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Attractiveness of Beer and Fermentation Products to the Gray Garden Slug, *Agriolimax reticulatum* (Muller) (Mollusca: Limacidae)

Whitney Cranshaw

**ATTRACTIVENESS OF BEER AND FERMENTATION
PRODUCTS TO THE GRAY GARDEN SLUG,
AGRIOLIMAX RETICULATUM (MULLER)
(MOLLUSCA: LIMACIDAE)**

Whitney S Cranshaw

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² Professor, Department of Bioagricultural Sciences and Pest Management, Colorado State University, Ft. Collins, CO 80523

ABSTRACT A series of field trials were conducted to determine the attractiveness of various malt beverages and fermentation products to the gray garden slug, *Agriolimax reticulatum* (Muller). Among 12 tested American beers, a 3-fold range in attractiveness was measured based on trap captures. Alcohol was not involved in attractiveness to slugs as the highest captures were effected with Kingsbury Malt Beverage, a non-alcoholic malt beverage. Furthermore, alcohol fortification of 48-hr flattened beers had variable, and occasionally negative, effects on slug captures. Sugar water/yeast combinations showed substantial attractiveness to slugs with mixtures involving lager yeast > baking yeast > ale yeast, water check. The addition of surface active compounds did not increase slug capture in sugar water/yeast baited traps. A brewery waste product (malted grain fiber) also showed attractiveness to garden slugs, with increased attractiveness following amendment with sucrose and active yeasts.

INTRODUCTION

The gray garden slug *Agriolimax reticulatum* (Muller) is a widespread pest of garden plantings throughout much of the temperate world. Control can be frustrating due to erratic performance of molluscicides available for control and/or limitations on the use of available molluscicides around food crops (Gordon 1983). Consequently, a wide variety of suggestions are offered in popular gardening literature regarding control of slugs (McKillip 1973).

The attractiveness of fermenting materials, particularly beer and malt products, has been long recognized (McKillip 1973, Selim 1974, Smith and Boswell 1970). Selim (1974) isolated active components from beer and found at least three constituents (diacetyl, acetoin, dihydroxyacetone) to be attractive to slugs. Other food based materials also have been shown to be attractive to slugs, including fermented *Drosophila* diet and grape juice (Smith and Boswell (1970).

METHODS AND MATERIALS

All trials were conducted in a heavily vegetated yard in Fort Collins, Colorado during April and May 1987. Attractants were evaluated based on slug captures in a commercially available slug trap (Slug Saloon^R, American Quality Products, Denver, CO) that measured 9.5 cm in diameter and was covered to exclude dilution by rainfall and irrigation. Approximately 180 ml of liquid were placed in each trap during trials, which filled the containers to within 2 cm of the container lip. Traps were placed among vegetation, arranged in a randomized complete block design with 4 replications. Individual traps were separated by a minimum 0.75 m. Traps were collected 48 hours after placement, unless otherwise indicated. All data were subjected to analysis of variance (ANOVA). Means among the treatments were separated using the multiple range test of Duncan (1955) at $P < 0.05$.

Attractiveness Comparison Trials of Commercial Malt Beverages. Trials were conducted to rank commonly sold malt beverages for attractiveness to slugs. Treatments included 12 brands of beer, one alcohol-free malt beverage, sugar water/baking yeast, one brand of wine, and tap water. Comparisons were made during a series of trials involving three treatments against a standard beer (Budweiser^R) that was used in all trials. The ratio of slug capture in treatments

was then calculated against the (Budweiser^R) standard to establish overall rankings of attractiveness.

Beer Flattening/Alcohol Fortification Trials. The effect of beer flattening and alcohol fortification on slug capture was evaluated with two beers (Budweiser^R, Pabst Blue Ribbon^R). In both trials, beer was flattened by decanting into a bowl 48 hours before the initiation of the trial. To further help define the importance of the ethanol in beer to slug capture, additional treatments were conducted involving fortification of the baits with ethanol. Ethanol was added at the rate of 6% by volume in the form of 95% ethanol.

Sugar Water/Yeast Trials. Trials involved the introduction of lager, ale, or baking yeasts (Red Star^R) into standard 5.5% sugar water solutions. During the 48-hr (29-31 May) course of these trials, relatively cool temperatures prevailed which may have inhibited fermentation.

