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TOXICITY OF COMMERCIALLY AVAILABLE HOUSEHOLD CLEANERS ON COCKROACHES, *BLATTELLA GERMANICA* AND *PERIPLANETA AMERICANA*

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ABSTRACT

Experiments to determine the toxicity of commercially available dishwashing liquids (Palmolive®, Dawn® and Joy®) and household cleaners (409®, Fantastik®, Fantastik® Orange, Dawn® Power Dissolver, and Greased Lightning®) against cockroaches were conducted with two application techniques, spray and immersion. All brands and formulations of dishwashing liquids and cleaners tested were equally as toxic to adult German cockroaches, *Blattella germanica* (L.), achieving 92-100% mortality at 1% dishwashing liquid solution and 83-100% mortality with 100% cleaner solution via an immersion application. The Palmolive® dishwashing liquid LC_{50} was 0.54% against adult German cockroaches with a spray application and 0.56% with an immersion application. Contact sprays were not effective against adult American cockroaches, *Periplaneta americana* (L.). However, dishwashing liquid immersion applications resulted in a 0.24% LC_{50}. Mortality of German cockroach nymphs compared to adults was tested by contact spray and immersion applications of Palmolive® dishwashing liquid. Mortality of nymphs and adults by immersion were equal with 94-100% nymphal mortality and 97-100% adult mortality at a 1.4% dishwashing liquid concentration. Upon immersion in the dishwashing liquid solution, German cockroaches arched their abdomen and air bubbles were observed escaping from the abdominal spiracles. Cockroaches were unable to remain at the surface of the solution and sank to the bottom of the container within 30 seconds of immersion.

Key Words: German cockroach, American cockroach, insecticides, low toxic, soap, toxicity, fatty acid salts

RESUMEN

Para determinar la toxicidad de los liquidos comerciales disponibles para lavar trastes (Palmolive®, Dawn® y Joy®) y los liquidos limpiadores usados en la casa (409®, Fantastik®, Fantastik® Orange, Dawn® Power Dissolver y Greased Lightning®) contra las cucarachas, se realizaron varios experimentos con técnicas de aplicaciónes por rocio y de inmersion. Todas las marcas y formulaciones de liquidos para lavar trastes probadas fueron igualmente tóxicos contra los adultos de la cucaracha alemana, *Blattella germanica* (L.), produciendo una mortalidad de 92-100% usando una solución del liquido para lavar trastes de 1% y una mortalidad de 83-100% usando una solución de 100% del los liquidos limpiadores en aplicaciones de inmersión. La CL_{50} para el liquido para lavar trastes, Palmolive®, fue 0.54% contra la cucaracha alemana en aplicaciones por rocio y 0.56% en las aplicaciones de por inmersión. Las asperciones de contacto no fueron efectivas contra la cucaracha americana, *Periplaneta americana* (L.). Sin embargo, la inmersión en liquido para lavar trastes resulto en una CL_{50} de 0.24%. La mortalidad de las ninfas de la cucaracha alemana comparada con los adultos fue evaluada con aplicaciones del liquido para lavar trastes Palmolive® asperjadas de contacto y de inmersion. La mortalidad de las ninfas y adultos por inmersión fue igual con 94-100% de mortalidad en la ninfas y 97-100% de mortalidad en los adults en pruebas de liquido de lavar trastes a una concentración de 1.4%. Al sumergir las cucarachas alemanas en una solución liquido para lavar trastes, se doblaron sus abdomenes hacia arriba y burbujas de aire escaparon de sus espiraculos abdominales. Las cucarachas no pudieron mantenerse en la superficie de la solución y estas se hundieron al fondo de la recipiente entre los 30 segundos después de sumergirlas.

