169 females) was captured in the emergence traps and 5835 males in pheromone traps over the entire flight period. A substantial number (203) of codling moths, *Laspeyresia pomonella* (L.), also emerged from the ground litter.

Discussion

Pheromone capture and emergence of *G. molesta* males from their ground litter overwintering sites were highly correlated in both 1977 and 1978, indicating that pheromone traps accurately monitored the actual emergence pattern of males. In 1978 pheromone capture also was highly correlated with the emergence of females, but not in 1977, possibly due in part to the small sample size that year.

The following may be concluded from the relationship between *G. molesta* emergence and pheromone trap catch. First, the strong linear correlation implies that under the conditions of this study, the pheromone traps were as "efficient" at high as at low densities of adults. There was no evidence of earlier male than female emergence or of competition between females and traps causing a delayed male pheromone trap capture (Fig. 6). For the codling moth this phenomenon contributes to error in predicting oviposition and larval eclosion at high densities which usually occurs beyond the first flight in spring (Reidl *et al.* 1976). Secondly, if there were overwintering sites other than in the ground litter, either they were influenced by the same environmental factors or they were not as numerous as ground sites, since emergence from ground sites alone accounted for most of the variation in pheromone trap catch. How typical the overwintering sites in this orchard were relative to other blocks is unknown. Thirdly, in a pest management program where pheromone trap sampling would likely be less frequent than the 2–3 times per week schedule used



FIGS. 1–4. 1, relationship between maximum daily temperature and the capture pattern in pheromone and emergence traps during spring adult emergence, 1977. 2, correlation between pheromone trap capture of males and emergence trap capture of both males and females during the spring flight, 1977. 3, relationship between maximum daily temperature and the capture pattern in pheromone and emergence traps during spring adult emergence, 1978. 4, correlation between pheromone trap capture of males and emergence trap capture of both males and females during the spring flight, 1978.

in this study, the correlation with emergence might be even higher because short-term variation would be averaged out over longer intervals. Finally, the pattern of earlier south than north side emergence implies that radiant energy contributes strongly to the pattern of adult emergence from the ground.

Part of the strong correlation between emergence and pheromone trap capture may be due to a hidden dependency. To be captured in the "emergence" trap requires not only emergence, but probably substantial activity as well to reach the top of the 1-m-high trap. Such activity likely would have a low temperature threshold similar to the 15°C (ca. 60°F) flight threshold reducing male attraction to pheromone lures (Rothschild and Minks 1974). Therefore, correlated with pheromone catch were probably both emergence *and* activity, the latter accounting for an unknown (but

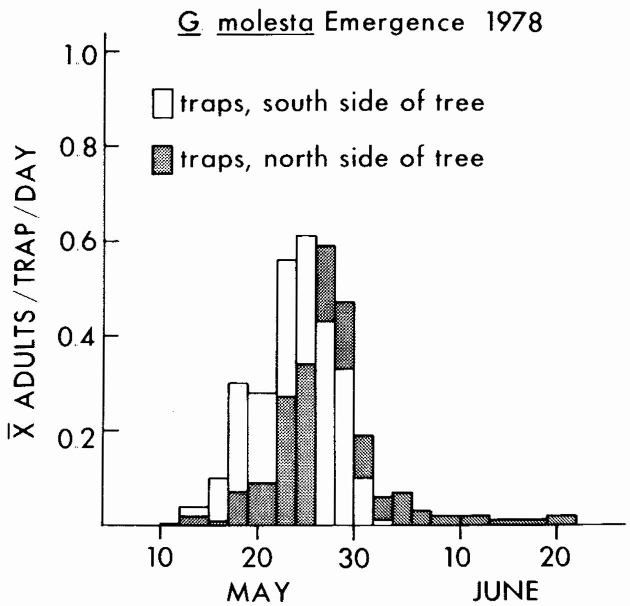


FIG. 5. Pattern of emergence from litter on the north and south sides of trees, 1978

