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A SAFE AND EFFECTIVE PROPYLENE GLYCOL BASED CAPTURE LIQUID FOR FRUIT FLY (DIPTERA: TEPHRITIDAE) TRAPS BAITED WITH SYNTHETIC LURES

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ABSTRACT

Antifreeze is often used as the capture liquid in insect traps for its preservative and evaporative attributes. In tests reported herein, fruit fly traps using non-toxic recreational vehicle (RV) propylene glycol based antifreeze captured significantly more *Anastrepha ludens* (Loew) than did traps with the automotive antifreeze. Automotive antifreeze has a characteristic odor due to the additive tolytriazole. The odor may have been mildly repellent. Whether better or equal in efficacy, fruit fly trapping programs should consider using the non-toxic formulation as an environmentally friendly alternative over the automotive antifreeze, which contains a number of hazardous compounds.

Key Words: fruit fly traps, antifreeze, propylene glycol, *Anastrepha*

RESUMEN

La antecongelante esta frecuentamente usada para el liquido en trampas de insectos para sus caracteristicas preservativa y evaporativa. En pruebas reportada aquí, las trampas para moscas de la fruta usando antecongelante basado en glicol de propilena tipo RV, usada en sistemas de agua potable, ha capturada mas *Anastrepha ludens* (Loew) que las trampas usando antecongelante tipo automovil. La antecongelante tipo automovil tiene un olor caracteristica por parte del aditivo tolytriazola. La ausencia de este olor es posiblemente el factor responsible para el aumento en capturas. Si es mejor o igual en eficacia, las programs de trampeo para moscas de la fruta necesitan considerar el uso de las formulaciones menos toxicos para proteger el medioambiente en lugar de la antecongelante tipo automovil, que contiene ingredientes peligrosos.

Translation provided by the author.

Ethylene glycol based automotive antifreeze is frequently used as a capture liquid in insect trapping programs using flight-intercept, pitfalls or pan-traps because of the preservative and evaporative advantages. Antifreeze is also readily available and less expensive than the technical grade material ethylene glycol, although there have been reports of effects on capture efficiency due to either repellency or attraction (Koivula et al. 2003; Schmidt et al. 2006) depending on the targeted species.

Surveillance and detection programs aimed at invasive species of *Anastrepha* fruit flies (Diptera: Tephritidae) have long relied on the McPhail trap (McPhail 1939; Steyskal 1977), a bell-shaped, inverted glass jar baited with a liquid attractant. The original design and its modern equivalents are essentially bottle traps in which the entering flies become immersed and die in the liquid bait, typically an aqueous slurry of protein or yeast (Lopez-Davila & Spishakoff 1963). Volatile compounds released by the yeast or by the bacterial degradation of the proteins are attractive to fruit flies, especially females (Martinez et al. 1994; Lee et al. 1995; Robacker & Bartelt 1997). Further research identified the key volatiles responsible for the attraction as acetic acid, ammonia, and amines, especially putrescine and its derivative 1-pyrroline (Keiser et al. 1976; Bateman & Morton 1981; Robacker & Warfield 1993; Robacker 2001).

Extensive testing of these synthetic lures demonstrated their efficacy in the field (Heath et al. 1997; Heath et al. 2004; Robacker & Thomas 2007). The deployment of synthetic lures however, requires trap designs that, unlike the solid McPhail trap, can be opened for access. Typically the newer traps are two-piece plastic cylinders that hold the lure in the upper part and the capture liquid in the lower part. Importantly, the development of synthetic lures allowed the use of capture liquids, such as the commercial polyalcohols, with better preservative properties than the live baits. In selecting a capture liquid for deployment in mass trapping programs, cost and safety are major considerations as well as the potential influences on attraction and capture of the target and non-target species.

Thomas et al. (2001) reported that captures of fruit flies in synthetically baited traps containing 10% propylene glycol based automotive antifreeze

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were significantly greater than when water and surfactant was used as the capture liquid. Those tests were conducted against *Anastrepha ludens* (Loew) in Mexico and *A. suspensa* (Loew) in Florida. The antifreeze effect was confirmed by Robacker & Czokajlo (2006) against *A. ludens* in Texas using both 2-component and 3-component synthetic lures. Those researchers and Hall et al. (2005) conducted tests for attractancy by automotive antifreeze alone. Hall et al. (2005) captured no *A. suspensa* in traps baited with antifreeze without the lures, and Robacker & Czokajlo (2006) found no significant difference in captures between traps with antifreeze alone and those with water and surfactant alone. The latter authors thus concluded that the increase in attraction with antifreeze was due to a synergism between the antifreeze and the synthetic lures.