Concern over health implications from the use of residual and broadcast spray treatments for management of German and American cockroaches, *Blattella germanica* (L.) and *Periplaneta americana* (L.), respectively, in sensitive environments has prompted research on insecticides with low mammalian toxicity. For more than 200 years, soaps, especially potassium salts, otherwise known as soft soaps, have been reported to exhibit insecticidal properties. Most of the research has been conducted on soft-bodied arthropods such as whiteflies (Butler et al. 1993; Javed & Matthews

2002), aphids (Fournier & Brodeur 2000; Fulton 1930; Pinnock et al. 1974), scales (Riehl & Carman 1953), mites (Osborne 1984), thrips (Oetting & Latimer 1995), and mealybugs (Lindquist 1981). In the 1920s and 1930s, the effects of soaps were studied on heavily sclerotized insects such as Japanese beetles (van der Meulen & Van Leeuwen 1929), Harlequin bugs (Fulton 1930), and Colorado potato beetles (Fulton 1930). The discovery of pesticides, such as DDT in 1939, slowed research on the insecticidal properties of soaps. Soaps did not experience a resurgence in scientific literature until the 1970s and 80s where they were used against various plant pests (Pinnock et al. 1974; Puritch 1975; 1978; Osborne & Henley 1982). Abbasi et al. (1984) demonstrated that commercially available soaps were toxic to crickets and American cockroaches. Szumlas (2002) documented avoidance behavior and toxicity to German cockroaches when sprayed with Dawn Ultra® dishwashing liquid. Currently, soaps, including potassium salts of fatty acids, are considered to be insecticides, acaricides, herbicides, and algaecides (US EPA 1992). Soaps are considered food substances; therefore, are generally recognized as safe by the Food and Drug Administration (FDA) (US EPA 1992).

Soaps and detergents should be more extensively investigated for use in sensitive environments. Comparative toxicity of household cleaners and dishwashing liquids for important pests, such as cockroaches, would provide valuable and useful information for pest managers. The purpose of this study was to determine knockdown and mortality of German and American cockroaches after exposure to commercially available household dishwashing liquids and cleaners with different application methods.

Materials and Methods

Insects

Blattella germanica and *P. americana* were reared in plastic tubs with harborages. Dry food (Lab Diet 5001 rodent Diet, PMI Nutrition International, Inc., Brentwood, MO) and water were provided *ad libitum*. Cockroaches were maintained at 23.6 ± 2.5°C and 51 ± 16% RH with a photoperiod of 12:12 (L:D). Adult males of *B. germanica* and *P. americana*, and gravid females of *B. germanica* were removed from the colony with featherweight forceps, separated by sex, and held in separate cloth-covered Mason glass jars (0.946 L) with food and water. Cloth covers were held in place by rubber bands. Adult males were removed from the colony within 24 h of the trial for which they were utilized. Adult females were discarded after their ootheca hatched and second and third instars were held until use in a trial. At no point in this study were the cockroaches anesthetized.

Immersion Assay

A modified Cornwell immersion technique was used to test the toxicity of a variety of commercially available dishwashing liquids and household cleaners (Cornwell 1976). The polyvinyl chloride (PVC) immersion apparatus (15 × 10 cm diam.) was coated with a 1:1 mixture of petroleum jelly/mineral oil within approximately 5 cm of the upper interior rim to prevent cockroaches from escaping. The lower end of the apparatus was covered with nylon mesh (Intex strainer, Reaves and Co., Durham, NC) held in place by a rubber band. Cockroaches were removed from the holding jar and placed into the immersion apparatus. The fluid level in the reservoir came to just below the petroleum jelly coating to ensure that the cockroaches would be fully wetted. The apparatus was lowered into the solution then gently shaken to ensure that all cockroaches were immersed. The apparatus was lifted from the reservoir after the 30-s immersion and allowed to drain for 15 s. The cockroaches were removed with featherweight forceps to clean, cloth-covered jars containing food, water, and harborage as previously described.

Dishwashing Liquid Concentration Assay

Adult male German cockroaches were used to test the toxicity of Palmolive® Green Apple dishwashing liquid (product no. 47937) (Colgate-Palmolive, New York, NY). The dishwashing liquid was mixed at 0.33, 0.7, and 1.4% (vol:vol) with tap water for a total volume of 400 mL. Tap water was selected as the untreated control and as the mixing agent as it is the most likely solvent a homeowner would use. Dishwashing liquid solutions were stirred for 30 s. Foam was skimmed from the liquid surface prior to trial. Solutions were mixed at ambient temperature and a fresh solution was mixed for each repetition.

