

Sexual Behavior of the Horned Beetle, *Allomyrina dichotoma septentrionalis* (Coleoptera, Scarabaeidae)

Yutaka IGUCHI

Laboratory of Biology, 1-10-6, Yamashita-cho, Okaya City, Nagano, 394 Japan

Abstract Sexual behavior of the horned beetle, *Allomyrina dichotoma septentrionalis* in plastic boxes was observed under three conditions: male-female, male-male, and female-female interactions. The courtship behavior showed the same pattern and consisted of the following five phases under any condition: *approaching*, *abdomen shaking*, *mounting*, *licking*, and *abdomen bending*. The male-male and the female-female courtship behavior were "homosexual" behavior. There were significant differences in the *one-cycle time* of abdomen shaking among the observed individuals. None of the males courted by the "homosexual" ones used their horns as weapons. The horns may be useless in preventing the courtship of "homosexual" males. Both males and females often fought against individuals of the same sex. However, none of the individuals courted by the "homosexual" ones attacked these "homosexual" ones. In *A. d. septentrionalis*, the "homosexual" behavior may inhibit the fighting behavior of individuals of the same sex.

Key words: *Allomyrina dichotoma septentrionalis*; "homosexual" behavior; male courtship behavior; female courtship behavior; fighting behavior.

Introduction

It is well-known in Japan that males of the horned beetle, *Allomyrina dichotoma septentrionalis* often fight each other for food or females. EBERHARD (1980) showed that males of various horned beetles use their horns as weapons in such fighting behavior. OBATA & HIDAKA (1983) analyzed the male fighting behavior of *Allomyrina dichotoma* and reported that males of this species recognized their rivals with visual sense. However, they did not report the courtship behavior nor "homosexuality" in this species at all.

In the summer of 1991, when I observed the male courtship behavior of *A. d. septentrionalis*, I found out by chance that some male courted another male in a plastic box where only males were kept together, and also that some female courted another female in a plastic box containing only females.

In 1992, therefore, I tried three experiments to obtain the information about the characteristics of the courtship behavior in this species.

In the three experiments, the *one-cycle time* (see below) of the abdomen shaking was also measured in order to examine its rhythm. As far as I know, there has been no report on such rhythm. However, I think it is important to

record the rhythm of the abdomen shaking, because we can understand the characteristics of the abdomen shaking more objectively and compare the abdomen shaking among different species in future. Therefore the present paper provides numerical data on the one-cycle time of abdomen shaking.

Materials and Methods

Adults used in this study derived from larvae that had been collected in June, 1992 in Tatsuno-machi, Kamiina-gun, Nagano Prefecture. All observations were made under the light of about 40 lux in a room of the Laboratory of Biology, Okaya City, Nagano Prefecture. The room temperature was not artificially controlled, and it changed naturally between 24 and 26°C. Each individual that showed courtship behavior was marked with the white paint. All individuals were kept in a transparent plastic box (33 cm long × 19 cm wide × 24 cm high) with artificial sap from an insect shop. The three experiments are summarized in Table 1.

Table 1. Summary of the three experiments carried out in 1992.

Experiment	Individual	Observation	
		Date	Time
1:	3 newly emerged ♂♂ (Males 1-3)	Aug. 08	0:00- 3:00
	3 newly emerged ♀♀ (Females 1-3)		
2:	3 newly emerged ♂♂ (Males 4-6)	Aug. 01	0:00- 3:00
3:	1 newly mated ♀ (Female 4)	Aug. 12	0:00- 3:00
	2 newly emerged ♀♀ (Females 5, 6)		

