

# HYDRAMETHYLNON BAITS AND STICKY TRAPS AND *BLATTELLA GERMANICA* (L.) (DICTYOPTERA: BLATTELLIDAE) BEHAVIOUR

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**Abstract**—During the first two days of laboratory trials, catches on sticky traps (Ekolex-V) of the German cockroach (*Blattella germanica*) were higher than those of subsequent days. In the case of sexed groups of adults, catches of the first and second days ranged from 14.2 to 28.3%. Consecutive daily catches then decreased to 0-16.3%. The cohorts of adults, once subjected to the effect of daily catching on sticky traps, seemed to be more cautious to enter them than those never exposed to traps. In the laboratory ascertained  $LT_{50}$  values for *B. germanica* adults for hydramethylnon bait stations (COMBAT<sup>®</sup>) ranged from 3.2 to 4.5 days,  $LT_{90}$  from 4.2 to 7.6 days. No distinct differences in  $LT_{50}$ ,  $LT_{90}$  and  $LT_{99}$  for groups of males never exposed to sticky traps (a) and for those exposed to traps (b) before bait application were found. However,  $LT_{90}$  and especially  $LT_{99}$  values for females of groups (b) were distinctly higher than those of groups (a). In the field trial *B. germanica* was effectively reduced by hydramethylnon bait stations. In a 6-12 (A.T.) week period the reduction ranged from 81.1 to 91.0%. After replacing bait stations by hydramethylnon gel formulation (MAXFORCE<sup>®</sup>), reduction of the cockroach population increased to 97.8%.

## INTRODUCTION

In households, health care facilities, offices etc., the German cockroach (*Blattella germanica*) causes serious hygienic problems. In the Czech Republic synthetic pyrethroids such as permethrin or deltamethrin were often used for residual spraying against cockroaches. While in 1983 six out of seven wild strains of *B. germanica* were found susceptible to permethrin, in 1989 already 13 out of 14 populations tested were more or less resistant to the synthetic pyrethroid (Rettich *et al.*, 1991). The rotation of insecticides from various insecticidal classes including those used in cockroach baits is recommended to overcome the developing resistance.

Hydramethylnon i.e. tetrahydro-5,5-dimethyl-2(1H)-pyrimidinone{3-[4-(trifluoromethyl)phenyl]-1{2-[4(trifluoromethyl)phenyl]ethenyl-2-propenylidene} hydrazone containing baits mounted into feeding stations has been used successfully in Czechoslovakia since the mid-eighties (Rettich, 1987, Rettich and Laštovka, 1990). However, it was sometimes reported by Pest Control operators that a part of *Blattella germanica* populations survived the bait treatment especially in localities where baits were used repeatedly. Also during routine laboratory testing of baits against *B. germanica*, we have observed cockroaches which showed some reluctance to enter bait stations or seemed to refuse the intake of a sufficient dose of the bait for a rather long time, which resulted in an unexpectedly long survival of those individuals. Moreover, we observed both in the laboratory and in the field, similar "behavioural resistance" of *B. germanica* to enter sticky traps after their repeated use.

The objectives of the study presented here were to demonstrate the above mentioned phenomena in laboratory trials and in field tests with two different bait formulations of hydramethylnon.

## MATERIAL AND METHODS

### Laboratory observations

For laboratory tests a permethrin resistant *B. germanica* strain collected in the field and then reared in insectarium for more than two years, was used. All laboratory tests were performed in a series of glass aquariums 75x35x35 cm. The inside edges of the aquariums were coated by fluon (PTFE, Imperial Chemical Industries, Limited) and the tops were tightly covered by gauze to prevent the escape of cockroaches. Three layers of corrugated filter paper 10x25 cm were used as a harbourage for insects. Water and food (standard rat chow) were always added *ad lib*.

### Traps

Counted and sexed groups of one hundred adults or naturally mixed populations of *B.germanica* with naturally developed adults/nymphs (N of adults cca 200) ratio were placed into aquariums. After five days of acclimation, sticky traps (EKOLEX V-Vetox Prague, Limited) were placed into aquariums daily (one per each aquarium in case of sexed cockroaches, two in the case of mixed populations) for a period of 8 and 19 days respectively. Caught roaches were counted daily and the catches of two consecutive days were combined. Non-trapped adult cockroaches were spared and used for further tests.

