Developmental and life history characteristics of the oyster mushroom fly, *Coboldia fuscipes* (Diptera: Scatopsidae)

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Abstract

This study was aimed to elucidate the developmental and life history characteristics of *Coboldia fuscipes* (Diptera: Scatopsidae) which causes serious damage to the oyster mushroom, *Pleurotus ostreatus*, in Korea. The average number of eggs oviposited by a single female was 282. Eggs are usually laid in a mass on the spawn. The total life span was 44.8, 34.4, 24.5 and 18.9 days in males and 43.2, 33.3, 24.1 and 17.9 days in females at 18, 21, 25 and 28°C, respectively. The developmental zero temperatures (t_0) for each stage were estimated from the regression lines as follows: 11.6°C for eggs, 11.5°C for larvae, 9.2°C in male pupae, and 8.8°C in female pupae. The required heat units were 38 degree-days for egg development, 180 for larval development, 66 for male pupal development, and 67 for female pupal development. The developmental threshold based on the total pre-emergence period was 11.6°C for males and 11.1°C for females, and the required heat units were 277 and 283 degree-days for males and females, respectively.

Key words: *Coboldia fuscipes*, developmental characteristics, life history, required heat units, developmental threshold

INTRODUCTION

Mushrooms have long been consumed as foods and herbs, and recently, consumption has rapidly increased. Accordingly, the number of mushroom farmhouses in Korea, which currently comprises almost 1.3% of all farmhouses, has increased (Rural Development Administration, 1996). Moreover, the world market is constantly increasing at a rate of nearly 24% per year, because of the anticancer and immune-promoting activities of mushrooms (Chang et al., 1993).

Among the marketed mushrooms, *Agaricus bisporus*, *Lentinus edode*, *Philomyces confusa*, and *Pleurotus ostreatus* are predominant in Korea. Of these, the oyster mushroom, *P. ostreatus*, is the most important in respect to the number of farmhouses and the market share. Blight and arthropod infestations are the two major problems of mushroom culture by conventional farmhouse operations. Mites, *Rhizoglyphis* spp. and *Histioglyphis* spp., the longicorn beetle, *Moecchotypha diphyis*, termites, *Reticulitermes speratus*, and mushroom

flies, *Lycoriella mali* and *Coboldia fuscipes* have been recognized as the most important arthropod pests (Kim, 1990; Choi et al., 1997; Kim et al., 1999). Mushroom flies, such as Sciaridae, Phoridae, and Cecidomyiidae were reported to cause severe damage to the oyster mushroom and *L. edode* (Kim and Hwang, 1996). Larvae of these mushroom flies damage the mushrooms by feeding on the mycelium. Furthermore, these pests were reported to transmit other pathogens, such as a pyemotid mite, nematodes and mold spores (Wetzel, 1981).

Kim and Kim (1981) reported that a cecidomyiid fly, *Mycophila* sp., caused severe damage to *A. bisporus* cultivated in Korea. Kim and Hwang (1996) reported that a sciarid fly, *Lycoriella* sp., and the cecidomyiid, *Mycophila* sp., are the two most serious pests of the oyster mushroom in the southern part of Korea. In addition, Choi et al. (1996) evaluated the effect of a *Bacillus thuringiensis* strain, which is known to kill dipteran insects, on the biological control of a sciarid fly, *Lycoriella* sp.

Our previous report showed that *C. fuscipes* lar-

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vae damaged the oyster mushroom by feeding on mycelium and the mushroom bed (Kim et al., 1999). In Japan, larvae of *Scatopse fuscipes* (Cook, 1971) are known to feed on mushrooms as well as decaying materials (Shiraki, 1981). Similarly, *Coboldia fuscipes* occurs at high densities in oyster mushroom houses in Korea (Kim et al., 1999). However, this fly has never been intensively studied in Korea.

We report here the developmental characteristics and life history of *C. fuscipes* collected from oyster mushrooms, based on data obtained in the laboratory to provide the basic bionomics data for the implementation of effective pest control measures.

MATERIALS AND METHODS

Insects. The scatopsid fly used for this study was identified as *C. fuscipes* by Prof. Emer. Mitsuhiro Sasakawa. Adult flies of *C. fuscipes* were collected using an aspirator from October 1 to November 15, 1997, at farm houses in Kyungsangnamdo (35.2°N, 128.1°E), Korea. The offspring were reared in a growth chamber at ambient temperatures of 18 ± 1 , 21 ± 1 , 25 ± 1 and $28 \pm 1^\circ\text{C}$ with $55 \pm 5\%$ relative humidity under 12 L–12 D. Adults of this fly occurred all year round and did not show any particular developmental delay at any stage at these temperatures. One unmated female and two males were set in a plastic petri dish (11 cm in diameter) which contained mushroom spawns, and their oviposition behavior was observed under a stereo-microscope ($\times 60$, Zeiss). Larvae were reared on a diet of oyster mushroom spawns. The detailed procedure was described previously in Choi et al. (1997).

