Movement of adult German cockroaches, *Blattella germanica* (Linnaeus), from an occupied harbourage shelter to a vacant new shelter

3. Interaction between males and females

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Abstract: When a harbourage shelter occupied by marked cockroaches was placed in one of two compartments divided by a partition with a small hole through which the cockroaches could come in and go out in a test container, and another new and vacant shelter was placed in the other, the movement frequency of male adults from one compartment to the other was much higher than that of female adults. The movement frequency of male adults increased with the increase of population density more sensitively than that of female adults. When female adults were released into a test container where only one shelter fully occupied by male adults had been placed, most of the male adults in the shelter were replaced by the female adults within 10 minutes. Female adults having fully occupied a shelter, however, were not replaced by introduced male adults. These results indicate that female adults prevail over male adults in their interaction for a suitable harbourage space, while male adults tend to seek new space more actively than female adults.

INTRODUCTION

We have found that the movement of adult German cockroaches, *Blattella germanica* (Linnaeus), from an old harbourage shelter to a new one is usually dependent on the increase of their population density. However, female adults sometimes did not move to the new shelter even under high density conditions, especially when there was a partition plate between the two shelters (Takahashi *et al.*, 1996). The presence of food and water close to the old shelter tended to deter the cockroaches from moving to the new shel-

ter (Takahashi *et al.*, 1997).

In these experiments, however, the movement of individual cockroaches between the two shelter had not been examined. Therefore, experiments with marked individuals were conducted under the same conditions as used in the previous experiments using a partition plate with a small opening between two compartments in each of which was placed a harbourage shelter.

Other experiments were also carried out in order to evaluate the influence of some interaction between males and females on their harbouring behaviour, by giving only one shelter to them. Results of these

experiments are reported here.

MATERIALS AND METHODS

Exp. 1. Movement of marked cockroaches between two compartments. Adult German cockroaches, *B. germanica* (L.) (Watarida strain), were individually marked and numbered by adhibiting a very small piece of adhesive plaster sheet on the pronotum. Each of the shelters was a tier of two panels of 5×5 cm size, a plywood floor panel and a plastic ceiling panel, with a 0.5 cm space between them. The plastic ceiling panel was transparent and orange-coloured, so that cockroaches did not avoid the shelter and could be easily observed. The shelter was essentially the same as that used in a previous experiment (Takahashi *et al.*, 1996).

The test container was a plastic tray of 13 cm×22 cm and 6 cm height, which was divided into 2 compartments, A and B, by a vinyl partition plate with a small central passage opening (1×0.5 cm) at a height of 3 cm to allow cockroaches to move between the compartments. The top 4 cm inner surface of the tray and that of the partition plate were coated with paraffin oil to prevent cockroaches from escaping. Food and water were placed in both compartments.

First, a shelter was given to 16 or 32 cockroaches in a plastic cup (8 cm diameter, 4 cm depth). After 7 days, when all the cockroaches settled in the shelter, the shelter with the cockroaches was carefully taken out, transferred to the test container, and placed in the centre of one compartment (A) of the two. Then another (new and vacant) shelter was placed in the other compartment (B).

All the females are without egg case at the beginning of the experiment. However, about 2/3 of the females surviving on the 12th day had egg cases.

The experiments were carried out in 8 h dark and 16 h light at $25\pm1^{\circ}\text{C}$, under uncontrolled relative humidity ranging from 50 to 65%. Two replicates were employed

in each experiment.

Exp. 2. Interaction between males and females. The test container was a plastic tray of the same type as used in Exp. 1 (13 cm×22 cm and 6 cm height), but was not divided into two compartments. A shelter (also the same as that used in Exp. 1) occupied by 16 adults of one sex was placed in the centre, and then 16 adults of the other sex were introduced into the container.

Female adults used were taken from our stock culture at random, and about 2/3 of them usually had their egg cases. They were provided with enough food and water during the experiment.

RESULTS AND DISCUSSION

1) Movement of individuals. Movement of individual males between A and B compartments in one of the replicates under the higher population density (32 per container) is shown in Fig. 1, and that of females in Fig. 2. In contrast with 16 among 30 females (Fig. 2), only 5 among 27 males (Fig. 1) were observed in A compartment every morning during the entire test period of 12 days. Similar results were obtained in another replicate.

