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Aerial Distribution of Sterile Melon Files, *Dacus cucurbitae* COQUILLETT, Anesthetized by Chilling

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Abstract

With the purpose of eradicating melon flies, Dacus cucurbitae COQUILLETT, an aerial distribution system was devised for the effective use of the sterile insect technique. Sterile pupae were placed in an emergence box which was stored in an air-conditioned container. The emerged files were reared with sugar and water, being followed by an anesthetization with a chilling treatment (3°C) in the second or third day after emergence. The immobilized flies were placed in an apparatus which was specifically designed for broadcasting sterile files effectively. The apparatus was installed one each on both sides of the helicopter. The files were released in an orderly manner with a device of a spiral type adapter. Inside temperature of the apparatus was maintained low to the possible extent of a coolant: i.e. 3°C at the start, followed by a gradual rise, reaching 5°C in 30 min and 10°C in 180 min after the helicopter took off. The survival rate in the emergence box was approximately 81% in 3 days after emergence. The survival rate and the flying capability after chilling were 73.3 and 68.1%, respectively. The survival rate of flies before and after passing through the release apparatus was 98.9 and 98.3% and the flying capability was 93.6 and 91.3%, respectively. There results indicate that the original high quality of the flies was not seriously damaged during the test period.

Discipline: Insect pest

Additional key words: apparatus for releasing files, emergence box, quality control, sterile insect technique

Introduction

In the fruit fly eradication project in which a sterile insect technique (SIT) is employed, it is an important subject to establish an effective method of releasing sterile flies in the fields. In the implementation of the eradication project of insect pests using the SIT, various techniques for distributing sterile flies have been employed according to the insect species, the number of released flies and the ecological conditions of the target area[1,3].

The first application of the SIT in Japan was carried out in Kume Island (58.5 km^2), against the melon flies, *Dacus cucurbitae* COQUILLETT which was eradicated with a success in 1977[4]. In that project, an on-earth application technique was adopted: the sterile pupae were raised in specially designed buckets for release, including emergence and natural dispersal, and those buckets were distributed manually over the island.

After the successful eradication of this species in Kume Island, sterile flies were released in Kerama Islands located between Okinawa Island and Kume Island to prevent Kume Island from reinfestation of the melon flies. At the same time, an aerial distribution of sterile flies was undertaken in Kerama Islands, where sterile pupae were packed in paper bags, which were broadcasted on the fields by a helicopter within a day after emergence.

An eradication project of the melon flies was commenced in 1984 in Miyako Islands (227 km^2),

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which were located 300 km southwest away of Okinawa Island. In designing the implementation of this project, it was estimated that in order to eradicate the concerned species, 40 million sterile flies would be required every week. However, it was neither practically possible to apply the bucket method nor the paper bag method, because the number of flies to be released was so large and many residential areas existed over the target areas.

With the purpose of alleviating such difficulties confronted, an aerial distribution technique was designed in 1983, when the sterile flies were anesthetized by chilling, loaded in the release apparatus, and then the immobilized flies were broadcasted by a helicopter. Loading capacity of the apparatus was one million in population size of the sterile flies[9]. After the eradication of this species in Miyako Islands[6], the release apparatus was modified in 1985/86 so that the loading capacity of the sterile flies could be enlarged. Since 1986, the modified apparatus for release have been subjected to field trials in Okinawa Islands. This report presents a result of the aerial distribution system with a modified release technique to eradicate melon flies.

Emergence box

An emergence box prepared consisted of a carton box (Plate 1-a), latticed partitions (Plate 1-b) and a diet plate with sugar (Plate 1-c)[8]. The latticed partitioning in the box serves in increasing resting areas of emerged flies. Top and central parts of both sides of the carton box were covered by screen (Plate 1-d). Pupae marked with a fluorescence dye were