A second trial was conducted to evaluate whether the use of detergent (Ivory Dishwashing Detergent^R) or wetting agent (Aqua-gro^R) could increase slug retention in dishes into which they have been attracted (Smith and Boswell 1970). The attractant consisted of sugar water (2.8% sugar by weight)/baking yeast solutions and was evaluated after 48 hours. A Budweiser^R beer standard was included in the trials.

Malted Grain Fiber Evaluations. Two trials were conducted evaluating the attractiveness of a brewery extract, Malted Grain Fiber (MGF-200) produced as part of the brewing process of Coors Breweries. Initial trials were conducted to determine rate response of the product when diluted in water. The second trial involved the addition of sugar or sugar plus baking yeast. The latter trial was examined daily for 3 days to determine length of trapping efficiency.

RESULTS AND DISCUSSION

A wide range in attractiveness occurred among the various malt beverages tested (Table 1). The non-attractiveness of alcohol, demonstrated by Smith and Boswell (1970), was emphasized in this trial since greatest attraction occurred using the non-alcoholic malt beverage Kingbury Malt Beverage^R. Among tested beers, there was a three-fold range in attractiveness with the brewer Anheiser-Busch products (Michelob^R, Budweiser^R, and Bud Light^R) attracting the greatest number of slugs to the traps.

Several volatile components associated with beer have been identified by Selim (1976) as being attractive to slugs including acetoin, diacetyl and dihydroxyacetone. The range in attractiveness of various malt beverages are likely due to differences in the concentrations of these attractants. For example, Meilgaard (1975) reports a three-fold range in diacetyl exists among typical United States beers.

The single wine tested (Gallo Pink Chablis^R) was not attractive to slugs, although Smith and Boswell (1970) reported that unfermented grape juice was a moderately attractive to slugs. Use of fermenting sucrose solutions to which baking yeast was added produced capture rates similar to beer. Selim (1974) had previously reported sucrose fermentation byproducts as attractive to slugs.

Table 1. Relative ranking of malt beverages for attractiveness to *Deroceras* sp. slugs when used as baits in saucer traps, Ft. Collins, CO, 20-31 May, 1987. Beverages tested in groups of three, against a Budweiser standard.

Treatment	Total number of slugs captured ^a	(Ratio to capture with Budweiser)
<i>Trial 1 (20-22 May)</i>		
Rainier	26 a	(0.36)
Strohs	48 ab	(0.67)
Schaefer	50 ab	(0.69)
Budweiser	72 b	(1.00)
<i>Trial 2 (22-24 May)</i>		
Pabst Blue Ribbon	33 a	(0.44)
Coors	42 ab	(0.56)
Miller	51 ab	(0.68)
Budweiser	75 b	(1.00)
<i>Trial 3 (24-26 May)</i>		
Bud Light	65 a	(0.89)
Budweiser	73 a	(1.00)
Michelob	76 a	(1.04)
Kingsbury Malt Beverage	83 a	(1.14)
<i>Trial 4 (26-28 May)</i>		
Tap water	3 a	(0.06)
Lite	31 b	(0.57)
Old Milwaukee	44 b	(0.81)
Budweiser	54 b	(1.00)
<i>Trial 5 (29-31 May)</i>		
Gallo Pink Chablis	7 a	(0.09)
Sugar water/baking yeast	43 ab	(0.57)
Coors Light	60 ab	(0.79)
Budweiser	76 b	(1.00)

^a Within a trial, numbers followed by the same letter are not significantly different ($P > 0.05$) by the multiple range test of Duncan (DMRT).

The effect of a pre-treatment 48 hour flattening of beer showed brand dependent differences (Table 2) in attractiveness to slugs. Flattened Pabst Blue Ribbon^R was equally attractive as fresh beer; Budweiser^R trapping efficiency was sharply reduced by flattening. Again, differences in various volatile components (Meilgaard 1975) among these beers and their rate of loss may explain the different results from flattening of the two beers. Alternatively, there could be differences in compounds produced by the staling process (Barker et al. 1985) from these two

Table 2. Slug capture as affected by pre-treatment beer flattening and by fortification with ethanol, Ft. Collins, CO, May-June^b, 1987.

