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SPECIES' COMPOSITION OF MOTHS CAPTURED IN TRAPS BAITED WITH ACETIC ACID AND 3-METHYL-1-BUTANOL, IN YAKIMA COUNTY, WASHINGTON

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ABSTRACT. Moths were captured in traps baited with acetic acid and 3-methyl-1-butanol at four sites in Yakima County, Washington, from March to October, 1999. Nine hundred and ninety-one moths captured were identified to 60 species. Three families of Lepidoptera were represented: Noctuidae, Thyatiridae, and Pyralidae. The majority of species (90%) and individuals (90%) were noctuids. These included many non-pest species and numbers of several pest species: the forage looper *Caenurgina erechtea* Cramer, glassy cutworm *Apamea devastator* Brace, bertha armyworm *Mamestra configurata* Walker, true armyworm *Pseudaletia unipuncta* Haworth, and spotted cutworm *Xestia c-nigrum* (L.). Noctuids collected included representatives of the subfamilies Catocolinae, Cuculliinae, Hadeninae, Amphipyrinae, and Noctuinae. The majority of moths trapped were captured during August and September.

Additional key words: trapping, attractant, survey, biodiversity, sampling.

Many insect species, including Lepidoptera, are attracted to baits containing fermenting sugar solutions or other sweet materials (Norris 1935). Such baits have long been used by moth and butterfly collectors (e.g., Holland 1903, Sargent 1976) and have been employed or investigated by applied entomologists attempting to monitor or control pest species of moths (Ditman & Cory 1933, Eyer 1931, Frost 1926, Landolt 1995, Landolt & Mitchell 1996). Recently, Yamazaki (1998) used sweet baits in traps as a means of sampling moths for survey and ecological work.

The identification of attractive chemical odorants from fermented sugar baits provides opportunities to develop useful insect lures. Three pest species of Noctuidae, *Lacanobia subjuncta* (Grote & Robinson), the bertha armyworm *Mamestra configurata* Walker, and the spotted cutworm *Xestia c-nigrum* (L.), are attracted to a combination of acetic acid and 3-methyl-1-butanol (Landolt 2000). Acetic acid and 3-methyl-1-butanol are found in fermented sweet baits and some microbial cultures (DeMilo et al. 1996, Utrio & Eriksson 1977). These compounds are thought to be feeding attractants for those moths (Landolt 2000) and are being developed as lures for monitoring and controlling pest species of Noctuidae (Landolt & Alfaro 2001, Landolt & Higbee 2002).

The purpose of this study was to determine what types of moths are attracted to acetic acid and 3-methyl-1-butanol more thoroughly than in previous surveys. In a study that documented attraction of *L. subjuncta*, *M. configurata*, and *X. c-nigrum* to these chemicals (Landolt 2000), other moths were captured but were not identified. We sought to determine if other pest species of Lepidoptera are attracted to this lure. A secondary objective was to document responses of non-target species in order to assess the complexity of using the lure to monitor pests. Knowledge of the types of insects responding to this lure may suggest additional uses of the attractant in survey and sampling studies, such as that of Yamazaki (1998).

MATERIALS AND METHODS

Moths were trapped with Butterfly Bait Traps (BioQuip Products, Santa Monica, California). These cage

TABLE 1. Species of moths captured in traps in Yakima County, 1999.