### Baits

Males, females with oothecae or females without oothecae (those subjected to traps and simultaneously those taken directly from the colony) were counted and separately placed into aquariums and exposed to hydramethylnon feeding stations (COMBAT<sup>®</sup>-Clorox International Comp. U.S.A.). The bait contains 1.65 % a.i. and is enclosed in a plastic tray of 25 cm<sup>2</sup>. One bait station per aquarium was used. Tests were run in duplicate in the same conditions (temperature 25 ± 2 °C, RH 55-60%). In the aquarium tests daily per cent mortality of treatments (N=100 insects) was corrected for control mortality using Abbotts formula (Abbott, 1925) and LT<sub>50</sub>, LT<sub>90</sub> and LT<sub>99</sub> (time in days needed to kill half, 90 and 99% of the experimental cohort of cockroaches) were estimated for each pair of treatments by probit analysis (Finney, 1971). Significant differences of estimates were determined by non-overlap of 95% fiducial limits.

### Field tests

A locality with a record of synthetic pyrethroid spraying failures was chosen for field tests. The hospital kitchen of cca 100 square metres with moderate hygienic standard operated daily but not through nights, was treated by hydramethylnon bait stations (COMBAT<sup>®</sup>, 1.9 % a.i., 64 cm<sup>2</sup>). The dose was 4 baits per 10 square metres. Before and after the bait application in regular weekly intervals the *B.germanica* population was estimated using 20 sticky traps placed everytime on the same place. Sticky traps were exposed for 3 days during weekends. After 3 months, the bait stations were removed and hydramethylnon was applied again this time in the form of gel (MAXFORCE<sup>®</sup> Gel, 2.15% a.i.). The dose was 1 g of gel applied in 3 - 5 dots per square metre. Occurrence of cockroaches was again evaluated by means of sticky traps.

## RESULTS

### Traps

During the first two days of trials, catches on sticky traps in aquariums inhabited by mixed populations *B.germanica* or by sexed groups of adults were significantly higher than those of following days. In the case of mixed populations of all instars, after 19 days of daily catching, only about one half of the adults were caught, while the total number of caught L1-L2 and L3-L7 nymphs was two and three times higher than uncaught individuals of the same category respectively (Table 1). When sexed groups of adults were subjected to daily catching, catches of the first and second day ranged from 14.2 to 28.3% (table 2). Consecutive daily catches then dropped dramatically (0-16.3%). The groups of cockroaches once subjected to the effect of daily catching on sticky traps seemed to be even more cautious to enter them than those never exposed to traps (Table 2).

### Baits

In the laboratory, ascertained LT<sub>50</sub> values for *B.germanica* males and females (carrying oothecae and without oothecae) subjected to the effect of hydramethylnon bait stations ranged from 3.2 to 4.5 days, LT<sub>90</sub> from 4.2 to 7.6 days (Table 3). No distinct difference was observed between LT<sub>50</sub>

Table 1: Cumulative daily catches of males, females and nymphs of *Blattella germanica* on sticky traps in laboratory from four mixed populations.

Days	Males	Females	Nymphs	
			L3 - L7	L1 - L2
1 - 2	79	65	410	815
3 - 4	36	28	183	475
5 - 6	24	24	184	593
7 - 10	49	42	182	627
11 - 12	35	40	132	549
13 - 16	21	30	106	689
17 - 19	32	43	109	966
Total caught	276	272	1306	4714
Not-caught*	202	304	453	2454

Explanation: \* - counted living insects in the end of test

Table 2: Percentual average daily catches of males, females without oothecae and females with oothecae of *Blattella germanica* on sticky traps in the laboratory.

Interval (days)	Males		Females without oothecae		Females with oothecae	
	a	b	a	b	a	b
1 - 2	28.3	22.5	23.4	14.2	28.5	14.4
3 - 4	15.1	7.6	8.2	3.1	6.2	4.8
5 - 6	16.3	6.2	6.7	3.3	9.7	3.4
7 - 8	10.9	8.0	4.8	2.5	0	4.3
total caught	57.0	37.9	39.0	18.9	39.0	23.4

Explanations: a - population before this trial never exposed to sticky traps

b - population exposed to sticky traps for 19 days, than held 5 days without traps than trapped again (see table 1)

Table 3: Efficacy of hydramethylnon baits on adults of *Blattella germanica* in laboratory.  $LT_{50}$ ,  $LT_{90}$  and  $LT_{99}$  values (95% fiducial limits in parentheses) in days

