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Trapping the Meal Moth, *Pyralis farinalis* L. (Lepidoptera: Pyralidae), with Acetic Acid and 3-methyl-1-butanol

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The meal moth, *Pyralis farinalis* L., is a pest of stored grains (Essig, 1958; Madrid and Sinha, 1982). It also feeds on dead vegetative material and is cosmopolitan in distribution (Zhang, 1994). Although males are attracted to (Z,Z)-11,13-hexadecadienal (Landolt and Curtis, 1982), a component of the sex pheromone of the navel orangeworm moth, *Amyelois transitella* (Walker) (Coffelt et al., 1979), there are no chemical attractants or other methods available for monitoring it.

The combination of acetic acid and 3-methyl-1-butanol was developed for trapping several pest species of noctuid moths (Landolt, 2000; Landolt and Alfaro, 2001; Landolt and Higbee, 2002). In these studies, a small number of *P. farinalis* moths were captured in traps placed in non-agricultural habitats (Landolt and Hammond, 2001). This observation suggests that *P. farinalis* may be attracted to acetic acid with 3-methyl-1-butanol.

We report here the results of experiments designed to determine if *P. farinalis* moths are indeed attracted to acetic acid with 3-methyl-1-butanol. In addition, an experiment was conducted to determine how captures of moths vary with varied amounts of attractant released from dispensers (Landolt and Alfaro, 2001). The reproductive status of captured female moths was also determined.

Universal moth traps with white bucket, yellow cone, and green top, also called Unitraps/C210, were used in trapping tests. Each trap contained a 2.5 cm square piece of Vaportape/C210 (Hercon Environmental, Emigsville, PA) to kill captured moths. Lures consisted of polypropylene vials (Nalge Nunc International, Rochester, NY) containing chemical applied to cotton balls. Each vial had a hole for diffusion of volatilized attractant from the dispenser. Vials were suspended upright within the bucket of the trap.

**Experiment 1:** The first experiment evaluated moth response to acetic acid, to 3-methyl-1-butanol, and to a combination of the two chemicals, used to bait traps. The objective of the experiment was to determine if the moths are attracted to these chemicals or the combination thereof. A randomized complete block design was used, with 5 replicate blocks, and with 4 treatments included in each block. Treatments were an unbaited trap as a control, a trap baited with an 8 ml vial releasing acetic acid, a trap baited with an 8 ml vial releasing 3-methyl-1-butanol, and a trap baited with two 8 ml vials, one releasing acetic acid and one releasing 3-methyl-1-butanol. Each vial contained 5 ml of the chemical and had a 3 mm hole in the lid. Traps were hung from stakes at a height of ca. 0.7 m, with 10 m between traps. This test was conducted in open ground between an apple orchard and a chicken farm, near the town of Moxee, Yakima County, Washington. The experiment was set up on 5 July 2001 and was continued for four weeks. Traps were checked twice per week (every 3 or 4 days) and treatments were randomized each time that the traps were checked. Vials were replaced at two weeks.

**Experiment 2:** The second experiment evaluated the effects of attractant release rate on moth response. Each trap was baited with an 8 ml vial that contained a mixture of 2.5 ml of acetic acid and 2.5 ml of 3-methyl-1-butanol. Attractant release rate was adjusted by altering the size of the hole in the vial lid. Treatments were hole diameters of 0.5, 1.0, 1.5, 3.0, 6.0, and 12 mm. A randomized complete block design was used, with each treatment included within each of 5 blocks. Traps were set up on 7 July 2003 in an apple orchard adjacent to the USDA-ARS Yakima Agricultural Research Laboratory, near Parker, Yakima County, Washington. Traps were placed in apple trees at a height of ca. 3 m and were checked and randomized each week, for three weeks. All vials were replaced at two weeks.

**Experiment 3:** The reproductive status of female moths captured in traps baited with vials releasing acetic acid and 3-methyl-1-butanol was also evaluated. The objective was to determine if females attracted to the lure were reproductively mature. Ten Universal moth traps were placed in an apple orchard near Parker, Washington. These traps were in apple trees, at a height of 3 m, and 20 m apart. Traps were baited with 15 ml vials (with 3 mm diameter holes in the lid) containing a mixture of 5 ml of acetic acid and 5 ml of 3-methyl-1-butanol. Traps were checked twice per week.
three times per week for one month, and vials were replaced at two weeks. Female moths captured were dissected
to determine presence of spermatophores in the bursa copulatrix, numbers of mature eggs, and presence of fat in the
abdomen. A system developed by Hitchcox (2000) was used to rank females as 1) immature and unmated, with no
spermatophores, no eggs, and fat present, 2) immature and mated, with one or more spermatophores, fewer than
10 mature eggs and some fat, 3) mature and mated, with one or more spermatophores, 10 or more mature eggs,
and 4) senescent, with one or more spermatophores, fewer than 10 mature eggs, and no fat.