Commercial automotive antifreeze comes in a variety of formulations including those that are clearly inappropriate for insect trapping programs. The use of ethylene glycol formulations should be discouraged for insect trapping because of its high mammalian toxicity (Hall 1991). Propylene glycol, on the other hand, is a GRAS material, "generally regarded as safe" by the U.S. EPA and FDA. It is a common food additive and ingredient in cosmetics and medicines. Although the acute oral toxicity of the parent compounds is not very different, the metabolites are crucially different. Propylene glycol metabolizes in the bloodstream to lactic acid and pyruvic acid, chemicals produced in the body during normal glycolysis, whereas ethylene glycol is metabolized to oxalic acid. The oxalic acid precipitates in the kidneys as calcium oxalate crystals resulting in renal failure and rapid death, usually within 24 h (Barceloux et al. 1999).

Weeks & McIntyre (1997) found no significant difference in captures of arthropods in pitfall traps where ethylene glycol or propylene glycol based antifreezes were the preservative liquid. Nevertheless, all automotive antifreeze formulations, including the newer organic acid (OAT antifreeze) formulations, are environmentally hazardous because of the blend of additives (around 5%), including lubricants, buffers and corrosion inhibitors. Therefore, tests were conducted with recreational vehicle (RV) antifreeze; i.e., formulations containing USP (food-grade) propylene glycol, such as those used to winterize swimming pools and for drinking water systems in cabins and mobile homes. These non-toxic formulations should not be confused with "plumbers" antifreeze, which contains 20% methanol which is toxic to humans. The primary consideration in this study was whether the synergistic effect seen with the automotive formulation was due to the propylene glycol itself, or to one or more of the additives, and its effects on attraction and trap captures.

Materials and Methods

The automotive formulation of propylene glycol used in all of the aforementioned experiments was Low Tox antifreeze/coolant (Prestone, Danbury CT). For this experiment we compared this same automotive formulation against a household formulation, Splash RV & Marine antifreeze (Superclean Brands, Inc., St. Paul, MN). The latter formulation is an aqueous solution of 27.5% propylene glycol, while the former is 95% propylene glycol by weight, thus the industrial strength products were diluted with water by 1:1 and 7:1 respectively, to achieve approximately equivalent strength, i.e. about 13%, for the test comparison.

The traps used for this experiment were the Multilure (Better World Manufacturing, Fresno CA). The lure deployed in the trap was Biolure (Suterra LLC, Inc., Bend OR), a two-component lure consisting of ammonium acetate and putrescine in dispensers suspended from the inside top of the trap. Altogether, 25 traps were deployed. Ten of the traps contained dilute Low Tox as the capture liquid, 10 contained dilute Splash as the capture liquid and 5 contained water with 3 drops of Triton X-100 (Dow Chemical, Midland, MI) surfactant added. In all traps the amount of capture liquid was 300 mL.

The experiment was conducted from mid-May to late Aug 2007 (16 weeks, the Biolures were renewed at 8 weeks). The traps were serviced weekly by filtering the capture liquid through a screen mesh to remove the insects. The water/triton was replaced weekly. However, the antifreeze liquids were recycled, only replacing that absorbed by the catch with an amount sufficient to maintain levels at 300 mL. Propylene glycol is an extremely stable compound, biodegradation occurs at about half the rate of ethylene glycol, and thus reuse is not only feasible but minimizes waste disposal concerns, as well as being cost effective. Used antifreeze is not listed by the EPA as a hazardous waste under 40 CFR 261, but under Executive Order 13148 federal agencies are required to follow EPA recommendations for handling solid waste. Those recommendations include injunctions against dumping automotive antifreeze on the ground or discharging it into sewage waste water systems (US-EPA, 2006). The design of this experiment anticipated that the liquid would be recycled in this manner if utilized in an area wide trapping program.

Traps were deployed in a fruit orchard consisting of alternate rows of orange and pear trees located at Allende, Nuevo Leon, Mexico (100°57'N; 25°18'W; elev. 500 m) where wild flies were known to be abundant. The traps were suspended at 2 m in every other orange tree in the trap-row and were rotated at each service interval to the succeeding trap-tree to minimize position effects within the orchard.

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For statistical analysis the means were compared by a *t*-test and the resulting probabilities calculated with the NCSS calculator (NCSS Statistical Software, Kaysville, UT).