Time to Knockdown Assay

Six replicates of 10 adult male German cockroaches were run at 0.33 and 0.7%, while 11 replications of 10 male adults were run at 1.4%. Cockroaches were immersed for 30 s. Percent knockdown immediately after immersion and mortality at 1, 3, and 24 h were recorded. Knockdown was the inability of the cockroach to right itself immediately after exposure, and mortality was no response to probing at the specified observation interval. The immersion apparatus, mesh, and reservoir were each emptied and triple rinsed with tap water between each trial.

Life Stage Assay

The relative toxicity of Palmolive® Green Apple dishwashing liquid (product no. 47937) was

tested on German cockroach nymphs and adult males. Five replications of early instars (n = ten 2nd and 3rd instars) and adults (n = 10 males) each were tested at 1.4% dishwashing liquid concentration. Nymphs were tapped into the immersion apparatus; adults were removed with featherweight forceps.

Dishwashing Liquid Formulation Assay

The toxicities of 3 formulations of Palmolive® dishwashing liquid, (product nos. 356140, 47937 and 359140), and 1 formulation each of Joy® (product no. 36045) (Proctor and Gamble, Cincinnati, OH), and Dawn® (product no. 33154) (Proctor and Gamble) were compared at a concentration of 1.0%. Five replications of 5 adult male German cockroaches were tested.

Modified Immersion vs. Spray Application of Dishwashing Liquid and Household Cleaners

The Cornwell immersion technique (Cornwell 1976) was compared with an airbrush spray technique with Palmolive® Green Apple (product no. 47937) and household cleaners. The household cleaners tested were Formula 409 (product no. 00628) (Clorox Co., Oakland, CA), Fantastik (product no. 10294), Fantastik Orange Action (product no. 18292) (S.C. Johnson and Son, Inc., Racine, WI), Dawn Power Dissolver (product no. 376320) (Proctor & Gamble, Cincinnati, OH), and Greased Lightning (product no. 19853) (A & M Cleaning Products, Inc., Clemson, SC).

Adult male German cockroaches and adult male American cockroaches were tested by immersion and spray application methods at 0.05, 0.1, 0.2, 0.4, and 0.8% concentrations of Palmolive® (47937), and 100% concentration of the cleaners except Dawn Power Dissolver which, due to its viscosity, was tested at 50% concentration. Dishwashing liquid solutions and cleaners, 100 mL each, were prepared in plastic deli cups (473 mL) and cockroaches were immersed by a modification of the previously described method that included a PVC compression couplet (Size 50-2, American Value, Greensboro, NC) with one end fitted with nylon mesh (M-D Building Products, Greensboro, NC) as the immersion apparatus.

In the airbrush technique, the cockroaches were placed into a petroleum jelly/mineral oil rimmed deli cup (473 mL) which was placed on a 10 × 10-cm square. The airbrush well was filled with 2 mL of solution and the line purged of air. The airbrush (Paasche Type H, Chicago, IL) was calibrated to distribute 2 mL of water in 10 s. The solution was sprayed over the entire square and deli container in a zigzag pattern. This amount of solution allowed for runoff with minimal pooling. Sprayed cockroaches were transferred to clean deli containers (236.6 mL) with filter paper substrate, food and water. Five replications of 5 cockroaches were made for each spray treatment.

Analysis

Abbott's formula (Abbott 1925) was used to adjust knockdown and treatment mortality for control mortality. Normality was tested with the Shapiro-Wilk test (P = 0.05) and non-normal data were ranked.

The percent knockdown and mortality of cockroaches in the immersion assay were analyzed by ANOVA. When P-values were significant, means were compared by Student Newman-Keuls test (α = 0.05). Time observations were analyzed by a two-way ANOVA where time after treatment and dishwashing liquid concentration were the main effects. Knockdown and nymph mortality were analyzed by a student's t-test. ANOVA was used to determine variability between dishwashing liquid formulations.

