Spec. Publ. Japan Coleopt. Soc. Osaka, (1): 201-204, June 11, 2001

Male Morphological Dimorphism in the Stag Beetle, *Dorcus rectus* (Coleoptera: Lucanidae)

Yutaka IGUCHI

Laboratory of Biology

Yamashita-cho 1–10–6, Okaya City, Nagano Prefecture, 394–0005 , Japan

Abstract The body length and mandible length of males of *Dorcus rectus* (MOTSCHULSKY) were measured. The frequency distribution of mandible length was bimodal. The body-mandible relationship consisted of two different allometric relationships. These results suggested that males of this species showed morphological dimorphism and could be divided into the minors and majors.

Introduction

Male morphological dimorphism is known for several beetle species (e.g., the family Lucanidae: INUKAI, 1924; ARROW, 1937; CLARK, 1977; SAKAINO, 1987; KAWANO, 1988, 1989; IGUCHI, 1992; the family Scarabaeidae: COOK, 1987; EBERHARD, 1987; EBERHARD & GUTIERREZ, 1991; SIVA-JOTHY, 1987; KAWANO, 1995a, 1995b; EMLEN, 1994; RASMUSSEN, 1994; IGUCHI, 1998; the family Ceralnbycidae: GOLDSMITH, 1985). In these beetles, males are divided into the minors and majors with respect to horn or mandible size. The majors have larger horns or mandibles than the minors.

Many species of stag beetles (the family Lucanidae) inhabit Japan, but only a few statistical studies on male dimorphism have been done (e.g., INUKAI, 1924; IGUCHI, 1992). Therefore I here report male dimorphism in *Dorcus rectus*. As I previously suggested the possibility of the existence of male dimorphism in this species (IGUCHI, 1992) on the insufficient evidence.

The present study is carried out to confirm the existence of male dimorphism in this species.

Materials and Methods

For this study, 119 male adults were employed, which were collected in and around Okaya City, Nagano Prefecture, during 1990-1994. For each male, body length and mandible length were measured. Body length was measured from the front of the head to the tip of the elytra along the center line of the body. Mandible length was measured in a straight line parallel to the center line of the body.

To analyze the relationship between body length and mandible length, I used the methods of EBERARD & GUTIERREZ (1991). First of all, the above morphological data were logarithmically transfonned. Next, the data were fit to the following quadratic equation:

$Y = AX^2 + BX + C$

where X was the natural logarithm of body length, Y was the natural logarithm of mandible length, and A , B and C were regression coefficients. Lastly, if A differed significantly from zero, I concluded that the regression was nonlinear and that the body-mandible relationship consisted of two allometric relationships.

My previous study (IGUCHI, 1992) on this species revealed that the body–mandible relationship varied continuously. Therefore, I fit the original (untransformed) data to Model 3 shown by EBERHARD & GUTIERREZ (1991). In other words, I fit the original data to the following two regression lines:

$y = ax + b \ (x \geqq p)$

$y = cx + d \ (x < p)$

where x was body length, y was mandible length, and a, b , c and d were regression coefficients. I determined a switch point p so that the sum of the squared deviations from the regression lines were the smallest.

Results and discussion

The test for the nonlinearity of the allometric relationship showed that A differed significantly from zero (t = 6.23, df = 116, P < 0.001). Therefore, following the above methods, I determined the switch point p as p = 27 and obtained the two regression lines shown in Fig. 1. Both regression lines were highly significant (small males, 12.78, df = 53, P < 0.00; large males, t = 11.34, df = 62, P < 0.001). The slopes of the regression lines differed significantly (t = 5.37,