Results and Discussion

Weekly capture data are shown in Table 1. In accordance with prior experience, both antifreeze formulations captured far more flies than those with water/surfactant as the capture liquid. The traps with the household antifreeze formulation captured significantly more flies than did the automotive formulation. The weekly mean of captures in the Splash traps was 89.5 flies versus 39.2 flies in the Low Tox traps ($t = 3.08$, $df = 30$, $P = 0.002$). Moreover, while both trap-lure combinations were strongly female biased, which is often the case with food-based lures (Thomas et al. 2001; Conway & Forrester 2007), the Splash traps caught significantly more males (as well as females) than did the Low Tox traps. The weekly mean of male captures was 19.0 in the splash traps versus 11.0 in the Low Tox traps ($t = 2.16$, $df = 30$, $P = 0.02$).

Because the additives in antifreeze are proprietary the material safety data sheets provided by the manufacturer list only those compounds which are considered to be significant safety hazards when used in accordance with the manufacturer's recommendations. The MSDS for the Splash formulation cites a single additive, 0.2% dipotassium phosphate, a water softener that is a common ingredient in laundry detergent and certain dairy products. Although dipottassium phosphate is a surfactant, the concentration is so low that addition of a drop of household detergent per trap is recommended. This antifreeze formulation is pink in color due to the addition of 0.002% rhodamine B dye, commonly used in the hydrologic industry as a tracer. There are no other additives in the Splash formulation though some other brands of RV antifreeze contain methyl salicylate or even corn syrup.

The additives in Low Tox antifreeze, according to the MSDS, comprise approx. 5% of the formulation. The only 1 of these materials listed in the MSDS is the carcinogen tolytriazole, a corrosion inhibitor. Based on industry-wide practices, the other additives include, but are not limited to: sodium silicate, disodium phosphate, sodium molybdate, sodium borate, dextrin (hydroxyethyl starch), and a green dye, disodium fluorescein (dyes are added to antifreeze to help trace the source of leaks, and as an identifier because the different formulations are incompatible).

Because of its low volatility propylene glycol by itself is odorless. The characteristic odor in the automotive antifreeze formulation is caused by the tolytriazole. According to Vogt (2005) the unpleasant odor in industrial use tolytriazole comes from impurities in the product that are formed

Table 1. Numbers of male and female Mexican fruit flies captured weekly in traps ($n = 10$) baited with Biolure comparing Splash vs. Low Tox propylene glycol antifreeze as the capture liquid. Control traps ($n = 5$) had water as the capture liquid.

	Splash (10 traps)			Low Tox (10 traps)			Water (5 traps)		
Trap-Week	♂	♀	Total	♂	♀	Total	♂	♀	Total
01 (May)	5	5	10	8	10	18	0	0	0
02 (May)	6	21	27	9	13	22	2	0	2
03 (May)	10	31	41	25	24	49	3	11	14
04 (Jun)	37	59	96	22	44	66	7	9	16
05 (Jun)	11	22	33	16	24	40	4	5	9
06 (Jun)	3	8	11	3	12	15	1	2	3
07 (Jun)	11	40	51	15	44	59	1	0	1
08 (Jul)	17	42	59	3	20	23	8	6	14
09 (Jul)	19	75	94	10	22	32	2	5	7
10 (Jul)	31	86	117	8	21	29	0	0	0
11 (Jul)	49	161	201	11	32	43	2	3	5
12 (Aug)	16	77	93	15	40	55	2	3	5
13 (Aug)	35	112	147	7	61	68	4	8	12
14 (Aug)	23	142	165	4	12	16	1	2	3
15 (Aug)	11	100	111	10	19	29	2	3	5
16 (Aug)	20	156	176	12	51	63	2	6	8
Totals	304	1137	1432	176	449	627	41	63	104
Mean	19.0	71.1	89.5	11.0	28.1	39.2	2.6	3.9	6.5
SD	13.0	51.6	60.3	6.3	15.5	18.7	2.2	3.4	5.2

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from the toluidine isomers (*ortho*-, *meta*- and *para*-toluidine) and *meta*-diamino toluene which are side-products in the manufacture of tolytriazole. These side-products are highly reactive and produce volatile aromatic amines which are responsible for the unpleasant odor.

While the present results are in accord with the previously observed attractant synergy between the Biolures and the propylene glycol, it may be that the odor in the automotive formulation detracts from this effect. The latter hypothesis needs to be confirmed with further study, as does the result indicating the improved performance of the antifreeze without the automotive components. In either case, even if the non-toxic formulation is no better or worse in terms of attractancy, there is no reason to accept the environmental hazard and waste disposal problems associated with use of the automotive formulations with the safer more economical, household product readily available.

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