LC_{50}s were estimated by probit analysis for each cockroach species and application type (immersion and spray) in the modified toxicity trial. Significant differences in the probit analyses were determined by non-overlap of the 95% confidence intervals (CI). Cockroach mortality data were analyzed by a two-way analysis of variance when application method and concentration of dishwashing liquid were the main effects. When P-values were significant, means were compared with Student Newman-Keuls test (α = 0.05).

Knockdown and mortality by household cleaners were analyzed by a three-way analysis of variance with cleaner, application type, and species as the main effects. Significant interactions (P < 0.05) were analyzed by a two-way analysis of variance with cleaner and species as the main effects for each application technique. Means were separated by Student Newman-Keuls test (α = 0.05). All data analyses were performed with SAS® (P < 0.05; SAS Institute 2001).

Results

Cockroaches exhibited escape behavior when submerged in the dishwashing liquid solutions. Submerged cockroaches arched their abdomens, lifted their wings, and sank to the bottom of the container (Fig. 1). After a few seconds, air bubbles escaped from spiracles. Cockroaches in the water controls did not exhibit this behavior and remained at the surface.

Immersion of German Cockroaches

Palmolive® Green Apple dishwashing liquid concentration was the only significant main effect for both knockdown (F = 24.67, df = 2; P<0.0001) and mortality (F = 18.94; df = 2; P < 0.0001) of German cockroaches (Table 1). There were no sig-

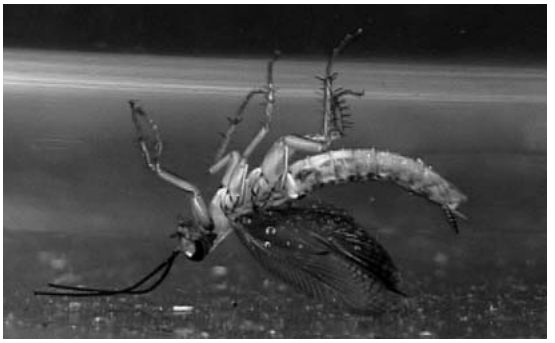

Fig. 1. German cockroach, *Blattella germanica*, posture following a 30 s exposure to 1.4% Palmolive® green apple dishwashing liquid.

nificant differences in cockroach knockdown or mortality between observation times nor was there a significant interaction between time and concentration.

There were no significant differences in knockdown (t = 1.67; P = 0.1120) or mortality (t = 1.14; P = 0.2689) when comparing nymphs to adult male German cockroaches. Mean knockdown for nymphs was 98.89 ± 1.11% and for adult males was 94.32 ± 2.16%. Mean mortality was 98.98 ± 1.02% for nymphs and 96.13 ± 2.16% for adult males. There were no significant differences between dishwashing liquid formulations for knockdown or mortality (Table 2).

Immersion versus Spray Applications

German cockroaches immersed in Palmolive dishwashing liquid, showed no significant interaction between application method and dishwashing liquid concentration. When knockdown was the response variable, the main effects, application method (F = 11.16, df = 1, P = 0.0018) and dishwashing liquid concentration (F = 23.90, df = 4, P = <0.0001) were significant. When mortality was the response variable, the main effects, application method (F = 5.40, df = 1, P = 0.0253) and dishwashing liquid concentration (F = 30.05, df = 4, P = <0.0001) also were significant (Table 3).

American cockroaches immersed in Palmolive dishwashing liquid, showed a significant interaction between application method and dishwashing liquid concentration for knockdown (F = 24.86, df = 4, P = <0.0001) and mortality (F = 13.16, df = 4, P = <0.0001). Spraying did not knockdown or kill American cockroaches at any dishwashing liquid concentration.

The immersion of American cockroaches resulted in the highest knockdown (100%) and mortality (84.00 ± 4.00%). The airbrush spray application was the least effective application method, achieving 0% knockdown and only 8.00 ± 4.90% mortality of American cockroaches at the highest dishwashing liquid concentration of 0.8%.