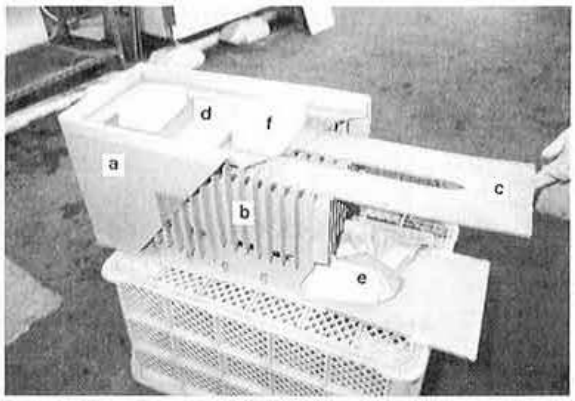

Plate 1. Emergence box
a: Carton box (30 × 62 × 30 cm),
b: Laticide partition, c: Diet plate with sugar,
d: Fine mesh, e: Small paper bag with pupae (20,000 pupae per bag).

filled in small paper bags (20,000 pupae per bag) (Plate 1-e), which were placed in front of the emergence box. Sponges saturated with water were placed on the top of the box (Plate 1-f).

Table 1 shows cumulative mortalities of adult flies reared with different combinations of adults[5]. When only sugar (D) and water (E) was provided, the mortality of adults was rapidly increased with the lapse of adult age, resulting in no flies survived in 4 days after emergence. The cumulative mortality reached 90% in 5 days after emergence when the flies were fed with water and protein hydrolysate (C). When flies reared with sugar and water (B), and standard diet and water (A) as well, more than 97% adult

Table 1. Cumulative mortality of adult flies reared with 6 different combination of diet

Age in day	Kind of diet*				
	A	B	C	D	E
	%	%	%	%	%
1	0.9	0.6	0.6	1.4	1.8
2	1.9	1.1	7.7	47.5	69.7
3	2.2	1.4	51.9	95.0	97.3
4	2.2	1.7	83.4	100.0	100.0
5	2.7	2.0	93.2		

* A: Standard diet (Water, sugar and protein hydrolysate),
B: Water and brown sugar,
C: Water and protein hydrolysate,
D: Sugar, E: Water.

Table 2. Emergence and survival rates, and flying capabilities under different densities of adults in an emergence box

Density	Days after emergence	Emergence rate	Survival rate	Flying capability
	%	%	%	%
30,000	1	84.8	82.8	78.7
	2	85.0	78.9	77.7
	3	84.8	81.7	77.7
40,000	1	84.4	82.6	78.1
	2	84.6	81.0	76.1
	3	85.3	80.4	77.7

flies survived in 5 days after emergence. These results suggest that sugar and water be essential nutrients for young adult flies to survive. Sugar melted in boiled water was coated on a carton plate which was inserted in upper part of the emergence box after the sugar plate was dried up.
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Table 2 shows emergence and survival rates, and flying capabilities at each age of the adults, which were reared under different densities in an emergence box; i.e. 30,000 and 40,000 pupae per box[8]. There were no significant differences in survival rate and flying capability of the adults between these two densities. It was therefore decided that the density of flies per emergence box be of a level of 40,000 in practice.

The pupae placed in an emergence box were stored in an air-conditioned container as stated below, and emerged flies were anesthetized by a chilling treatment before loading on an equipment for aerial release. Temperature of the container was kept at 23°C for 3 days until flies emerged, being followed by a lower temperature of 20–18°C. Since longevity of newly emerged flies was longer under low temperature and dark conditions, the container was kept dark except in the working period. Humidity of the container was maintained at 60% RH so that the sugar diet plate did not turn sticky due to hygroscopic nature of the sugar contained. The flies were subjected to anesthetization by chilling on the third day after emergence.

Anesthetization of adult flies

Carbon dioxide is commonly used to anesthetize insect. Several reports indicate, however, that this chemical has adverse effects on the biological functions of some species. Anesthesia of the mediterranean fruit flies, *Ceratitis capitata*, caused by carbon dioxide resulted in increasing mortality[2]. Anesthesia of the melon fly' adults induced by