Developmental characteristics and life cycle. To investigate the developmental characteristics of the larvae at different temperatures, the length and width of the body, and the width of the head were measured daily under a stereo-microscope with an objective micrometer for a total of approximately 100 individuals that were fixed in 70% alcohol. Furthermore, the body weight of the larvae was measured using a chemical balance. The duration of each stage was thus estimated, and the number of eggs laid by each female was also counted. Life cycle characteristics of this fly were obtained from the rearing experiments at 18 ± 1 , 21 ± 1 , 25 ± 1 and $28 \pm 1^\circ\text{C}$. Heat requirements for the development of

each stage were determined by regression analysis as described in Takeda and Chippendale (1982). Observations continued from egg to adult at 3 h intervals. Approximately 800 individuals were maintained in each treatment. The experiments were repeated three times. Means and standard errors were calculated, and developmental parameters were estimated using these data and linear regression.

RESULTS AND DISCUSSION

Developmental characteristics and life history

Mean weight and size of eggs were $1.23 \pm 0.1 \mu\text{g}$ (mean $\pm$ SD, $n=60$) and $0.1 \times 0.3 \text{ mm}$, respectively. The mean durations of the egg period were 5.3, 4.5, 2.8 and 2.3 days at 18, 21, 25 and 28°C , respectively (Table 1).

Soon after hatching, larvae started to eat both the mycelium and potato dextrose agar medium in the petri dish. Larvae moulted three times at all rearing temperatures. Mean weight and length of the 1st instars were $1.7 \pm 0.2 \mu\text{g}$ and $0.4 \pm 0.1 \text{ mm}$, respectively. The 4th stadium larvae had a mean weight and length of $112.3 \pm 10.4 \mu\text{g}$ and $4.1 \pm 0.6 \text{ mm}$, respectively.

Figure 1 shows developmental patterns of larvae at different temperatures. The maximum values were similar for all measurements at the different temperatures of 21, 25, and 28°C . Mean larval periods, however, differed, being 25.9, 19.8, 14.1 and 10.5 days at 18, 21, 25 and 28°C , respectively (Table 1).

Pupal periods were sexually dimorphic, with those of males being longer. Mean pupal periods of males and females were 7.5 and 7.1, 6.2 and 5.7, 4.5 and 4.3, and 3.5 and 3.4 days at 18, 21, 25 and 28°C , respectively (Table 1). The body size of females was slightly larger than that of males. Mating occurred immediately after emergence, and females subsequently laid 282 ± 21 eggs on spawn, forming a mass of eggs. There were no statistical differences in the mean numbers of eggs laid per female grown at the different temperatures ($p > 0.05$, by LSD test). Adults did not feed on the mycelium and mushroom tissues. Mean longevity was 6.1 and 4.9, 3.9 and 3.3, 3.1 and 2.9, and 2.6 and 1.7 days at 18, 21, 25 and 28°C for male and female adults, respectively (Table 1). A similar pattern was also observed for other species of mushroom fly, *Lycoriella* sp. (Wetzel, 1981; Choi et al.,

Fig. 1. Larval development of *C. fuscipes* at 21 (●), 25 (○) and 28°C (■).

Table 1. Mean developmental time (mean $\pm$ SE days) of *C. fuscipes* at different temperatures

Temperature (°C)	Developmental time (N)				
	Egg	Larva	Pupa (♂/♀)	Adult (♂/♀)	Total ^a (♂/♀)
18	5.3 $\pm$ 0.1 (750)	25.9 $\pm$ 0.8 (721)	7.5 $\pm$ 0.3 (178) 7.1 $\pm$ 0.3 (140)	6.1 $\pm$ 1.3 (56) 4.9 $\pm$ 0.7 (51)	44.8 $\pm$ 2.5 43.2 $\pm$ 1.9
21	4.5 $\pm$ 0.1 (800)	19.8 $\pm$ 1.2 (743)	6.2 $\pm$ 0.1 (205) 5.7 $\pm$ 0.2 (168)	3.9 $\pm$ 1.0 (62) 3.3 $\pm$ 0.5 (51)	34.4 $\pm$ 2.4 33.3 $\pm$ 2.0
25	2.8 $\pm$ 0.1 (772)	14.1 $\pm$ 0.4 (751)	4.5 $\pm$ 0.1 (196) 4.3 $\pm$ 0.2 (190)	3.1 $\pm$ 0.8 (73) 2.9 $\pm$ 0.6 (66)	24.5 $\pm$ 1.4 24.1 $\pm$ 1.3
28	2.3 $\pm$ 0.1 (790)	10.5 $\pm$ 0.7 (770)	3.5 $\pm$ 0.2 (221) 3.4 $\pm$ 0.2 (174)	2.6 $\pm$ 0.4 (80) 1.7 $\pm$ 0.3 (57)	18.9 $\pm$ 1.4 17.9 $\pm$ 1.3

^a From the beginning of egg to adult emergence.

1997).

