Comparison of Dispersal Ability and Longevity for Wild and Mass-Reared Melon Flies, *Dacus cucurbitae* COQUILLET (Diptera : Tephritidae), Under Field Conditions

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The dispersal rate and longevity of the melon fly, *Dacus cucurbitae* COQUILLET, were compared for wild and mass-reared strains under field conditions at Ishigaki Is., Okinawa, Japan from 1978 to 1979. The wild strain was reared with squash for 3 generations, and the mass-reared strain was given an artificial diet for 29–39 generations after colonization. Flies of the wild strain travelled a greater distance than those from the mass-rearing. The longevity of flies in the wild strain was also longer than for those in the mass-reared strain. From these results, it was ascertained that some deterioration in the quality of flies had occurred in the course of mass-rearing.

INTRODUCTION

In the mass-rearing of insects for the sterile insect release method (SIRM), the importance of quality control of the insects has been emphasized (BOLLER, 1972; CHAMBERS, 1977).

In 1972, a large scale experimental project to eradicate the melon fly, *Dacus cucurbitae* COQUILLET, with SIRM was initiated on Kume Island, Okinawa (IWAHASHI, 1977). In this project, a mass-rearing facility was established at the Yaeyama Branch of the Okinawa Prefectural Agricultural Experiment Station, where 1,500,000–4,000,000 pupae of the melon fly have been produced per week since 1974.

Since 25,000 adults were released in a cage (45×60×120 cm) equipped with feeding and oviposition sites, finding their food, mates and oviposition sites was easily accomplished, requiring only a slight movement. It was suspected that generation-to-generation rearing of flies in this way was the cause of any decline in the dispersal ability of the fly.

KAKINOHANA et al. (1977) showed that after 11 generations of rearing, melon flies were not significantly different in dispersal ability from the wild fly. In this paper, dispersion ability and longevity will be investigated for melon flies which have been reared for a much longer time.

MATERIALS AND METHODS

Insect. The methods of mass-rearing were principally the same as those described

in KAKINOHANA et al. 1975. Larvae were reared with an artificial diet containing wheat bran, sugar, dry yeast, sodium benzoate and HCl under room conditions of 20 ± 1.5 or $27\pm 1.5^\circ\text{C}$, 70–80% RH and 12 hours photophase (6 a.m. to 6 p.m.). Adults were released in a cage ($45\times 60\times 120$ cm) with water and a mixture of protein hydrolyzate and sugar under a constant temperature of $27\pm 1.5^\circ\text{C}$ and 12 hours photophase. Females laid eggs in an oviposition device inserted into the cage.

Wild larvae were collected from infested fruit of squash or bitter melon on Ishigaki Is., then reared with a diet of squash. In a cage ($30\times 30\times 45$ cm), about 1,000 adults were reared with the same artificial diet as in the mass-rearing. Rearing continued for three generations before experiments were carried out.

Study field. On Ishigaki Is., 400 km south of Okinawa Is., an experimental plot was set up in a location having small groves, bushes and fields planted with vegetables, sugar cane and pineapple.

Release method. Three experiments were carried out from February 1978 to July 1979. According to the method of calculation offered by KAKINOHANA et al (1979), the mean number of generations in the mass-reared strain of the fly was about 28.5–38.7 at the time of the experiments. Wild flies used for the experiments were reared at the time of each experiment.

Male adults 20 to 30 days old were anesthetized with carbon dioxide for about 30 seconds, then transferred to a petri dish, chilled and marked with lacquer on the dorsal part of the thorax to discriminate between them. Marked flies were kept in a cage for one night to recover from anesthetization, and then allowed to fly out from the cage at the release point the next morning.

Trapping method. In the experimental plot, 42 to 62 Steiner-type traps (STEINER, 1957) baited with 4.75 g cue-lure and 0.25 g naled were placed randomly more than 50 m apart from each other within a radius of about 1 km from the release point (Fig. 1). Flies trapped were counted every second or third day. The design of the ex-

Fig. 1. Map of study area (Experiment 1).

Open and solid circles show the release point and the trapping sites, respectively. Shaded areas indicate small groves and bushes.

Table 1. DESIGN OF EXPERIMENTS

Experiment	Date of release	Strain	No. of generations after colonization	Age of released flies (in days)	No. of released flies	No. of traps
I	Feb. 23 1978	Wild	3	20	1582	62
		Mass-Reared	28.5 ± 1.1^a	20	830	
II	Jul. 1 1978	Wild	3	20	1008	62
		Mass-Reared	31.2 ± 1.2	20	1076	
III	Jul. 3 1979	Wild	3	30	1715	42
		Mass-Reared	38.7 ± 1.4	30	1515	

^a Mean $\pm$ S.D. (Estimated by the method offered by KAKINOHANA et al., 1979).

periments is summarized in Table 1.

RESULTS

Comparison between the dispersal rates of wild and mass-reared flies

Traps are grouped by distance from the release point at intervals of 50 m. The number of flies (m_d) recaptured in traps of the d-distance class is converted into the index, Y_d as follows:

$$Y_d = \frac{10^3 m_d}{M_0 T_d} \quad (1)$$

where M_0 is the number of flies released, and T_d is the number of traps in the d-distance class. This index is based on the assumption that if 1,000 marked flies are released, the number of flies recaptured per trap would be proportional to m_d/M_0 . In Fig. 2, values of $\log(Y_d + 1)$ are plotted against the distance from the release point.

Fig. 2. Dispersal of released flies.

The number of flies recaptured are converted into an index Y_d (see text). Figures in parentheses indicate days from the release to the recapture. Open and solid circles are for mass-reared and wild flies, respectively.