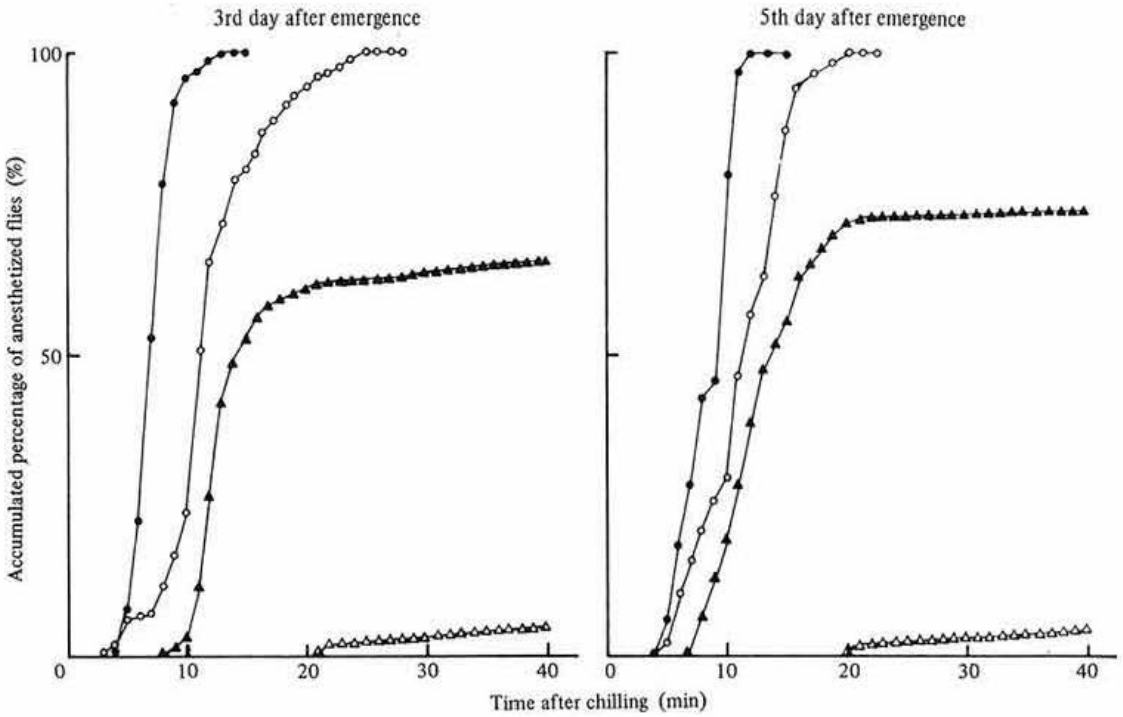

Fig. 1. Relationships between accumulated percentage of immobilized flies and duration of chilling in the 3rd(left) and 5th(right) day after emergence
●, ○, ▲ and △ indicate chilling temperatures of 3°, 5°, 6° and 8°C, respectively.

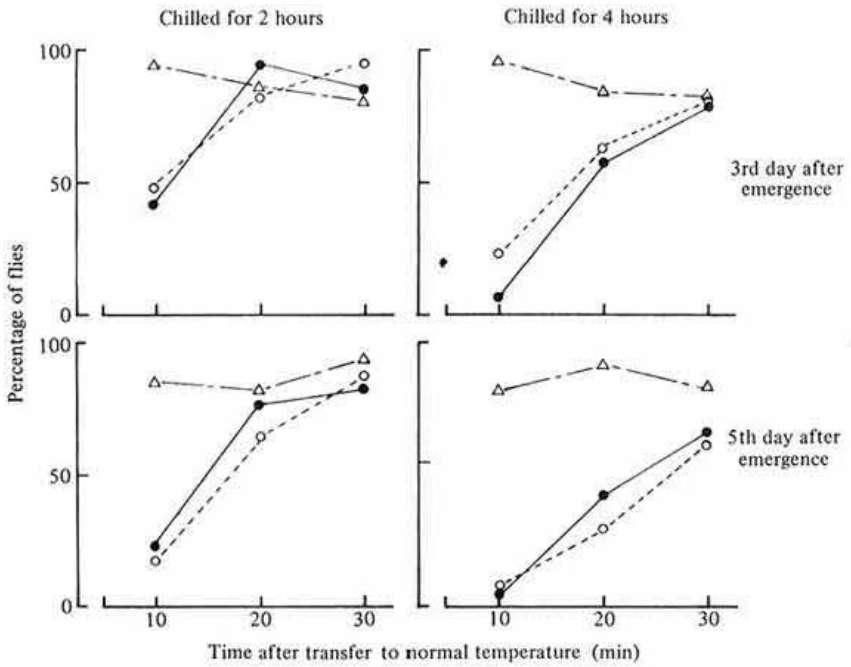

Fig. 2. Relationships between percentage of recovered flies and time for recovery after transfer to normal temperature (27°C) from different chilling conditions ●, ○ and △ indicate chilling temperatures of 2°, 5° and 10°C, respectively.

carbon dioxide also increased mortality, while a chilling treatment at 2°C for 24 hr had no adverse effect on the survival of adults[5].

