Biological effect of 1-dodecanol in teneral and post-teneral *Rhodnius prolixus* and *Triatoma infestans* (Hemiptera: Reduviidae)

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Topical application of 1-dodecanol was significantly more toxic against teneral first nymphs (1-3 h old) than post-teneral first nymphs (24 h old). The lethal dose ratios were 711,500 for Rhodnius prolixus *and 3613 for* Triatoma infestans. *No significative difference between* LD_{50} *was found when 1-dodecanol was injected in recently hatched adult* R. prolixus *(1-4 h old) nor in older adults (24 h old). These values were similar to those calculated for deltamethrin (an effective triatomicide), showing that 1-dodecanol had no insecticidal properties when it was applied by injection. Topical application of high dose of 1-dodecanol (1 µg/i) on teneral first nymphs of* R. prolixus, *produced an interruption of the darkening process of the cuticle, and probably in the development of its physiological properties.*

Key words: *Triatoma infestans* - *Rhodnius prolixus* - dodecanol - cuticle

Rhodnius prolixus Stahl, 1859 and *Triatoma infestans* (Klug, 1834) (Hemiptera: Reduviidae) are the major vectors of Chagas disease in Latin America. As no vaccine or suitable drugs are available, the control of this disease relies on the vector control by insecticide application in the infested houses. The use of these compounds requires caution to avoid toxicity to man and other non-target organisms. Moreover the development of insecticide resistance in field populations was already demonstrated by Vassena et al. (2000). Studies about safe compounds with insecticidal properties acting on novel targets are necessary for better alternative control against triatomine vectors.

Aliphatic alcohols (from C2 to C18) showed ovicide and larvicide effect against the mosquitoes *Aedes aegypti* Linneo and *Aedes scutellaris* Walker. In particular, 1-decanol, 1-undecanol and 1-dodecanol proved to be highly effective on eggs, larvae and pupae of both species (Sinniah 1983). Mougabure Cueto et al. (2002) demonstrated insecticide activity of aliphatic alcohols against susceptible and permethrin-resistant *Pediculus humanus capitis*. The highest activity was found for the 1-dodecanol and the lowest for 1-octanol. Toxicity to head lice increased with the increase in carbon atoms in the alcohol and was not correlated with resistance to permethrin. Another work showed that the addition of 1-dodecanol to d-phenothrin lotions, increased the pyrethroid insecticide activity to head lice (Mougabure Cueto 2000). The insecticidal activity of aliphatic alcohols was attributed to some effect on the cuticle structure. For head lice, it was concluded that the aliphatic alcohol must partitioned between the water of the lotion and the epicuticular waxed layer of the insect, and derivatives of greater hydrophobic should move readily into the head lice wax (Mougabure Cueto et al. 2002). The lack of correlation between permethrin resistance and alcohol pediculicide activity was attributed to a mode of action different to pyrethroid. Enhancement of pediculicidal activity produced by the incorporation of 1-dodecanol to experimental lotions, was attributed to a higher penetration of the insecticide due to the cuticle damage produced by the alcohol (Mougabure Cueto et al. 2000).

The aim of this study was to investigate the biological effect of 1-dodecanol against *R. prolixus* and *T. infestans*, and the relationship between the triatomicide activity and the cuticle development.

MATERIALS AND METHODS

Insects - *R. prolixus* and *T. infestans* susceptible strains (CIPEIN strain) reared in the laboratory at 28 ± 1°C, 50-60% r.h. and 12:12 h light-dark period. Teneral first nymphs and post-teneral first nymphs were selected for topical application. Teneral first nymphs aged from 1 to 3 h old, and post-teneral first nymphs aged from 24 to 36 h old. Teneral adults and post-teneral adults of *R. prolixus* were selected for the injection bioassay. Teneral adults aged from 1 to 4 h old, and post-teneral adults aged from 24 to 48 h old.

Chemicals - 1-dodecanol (98%, Aldrich, Milwakee, WI, US), deltamethrin (97%, AgrEvo, Buenos Aires, Argentina).

Bioassay - *R. prolixus* and *T. infestans* first nymphs were treated by topical application (0.1 µl and 0.2 µl respectively) of 1-dodecanol solutions on the dorsal abdomen, according to the WHO (1994) protocol. *R. prolixus* adults were treated by injection in the tibia-femur articular

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membrane, with 1 µl of deltamethrin or 1-dodecanol in olive oil, according to Wood et al. (1993). Post treatment, the insects were kept at breeding condition and the mortality were recorded at 24 h. The criterion for mortality was inability of insects to walk over a filter paper 7 cm diameter (first nymphs) or 11 cm diameter (adults).

R. prolixus teneral first nymphs, were treated by topical application of 0.1 µl of 1-dodecanol in acetone (10% p/v) on the dorsal abdomen and kept at breeding condition to observe the effect of the treatment on the darkening process of the cuticle.

Statistical analysis - Values of DL_{50} were calculated by probit analysis (Lichfield & Wilcoxon 1949) and were expressed as nanograms of 1-dodecanol (ng a.i.) per treated nymph, and micrograms of 1-dodecanol (µg a.i.) per treated adult. Lethal dose ratio (LDR) and 95% C.I. were calculated as described by Robertson and Preisler (1992). The observed mortality data were corrected for control mortality using Abbott's formula (Abbott 1925).

