

Original Article

Sex Pheromone Activity of Synthetic Periplanone-B in Male Cockroaches of Genera *Periplaneta* and *Blatta*

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Pheromone activity of synthetic periplanone-B (PB) was bioassayed in six species of genera *Periplaneta* and *Blatta*. The activity was very high in the males of *P. americana* and low in the males of *P. japonica*, *P. brunnea* and *B. orientalis*. Attractivity of PB to the males of *Periplaneta* species was tested in houses at several locations. PB in traps attracted *P. brunnea* and *P. japonica* in addition to conspecific *P. americana*.

INTRODUCTION

The six cockroach species of genera *Periplaneta* and *Blatta*, *Periplaneta americana*, *P. japonica*, *P. australasiae*, *P. brunnea*, *P. fuliginosa* and *Blatta orientalis*, widely distribute from tropical to temperate zones of the world. Female sex pheromone of these species has been considered to play an important role in breeding as well as in isolated breeding of a species among the closely related species.

Since the discovery of sex pheromonal activity of germacrene-D to male *P. americana* and its structural relationship to periplanones, our attention has been on the interspecific variation of sex pheromone activity of *P. americana* to the related species.^{1,2)} So far two sex pheromone compounds were identified in *P. americana* and the activity of the components were tested to male *Periplaneta* species.³⁾ A bioassay of sex pheromone activity was established in our laboratory by observing the behavioral responses of the males of the six *Periplaneta* and *Blatta* species.⁴⁾ The bioassay of sex pheromone activity thus established in the laboratory was applied to compare the behavioral responses of the six

species to synthetic periplanone-B (PB).

Recently Seelinger bioassayed the sex pheromone activity of periplanone-A (PA) and PB obtained from cages of female *P. americana* toward male *P. americana*, *P. australasiae* and *Blatta orientalis* using a wind tunnel, and reports that PB elicits locomotion and upwind orientation in the males of *P. americana* and *B. orientalis*, but not of *P. australasiae*, while PA induces locomotion in the males of all three species.⁵⁾ The laboratory bioassay with synthetic (\pm)-PB by Tobin *et al.*⁶⁾ shows that PB induces a complete repertoire of behavior released by a sex pheromone extract of *P. americana*, while Chow & Wang⁷⁾ indicate that synthetic PB attracts *P. americana* males to traps. The attraction test with PA and PB by Waldow & Sass⁸⁾ shows that the males of *P. americana* are attracted by PB and the males of *P. australasiae* by PA.

This paper is to quantitatively compare the behavioral responses to synthetic (\pm)-PB among the males of *Periplaneta* and *Blatta* species. (\pm)-PB was also evaluated as a bait based on the attractivity tests on the males of genera *Periplaneta* in Malaysia and Japan.

MATERIALS AND METHODS

1. Insects

Colonies of *P. americana*, *P. japonica*, *P. australasiae*, *P. brunnea*, *P. fuliginosa* and *Blatta orientalis* were fed with mouse food and water, and maintained in a light cycle of 12L-12D at $25 \pm 2^\circ\text{C}$. After imaginal ecdysis, males were separated from a colony two weeks before bioassay.

2. Bioassay

About 100 males were kept in a sheltered container ($34 \times 49 \times 27$ cm). Samples of pheromone were impregnated on a glass plate (2×2 cm) and placed 10 cm away from the shelter. Responses were evaluated by the following criteria:

- (±) one to three males responded after 1 min or later.
- (+) less than ten males responded within 1 min.
- (++) more than ten males responded within 30 sec.
- (###) thirty or more males responded immediately after exposure to a sample.

3. Sex Pheromone

Synthetic (±)-periplanone-B was supplied by Prof. J. Tsuji and Dr. T. Takahashi, Tokyo Institute of Technology. PB was dissolved in hexane for bioassay. Tablets containing 0.1 μg or 0.5 μg of synthetic PB were prepared by Ube Industries, Ltd. in a slow release formulation.

4. Trapping Test

Traps were made of cardboard, and a sticky material was spread on the bottom (9×21 cm). A tablet containing PB was placed at the center of the sticky bottom. A commercial food bait was used for the blank test.

RESULTS AND DISCUSSION

The threshold amount of isolated periplanone-B sufficient to elicit a behavior response in *P. americana* males was about 10^{-16} g. Synthetic PB was revealed to have almost the same activity. The comparative intensity of responses among the six species to synthetic PB is shown in Table 1. Synthetic PB elicited

Table 1 Behavioral responses of six species of genera *Periplaneta* and *Blatta* to (±)-periplanone-B.