Sex	$LT_{50}$	$LT_{90}$	$LT_{99}$
Males (a)	3.5 (*)	5.0 (*)	6.7 (4.6 -*)
Males (b)	3.3 (2.6 -4.0)	4.5 (3.8 -7.6)	5.8 (4.6 -14.6)
Females (a) without oothecae	3.2 (2.9 -3.4)	4.2 (3.8 -4.8)	5.2 (4.6 -6.6)
Females (b) without oothecae	4.5 (3.1 -5.9)	7.6 (5.8 -16.5)	11.7(7.9 -45.8)
Females (b) with oothecae	4.2 (3.6 -4.9)	7.1 (5.9 -10.2)	11.1(8.3 -19.9)

Explanation: a - populations never exposed to sticky traps

b - populations exposed to sticky traps for period of 8 days

\* - not possible to assess

values estimated for females and  $LT_{50}$ ,  $LT_{90}$  or  $LT_{99}$  values estimated for males of insect cohorts never exposed to sticky traps (groups (a)) and for those before testing against hydramethylnon baits exposed to sticky traps (groups (b)).  $LT_{90}$  and especially  $LT_{99}$  values for females of groups b were distinctly higher than those of groups (a) (with non-overlapping 95% fiducial limits). Delayed killing effect of hydramethylnon baits for females of the groups (b) may signalize later intake of the bait.

The field population of *B.germanica* was effectively reduced by hydramethylnon bait stations three weeks after the treatment (A.T.). In 6-12 (A.T.) weeks period, the reduction (based on sticky traps catches) ranged from 81.1 to 91.0%. However, some live cockroaches were seen resting in crevices located less than 1 m from nearest bait stations through the whole testing period. After replacing bait stations by hydramethylnon gel formulation, reduction of the cockroach population

Table 4: Reduction of adults and nymphs of *Blattella germanica* after the application of hydramethylnon bait stations and gel in a hospital kitchen

Weeks A.T.  Bait stations	Reduction* in %			
	Adults	Nymphs		Total
		L3 - L7	L1 - L2	
1	27.0	20.4	9.2	20.9
2	0	0	0	0
3	67.6	63.0	32.6	54.5
4	70.3	81.5	74.4	76.1
6	86.5	81.5	88.4	86.6
7 - 8	86.5	83.3	94.2	91.0
9 - 10	75.7	86.1	91.9	85.1
11 - 12	89.2	85.2	95.3	89.6
<b>Gel</b>				
14	98.3	98.1	88.9	94.8
15	94.6	88.9	97.7	93.3
17	100	100	93.0	97.8
20	98.3	98.1	97.7	97.8

Explanation: A.T. - after treatment

\* - against the average of 3 consecutive catches made weekly before the treatment

increased to 97.8% (Table 4). In the end of the field trial, no living cockroaches could be observed in formerly inhabited harborages.

## DISCUSSION

In laboratory conditions, the first two days catches of *B. germanica* adults on sticky traps were significantly higher than the catches of the subsequent days. The phenomenon may be partly explained by cautious behaviour of a part of cockroach adult population to enter new places. The similar effect was observed in the field with baited and unbaited sticky traps of different construction (Rettich, unpublished). The cautiousness together with the high ability of *B. germanica* to proliferate in favourable conditions, makes the use of sticky traps as the only control measure rather doubtful. Similarly, Ballard and Gold (1984) concluded that cockroach traps are most effective as monitoring device, rather than providing acceptable control.

Hydramethylnon applied in baits is effective for *B. germanica* control including resistant populations, in spite of the fact that it produces rather delayed mortality especially in field conditions. The high efficacy of hydramethylnon was amply documented in literature (Milio *et al.*, 1986, Silverman and Shapas, 1986, MacDonald *et al.*, 1987, Appel, 1990 and others). Delayed effect of hydramethylnon caused by specific mechanism of action (Lovell, 1979, Hollingshaus, 1986) may be even more postponed when baits are mounted into plastic trays. Though the design of trays takes advantage of the cockroach natural desire for entering narrow channels (thigmotaxis), some individuals of the cockroach population may exhibit the reluctance to do so. The postponed full kill of *B. germanica* females (both carrying and not-carrying oothecae) was evident when the cockroaches were selected by sticky traps before their exposure to the baits in feeding stations. It is necessary to point out that in the case of hydramethylnon, some individuals which do not enter bait stations may be killed by possible coprophagy of hydramethylnon laden feces, the phenomenon described by Silverman *et al.* (1991).

In the field trial the registered reduction of *B. germanica* increased when hydramethylnon feeding stations had been replaced by the other formulation of the toxicant. The enhanced mortality may be explained not only by the higher chance for cockroaches to find the bait in the case of more uniform distribution of the gel formulation, but also by the additional kill of cockroaches which had not taken the sufficient dose of hydramethylnon from the bait trays owing to their bait station "cautiousness".

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