The KD_{50}s, concentration required to knockdown 50% of the test population, were lower than the LC_{50}s, concentration required to kill 50% of the test population, for both the spray (KD_{50} = 0.3655%, LC_{50} = 0.5399%) and immersion (KD_{50} = 0.1666%, LC_{50} = 0.5602%) applications for German cockroaches. There was no significant difference between application types for German cockroach mortality although it took a significantly lower dishwashing liquid concentration to achieve knockdown with the immersion application. When compared with the concentration needed to achieve LC_{50} for German cockroaches (LC_{50} = 0.56%), it took a significantly lower concentration of dishwashing liquid to achieve LC_{50} for American cockroaches using the immersion application (LC_{50} = 0.24%) (Table 4).

When comparing the toxicity of household cleaners, there was no significant three-way interaction between cleaners, application type, and species for knockdown or mortality. Interestingly, the only significant interaction was between species and application type (F = 12.56, df = 1; P = 0.0007) and the only significant main effects were species (F = 10.99, df = 1; P = 0.0014) and application type (F = 12.56, df = 2; P < 0.0001). For both knockdown and mortality, the combined variable species-application type and cleaner became the main effects for a two-way analysis of variance where the interaction was not significant. The combined variable species-application type was significant for knockdown (F = 29.7, df = 3; P = <0.0001) and mortality (F = 12.04, df = 3; P =

TABLE 1. PERCENT KNOCKDOWN AND MORTALITY OF ADULT GERMAN COCKROACH MALES WHEN EXPOSED TO PALMOLIVE® DISHWASHING LIQUID BY IMMERSION.

Palmolive® Green Apple	*n*	% Knockdown ± SE	% Mortality ± SE
0.33%	60	11.67 ± 6.54 a	10.48 ± 6.21 a
0.7%	60	98.25 ± 1.75 b	85.00 ± 15.00 b
1.4%	110	96.26 ± 2.09 b	96.26 ± 2.09 b

Means within a column followed by the same letter are not significantly different (P < 0.05, Student Newman-Keuls test SAS Institute 2001). Abbott's formula (1925) was used to correct for control mortality of 2.5% for both knockdown and mortality.

TABLE 2. PERCENT KNOCKDOWN AND MORTALITY OF ADULT GERMAN COCKROACH MALES WHEN EXPOSED TO DIFFERENT FORMULATIONS OF DISHWASHING LIQUID BY IMMERSION.

Soap formulation	*n*	% Knockdown ± SE	% Mortality ± SE
Palmolive® Green Apple (47937)	25	100.00 ± 0.00	100 ± 0.00
Palmolive® Anti-Bacterial (359140)	25	95.83 ± 4.17	96 ± 4.00
Palmolive® Original (356140)	25	100.00 ± 0.00	100 ± 0.00
Dawn® Plus Ultra (33154)	25	100.00 ± 0.00	100 ± 0.00
Lemon Joy® (36045)	25	100.00 ± 0.00	96 ± 4.00

Abbott's formula (1925) was used to correct for control mortality of 4% for knockdown and 0% for mortality.

<0.0001). Means separation by SNK indicated that American cockroaches that were sprayed had significantly less knockdown (56.8%) and mortality (75.2%) compared with all other combinations of cockroach species and application methods (99-100%) (Table 5).

DISCUSSION

Historically, soaps were only considered effective against soft bodied insects. However, Abbasi et al. (1984) reported that a splash of commercially available soaps in water would kill American cockroaches at a 1-2% solution. SzumLas (2002) reported that the LC_{50} for Dawn Ultra® dishwashing liquid sprayed on German cockroaches was 0.4% and dishwashing liquid concentrations higher than 1% achieved 95% or greater knockdown or mortality.