Fig. 1 shows the relationship of the accumulated percentage of immobilized flies with the duration of chilling at different temperatures[7]. In that experiment, duration required for complete anesthetization was taken into consideration, where flies fell down from their resting sites. The flies were not anesthetized at a temperature above 6°C, whereas they were completely anesthetized at a low temperature below 5°C. These results indicate that the adults should be exposed to a temperature below 5°C for 10–20 min for full anesthetization.

Recovery rates of flies and duration required for recovery after transfer to normal temperature (27°C) from various chilling temperatures are presented in Fig. 2[7]. The time of recovery from anesthetization was recorded when the flies flew out from the fallen sites. It was concluded that 30 min were needed for the flies to recover their normal flying ability.

Apparatus system for releasing sterile flies

An apparatus system for broadcasting sterile flies set on each side of a helicopter (Plate 2-D) consisted of a release apparatus (Plate 2-Ca), a fly loading device (Plate 2-Ba) and a spiral type adapter (Plate 2-Cb) to release the flies from the apparatus in an orderly manner. On the third day after emergence,the flies immobilized by chilling (3°C) were collected in a plastic box from the emergence boxes, then loaded in a device (Plate 2-A), and covered by an aluminum board (Plate 2-Bb). The loading device was installed upside down when set in the apparatus, and a covering board was pulled out, thereby the immobilized flies fell down on the spiral. The apparatus for releasing flies was made of heat-insulating materials (Plate 2-Ca). Inside temperature of the release apparatus was maintained low

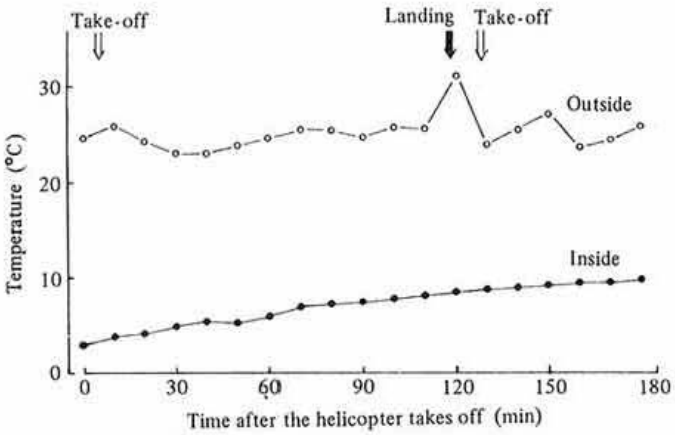

Fig. 3. Temperatures inside (●) and outside (○) the apparatus during the flies release