Species	Orchard	Parker	Moxee	Ahtanum	Total	
					♀	♂
Thyatiridae						
Euthyatira semicircularis (Grote)	0	0	0	1	1	0
Habrosyne scripta (Gosse)	0	1	0	0	1	0
Pseudothyatira cymatopheroides (Guenée)	0	0	1	0	1	0
Noctuidae						
Catocolinae						
Caenurgina erechtea (Cramer)	0	1	8	1	8	2
Catocala stretchi Behr	0	0	2	0	2	0
Catocala briseis Edwards	0	0	0	2	2	0
Zale lunata (Drury)	0	3	1	1	5	0
Plusiinae						
Autographa californica (Speyer)	0	0	2	0	2	0
Amphipyrinae						
Protagrotis obscura (Barnes & MacDunnough)	0	0	0	1	0	1
Apamea (Agroperina) dubitans (Walker)	0	1	1	2	1	3
Apamea amputatrix (Fitch)	0	1	0	1	2	0
Apamea (Crymodes) devastator (Brace)	0	5	77	58	54	89
Apamea occidens (Grote)	0	0	1	0	1	0
Aseptis characta (Grote)	0	0	18	0	9	9
Caradrina meralis (Morrison)	0	1	9	0	4	6
Caradrina morpheus (Hufnagel)	0	0	1	0	0	1
Chytonix divesta (Grote)	0	1	0	0	0	1
Oligia indirecta (Grote)	0	0	0	3	1	2
Oligia tonsa (Grote)	0	1	9	0	5	5
Athetis mindara (Barnes & MacDunnough)	0	0	1	0	1	0
Spodoptera praefica (Grote)	0	0	2	0	0	2
Cuculliinae						
Epidemas cinerea Smith	0	0	8	0	4	4
Hadeninae						
Aletia oxygala (Grote)	0	7	18	91	63	53
Leucania farcta (Grote)	0	1	0	1	1	1
Discestra oregonica (Grote)	0	0	0	1	1	0
Discestra mutata (Dod)	0	0	0	1	1	0
Dargida procinta (Grote)	1	3	130	4	67	71
Lacanobia subjuncta (Grote & Robinson)	1	0	0	0	1	0
Lacinipolia stricta (Walker)	0	3	0	14	10	7
Lacinipolia vicina (Grote)	0	0	8	0	4	4
Lygephila victoria (Grote)	0	0	1	0	1	0
Mamestra configurata (Walker)	0	0	21	3	12	12
Protorthodes curtica (Smith)	0	4	17	24	27	18
Anhimella contrahens (Walker)	0	0	2	0	0	2
Pseudaletia unipuncta (Haworth)	0	26	15	3	20	24
Noctuinae						
Abagrotis negascia (Smith)	0	2	1	1	4	0
Agrotis ipsilon (Hufnagel)	1	0	0	0	1	0
Agrotis venerabilis (Walker)	0	0	2	0	2	0
Agrotis vetusta (Walker)	0	2	2	4	5	3
Diarsia rosaria (Grote)	1	1	0	3	4	1
Euxoa albipennis (Grote)	0	0	1	1	2	0
Euxoa atomaris (Smith)	1	0	1	0	1	1
Euxoa auxiliaris (Grote)	0	0	1	0	1	0
Euxoa choris (Harvey)	0	0	1	0	1	0
Euxoa declarata (Walker)	0	0	1	0	0	1
Euxoa idahoensis (Grote)	1	0	1	1	3	0
Euxoa infausta (Walker)	1	0	0	0	1	0
Euxoa septentrionalis (Walker)	1	8	135	9	101	52
Feltia jaculifera (Guenée)	0	0	33	1	17	17

TABLE 1. Continued

Species	Orchard	Parker	Moxee	Ahtanum	Total ♀	Total ♂
Peridroma saucia (Hübner)	0	0	1	0	0	1
Rhynchagrotis formalis (Grote)	0	0	6	0	6	0
Spaelotis bicava LaFontaine	0	0	1	0	1	0
Spaelotis clandestina (Harris)	0	0	2	0	2	0
Xestia c-nigrum (L.)	1	5	12	8	15	11
Xestia (Anomogyna) infimatis (Grote)	0	0	2	1	3	0
Xestia plebeia (Smith)	0	0	1	4	5	0
Xestia xanthographa (Denis & Schiffermüller)	0	0	1	0	1	0
Pyralidae						
Hypsopygia costalis (Fabr.)	0	0	0	93	38	55
Udea profundalis (Packard)	0	0	1	0	0	1
Pyralis farinalis L.	2	2	3	1	7	1

traps are fiberglass screen cylinders (90 cm high and 38 cm wide) hung vertically about 3 cm above a 40 cm wide wooden platform (figured in Covell 1984:16). The trap entrance is a screen cone at the bottom of the screen cylinder and above the wooden platform. The lure was a 30 ml polypropylene vial containing 15 ml of a 1:1 mixture of glacial acetic acid (Baker Chemical, Pittsburgh, Pennsylvania) and 3-methyl-1-butanol (Aldrich Chemical, Milwaukee, Wisconsin) on cotton. Release of the chemicals from the vial was through a 6.4 mm diameter hole in the vial lid. The vial was positioned on the wooden platform directly beneath the center of the trap opening, held in place by three corks glued to the platform. Our objective was to obtain relatively undamaged specimens that are identifiable; large numbers of insects captured in the butterfly bait trap can perch relatively undisturbed on the screening of the trap after capture.

Four cage traps were set up on 12 March 1999, each at a different site with somewhat different habitats in Yakima County, Washington. All traps were hung from tree branches. The first trap was placed within a commercial apple orchard near the town of Donald, 11 km southeast of Union Gap. This site received multiple applications of conventional pesticides for control of insect pests. The second trap was placed along the edge of a forested riparian habitat along the Yakima River, 7 km southeast of Union Gap, and adjacent to an apple orchard. The third trap was placed in a windbreak of Douglas Fir trees, at the Moxee Experimental Farm, 20 km east of Moxee. This trap was near mixed irrigated agriculture and native dryland or steppe plant community. The fourth trap was placed along a riparian habitat, along Ahtanum Creek, 10 km west of Union Gap, and adjacent to small farms and pasture. Traps were checked once or twice per week, depending on the amount of moth activity, and lures were replaced every 2 weeks. Traps were maintained until 1 October 1999.