Data for the lower population density (16 per container) were also determined in the same way as shown in Figs. 1 and 2, and movement frequency of the total number of cockroaches in the two replicates surviving at the 12th day is shown in Fig. 3. The numbers of cockroaches surviving were $14+16=30$ males and $16+16=32$ females at the lower population density, and $27+17(7\text{ escaped})=44$ males and $30+26=56$ females at the higher density.

Under the lower population density, 50% of males changed their harbourage compartment twice or more, whereas 28% of females did so. Under the higher density condition (32 per container), 69% of males changed the compartment twice or more, and so did about 36% of females.

Among the females, those with egg

Fig. 1. Movement of 32 adult males between A and B compartments in a test container.

A, Compartment where an occupied harbourage shelter was placed; B, Compartment where a new shelter was placed; ●, In the shelter; ○, Outside the shelter; D, Death.

Fig. 2. Movement of 32 adult females between A and B compartments in a test container.

A, Compartment where an occupied harbourage shelter was placed; B, Compartment where a new shelter was placed; ●, In the shelter; ○, Outside the shelter; D, Death.

Fig. 3. Comparison of movement frequency of adult cockroaches between compartments during the test period (Total number of surviving cockroaches in two replicates).

Initial population density, L: 16, H: 32; Movement frequency, ■ ≤1, ▨ =2, □ ≥3.

cases were 19 and 36, at the low and high densities, respectively, on the 12th day. The pattern of frequency composition for the females with egg cases was similar to that for the total females (Fig. 3).

Under the both population density conditions, 16, and 32 cockroaches per container, males were clearly more mobile than females between the two compartments, responding sensitively to the increase of population density (Fig. 3). The movement frequency of females did not increase so much as in males. The data suggest that female adults not only have less mobility (Kanayama *et al.*, 1993), but also are not so sensitive as males to the increase of population density.

2) *Interaction between males and females.* When 16 females were released in a test container where 16 males had already occupied the shelter, the males tended to come out of the shelter, and

most of the females entered the shelter within 60 minutes (Fig. 4A). After 60 minutes, the number of males remaining in the shelter was merely one-third of the initial number. Thereafter, the prevalence of the females in the shelter continued (Fig. 4B).

When males were released in a test container where females had already occupied the shelter, most of the males tried to enter the shelter within 10 minutes, but females did not come out of the shelter (Fig. 5A). Most of the males, however, could not stay longer in the shelter occupied by females (Fig. 5B). The results of a preliminary experiment carried out for 8 days were similar to those described here.

When females were released near to the shelter occupied by males (Fig. 4), many males quickly came out of the shelter and chased the females, taking a calling-pose. This indicates that most of the males spon-

Fig. 4. Change in the number of cockroaches harbouring in the shelter.

Sixteen females were released in a test container where sixteen males had already occupied the shelter.

taneously left the shelter responding to the females to make copulation, while females entered the shelter pushing out males still remaining in the shelter, and prevailed over the males within 10 minutes. On the other hand, when females had already occupied the shelter, later-released males did not prevail over the females in the shelter (Fig. 5).

These results seem to show not only that females less frequently move about but that males and females have some interaction in the shelter and females can predominantly obtain the suitable harbourage space.

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Fig. 5. Change in the number of cockroaches harbouring in a shelter.

Sixteen males were released in a test container where sixteen females had already occupied the shelter.

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摘 要

チャバネゴキブリ成虫の新潜伏場所への移動
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通行口のあるバリアーパネルで2分割した試験容器の一方の区画内に、個体識別用にマーキングしたチャバネゴキブリ成虫が潜伏定着しているシェルターを置き、

他方の区画内に空の新しいシェルターを置くと、通行口を通る2区間の移動頻度は雄成虫が高く、雌のそれは低かった。また、雄の移動頻度は個体群密度の増大に敏感に反応して増大したが、雌の移動頻度はあまり変わらなかった。

雄成虫が許容密度限度近く定着しているシェルターの置かれた試験容器(分割していない)内に同数の雌成虫を放すと、10分以内にシェルター内の大部分の雄が雌と入れ替わり、その後も雌が優勢に潜伏した。逆に、雌成虫が定着しているシェルターの置かれた試験容器内に雄成虫を放すと雌は優勢に潜伏したままで、雄による置き換わりは起こらなかった。以上のことは、雌成虫の移動頻度が少ないことだけでなく、雄成虫と雌成虫との間に相互作用があり、雌成虫が優先的に潜伏することを示している。