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*cucurbitae* (COQUILLET) (Diptera: Tephritidae)

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**Abstract** The relationship between age and the development of ovaries in the female wild melon fly, *Bactrocera* (= *Dacus*) *cucurbitae*, when reared under a short-day photoperiod, was studied to clarify the reason why the mating of the wild melon fly is delayed during the winter season of the Ryukyu Isles. The percent of flies with mature eggs was only 9.3 in the age group of 26 to 35 days and 83.3 in the age group of 96 to 105 days. The variation in the number of eggs within each age group was considerably larger as the flies became older, indicating that the sexual maturity of the female varied and was also delayed in the winter.

**Key words** *Bactrocera cucurbitae*; Melon fly; Sexual maturity

## Introduction

One of the essential prerequisites for successful application of the sterile insect technique is to prevent the deterioration in quality of mass-reared insects. The quality is usually represented by the sexual competitiveness (Haisch, 1970; Iwahashi et al., 1983). Thus the comparison of mating behavior between the mass-reared and wild insects is of great significance.

The melon fly, *Bactrocera cucurbitae*, may be one of the best studied insects. Its mating

behavior has been well studied for both mass-reared and wild flies (e.g. Suzuki and Koyama, 1980; Soemori, 1980; Iwahashi and Majima, 1986). Table 1, derived from the first two works and Iwahashi (unpubl.), shows a comparison of the age of sexual maturation between mass-reared and wild melon flies during each period of three different seasons. Mass-reared flies began to mate at days 3 to 6 of adult life and 50% of them were mated by day 9 in all three seasons. Wild flies started mating at days 5 to 6

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and 50% of them were mated by days 12 to 13 in the summer and fall. The difference between the two groups was not so large during the summer and fall months. However, in the winter the first mating in the wild flies occurred at day 26 and only 35% of the females had mated by day 70 when the experiment was concluded (Soemori, 1980). Soemori pointed out that the mass-reared flies tended to mate more readily than the wild ones. However, he did not discuss why the mating rate of the wild flies became so low in the winter. There might be some factors decreasing the mating rate, such as delayed sexual maturity, female mate choice (Hibino and Iwahashi, 1989, 1991; Kasiya, 1992), artificial rearing conditions of adult flies and so on. Here, we show that the delayed sexual maturity of the female which is induced by a short-day photoperiod may be the cause of the low mating rate of the melon fly in the subtropical winter in Okinawa.

#### Materials and Methods

Infested fruit of the bitter cucumber, *Momordica charantia* L., were collected in the southern part of Okinawa Is. in October 1986. More than 500 adult flies obtained from these fruit were reared in a screen cage (30 X 30 X 45cm), and fed on a mixture of protein hydrolysate and sugar, and water. Progeny (F1) which had emerged from December through February were collected, sexed within 3 days. Females flies were grouped every 10 days and fed on the same diet as for their parents. Each group was reared in a small screen cage of 20 X 20 X 20 cm at  $27 \pm 1^\circ\text{C}$  at natural daylight conditions, that is, the same conditions as used by Soemori (1980). All of adult flies were dissected when the flies which had emerged on February 5 became 26 days old, since the first mating occurred 26 days after adult eclosion in the Soemori's winter experiment. Only females were

Table 1. Comparison of age (days posteclosion) of the first mating and age at which more than 50% of the female were mated between mass-reared and wild melon fly, *Bactrocera cucurbitae* females in various seasonal conditions in Okinawa.

表1 沖縄における各季節下でのウリミバエ *Bactrocera cucurbitae* の大量増殖虫と野生虫の初回交尾及び50%交尾日齢の比較

Age of: 日齢	Mass reared flies examined in 大量増殖虫			Wild flies examined in 野生虫		
	Summer* 夏期	Fall** 秋期	Winter*** 冬期	Summer* 夏期	Fall** 秋期	Winter*** 冬期
First mating	3	6	6	5	6	26
初回交尾						
More than 50% females mated	4	8	9	12	13	>70
50%以上の雌が交尾						

\*July, 1979; 15L:9D and  $27 \pm 1^\circ\text{C}$  (Suzuki and Koyama, 1980).

\*\*October, 1985; natural daylight and temperature (Iwahashi, unpubl.).

\*\*\*December, 1978 - February, 1979; natural daylight and  $27 \pm 1^\circ\text{C}$  (Soemori, 1980).

\*1979年7月; 15明:9暗期、 $27 \pm 1^\circ\text{C}$  (Suzuki and Koyama, 1980)。

\*\*1985年10月; 自然日長及び外気温 (岩橋、未発表)。

\*\*\*1978年12月から1979年2月; 自然日長及び $27 \pm 1^\circ\text{C}$  (添盛、1980)。



used in this study since in the male the degree of maturation was difficult to assess by dissection. Thus we dissected females of 8 groups ranging from 26-35 to 96-105 days old.