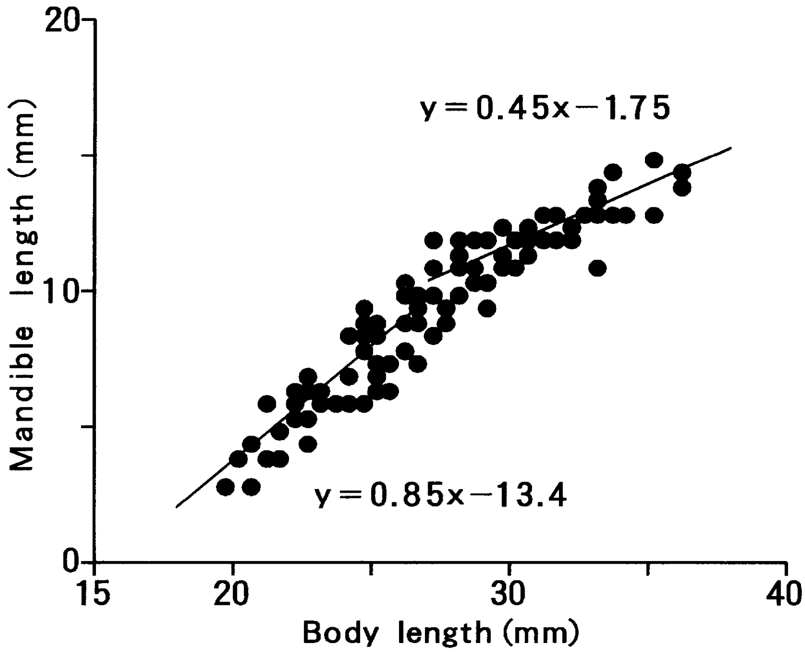

Fig. 1. Relationship between body length and mandible length for 119 males collected in and around Okaya City, Nagano Prefecture. The two regression lines were separately fit to minors (body length < 27 mm) and majors (body length ≧ 27 mm).

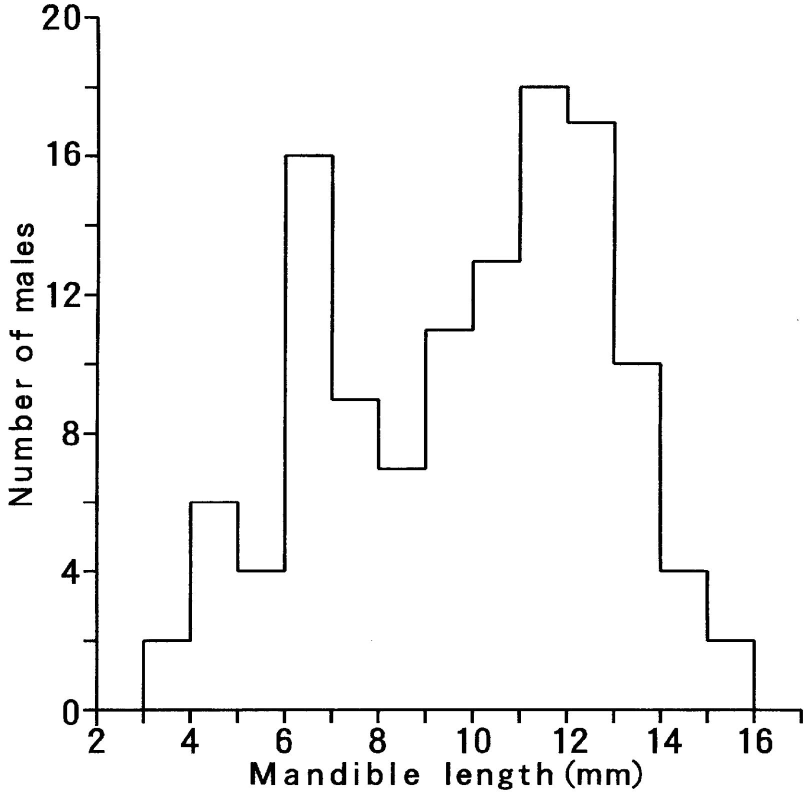

Fig. 2 . Frequency distribution of mandible length for 119 males collected in and around Okaya City, Nagano Prefecture .

df = 115, $P < 0.001$).