The life cycle of *C. fuscipes* was estimated from the aforementioned data. The total life span of *C. fuscipes* at 18°C was 44.8 days in males and 43.2 days in females, whereas at 28°C, it was 18.9 days in males and 17.9 days in females.

Heat requirements for the development of each stage

To reconstruct the annual life cycle of *C. fuscipes* in nature, the developmental parameters were calculated based on the data obtained at different temperatures. The reciprocals ($1/d=V$: velocity) were plotted for different temperatures, and linear regression parameters were calculated. The developmental zero temperatures ($t_0=a/b$) at which

Table 2. Parameters of linear regression ($y=a+bx$) for the rate of development against ambient temperatures at each stage of *C. fuscipes*. y , developmental velocity (V); x , temperature (t); t_0 , threshold temperature for development; K , required heat units, degree-days; r , correlation efficient.

Developmental stage		Regression and developmental parameters				
		a	b	t_0	K	r
Egg		-0.305	0.0264	11.6	37.9	0.985
Larva		-0.064	0.0056	11.5	180.0	0.989
Pupa	♂	-0.149	0.0152	9.2	65.8	0.988
	♀	-0.131	0.0149	8.8	67.1	0.995
Pre-emergence total	♂	-0.042	0.0036	11.6	277.0	0.992
	♀	-0.039	0.0035	11.1	283.0	0.991

no development occurs ($V=0$) were estimated from these parameters. Table 2 shows that t_0 for embryonic development was about 11.6°C. In this study, about 94 to 98% of eggs hatched, indicating no difference in hatchability at the different rearing temperatures. T_0 for larval development was about 11.5°C. T_0 for pupal development was sexually dimorphic, being about 9.2°C for males and 8.8°C for females. The required heat units ($K=1/b$) were calculated as 38 (eggs), 180 (larvae), 66 (male pupae), and 67 (female pupae) which add up to 277 (males) and 283 (females) degree-days.

When effective heat units above 11.6°C were calculated based on the average monthly temperatures in the field from 1995 to 1997, 1,685 degree-days appeared to be available for males. Thus, the maximum number of annual generations was 6.1 ($=1,685/277$). However, a more realistic estimation would be five generations per year since this calculation does not include preoviposition period after adult emergence. In actuality, life cycle can not be determined solely by the heat units, because the available diet in the field fluctuates seasonally. In contrast, this pest may be able to repeat more generations all year round in farm houses with a sufficient supply of food and under favorable temperature conditions for development. A comparison between the farm house and natural populations is an extremely intriguing topic for future study. The present data including fecundity and thermal requirements for development of this species may serve as a guide for the establishment of control measures against this pest in farmhouses.

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REFERENCES

- Chang, S. T., J. A. Buswell and S. W. Chiu (1993) *Mushroom Biology and Mushroom Products*. Chinese Univ. Press, Hong Kong, pp. 4–13.
- Choi, K. H., H. C. Park, P. D. Kang, E. K. Kang and H. D. Sohn (1997) Development characteristics and life cycle of a Sciarid fly (*Lycoriella* sp.) in indoor rearing. *Kor. J. Appl. Entomol.* 36: 77–82.
- Choi, K. H., H. C. Park, H. W. Park, B. R. Jin, S. K. Kang and H. D. Sohn (1996) A study on the biological control of Sciarid fly (*Lycoriella* sp.) using *Bacillus thuringiensis*. *Kor. J. Life Sci.* 6: 293–298.
- Cook, E. F. (1971) The Australian scatopsidae. *Aust. J. Zool., Suppl.* 8: 90.
- Kim, K. C. and C. Y. Hwang (1996) An investigation of insect pest on the mushroom (*Lentinus edode*, *Pleurotus ostreatus*) in south region of Korea. *Kor. J. Appl. Entomol.* 35: 45–47.
- Kim, K. P. (1990) The ecology and management on mushroom pest. *New Gardening* 4: 43–47 (in Korean).
- Kim, S. R., K. H. Choi, E. S. Cho, W. J. Yang, B. R. Jin and H. D. Sohn (1999) An investigation of the major dipteran pests on the oyster mushroom (*Pleurotus ostreatus*) in Korea. *Kor. J. Appl. Entomol.* 38: 41–46.
- Kim, T. S. and K. P. Kim (1981) Selection of pesticides for control of mushroom infesting fly. *Res. Rep. RDA* 24: 660–671 (in Korean).
- Rural Development Administration (1996) *Agricultural Promotion Business Statistical Data*. Suwon, pp. 192–193 (in Korean).
- Shiraki, T. (1981) *Classification of Insects*. 4th ed. Hokuryukan Co. Press, Tokyo. 668 pp.
- Takeda, M. and G. M. Chippendale (1982) Phenological adaptation of a colonizing insect: the southwestern corn borer, *Diatraea grandiosella*. *Oecologia* 53: 386–393.
- Wetzel, H. A. (1981) Integrated pest management. *Mushroom News* 29 (8): 29–33.