Table 2. PERCENTAGE OF RECAPTURED FLIES AND MEAN DISTANCE OF DISPERSAL FROM THE RELEASE POINT FOR THE WILD AND MASS-REARED FLIES

Experiment	Strain	Percentage recapture ^a	Mean distance of dispersion (meters) ^b
I	Wild	15.17	171.8
	Mass-Reared	9.16	149.0
II	Wild	2.38	90.1
	Mass-Reared	1.02	57.9
III	Wild	13.33	70.46
	Mass-Reared	5.06	51.05

^a Percentage of flies recaptured in all the traps after 20 days (in experiment II) or 21 days (in experiments I and III) from the time of release out of the number of flies released.

^b See text.

This figure demonstrates that wild flies were usually recaptured more frequently than mass-reared ones within 3 days after release, but later the difference between the two strains became obscure. Within 3 days after the release, the wild flies were recaptured in traps distant from the release point, while the mass-reared flies were recaptured only in the traps near the release point. Later, the difference between the numbers of flies in each strain recaptured became obscure. From these results, it seems that wild flies disperse farther than mass-reared flies in the early period after release.

Table 2 shows the percentage recaptured and mean distance of dispersal ($\bar{X}$). The latter index is calculated by the following formula:

$$\bar{X} = \frac{\sum_{j=1}^n X_j \cdot N_j}{\sum_{j=1}^n n_j} \quad (2)$$

where n is the number of traps, X_j is the distance between the release point and trap j , and N_j is the total number of flies recaptured in trap j in 20 days (in experiment II), or in 21 days (in experiment I and III) after release.

In each of the experiments, the values for the percentage recaptured and mean distance of dispersion showed that the wild flies were higher in dispersion ability than the mass-reared flies.

Comparison of longevity for wild and mass-reared flies

The number of flies recaptured was converted into the index Z_i' , which is defined by HAMADA (1976) as follows:

$$Z_i' = \frac{10^4 \cdot m_i}{U_i \cdot M_{0(i)}} \quad (3)$$

where m_i and U_i are the number of marked and native flies caught at time i , respectively, and $M_{0(i)}$ is a modification of M_0 proposed by Itō (1973).

$$M_{0(i)}' = M_0 - \sum_{j=1}^{i-1} m_j' \quad (4)$$

where M_0 is the number of marked flies released at time 0 and m_j is the number of marked flies caught at time j .

In Fig. 3, values of $\log Z_i'$ are plotted against time i (day). If the mortality rate of marked flies per unit time is constant, the following relationship can be expected between Z_i' and i .

Fig. 3. Survival of released flies.

The number of flies recaptured in each of the observation days are converted into the index Z_i' (See text). Open and solid circles indicate mass-reared and wild flies, respectively.

Table 3. COMPARISON OF REGRESSION EQUATION, SURVIVAL RATE AND Z_0' FOR THE WILD AND MASS-REARED FLIES

Experiment	Strain	Regression equation	S^a	Z_0'
I	Wild	$\log Z_i' = 0.84 - 0.05 i$	0.89	6.92
	Mass-Reared	$\log Z_i' = 1.11 - 0.10 i$	0.79	12.88
II	Wild	$\log Z_i' = -0.61 - 0.06 i$	0.87	0.24
	Mass-Reared	$\log Z_i' = -0.65 - 0.10 i$	0.79	0.22
III	Wild	$\log Z_i' = -0.05 - 0.08 i$	0.83	0.89
	Mass-Reared	$\log Z_i' = -0.11 - 0.11 i$	0.78	0.71

^a Survival rate per day.

$$\log Z_i' = \log Z_0' + i \log S \quad (5)$$

where S is survival rate during unit time (day) and Z_0' is a theoretical value of recaptures at time 0. Values of S and Z_0' can be estimated from this equation. Flies recaptured in all the traps were pooled for the drawing Fig. 3.

As seen in Table 3, the survival rate estimated for the wild strain was higher than that for the mass-reared strain in each experiment.

DISCUSSION

As already mentioned, it was reported by KAKINOHANA et al. (1977) that when reared *en masse* for 11 generations, melon flies did not differ in dispersion ability from wild flies. In the present study, however, flies were reared for a much longer period, after which it became apparent that their dispersal ability had been lowered and that their survival rate had declined.

Wild *Dacus oleae* flies dispersed a greater distance than laboratory-reared ones, although no difference was found between the dispersal rates of normal and irradiated laboratory-cultured flies (FLETCHER and ECONOMOPOULOS, 1976). AHERENS et al. (1976) reported that in the screwworm, *Cochliomyia hominivorax*, a newly introduced strain outperformed the old standard production strain in terms of dispersal and survival.

BUSH and NECK (1976) reported in an electrophoretic study that the OLD APHIS strain of screwworms, which had been reared continuously in the mass-rearing facility over 40 generations, had a lower level of genetic variation at the loci examined than that found in the TEX-MEX population, which had just been introduced to the facility. The most dramatic change occurred at the α -glycerophosphate dehydrogenase locus. This enzyme serves a key role in energy flow during flight.

It is thus assumed that in the present study, the deterioration in the dispersion ability of mass-reared flies was brought about by selection pressure provided by the laboratory environment, especially confinement of adults to a small cage in which flies could not fly long distances over many generations.

The released flies must have dispersed in search of food and suitable living circumstances, and therefore flies having less dispersion ability seems to have had less chance to survive. The shortened longevity of mass-reared flies observed in the field is thus considered to have been related to the decline in their ability to disperse. The dispersal rate is also crucial for locating mating sites and encountering mating partners.

In conclusion, it can be said that comparison of the dispersal ability and longevity of wild and mass-reared flies under field conditions is a useful means of quality monitoring in the course of the mass rearing of insects.

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