The frequency distribution of mandible length was clearly bimodal (Fig. 2). The mandible length of the lowest class between the two peaks was 8–9 mm. On the other hand, the x value of the switch point in the body-mandible relationship was approximately 10 mm (Fig. 1). These values of mandible length were obtained by different methods. Nevertheless, they were almost the same.

The body-mandible relationship did not show clear sigmoidal curve. However, the present results strongly suggested that the males of this species showed morphological dimorphism and could be divided into minors (small males) and majors (large males).

要　　約

井口　豊：コクワガタ雄の二型性について．——— 長野県岡谷市周辺で採集されたコクワガタ雄の体長と大顎長が測定された．体長—大顎長の関係は二つの直線として表現され，大顎長の頻度分布は二山となった．このことから，コクワガタ雄は形態的な二型性を示すと判断された．

References

ARROW, G. J., 1937. Dimorphism in the males of stag-beetles (Coleoptera: Lucanidae). *Trans. R. Ent. Soc. Lond.*, **86**: 239–245 .

CLARK, J. T., 1977. Aspects of variation in the stag beetle *Lucanus cervus* (L.) (Coleoptera: Lucanidae). *Syst. Ent.*, **2**: 9–16.

COOK, D., 1987. Sexual selection in dung beetles. I. A multivariate study of the morphological variation in two species of *Onthophagus* (Scarabaeidae : Onthophagini). *Aust. J. Zool.*, **35**: 123–132.

EBERHARD, W. G., 1987. Use of horns in fights by the dimorphic males of *Ageopsis nigricollis* (Coleoptera , Scarabeidae , Dynastinae). *J. Kans. Entomol. Soc.*, **60**: 504–509.

——— & E. E. GUTIERREZ., 1991. Male dimorphisms in beetles and earwigs and the question of developmental constraints. *Evolution*, **45**: 8–28.

EMLEN, D. J. 1994. Environmental control of horn length dimorphism in the beetle *Onthophagus acuminatus* (Coleoptera: Scarabaeidae). *Proc. R. Soc. Lond. Biol. Sci.*, **256**: 131–136.

GOLDSMITH, S. K., 1985. Male dimorphism in *Dendrobias mandibularis* AUDINET-SERVILLE (Coleoptera: Cerambycidae). *J. Kans. Ent. Soc.*, **58**: 534–538.

IGUCHI, Y., 1992. Individual variation in males of *Macrodorcas rectus* (MOTSHULSKY). *Kontyu to Shizen*, (**27**): 16–19.

——— 1998. Horn dimorphism of *Allomyrina dichotoma septentrionalis* (Coleoptera: Scarabaeidae) affected by larval nutrition. *Ann. Ent. Soc. Am.*, **91**: 845–847.

INUKAI, T., 1924. Statistical studies on the variation of stag beetles. *Trans. Sapporo Nat. Hist. Soc.*, **9**: 77–91.

KAWANO, K., 1988. Why are the horns of Lucanid beetles so imposing? Evolutionary process through competition among males II. *Gekkan-Mushi*, (**210**): 8–15.

——— 1989. Evolutionary mechanism of polymorphism in Lucanid beetles. Evolutionary process through competition among males III. *Gekkan-Mushi*, (**220**): 16–21.

——— 1995a. Horn and wing allometry and male dimorphism in giant rhinoceros beetles (Coleoptera: Scarabaeidae) of tropical Asia and America. *Ann. Entomol. Soc. Am.*, **88**: 92–99 .

——— 1995b. Habitat shift and phenotypic character displacement in sympathy of two closely related rhinoceros beetles species (Coleoptera: Scarabaeidae). *Ann . Entomol . Soc. Am.*, **88**: 641–652.

SAKAINO, H., 1987. Polymorphism in the stag-beetles, and its constructions. *Gekkan-Mushi*, (**197**): 16–20.

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.