♂♂	Dose(g)				
	10^{-14}	10^{-13}	10^{-12}	10^{-11}	10^{-10}
<i>P. americana</i>	++	##	##	##	##
<i>P. japonica</i>	±	+	++	##	##
<i>P. brunnea</i>	—	—	±	+	++
<i>B. orientalis</i>	—	—	—	—	±
<i>P. australasiae</i>	—	—	—	—	—
<i>P. fuliginosa</i>	—	—	—	—	—

a response not only in *P. americana* males but also in *P. japonica*, *P. brunnea* and *B. orientalis* males. There was no response in *P. australasiae* and in *P. fuliginosa*. A similar result has been reported with purified sex pheromones from female *P. brunnea* and *P. australasiae*.³⁾ The required threshold amount of synthetic PB to elicit a response in male *P. japonica* was about 10^{-14} g, which is 100 times the amount required to elicit a similar behavior in male *P. americana*. PB was less active to *P. brunnea* and *B. orientalis*. The interesting finding that germa-crene-D also elicits a response in male *P. americana* as well as in male *P. japonica* may suggest that *P. japonica* sex pheromone and periplanones are related in structure.⁹⁾ There is the report that a filter-paper extract from a cage of female *P. japonica* elicits a high response in both *P. americana* and *P. japonica*.¹⁰⁾ Purification of sex pheromone is now in progress in our laboratory.

Attractivity of PB in housing areas was tested at several locations. Trapping results indicated that PB tablets were effective in attracting three *Periplaneta* species (Tables 2 and 3). As the tables indicate, 0.5 μg PB was higher in attractivity than 0.1 μg PB in both *P. americana* and *P. brunnea* males in Malaysia. Similar results were obtained in Osaka and other cities in the western part of Japan, where infestation by more than two species has recently recorded.¹¹⁾ *P. japonica* is considered to be the oldest domestic species in the northern part of central Honshu. A preliminary trapping test was carried out in Shigaraki, Shiga Prefecture in central Japan. The result of a pair of traps in a room is shown in Table 3.

Table 2 Number of *Periplaneta* caught by food bait, 0.1 μg periplanone-B and 0.5 μg periplanone-B for 32 days.

Species		Food bait	PB 0.1 μg	PB 0.5 μg
<i>P. americana</i>	♂♂	13	35	72
	♀♀	23	26	19
<i>P. brunnea</i>	♂♂	4	8	24
	♀♀	11	3	4
<i>P. fuliginosa</i>	♂♂	0	1	0
	♀♀	0	0	0
Nymphs ^{a)} 0.5 cm ^{b)}		83	23	27
	1.0	58	12	30
	1.5	43	18	10
	2.0	52	11	16
	2.5	16	6	8
	3.0	7	0	4

^{a)} Mostly *P. americana* and *P. brunnea*. Total 32 traps were set in apartments at three locations in Seremban, Negeri Sembilan, Malaysia.

^{b)} Body length.

Table 3 Number of *P. japonica* caught per trap by 0.5 μg synthetic periplanone-B in tablets and food bait over a 3-week period (Shigaraki, Shiga Prefecture, Japan).

Species		0.5 μg periplanone-B	Food bait
<i>P. japonica</i>	♂♂	12	6
	♀♀	4	2
Nymphs		9	2

PB trapped more male *P. japonica* than food bait.

Males of the three species which were highly responsive to PB in the laboratory bioassay were also susceptible to PB traps in infested houses. Nymphs and females of these species were also caught through the trapping test. Since nymphs and females are not usually responsive to sex pheromone in a laboratory bioassay, this was understood probably due to their aggregation behavior. Such a response has yet to be confirmed by further investigation. Studies on the use of synthetic (\pm)-PB for population survey and control by mass trapping are now in progress.

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要 約

合成ペリプラノンBの*Periplaneta*属, *Blatta*属雄ゴキブリに対する性フェロモン活性

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ワモンゴキブリの性フェロモンの一つペリプラノンB(PB)の合成化合物を使って, *Periplaneta*属, *Blatta*属6種の雄に対する性フェロモン活性を実験室内で生物検定した。その結果, ワモンゴキブリ以外にヤマトゴキブリ, トビイロゴキブリ, トウヨウゴキブリにもフェロモン活性があった。ゴキブリの生息地域における誘引試験でも, 合成PB 0.5 μg 含有錠剤はワモンゴキブリ, トビイロゴキブリ, ヤマトゴキブリに有効であった。