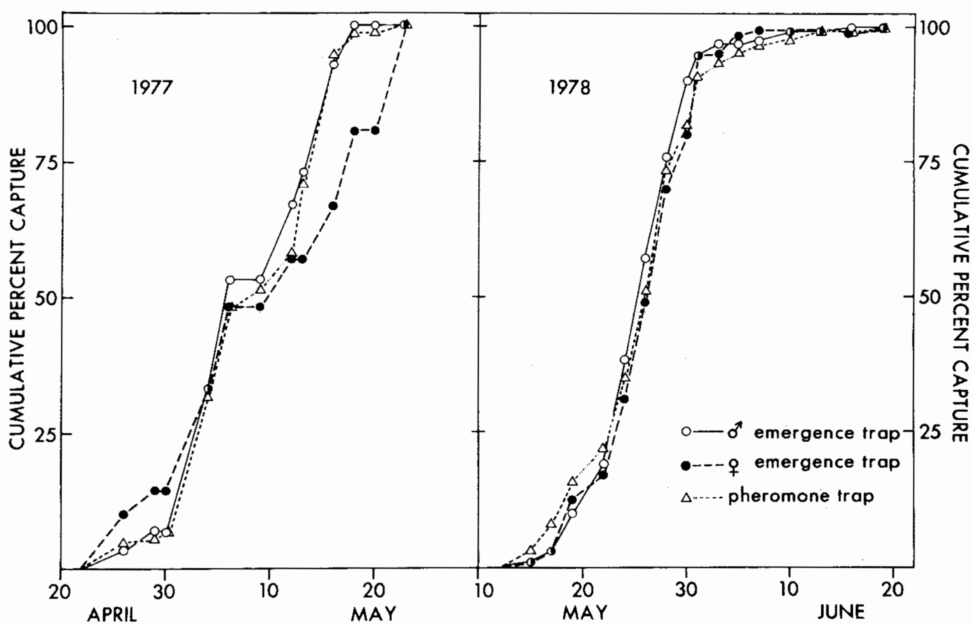


FIG. 6. Pattern of cumulative percent pheromone trap capture of males compared to adult emergence in both years, 1977 and 1978.

possibly high) portion of the correlation. Since only emerged, active moths account for events of biological significance such as mating and oviposition, however, the importance of these results to our objectives remains undiminished.

Reidl *et al.* (1976) found differences between the summer and spring flight emergence – pheromone trap catch relationship in *L. pomonella*. It is not known whether such differences occur in *G. molesta* since emergence during later flights was not monitored. Relating pheromone trap capture to emergence in these flights would be more difficult, since there is often overlap between the second and third generation adults. For the spring flight of *G. molesta*, however, pheromone trap capture of males accurately reflected the temporal pattern of adult male emergence. Pheromone capture's relationship to adult female emergence was less clear, although in 1978 with a large sample size the two were highly correlated. It would appear that *G. molesta* pheromone trap catch data accurately reflect the adult emergence pattern and therefore can be used in pest management predictive models (Welch *et al.* 1978) to predict subsequent phenological events.

Acknowledgment

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References

Armstrong, T. 1929. Notes on the life history of the Oriental peach moth at Vineland Station. *Rep. ent. Soc. Ont.* **59**: 65–72.

Baker, T. C., and R. T. Cardé. Analysis of pheromone-mediated behaviors in male *Grapholitha molesta*, the Oriental fruit moth (Lepidoptera: Tortricidae). *Environ. Ent.* (in press).

Batiste, W. C., A. Berlowitz, W. H. Olson, J. E. DeTar, and J. L. Joos. 1973. Codling moth: estimating time of first egg hatch in the field — a supplement to sex-attractant traps in integrated control. *Environ. Ent.* **2**: 387–391.

Cardé, A. M., T. C. Baker, and R. T. Cardé. 1979. Identification of a four component sex pheromone of the Oriental fruit moth, *Grapholitha molesta* (Lepidoptera: Tortricidae). *J. Chem. Ecol* **5**: 423–427

Minks, A. K. and D. J. de Jong. 1975. Determination of spraying dates for *Adoxophyes orana* by sex pheromone traps and temperature recordings. *J. econ. Ent.* **68**: 729–732.

Reichart, G. and J. Bodor. 1972. Biology of the Oriental fruit moth (*Grapholitha molesta* Busck) in Hungary. *Acta Phytopath. Acad. Sci. Hung.* **7**: 279–295.

Reidl, H., B. A. Croft, and A. J. Howitt. 1976. Forecasting codling moth phenology based on pheromone trap catches and physiological-time models. *Can. Ent.* **108**: 449–460.

Rothschild, G. H. L. and A. K. Minks. 1974. Time of activity of male Oriental fruit moths at pheromone sources in the field. *Environ. Ent.* **3**: 1003–1007.

Welch, S. M., B. A. Croft, J. F. Brunner, and M. F. Michels. 1978. PETE: An extension phenology modeling system for management of multi-species pest complex. *Environ. Ent.* **7**: 487–494.

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