To assess the relative effectiveness of the butterfly bait trap in comparison to methods used in previous studies (Landolt & Alfaro 2001) we compared four butterfly bait traps to four Universal moth traps (UniTrap). Universal moth traps have been used in previous experiments for trapping *L. subjuncta* (Landolt & Alfaro 2001). All traps were baited with 30 ml polypropylene vials with a 6 mm hole in the lid. Vials were loaded with 15 ml of a 1:1 mixture of acetic acid and 3-methyl-1-butanol. The eight traps were placed in one row of an apple orchard, with butterfly bait traps and UniTraps alternated in the row. All traps were positioned so that the bait was at a 2 m height and traps were 20 m apart. Treatment (trap design) positions were switched each time that traps were checked. Traps were checked twice per week from 4 to 17 May 2000. Treatment means for pooled male and female trap catch data were compared using Student's *t*-test, with separate analyses for *L. subjuncta*, *M. configurata*, and *X. c-nigrum* trap catch data.

Voucher specimens are deposited in the collection of the Department of Entomology, Washington State University, Pullman, Washington.

RESULTS

A total of 991 moths were collected in the 4 butterfly bait traps maintained from 12 March to 1 October 1999. Sixty species were recovered (Table 1). Some specimens (<10%) in several late summer samples were not identifiable because of severe loss of wing scales. Noctuids constituted 90% of specimens and 91% of species (56 of 62) of moths captured in traps. The remaining species were in the families Thyatiridae (3 species) and Pyralidae (3 species) (Table 1). A rela-

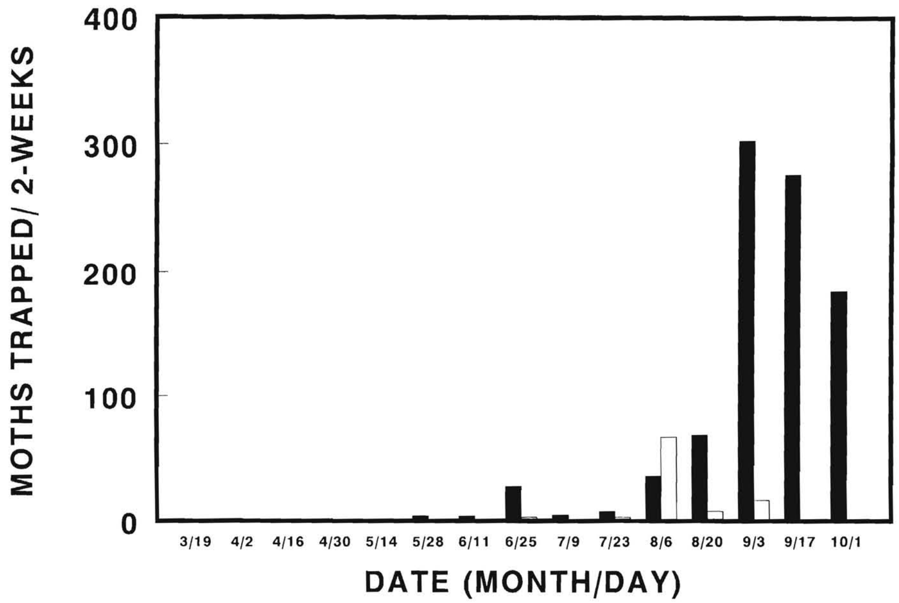

FIG. 1 Numbers of Noctuidae (black bars) and Pyralidae (white bars) captured in 4 cage traps baited with acetic acid and 3-methyl-1-butanol lures, at 2 week intervals through the season. Yakima County, Washington State, 1999.

tively small number of species constituted a large percentage of the moths captured. The four noctuid species *Apamea devastator* Brace, *Dargida procincta* Grote, *Aletia oxygala* (Grote), and *Euxoa septentrionalis* Walker and the pyralid *Hypsopygia costalis* (Fab.) together constituted 65% of the moths trapped and identified. For most species of noctuids trapped, both sexes were caught (Table 1).

During the seasonal study there were relatively few types of other insects (non-Lepidoptera) captured in the traps. Of note, no butterflies and no bees (Apoidea) were caught. However, eight *Sceliphron caementarium* (Drury) mud dauber wasps (Sphecidae) were captured at the Ahtanum Creek site and the yellow jackets *Vespula germanica* (Fabr.) and *Vespula pensylvanica* (Saussure) (Vespidae) were captured fairly consistently in late summer at all sites. Very few moths were captured in traps before August, with most moths captured from late August through late September (Fig. 1).