The results from this study are in close agreement with Szumlas (2002) and Abbasi et al. (1984). However, this study differed from the others in that the cleaners used were quantified and different formulation and application types were tested. The close agreement of the LC_{50}s on German cockroaches with the airbrush application from this study and the results from Szumlas' hand-held spray bottle study (2002) indicates that the airbrush technique presented here is an effective method for delivering a measurable dose of dishwashing liquid or cleaner as a toxicant to German cockroaches.

The LC_{50} for a 2-mL spray on German cockroaches was 0.54%, and 0.56% when the cockroach was immersed for 30 s. The LC_{50} for American cockroaches exposed by immersion was 0.24%, but not significantly less than the LC_{50} (0.56%) for the German cockroaches. To achieve 95% mortality with an immersion application, dishwashing liquid solutions at 2.07% are needed for German cockroaches and 1.75% for American cockroaches, respectively. German cockroach nymphs and adults were equally affected by the dishwashing liquid concentrations, and after 30 s immersion cockroaches that were knocked down remained so and never recovered.

There was no difference in knockdown or mortality between 5 dishwashing liquids or 5 cleaner formulations based on 2 application methods tested. The airbrushspray application was equally as effective as the immersion application for German cockroaches, but was less effective for Ameri-

TABLE 3. PERCENT KNOCKDOWN AND MORTALITY OF ADULT GERMAN AND AMERICAN COCKROACH MALES WHEN EXPOSED TO PALMOLIVE® DISHWASHING LIQUID (FORMULA 47937) (*n* = 25).

		German Cockroaches		American Cockroaches	
Application	% Palmolive®	% Knockdown ± SE	% Mortality ± SE	% Knockdown ± SE	% Mortality ± SE
Immersion	0.05%	4.00 ± 4.00 a	0.00 ± 0.00 a	24.00 ± 7.48 a	12.00 ± 8.00 a
	0.10%	36.00 ± 11.66 b	4.00 ± 4.00 a	80.00 ± 6.32 b	20.00 ± 8.94 a
	0.20%	64.00 ± 4.00 c	4.00 ± 4.00 a	84.00 ± 4.00 b	44.00 ± 9.80 b
	0.40%	72.00 ± 10.20 c	36.00 ± 11.66 b	88.00 ± 8.00 bc	68.00 ± 4.90 c
	0.80%	96.00 ± 4.00 d	68.00 ± 10.2 c	100.00 ± 0.00 c	84.00 ± 4.00 c
Airbrush spray	0.05%	0.00 ± 0.00 a	3.33 ± 3.33 a	0.00 ± 0.00	0.00 ± 0.00
	0.10%	12.00 ± 12.00 a	7.50 ± 7.50 a	0.00 ± 0.00	0.00 ± 0.00
	0.20%	24.00 ± 7.48 ab	22.50 ± 11.30 a	0.00 ± 0.00	0.00 ± 0.00
	0.40%	68.00 ± 8.00 b	58.33 ± 6.50 b	0.00 ± 0.00	0.00 ± 0.00
	0.80%	68.00 ± 18.55 b	79.11 ± 11.41 b	0.00 ± 0.00	8.00 ± 4.90

Means within a group followed by the same letter are not significantly different ($P < 0.05$, Student Newman-Keuls test SAS Institute 2001). Abbott's formula (1925) was used to correct for control mortality, which was 0% for knockdown and 4% for mortality. The American cockroach assay had 0% control mortality.

TABLE 4. TOXICITY OF PALMOLIVE® DISHWASHING LIQUID TO ADULT MALE GERMAN AND AMERICAN COCKROACHES WITH 2 APPLICATION TECHNIQUES.

			Knockdown				Mortality			
Application	Species	*n*	Slope ± SE	KD_{50}	95% CI	x^2	Slope ± SE	LC_{50}	95% CI	x^2
Spray	German	150	2.02 ± 0.43	0.37%	0.2675-0.5348	3.37	2.65 ± 0.49	0.54%	0.4162-0.7843	0.22
Immersion	German	150	2.35 ± 0.37	0.17%	0.1260-0.2158	4.42	2.89 ± 0.57	0.56%	0.4375-0.8010	2.03
	American	150	2.07 ± 0.85	—	—	6.96	1.90 ± 0.32	0.24%	0.1758-5.3090	0.34

KD_{50} is the concentration required to knockdown 50% of the test population and LC_{50} is the lethal concentration required to kill 50% of the test population. Significant differences determined by nonoverlap of the 95% confidence intervals (SAS Institute 2001).

can cockroaches. All cleaners tested achieved 92-100% mortality for the German cockroaches by both the spray and immersion applications. As an immersion application, 100% mortality was achieved for the American cockroaches. The spray application was less effective for American cockroaches with some cleaners achieving only 38% mortality and others reaching 100% mortality.