Treatment		Total slug capture ^a
	<i>Trial 1^b</i>	
Pabst Blue Ribbon, fresh		125 a
Pabst Blue Ribbon, flattened ^c		130 a
Pabst Blue Ribbon, flattened + 95% ethanol ^d		35 b
Tap water + 95% ethanol ^d		16 b
	<i>Trial 2^b</i>	
Budweiser, fresh		118 a
Budweiser, flattened ^c		28 ab
Budweiser, flattened + 95% ethanol		51 ab
Tap water		1 b

^a Total of 4 replications. Numbers followed by the same letter that are within the same trial are not significantly different ($P > 0.05$) by DMRT.

^b Standard traps involved the 9.5 cm diameter Slug Saloon^R. Traps arranged in a randomized complete block design with 4 replications. Trial 1 run from May 17-18; Trial 2 from May 31-June 2.

^c Flattening effected by decanting beer into an open bowl 48 hours before the initiation of the experiment.

^d Ethanol (95%) added to the solution to increase the alcohol content 6% by volume.

beers. Fortification of flattened beer treatments with alcohol did not affect capture. The non-attractiveness of alcohol had similarly been noted by Smith and Boswell (1970).

Use of various yeast types showed significant differences in attractiveness (Table 3). Lager yeast was highly attractive to slugs. Conversely, ale yeasts were no more attractive than sucrose solutions, which presumably undergo some fermentation due to colonization by air-borne microorganisms. Yeast strains have been shown to be a major factor in production of differences in volatile components involved in beer flavor (Jacobsen et al. 1979). Addition of surfactant compounds (Ivory Dishwashing Liquid^R, Aqua-gro^R) added to fermenting liquid attractants did not increase trapping efficiency (Table 4).

Malted grain fiber brewing byproducts added to water also showed some attractiveness to slugs (Table 5) although interestingly there was not a demonstrated rate response among the rates tested in this study. Attractiveness of the mixture to slugs was of short duration, a single evening, but could be increased over time by the use of sucrose and was further increased by sucrose/baking yeast additives (Table 6). Sucrose allows for increased fermentation to occur in the attractant mixtures. These latter results further indicate that some volatile products produced during active fermentations have a high level of attractiveness to slugs.

Table 3. Slug capture in sucrose sugar water^a baited traps as affected by the addition of various yeast types, Ft. Collins, CO, 29-31 May, 1987.

Yeast ^b	Total slug capture ^c
Lager yeast	25 a
Baking yeast	13 ab
Sugar water check	8 ab
Ale yeast	6 b

^a Standard sucrose sugar water solutions of 2.8% by weight.

^b Red Star[®] brand.

^c Total of four replications. Numbers followed by the same letter are not significantly different ($P > 0.05$) by DMRT.

Table 4. Slug capture as affected by the addition of Ivory Dishwashing Liquid or Aqua-gro to sugar water/baking yeast mixtures, Ft. Collins, CO, 11-13 June, 1987.

Treatment	Total slug capture ^a
2.8% sugar water/baking yeast	49 a
2.8% sugar water/baking yeast/2.8% Ivory Dishwashing Liquid	42 a
2.8% sugar water/baking yeast/2.8% Aqua-gro	25 a
Budweiser beer	174 a

^a Total of four replications. Numbers followed by the same letter are not significantly different ($P > 0.05$) by DMRT.

Table 5. Slug capture as affected by variable rates of a malted grain fiber^a brewery extract, Ft. Collins, CO, 1-3 May, 1987.

Treatment	Total slug capture ^b
1.9 gr malted grain fiber/water	25 a
1.3 gr malted grain fiber/water	31 a
0.6 gr malted grain fiber/water	21 a
Water check	0 b

^a MGF-200 malted grain fiber, Coors Food Products Company.

^b Total of four replications. Numbers followed by the same letter are not significantly different ($P > 0.05$) by DMRT.

Table 6. Slug capture over time as affected by amendments to malted grain fiber brewery extract^a attractants, Ft. Collins, CO, 3-6 May, 1987.

Treatment	Total slug capture ^b		
	Day 1	Day 2	Day 3
1.3 gr malted grain fiber/water	25 b	16 b	20 b
1.3 gr malted grain fiber/water/5 gr sucrose	28 b	42 c	44 c
1.3 gr malted grain fiber/water/ 15 gr sucrose/0.1 gr baking yeast	13 ab	42 c	95 d
Water check	1 a	1 a	1 a

^a MGF-200 malted grain fiber, Coors Food Products Company.

^b Totals of four replications. Numbers within a column followed by the same letter are not significantly different ($P > 0.05$) by DMRT.

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