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Differences in the Frequency of Fights between Minor and Major Males in the Horned Beetle *Trypoxylus dichotomus septentrionalis* (Coleoptera: Scarabaeidae)

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Abstract Males of *Trypoxylus dichotomus septentrionalis* (KONO) is dimorphic in horn size and often fight with other males for food or females. I divided male adults into the minors (small males) and the majors (large males) and observed differences in the frequency of fights between the two morphs under laboratory conditions. On average, the majors showed fighting behavior more frequently than the minors. However, some minors showed fighting behavior as frequently as the majors. Horn length did not influence the frequency of fights in the minors.

Introduction

Males of *Trypoxylus dichotomus septentrionalis* (KONO) (= formerly *Allomyrina dichotomus septentrionalis*) are known to fight each other for food or females. Past studies have shown that males used their horns as weapons in intraspecific fights (OBATA & HIDAKA, 1983; SIVA-JOTHY, 1987). Moreover, recent studies have shown that males of this species are divided into two morphs on the basis of hon size, minors (small males) and majors (large males) (SIVA-JOTH, 1987; IGUCHI, 1998, 2000). SIVA-JOTHY (1987) pointed out that minors used an alternative tactic to avoid fighting with majors.

OBATA & HIDAKA (1983) observed that males of this species were aggressive when their feeding was interrupted. However, OBATA & HIDAKA (1983) did not notice the male morphological dimorphism of this beetle. Therefore, they did not examine any differences in fighting behavior between minors and majors. On the other hand, SIVA-JOTHY (1987) reported that majors showed fierce fighting behavior, but that minors did not fight with other males. However, SIVA-JOTHY (1987) did not observe in detail how minors behaved when their

feeding was interrupted. In fact, I sometimes observed that minors fought each other for food in both laboratory and field populations. Particularly minors seemed to show fighting behavior frequently on showing hind-leg swinging behavior (hind-leg swinging behavior was first reported in IGUCHI, 1997).

The aim of the present study is to clarify whether minors show fighting behavior like majors. Through a laboratory experiment, I examined differences in the frequency of fights between minors and majors.

Materials and Methods

For this study, 71 final instar larvae were collected in the soil in the western part of Tatsuno-machi, Kamiina-gun, Nagano Prefecture. Each larva was reared in a glass bottle (9 cm in diameter and 16 cm in height) filled with the soil from its habitat (12 cm deep). All the bottles were placed together outdoors in Okaya City, Nagano Prefecture. Throughout this study, no more humus or soil was added, but water was sprinkled to keep the soil moist.

In this rearing experiment, 30 males emerged. For each male, the length of the head horn was measured to 0.1 mm with a slide caliper. The frequency distribution of horn length was clearly bimodal (Fig. 1). Therefore, these males were divided into minors (horn length < 9 mm) and majors (horn length $\geqq$ 9mm). Of the 30 males, 5 males became physically weak or died soon. Therefore, the other 25 males (13 minors and 12 majors) were used for the following laboratory experiment.

In the experiment, each male was reared in a plastic container (20 cm × 12.5 cm × 12 cm deep). A wood block was also put in this container, and artificial sap was put as food on the top of the wood block. A medium-sized male (8 mm in horn length) was chosen and named Male 0. The other 24 males (12 minors and 12 majors) were also named Males 1–24 respectively. I observed whether Males 1–24 fought with Male 0. For example, the fighting behavior of Male 1 was recorded in the following way:

While Male 1 is feeding and showing hind-leg swinging behavior, I picked up Male 0 and pushed his head horn against Male 1's head horn until Male 1 attacked Male 0 or left the sap site without any attacks. If Male 1 attacked Male 0, this behavior was recorded as a fight of Male 1. This experiment was repeated three times.

The same experiment was carried out for each of the 24 males under the artificial light of 20–30 lux between 19:00 and 3:00. This experiment was similar to that of OBATA & HIDAKA (1983), but they observed whether males attacked a Styrofoam model instead of a living male.

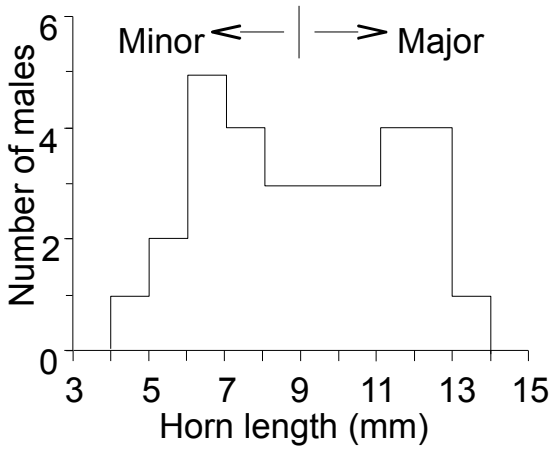

Fig. 1. Frequency distribution of horn length for 30 males obtained from a rearing experiment. The males were divided into minors (horn length < 9 mm) and majors (horn length ≧ 9 mm).