Soap solutions act as contact insecticides and have no residual activity. The blend of fatty acid salts in commercially available formulations is proprietary information, but the soft soaps that make up these formulations are made of sodium or potassium fatty acid salts. A problem with using commercially available soaps is that the formulations often change. In fact, by the conclusion of this study, the Fantastik® Orange Action formulation had been replaced on the store shelves with Fantastik® Lemon. Because of the rapid knockown to cockroaches, soaps and cleaners may act as nerve toxicants that result in paralysis and death of the insect. Other mode-of-action theories include spiracle blockage, cellular disruption, and cuticle desiccation (Olkowski et al. 1996; Puritch 1981; Ware 1994), but these modes of action would not result in such rapid death. Soap solutions, due to their low mammalian toxicity, have potential for use as a pest management options in sensitive environments such as occupied hospital rooms, in classrooms with children, and in day-care centers while children are present. Dishwashing liquid and household cleaners are readily available and are common items already found in the home. The results of this study indicate that different brands and formulations knocked-down and killed cockroaches equally ef-

TABLE 5. PERCENT KNOCKDOWN AND MORTALITY OF ADULT GERMAN AND AMERICAN COCKROACH MALES WHEN EXPOSED TO HOUSEHOLD CLEANERS BY A SPRAY OR IMMERSION APPLICATION (n = 25).

Species	Application	Cleaner	% Knockdown ± SE	% Mortality ± SE
German	Spray	409®	100 ± 0.00	100 ± 0.00
		Fantastik®	100 ± 0.00	100 ± 0.00
		Fantastik® Orange Action	96 ± 4.00	100 ± 0.00
		Dawn® Power Dissolver (50%)	100 ± 0.00	96 ± 4.00
		Greased Lightning®	100 ± 0.00	100 ± 0.00
German	Immersion	409®	100 ± 0.00	100 ± 0.00
		Fantastik®	100 ± 0.00	100 ± 0.00
		Fantastik® Orange Action	100 ± 0.00	96 ± 4.00
		Dawn® Power Dissolver (50%)	100 ± 0.00	100 ± 0.00
		Greased Lightning®	100 ± 0.00	100 ± 0.00
American	Spray	409®	60 ± 18.97	56 ± 17.20
		Fantastik®	72 ± 17.44	92 ± 4.90
		Fantastik® Orange Action	48 ± 19.60	64 ± 14.70
		Dawn® Power Dissolver (50%)	32 ± 10.20	84 ± 16.00
		Greased Lightning®	72 ± 19.60	80 ± 20.00
American	Immersion	409®	100 ± 0.00	100 ± 0.00
		Fantastik®	100 ± 0.00	100 ± 0.00
		Fantastik® Orange Action	100 ± 0.00	100 ± 0.00
		Dawn® Power Dissolver (50%)	100 ± 0.00	100 ± 0.00
		Greased Lightning®	100 ± 0.00	100 ± 0.00

fectively. Not only were the dishwashing liquids effective against adult cockroaches, but they were equally as effective against the cockroach nymphs, which make up the majority of household cockroach populations. The effectiveness is further supported in the fact that there was little if any recovery of the cockroaches after the initial knockdown. Soaps are inexpensive and concentrations of soap needed to knockdown or kill pest cockroaches are very low. This results in not only an effective, but economical pest management option. While soap solutions may not completely replace the currently used pesticidal baits and sprays, they have a place as a sanitation tool that may aid in cockroach management.

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