TABLE 2. Means (±SE) numbers of 3 pest species of Noctuidae captured in Universal moth traps (Unitrap) and in butterfly bait traps (cage) baited with acetic acid and 3-methyl-1-butanol, in apple orchards in Yakima County, Washington. May 2000.

Moth species	Unitrap	Cage trap	t value	p
Lacanobia subjuncta	3.7 ± 0.9	2.5 ± 0.6	1.40	0.09
Mamestra configurata	1.1 ± 0.4	0.6 ± 0.2	2.24	0.02
Xestia c-nigrum	3.6 ± 1.1	3.2 ± 0.9	0.49	0.31

In the comparison of butterfly bait traps and UniTraps, significantly more *M. configurata* moths were captured in UniTraps (Table 2). However, numbers of the other 2 species of pest moths targeted in this study, *L. subjuncta* and *X. c-nigrum*, were not significantly different between trap types (Table 2).

DISCUSSION

Landolt (2000) found that the combination of acetic acid and 3-methyl-1-butanol is attractive to both sexes of 3 noctuid pests that are common in Washington state apple orchards; *L. subjuncta*, *M. configurata*, and *X. c-nigrum*. The results of this study confirm that this lure attracts a variety of moths, predominantly of the family Noctuidae (Table 1). The capture of several other pest species, including the glassy cutworm *A. devastator*, the true armyworm *Pseudaletia unipuncta* (Haworth), and the forage looper *Caenurgina erechtea* (Cramer) (Table 1) indicates that this chemical attractant may have broad application for use in monitoring and control of noctuid pests of agricultural crops. These and other species captured (Table 1) indicate a taxonomically diverse response within the family Noctuidae, with 5 of the noctuid subfamilies represented in the sampling. This lure in a suitable trap may prove useful also as a means of sampling moth biodiversity, as was attempted by Yamazaki (1998) using fermented sugar solutions.

It is interesting that numbers of these 3 moth species were captured consistently in apple orchards during the comparison of the two trap designs and were only infrequently trapped at the 3 non-agricultural sites used for the season-long study (Table 1), while only one female *L. subjuncta* was captured in the season-long study in a different apple orchard. Populations of these moths are expected to vary with the season (Hitchcox 2000) and appear to vary greatly between orchards, depending on prior history and management practices (unpublished data).

The reasons for the pronounced seasonal pattern in captures of moths are not known but may include a relative abundance of some species of moths at trapping sites late in the season compared to early summer. For example, the cutworm *Euxoa septentrionalis* (Walker) (135 captured) is univoltine and flies from late August into October (Lafontaine 1987). There are other species of moths known to be attracted to acetic acid and 3-methyl-1-butanol which are bivoltine and are present earlier in the season, such as *M. configurata* and *L. subjuncta,* (Landolt 2000). Perhaps they were simply not present at the trapping sites used in this study but have been common in other apple orchards.

There was a near absence of species in the noctuid subfamily Cuculliinae in traps (Table 1). In contrast to our study, Yamazaki (1998) captured 15 species of cuculliine moths during spring with fermented sugar solutions. Their general absence in our traps (excepting *Epidemas cinerea* Smith) may be due to an absence of host plants at the sites sampled. Moreover, Yamazaki (1998) worked in a secondary forest, which was not a habitat type included in this study. It is also possible that some moths attracted to fermented sweet baits may be attracted by different blends of chemicals, and not to the combination of acetic acid and 3-methyl-1-butanol.

It is not known if the lack of captures for other groups of insects, such as butterflies, relates to low or nonexistent populations or to low or non-existent responsiveness of those insects to acetic acid and 3-methyl-1-butanol. It is suspected that yellow jacket wasps may have been visually attracted into traps by the presence of prey items (captured insects). However, both *V. germanica* and *V. pensylvanica* are weakly attracted to some degree by the combination of acetic acid and 3-methyl-1-butanol (Landolt et al. 2000).

Based on the results of the trap comparison test, we do not think that many species of moths were missed due to the use of the cage trap, rather than the Uni-Trap, which has been used extensively in studies to develop the lure for pest species (Landolt & Alfaro 2001). However, some species of moths attracted to acetic acid and 3-methyl-1-butanol likely are better captured with different designs of traps.

In summary, this study indicates broad attractiveness of acetic acid with 3-methyl-1-butanol to a diversity of moth species, predominantly Noctuidae, with a number of agricultural species included. This lure, in an appropriate trap, may then be useful as a means of sampling moth populations in ecological or environmental studies, for general collecting of moths, and for monitoring of pest populations in agricultural crops. The general attractiveness of the lure to noctuids is of some concern for lure use in monitoring specific agricultural pests, because the monitoring of targeted species will be complicated by the trapping of non-target species, requiring time spent sorting specimens.

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