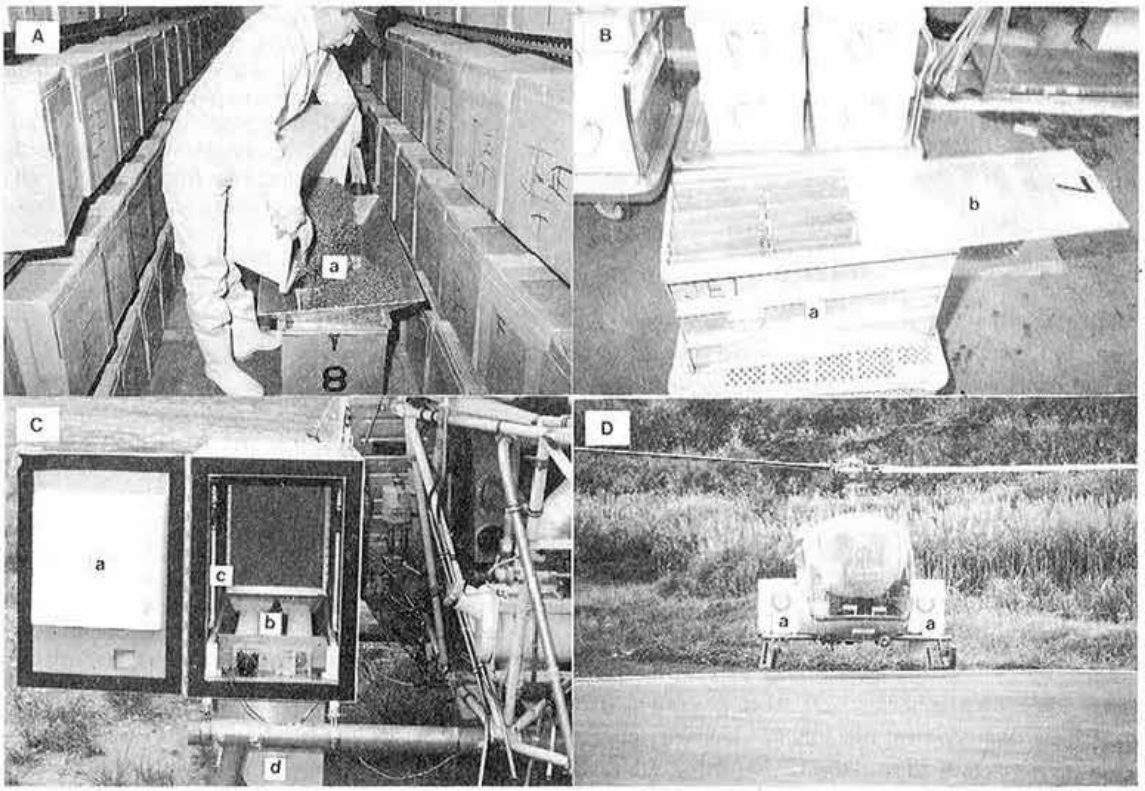

Plate 2. Apparatus system for releasing sterile flies

A: Installing a release device with immobilized flies, Aa: Immobilized flies, Ba: Loading device (37 × 45 × 72 cm), Bb: Covering board, Ca: Apparatus for releasing, Cb: Spiral type adapter, Cc: Coolant to maintain the inside temperature of apparatus constant, Cd: Gate for releasing sterile flies, Da: Loading of release apparatus (46 × 67 × 98 cm) on a helicopter; approximately 4 million flies are released during a flight.

to the possible extent of a coolant (Plate 2-Cc). The number of released flies per given period was automatically regulated by rotation speed of the spiral. As capacity of loading was 2 million flies per each system, it was possible to release 4 million flies per flight.

The survival rates of flies before and after passing through the release apparatus was 98.9 and 98.3%, and the flying capabilities were 93.6 and 91.3%, respectively. These results show that the survival rates and the flying capabilities are both not affected by the above-stated apparatus system, if the inside temperature is maintained at 3—10°C.

Fig. 3 shows temperatures in sequence of time inside as well as outside the apparatus during the fly release in practice. The starting temperature of 3°C inside the apparatus reflected the air-conditioning of the container for anesthetizing adults by chilling before loading. Inside temperature of the apparatus rised gradually and reached 5°C in 30 min and 10°C in 180 min after the helicopter took off. Even in case where the apparatus gate was opened through the flies release, the inside temperature was maintained belw 10°C.

Conclusion

Following the first application in Miyako Islands, the aerial distribution system to broadcast sterile melon flies subjected to anesthetization by chilling has been extensively employed for the trials in Okinawa Islands. Since the achievements of this system entirely depend on the effectiveness of the treatments, consisting of rearing of healthy pupae and young adults in an emergence box, anesthetizing of sterile flies and releasing from an aircraft, regular tests for quality control of flies are required. Toward this end, samples were collected to monitor the quality of flies at each working process of the above trial. Measurements were taken in regard to emergence rate, survival rate, flying capability and number of released flies. During the period under testing, the survival rate in the emergence box was 81.1 ± 5.0% (mean ± S.D.). The survival rate and the flying capability after chilling were 73.3 ± 8.6% and 68.1 ± 10.5%, respectively. These results show that original high quality of the flies was notseriously damaged in the testing period. For practical use of the above system in a large scale, some modifications have been made with the purpose of keeping the quality of flies and reducing the cost and labor requirements.

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