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Research Note

Impact of starvation on intrinsic rate of increase (r_n) of the German cockroach, *Blattella germanica* (L.) (Dictyoptera: Blattellidae), in the presence of an insecticidal bait

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Abstract. A laboratory-simulated study was conducted to investigate the impact of starvation (food and water deprivation) on the intrinsic rate of increase (r_n) of the German cockroach, *Blattella germanica* (L.), in the presence of an insecticidal bait formulation (2% hydramethylnon gel bait). A total of five treatment regimes were set up: food, water and bait (FWB), food and bait only (FB), water and bait (WB), bait only (B) and, food and water only (FW) as control. Results indicated no significant difference ($P > 0.05$) occurred among the r_n values of the four treated regimes (FWB, FB, WB and B); however, they were significantly different ($P < 0.05$) from that of the control (FW). The implication of this finding is discussed.

The German cockroach, *Blattella germanica* (L.) is prevalent insect pest in hotels and food outlets in the Southeast Asian region (Lee *et al.*, 1999a; Lee & Robinson, 2001). Current control strategy which relies heavily on the use of residual contact insecticides has caused the development of insecticide resistance problems in field populations of this species (Lee, 1997; Lee & Lee, 1998; Lee *et al.*, 1996a; 1999b; 2000). The use of insecticidal baits as a resistance management strategy has been shown to be effective against German cockroaches in Malaysia (Lee, 1998). Baiting is increasingly popular because it can achieve a similar level of control with a reduced likelihood of pesticide misapplication (Robinson, 1988). Many studies have demonstrated both gel and bait stations are effective tools in managing field populations of the German cockroach (Reierson *et al.*, 1983; Milio *et al.*, 1986; Appel, 1990; Appel, 1992; Ogg & Gold, 1993; Appel & Benson, 1995).

One important factor that governed the effectiveness of bait in the field is sanitation (Christensen, 1991; Lee & Lee, 2000a). From the pest management standpoint, sanitation is a reflection of the available food, water and harbourage in an environment (March & Bertholf, 1986). Although these three resources had been reported as factors that regulate population numbers (Clark *et al.*, 1967), several other studies did not find a direct relationship between level of cockroach infestation with sanitation rating (Bennett, 1978; Bertholf *et al.*, 1983; Lee & Lee, 2000b) Nevertheless, the performance of,

and attraction to an insecticidal bait product can be greatly reduced by the availability of competing resources such as food and water (Bertholf, 1983; Lee & Lee, 2000a). With the reduction of available food and water source in the environment, cockroaches will be more likely to get into contact with the baits.

Earlier, Lee & Heng (2000) reported the negative effects of food and water deprivations of several biological parameters of the German cockroach. Although the starvation effects on each parameter was carefully scrutinized in that study, its impact on overall population growth in the presence of bait was unknown. This information is important because in pest management, we should be targetting at the pest population as a whole, and not on individuals (Metcalf & Luckmann, 1975; Grothaus *et al.*, 1981). Here, we report a simulated study on the effects of starvation (food and water deprivation) on intrinsic rate of increase (r_n) of laboratory colonies of the German cockroach, in the presence of insecticidal bait.

The insecticide-susceptible strain of *B. germanica* was used this study. This strain was previously originated from Zeneca Agrochemicals, U.K. which has been reared without exposure to insecticide for more than 40 years. At Universiti Sains Malaysia, they were reared under environmental conditions of $27 \pm 2^{o}C$, $50 \pm 5\%$ relative humdity and 12-hour photoperiod, with normal food [dog pellet] (Pedigree Crunchy Bites) and water provided *ad libitum*. Label claim on the dog pellet package indicated that it contained 21% protein, 10% lipid, 5% fiber, and 1.3% salt. The insecticidal bait used in this study was a 2% hydramethylnon-based gel bait (Siege®, BASF Malaysia).

A total of 20 each of adult males, adult females (10 each of gravid and non-gravid females), late-, mid- and early instar nymphs were introduced into a test arena (22 x 38 x 27 cm) with its upper inside surface smeared with a thin layer of petroleum jelly to prevent cockroaches from escape. They were acclimatised for a week with ample numbers of harbourages (folded corrugated cardboard) which were provided on one side of the arena with water source, while normal food was provided at the other side of the arena. The cockroaches were acclimatized in this condition for 7 days before the experiment started. A total of 45 replicates was set up.

After the acclimatisation period, a total of nine replicates each were subjected to the following treatment regimes: (1) food and water, in presence of toxic bait (FWB), (2) food and bait only (water given once every three days) (FB), (3) water and bait only (normal food was given once every three days) (WB), (4) bait only (water and normal food were given once every three days) (B), and (5) food and water only (control) (FW). At 7, 14 and 28 days post-treatment, three replicates were randomly selected from each treatment regimes, and the number of cockroaches left in each arena was manually counted. Dead cockroaches were not removed from the test arena to simulate the real condition in the field.

The intrinsic rate of increase (r_n) of each population in test arena was calculated using the following formula, as described by Lee *et al.* (1996b): $r_n = [\log_e (n_{t+1}) - \log_e (n_t)] / \text{time}$, where r_n = daily rate of population increase; n_t = population at time t; n_{t+1} = population at time t + 1; time = difference between t + 1, and t. Data collected for r_n were subjected to analysis of variance, and means were separated with least significant difference (LSD) test, using SPSS ver. 10.01 statistical software.