#### Results and Discussion

Table 2 shows the relationship between age and the frequency of females with mature eggs. In the youngest group of 26 to 35 days old, only 9.3% of the flies had mature eggs. The percent of flies with mature eggs increased with age. The

maximum rate was 83.3% in the oldest group (96-105 days old). In the experiment of Soemori (1980) 35% of the females mated before day 70, while in a similar group of 66-75 days old in our experiment 55% of the females had mature eggs, suggesting that there might have been some females which were sexually matured but did not mate in Soemori's experiment. However, even if there were some such females, the delayed sexual maturity may be mainly responsible for the low mating rate of the melon fly in winter.

Table 2. Relationships between age and sexual maturation in females of wild melon fly *Bactrocera cucurbitae* in winter.\*  
表2 冬期におけるウリミバエ *Bactrocera cucurbitae* 野生雌の日齢と性成熟の関係\*

	Age-group (day)								Kendall's rank correlation test: Kendall の順位 相関検定	P
	26-35	-45	-55	-65	-75	-85	-95	-105		
No. flies dissected 解剖した雌数	43	22	42	20	42	11	24	30		
No. flies which had matured eggs 成熟卵所有雌数	4	3	10	9	23	7	13	25		
% of flies which had matured eggs 成熟卵所有雌率 (%)	9.3	13.6	23.8	45	54.8	63.6	54.2	83.3	0.857	0.00087 ( $<0.001$ )
Median no. eggs** 卵数の中央値	9.5	31	14.5	4	12	18	20	26	0.357	0.138 ( $>0.05$ )
Minimum no. eggs** 卵数の最小値	3	18	4	2	2	9	1	3		
Maximum no. eggs** 卵数の最大値	20	41	52	13	67	36	69	64		

\*Flies emerged from December through February were reared under  $27 \pm 1^\circ\text{C}$  and natural daylight conditions. When flies which had emerged on February 5 became 26 days old, all flies were dissected simultaneously.

\*\*refers only to flies with mature eggs.

\*12月から2月に $27 \pm 1^\circ\text{C}$ 、自然日長下飼育で羽化した虫について調べた。

2月5日に羽化したハエが26日齢になったとき、すべてのハエを同時に解剖した。

\*\*成熟卵を持っていた個体についてのみ調べた。



In the females with mature eggs, the median number of eggs ranged from 4 to 31 and was not correlated with age (Table 2). The variation in the number of eggs within each age group was considerably large even when the flies became older, indicating that the sexual maturity of the female not only delayed but also varied in winter.

The experimental regimes in the experiment by Soemori (1980) and this study were same to that of Suzuki and Koyama (1980) except for light conditions. The summer experiment of the latter was conducted under artificial long-day condition of 15L:9 D, while the winter experiments by Soemori (1980) and by us were conducted under natural short-day conditions. There is then the possibility that the delayed and asynchronous sexual maturity of melon fly females in winter may be a kind of diapause induced by a short-day photoperiod.

In another summer experiment (Soemori and Nakamori, 1981) conducted under natural light conditions at 27°C, only 28% of wild flies mated by day 40, while more than 50% of mass-reared flies did so by day 8, suggesting that the rate of mating of wild flies may be low even under a long-day photoperiod. However this can not be directly ascribed to delayed sexual maturation. Overcrowding of adults in cages and/or female mate choice (Hibino and Iwahashi, 1989, 1991; Kasuya, 1992), may be involved in the low mating rate of the wild melon flies. Thus we infer that a short day may cause delayed sexual maturation in the female melon fly in winter. The delaying effect might be clearer under natural conditions, since the mean winter temperature in Okinawa is about 15°C, much lower than the temperature used in the experiment.

It might have been advantageous for the female to avoid the cool winter and reproduce in the spring, by increasing longevity and delaying sexual maturity. If asynchronous sexual maturation occurs in response to short days in mild winter, some females can reproduce under decreased competition for host plants. If such adaptive benefits exist,

the melon fly would have evolved the delayed and asynchronous responses to the winter short days in the northern limit of their distribution. It would seem worthwhile to determine whether this species is actually sensitive to photoperiod by conducting appropriate experiments.

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#### 要 旨

沖縄では冬期にウリミバエ *Bactrocera* (= *Dacus*) *cucurbitae* 野生虫の交尾が大幅に遅れることが知られている。この原因解明のため、冬期に短日の自然日長下でウリミバエ野生雌を飼育し、卵の発育状態を調べた。その結果成熟卵を持つ雌の割合は、26日から35日齢で9.3%と低く、105日齢でも83.3%となり、性成熟が極端に遅れていた。しかも性成熟の度合は個体によってばらついていることもわかった。この結果を冬期の沖縄における本種の繁殖戦略の観点から考察した。