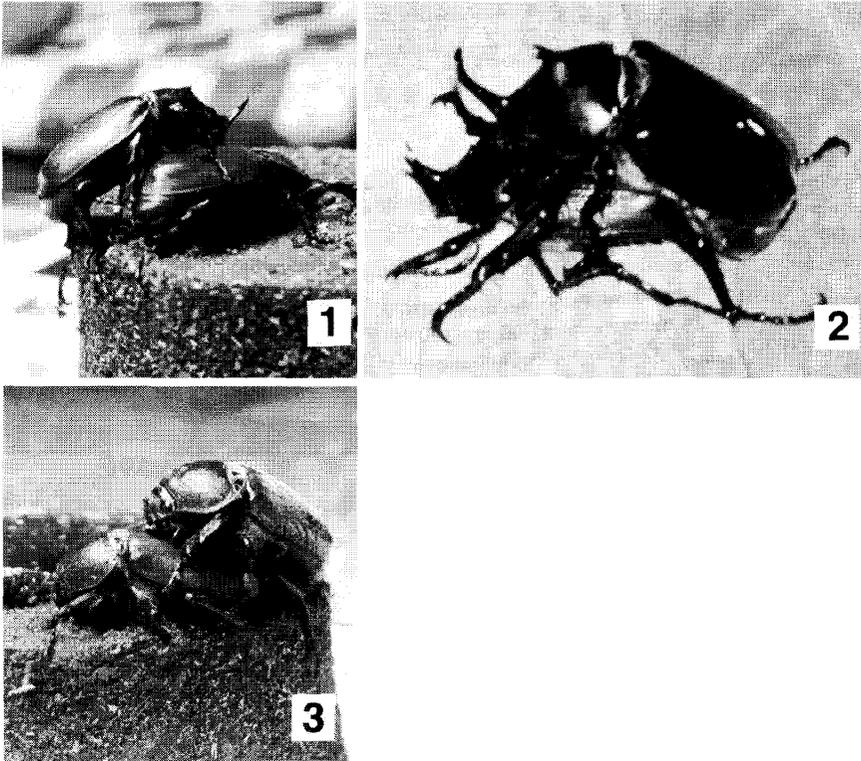
Results

Experiment 1: Male-female interaction

All three males courted females that were sucking sap (Fig. 1). One of them (Male 1) succeeded to copulate with a female (Female 1), and this copulation lasted for about 30 minutes.

The courtship behavior of Male 1 consisted of the following five phases:

- (1) *Approaching*: Male 1 approached Female 1.
- (2) *Abdomen shaking*: Male 1 shook his abdomen regularly from side to side with a sound.
- (3) *Mounting*: Male 1 mounted and hugged Female 1 with his forelegs and midlegs.
- (4) *Licking*: Male 1 licked the elytra and pronotum of Female 1 and tapped them with his antennae.
- (5) *Abdomen bending*: Male 1 bent his abdomen ventrally.



Figs. 1-3. 1. A male courting (mounting and licking) a female. 2. A male courting (abdomen bending) a male. 3. A female courting (mounting and licking) a female.

The courtship behavior of two other males (Males 2 and 3) also consisted of these five phases. However, neither of them succeeded to copulate with any of females (Females 2 and 3) during this observation, because these females rejected copulation and then ran away in spite of the eager courtship behavior and persistent chasing of the males.

It was also observed that when a male was courting a female, he attacked both males and females that approached him.

The one-cycle time (duration of one bout) of abdomen shaking (left-right-left or right-left-right) was measured for each male (Table 2).

Experiment 2: Male-male interaction

One of the three males (Male 4) showed courtship behavior to another male (Male 5) that rested motionless at a corner of the plastic box. It consisted of the above-mentioned five phases.

In abdomen shaking, Male 4 cyclically moved his abdomen with the one-cycle time shown in Table 2. Male 5 made no response to Male 4 during

Table 2. Average one-cycle time of abdomen shaking measured eight times per individual by a stop watch.

Experiment	Individual	No. measured	Mean \pm SD (sec.)
1	Male 1	8	1.07 \pm 0.03
	Male 2	8	1.28 \pm 0.06
	Male 3	8	1.12 \pm 0.05
2	Male 4	8	2.08 \pm 0.08
3	Female 1	8	2.10 \pm 0.10
	Female 2	8	1.63 \pm 0.04

approaching and abdomen shaking. When mounting and licking occurred, however, Male 5 hated to be courted and then ran away without fighting against Male 4. Therefore the last phase, abdomen bending, could not be sufficiently observed here. However, it was clearly observed in the summer of 1991 that a male hugged another male tightly with his forelegs and midlegs and repeatedly projected his penis toward the abdomen of the hugged male (Fig. 2).

Male 4 courted Male 5, but attacked and drove away another male (Male 6).

