SHORT COMMUNICATIONS

Possible Role of Feces for Directional Orientation of the German Cockroach, *Blattella germanica* L. (Orthoptera : Blattellidae)¹

It is well known that domiciliary cockroaches are nocturnal. They hide and rest in the cracks and crevices of rooms in the day-time. At night they crawl out from the crevices to search for food and water, returning to their hiding places before daylight.

Learning in cockroaches has been studied by some investigators. TURNER (1913) studied on the behavior of the common cockroach, *Periplaneta* (*Blatta*) *orientalis* L., using an open maze, and concluded that the cockroach could be taught to run the maze in less than 24 hrs. In the case of the German cockroach, *Blattella germanica*, however, opposite results have been reported as to whether or not any chemicals participated in learning efficiency (ALLOWAY, 1972).

In our preliminary experiments in maze learning of the adult male German cockroaches, it was observed that they preferred the route contaminated with their own feces for running than the clean one. Therefore, it seems necessary that all experiments in maze learning should be confirmed by the critical experiments evaluating the significance of any chemicals participating in the experimental environments.

The following experiments were carried out to determine a possible role of feces excreted from the German cockroach on the directional orientation of the insect.

A T-maze was used to test the effect of feces on directional orientation of the cockroaches. The maze was made from plastic blocks of $20 \times 20 \times 1$ cm, $20 \times 10 \times 1$ cm and $2 \times 3 \times 1$ cm. They were arranged to make a T-maze, 30 or 80 cm in stalk, 20 cm in both branches, 2 cm in route width and 1 cm in route height, on a plastic plate as shown in Fig. 1. The top of the maze was covered with a plastic plate like the bottom of the maze.

One side of the T-maze was closed by a plastic block ($2 \times 3 \times 1$ cm) placed at the point D, then small boxes ($10 \times 10 \times 1$ cm) were attached to the entrance and the exit. Then adult male cock-

Fig. 1. T-maze used for preference tests of the German cockroach male adults. The cockroaches were released from A one by one, and allowed to prefer either B or C route. (A to D: 30 or 80 cm, B to D and C to D: 20 cm)

roaches were introduced into the consequent L-maze for several days to contaminate the route with feces. The small box at the entrance was darkened by covering it with a sheet of black paper, while dog biscuits (Oriental Yeast Co. Ltd.) and water were kept in the exit box. Several days later, when the maze was contaminated with feces, these cockroaches and the closing block were removed and a small box was attached at the third opening of the T-maze. Then adult males newly selected from our laboratory colony were introduced one by one from the small box at the entrance of the T-maze (A) and allowed to select left or right branch.

As shown in Table 1, a statistically significant number of cockroaches preferred the side which had been previously contaminated with feces. When a methanol extract of the feces (2.5 mg) was applied to the stalk and the left or right branch of a clean T-maze on the upper interior surface, the cockroaches preferred the impregnated branch as shown in Table 2.

One adult male of the German cockroach excretes 0.976 ± 0.401 mg ($N=120$) feces in a day under photoperiod of 8L : 16D at 25°C. Methanol extract (185.5 ± 38.0 μ g) obtained from these amount of feces had a significant effect for this directional orientation of the insect.

When the height of the maze was doubled, antennae of the insect could not touch the upper interior surface. In this case, cockroaches could not trail when 2.5 mg of methanol extract was applied.

The results of the present study clearly showed that adult males of the German cockroach preferred the route which had been contaminated with their own feces. Methanol extracts of the feces had the same effect as feces. In addition, our preliminary experiments showed that some component(s) are contained in the feces which elicit this directional

¹ Appl. Ent. Zool. 9 (4): 271—272 (1974).

Table 1. PREFERENCE TESTS OF THE GERMAN COCKROACH MALE ADULTS WITH T-MAZE OF WHICH EITHER RIGHT OR LEFT ROUTE WAS CONTAMINATED WITH THEIR OWN FECES.

Maze size (cm)	Contaminated with, for	Contaminated route	Preferred (%)		No. of insect tested	χ^2 test ^a P < 0.01
			Left	Right		
30×20×1	20 males, 2 day	Right	14	86	49	s
30×20×1	20 males, 7 day	Right	6	94	18	s
80×20×1	30 males, 1 day	Left	93	7	30	s
80×20×1	30 males, 1 day	Right	11	89	90	s
30×20×1	not contaminated		52	48	29	ns
30×20×1	not contaminated		47	53	30	ns
30×20×1	not contaminated		40	60	30	ns
80×20×1	not contaminated		39	61	31	ns
80×20×1	not contaminated		45	55	58	ns

^a s, significant; ns, not significant.

Table 2. PREFERENCE TESTS OF THE GERMAN COCKROACH MALE ADULTS WITH T-MAZE OF WHICH EITHER RIGHT OR LEFT ROUTE WAS IMPREGNATED WITH METHANOL EXTRACT OF THE FECES.

Maze size (cm)	Amounts of methanol extract	Route impregnated	Preferred (%)		No. of insect tested	χ^2 test ^a P < 0.01
			Left	Right		
80×20×1	2.5mg	Left	93	7	30	s
80×20×1	2.5mg	Left	97	3	60	s
80×20×1	2.5mg	Right	13	87	30	s
80×20×1	185.5 μ g	Right	2	93	46	s
80×20×2	2.5mg	Left	27	73	30	ns

^a s, significant; ns, not significant.

orientation from the insect by contact and/or short range chemoreception through antennal receptors. It may be suggested that the German cockroaches crawl out of their hiding places and return to their resting sites probably by means of direction by chemical substance(s) contained in their feces.

Recently, BELL, BURK and SAMS (1973) have shown that orientation of the American cockroach, *Periplaneta americana* L., is directed by the aggregation pheromone secreted in the feces and tropochemotactic orientation is dependent on olfactory perception of the pheromone by antennal receptors.

Studies on the relationship between the aggregation pheromone (ISHII and KUWAHARA, 1967) found in the feces and the chemical substance(s) participating on directional orientation of this insect are now in progress and results will be presented in subsequent papers.

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