RESULTS

Table I summarizes probit analysis of dose-mortality values for first nymphs of *R. prolixus* and *T. infestans*, after topical application with 1-dodecanol. For both species, teneral nymphs were significantly more sensitive than the post-teneral nymphs. Results of the comparative efficacy of 1-dodecanol injected in *R. prolixus* adults are shown in Table II. No significative difference was found between teneral and post-teneral adults. Injection of Deltamethrin produced significantly higher activity than 1-dodecanol against *R. prolixus* older adults (Table II).

External appearance of 24 h old first nymph treated by topical application with 1-dodecanol when it was 1-4 h old is shown in Fig. 2a, and untreated teneral and post-teneral nymphs are shown in Fig. 1a and 1b respectively. For comparison, the external appearance of 24 h old first nymphs treated by topical application of deltamethrin (1µg/i) at 1-4 h old is shown in Fig. 2b. The cuticle of 24 h old nymphs treated at teneral stage with 1-dodecanol, was as red as recently hatched nymphs. Meanwhile cuticle of the nymphs treated with deltamethrin showed as black as control post-teneral nymphs.

DISCUSSION

Topical application of 1-dodecanol was more toxic against recently hatched first nymphs than older first nymphs (711.5x). LD_{50} values for teneral nymphs were similar to those reported for the insecticide deltamethrin (Vassena et al. 2000). These results suggested that the cuticle could play an important role in triatomine intoxication by 1-dodecanol, as well as an external target or as a weak first barrier to reach an internal target. However, 1-dodecanol activity didn't show significative difference between teneral and post-teneral adults when the cuticle barrier was avoided. In addition, the darkening process of the cuticle was affected by the application of 1-dodecanol. These results supported the hypothesis that the insecticide activity of 1-dodecanol could be associated with the developing cuticle. Similar mode of action was proposed for the insecticidal effect of aliphatic alcohols against *Aedes* spp. (Sinniah 1983). According to this author, the alcohols were able to penetrate the eggs, larvae and pupae of the mosquitoes by breaking down the lipid compo-

TABLE I

Insecticide sensitivity of *Rhodnius prolixus* and *Triatoma infestans* teneral (t) and post-teneral (pt) first nymphs (NI), treated with 1-dodecanol (do) or deltamethrin (delta) by topical application

Treatment	NI	n	S ± σ	LD_{50} (ng/i) (95% CL)	LDR [a] (95% CL)
			R. prolixus		
do	t	90	3.9 ± 1.06	0.03 (0.02-0.05)	-
do	pt	132	5.2 ± 0.73	18700 (16400-21200)	711500 (454200-1115000)
delta [b]	pt	89	-	0.010 (0.007-0.016)	-
			T. infestans		
do	t	120	2 ± 0.68	9.1 (4.4-24.2)	-
do	pt	120	2.1 ± 0.73	32900 (15800-49800)	3613 (1401-9319)
delta [b]	pt	50	-	0.10 (0.06-0.16)	-

a: lethal dose ratio (Robertson & Preisler, 1992); *b*: Vassena et al. (2000)

TABLE II

1-dodecanol (do) and deltamethrin (delta) sensitivity of *Rhodnius prolixus* teneral (t) and post-teneral (pt) adults (A), treated by injection

Treatment	A	n	S ± σ	LD_{50} (µg/i) (95% CL)	LDR [a] (95% CL)	LDR [b] (95% CL)
do	t	60	2.2 ± 0.92	160.8 (70.3-350.3)	-	-
do	pt	132	1.6 ± 0.60	436.8 (253.2-2025.3)	2.72 (0.89-8.32)	145700 (50600 - 419200)
delta	pt	45	2.2 ± 0.64	0.003 (0.001-0.005)	-	-

a: lethal dose ratio post-teneral/teneral adults (Robertson & Preisler 1992); *b*: lethal dose ratio 1-dodecanol/deltamethrin for post-teneral adults (Robertson & Preisler 1992)

Fig. 1: external appearance of untreated nymphs I. a: teneral nymph; b: post-teneral nymph

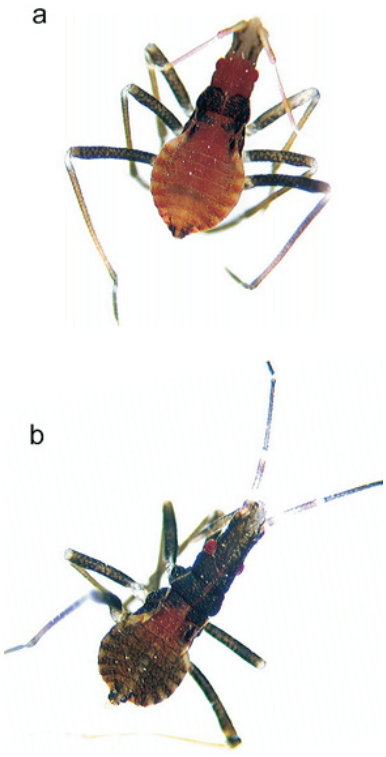

Fig. 2: external appearance of 24 h old first nymph treated by topical application at teneral stage. a: with 1-dodecanol; b: with deltamethrin (1 µg/i)

sition. For the triatominae here studied, the 1-dodecanol could produce an interruption in the cuticular tanning process and consequently in the development of the physiological properties. Some alterations in the impermeability of the cuticle could lead to the dehydration and the death of the treated nymph.

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