In both 1991 and 1992, none of the males courted by the "homosexual" ones attacked these "homosexual" ones.

Experiment 3: Female-female interaction

The mated female (Female 4) and one of the two virgin females (Female 5) showed the same courtship behavior as males. Female 4 courted Female 5 that was sucking sap between 1:00 and 2:00 on August 12, and also Female 5 courted Female 4 that was sucking sap between 22:00 and 23:00 on August 12 (Fig. 3). In the summer of 1991, it was also observed that a virgin female courted another virgin female that was sucking sap.

The courtship behavior of these females also consisted of the above-mentioned five phases. The one-cycle time of abdomen shaking in each female is shown in Table 2. None of the females courted by the "homosexual" ones made any response to their courtship behavior and kept sucking sap for a while.

Discussion

In Experiments 2 and 3, both male and female showed "homosexual" behavior just in the same pattern as in the usual male courtship behavior. This result suggests that the courtship behavior of *A. d. septentrionalis* is not necessarily special behavior that males show in order to attract females. OBATA & HIDAKA (1983) reported that males of *A. dichotoma* recognized their rivals with visual sense and then attacked them, and that males recognized females with

chemical sense and then courted them. In Experiment 2, however, Male 4 courted Male 5 and attacked Male 6. In Experiment 1, moreover, one of the "normal" males courting a female attacked not only other males but also other females. These results suggest that males do not always recognize males and females with visual or chemical sense.

FUKAYA (1991) supposed that in the longicorn beetle *Psacotha hilaris* a male pheromone released the male-male mounting behavior. In *A. d. septentrionalis*, the male-male and female-female mounting behavior may be released by male pheromone or female one under the artificial condition.

The one-cycle time of abdomen shaking was nearly constant in each individual, but there were differences among the six individuals that showed the courtship behavior (Table 2). Notably, there was a significant difference even among the three individuals in Experiment 1 ($P < 0.001$; ANOVA). This suggests that the constancy in any individual of the one-cycle time of abdomen shaking may be more important than the numerical value of the one-cycle time in the courtship behavior of *A. d. septentrionalis*. The numerical differences among the six individuals may possibly be only a consequence of individuality.

In our experiments, males often fought each other, as mentioned by OBATA & HIDAKA (1983). Sometimes females also fought each other for sap. In this case, the females butted each other. "Head-butting" between females were often observed in the field by SIVA-JOTHY (1987). In Experiments 2 and 3, however, none of the individuals courted by the "homosexual" ones attacked these "homosexual" ones while they were keeping the courtship behavior. In *A. d. septentrionalis*, the "homosexual" behavior may inhibit the fighting behavior of individuals of the same sex.

OBATA & HIDAKA (1983) reported that the horns of male *A. dichotoma* functioned as weapons. According to SIVA-JOTHY (1987), the bigger horns of major males, the more dangerous. In the present study, however, none of the males courted by the "homosexual" ones used their horns as weapons. That is, the horns were entirely useless in preventing the courtship of "homosexual" males.

The present study was carried out under a limited artificial condition. There is a possibility that the "homosexual" behavior is a product of the artificial condition. Consequently, many field observations and further detailed experiments should be carried out not only to obliterate the possibility of artificiality under some conditions but also to understand the mate recognition system of this species.

References

- EBERHARD, W. G., 1980. Horned beetles. *Sci. Am.*, **242**(3): 124-131.

- FUKAYA, M., 1991. Male mating behavior and female sex pheromone of the yellow spotted longicorn beetle, *Psacotheta hilaris* (Pascoe). *Nature and Insects, Tokyo*, **26**(12): 24–28. (In Japanese.)
- OBATA, S. & T. HIDAKA, 1983. Recognition of opponent and mate in Japanese horned beetle, *Allomyrina dichotoma* L. (Coleoptera, Scarabaeidae). *Kontyû, Tokyo*, **51**: 534–538.
- SIVA-JOTHY, M. T., 1987. Mate securing tactics and the cost of fighting in the Japanese horned beetle, *Allomyrina dichotoma* L. (Scarabaeidae). *J. Ethol.*, **5**: 165–172.

(Received December 6, 1995; Accepted May 17, 1996)