Results and Discussion

As shown in Fig. 2, all the 12 majors showed fighting behavior 2 or 3 times. In contrast, only 5 of the 12 minors showed fighting behavior 2 or 3 times. Consequently, majors tended to show fighting behavior more frequently than minors (Mann-Whitney *U*-test, $U = 23$, $P < 0.01$) and the numbers of fights were more variable in minors than in majors (*F*-test, $F(12, 12) = 10.0$, $P < 0.01$).

As shown in Fig. 3, there was no significant correlation between horn length and fight number in minors (Kendall rank correlation, $\tau = 0.354$, $P > 0.1$). This result meant that horn length did not influence the frequency of fights in minors.

Except for the study of SIVA-JOTHY (1987), there was no previous study on behavioral differences between minors and majors in *T. d. septentrionalis*. SIVA-JOTHY (1987) reported that majors fought with other males violently, but that minors did not fight with other males either in the laboratory or in the field. However, he did not examine differences in the frequency of fights between minors and majors. The present results suggest that the fighting behavior of majors is not only more violent but also more frequent than minors. Nevertheless, the present results mean that even minors sometimes show fighting behavior regardless of their horn length. This was inconsistent with the observation of SIVA-JOTHY (1987). This is probably because his study focused on injury caused by intraspecific fights rather than the frequency of fights. Moreover, he may not have paid attention to minors showing hind-leg swinging behavior. In fact, the present study showed such fighting behavior in minors. As

mentioned in the Introduction, minors showing hind-leg swinging behavior seem to be more aggressive than usual. In future studies, it is necessary to observe differences in the frequency of fights between males showing hind-leg swinging behavior and males not showing this behavior.

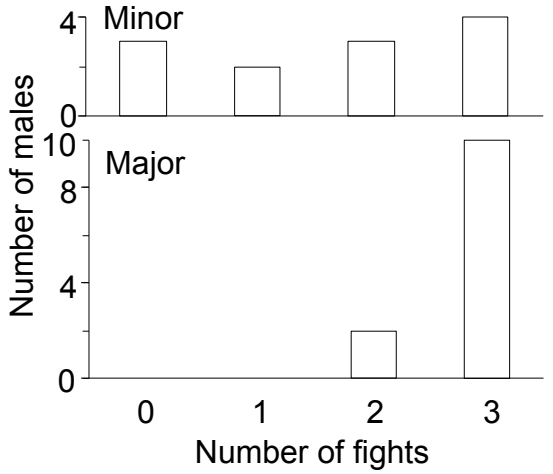

Fig. 2. Frequency distribution of fights in 12 minors and 12 majors. The horizontal axis shows how many times the minors or minors showed fighting behavior.

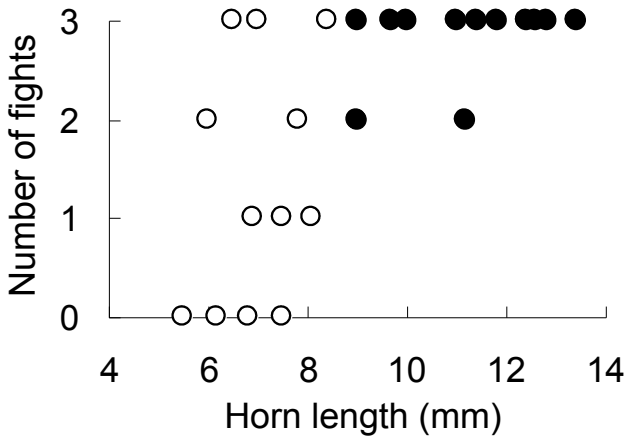

Fig. 3. Relationship between horn length and fight number in 12 minors (●) and 12 majors (○). The vertical axis shows how many times the minors or majors showed fighting behavior.

要　　約

井口豊：カブトムシ雄の角長と闘争頻度について ――― カブトムシ雄を角長に基づいて大型と小型に分け，それぞれの闘争頻度を実験的に観察した．その結果，大型は小型より頻繁に闘争行動を示すことがわかった．ただし，小型の闘争頻度にはバラツキがあり，大型と同じくらい頻繁に闘争行動を示す小型も存在することがわかった．小型では，角長は闘争頻度に影響しなかった．

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