There appeared to be no significant difference ($P > 0.05$) in terms of intrinsic rate of increase (r_n), among all four treatment regimes (FWB, FB, WB, B) where baits were provided to the simulated populations (Table 1), but all r_n valules of these regimes were significantly different ($P < 0.05$) from that of the

Table 1. Intrinsic rate of increase (r_n) of the German cockroach under different treatment regimes, in presence of an insecticidal bait (2% hydramethylnon gel bait)

treatment regime	n_t	t	replicate	n_{t+1}	r_n	Mean $r_n \pm$ S.E.M.[a]
FW	101	7	1	159	0.0648	
(control)	158	7	2	213	0.0427	
	167	7	3	215	0.0361	
	101	14	1	205	0.0506	
	158	14	2	287	0.0426	
	167	14	3	376	0.0580	
	101	28	1	512	0.0580	
	158	28	2	527	0.0430	
	167	28	3	603	0.0459	0.0491 ± 0.0031a
FWB[b]	188	7	1	117	-0.0678	
	143	7	2	136	-0.0072	
	137	7	3	65	-0.1065	
	188	14	1	41	-0.1088	
	143	14	2	52	-0.0723	
	137	14	3	84	-0.0349	
	188	28	1	21	-0.0783	
	143	28	2	40	-0.0455	
	137	28	3	55	-0.0326	-0.0615 ± 0.0115b
FB[b]	239	7	1	147	-0.0694	
	272	7	2	127	-0.1088	
	206	7	3	53	-0.1939	
	239	14	1	30	-0.1482	
	272	14	2	46	-0.1269	
	206	14	3	90	-0.0592	
	239	28	1	1	-0.1956	
	272	28	2	98	-0.0365	
	206	28	3	30	-0.0688	-0.1119 ± 0.0195b
WB[b]	164	7	1	73	-0.1156	
	162	7	2	83	-0.0955	
	100	7	3	104	0.0056	
	164	14	1	117	-0.0241	
	162	14	2	77	-0.0531	
	100	14	3	46	-0.0555	
	164	28	1	3	-0.1429	
	162	28	2	60	-0.0355	
	100	28	3	40	-0.0327	-0.0610 ± 0.0590b
B[b]	125	7	1	70	-0.0828	
	137	7	2	32	-0.2078	
	140	7	3	118	-0.0244	
	125	14	1	85	-0.0276	
	137	14	2	155	0.0088	
	140	14	3	84	-0.0365	
	125	28	1	30	-0.0510	
	137	28	2	30	-0.0542	
	140	28	3	81	-0.0195	-0.0550 ± 0.0102b

[a]Mean values followed by same letter within the same column are not signficantly different ($P > 0.05$; LSD test).
[b]All cockroaches under this treatment regime died by 56 days.

control. These regimes recorded negative values for r_n, implying that the populations were decreasing with time. All cockroaches in these regimes died by 56 day post-treatment. This may possibly suggest that the gel bait is highly attractive material to the cockroaches, even under the choice of normal food. It was not known, however, the impact of bait presence in each treatment regime, which was not studied. This warrants further investigation in future.

The results obtained were different from those reported by Lee & Lee (2000a) earlier in a field trial that improved sanitary condition increased bait performance against American cockroaches. There is no significant difference between regime provided with bait only (B), with those that were provided with food (FB), water (WB), or both together (FWB) (Table 1). This could likely due to differential response in two cockroach species to bait formulation and competing food. Earlier, Lee (2001) recorded the insignificant effects of sanitary condition on 2% hydramethylnon- and 0.1% fipronil-based bait performance against German cockroaches in the field. In addition, the current study that was conducted in the laboratory may not be a good representative of the actual situation that could happen under field condition because food and bait are closely located to each other in the test arena.

German cockroach finds its food source solely by chance (Ebeling & Reierson, 1970). In addition, its ability to detect the presence of water through its hygroreceptor is no more than a few centimetres away (Altner & Loftus, 1985). Because of these factors, bait performance will be highly governed by the number of bait placement in the field condition (Reierson *et al.*, 1983) and location of placement (Reierson, 1995). An increase in the number of placements will elevate the field performance of baits because the chance of cockroaches finding the material will be higher.

The control (FW) regime registered an r_n value of 0.049. This result concurs well with those reported earlier by Grothaus *et al.*, (1981) who recorded 0.045; and Lee *et al.* (1996b) reported r_n of 0.047 with the VCRU susceptible strain. These values, however were much higher in Lim (1994) (r_n = 0.03) and Reid (1989) (r_n = 0.023), but lower than that reported by Archbold *et al.* (1987) (r_n = 0.052). The differences in r_n values obtained are possibly due to strain differences (Lee *et al.*, 1996b), rearing condition (Koehler *et al.*, 1994), number of insects used, age/stages used for establishment and sampling time.

This current study demonstrated that food and water deprivation may not have an important role in affecting bait performance against German cockroach populations. More studies, particularly determining the impact of starvation on population growth, and on how bait number and placement affect population growth, should be done in future.

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