Data from the first experiment were analyzed by a paired $t$-test to determine differences between treatments.
Data from the second experiment were analyzed using linear regression. Statistical analyses were conducted using
StatMost (DataMost, 1995).

Experiment 1: Significantly higher numbers of meal moths were captured in traps baited with the combination
of acetic acid and 3-methyl-1-butanol ($11.5 \pm 4.0$), compared to unbaited traps ($0.0 \pm 0.0$) ($t = 2.81$, d.f. = 4,
$P = 0.03$). Four moths were captured in traps baited with 3-methyl-1–butanol (not significantly different than
control) and no moths were captured in traps baited with acetic acid. Totals of 19 females and 34 males were
captured during this test, and responses by the two sexes to the lures were similar.

Experiment 2: Numbers of $P.\ farinalis$ moths captured in traps baited with the combination of acetic acid and
3-methyl-1-butanol increased with increases in vial hole diameter (Fig. 1). There was a significant linear regression
of numbers of moths captured with vial hole diameters ($r^2 = 0.38, P = 0.0003$, d.f. = 30). Greatest numbers of moths
captured were with vials with 12 mm holes. Totals of 34 females and 73 males were captured in this experiment.

Experiment 3: One trapped female was in class I; unmated and immature, and one female in class II; mated
and immature. Fifteen of the 26 trapped female $P.\ farinalis$ dissected were in reproductive class III. These were
mated and mature, with 10 or more mature eggs and some fat in the abdomen. Nine of the 26 trapped females
were in class IV, which were senescent or nearly so. These were mated but had no fat in the abdomen and few
mature eggs. All mated females possessed a single spermatophore in the bursa, indicating that a single mating
may be normal in this species.

These results demonstrate that $P.\ farinalis$ moths are attracted to acetic acid with 3-methyl-1-butanol,
evidenced by their capture in traps baited with that combination of chemicals. Landolt and Hammond (2001)
captured $P.\ farinalis$ with the same lure. However, they did not include un-baited traps as a control. Both
chemicals are produced by microbes, and may be a chemical signal indicating the presence of sugars (Landolt,
2000). However, $P.\ farinalis$ also infests moldy grain and the possibility that these chemicals may function as an
oviposition attractant for females should be considered.

![Fig. 1. Mean (± SE) numbers of Pyralis farinalis moths captured in traps baited with acetic acid and 3-methyl-1-butanol in vials with differing hole diameters.](image-url)
The response to acetic acid and 3-methyl-1-butanol by *P. farinalis* appeared to be synergistic, in that the response of moths to the two compounds released together was greater than the summed responses of moths to the chemicals presented separately. This finding is similar to that shown for the true armyworm *Pseudaletia unipuncta* (Haworth) (Landolt and Higbee, 2002). The noctuid moth *Lacanobia subjuncta* (Grote and Robinson), bertha armyworm *Mamestra configurata* (Walker) and spotted cutworm *Xestia c-nigrum* (L.) were also more strongly attracted to these two compounds when presented together, compared to either chemical presented separately (Landolt, 2000).

A mixture of acetic acid and 3-methyl-1-butanol might be useful as a means of monitoring or detecting the presence of populations of *P. farinalis*. The pheromone for this moth is not identified, but may include (Z,Z)-11,13-hexadecadienal which is attractive to males (Landolt and Curtis, 1982). This chemical is not presently commercially available for use as a lure. The methods of dispensing acetic acid and 3-methyl-1-butanol used here and reported by Landolt and Alfaro (2001) provide a means of controlled release of the chemicals for at least four weeks at moderate temperatures. The results of the second experiment of this study indicate that the strongest response was elicited using vials with a hole of 12 mm diameter in the lid. It is possible that a larger diameter release area, providing a higher release rate, may attract even more moths. There is a point however where the longevity of the lure and size of the dispenser becomes problematic when a much higher release area is used. The response of possibly large numbers of species of moths to this lure (Landolt and Hammond, 2001) makes it difficult to use the lure as a means of monitoring or detecting a single species. The captures of moths in the trap must be sorted in order to find and tally the species of interest. Without proper trap maintenance, loss of scales on captured moths can make species identification difficult. Given that most species of moths recorded as responding to this lure are noctuids (Landolt and Hammond, 2001), perhaps this problem is less difficult with a fairly distinct pyralid, such as *P. farinalis*.

The response of females to this lure suggests some potential for use in managing *P. farinalis* populations through mass trapping or baiting techniques. This idea is also supported by the observation, in this study, of a preponderance of females trapped in class III, with mature eggs to be laid. Perhaps a significant number of females can be attracted before oviposition takes place. This approach has been tried with *L. subjuncta* in apple orchards, with first results indicating a significant reduction in numbers of moths in orchards (Landolt, 2003).

**Literature Cited**


