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Successful Eradication Programs on Fruit Flies in Japan

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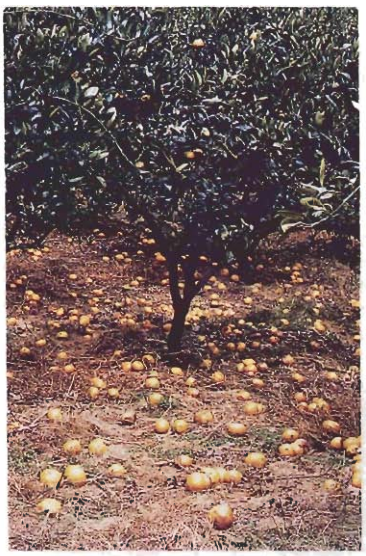
Introduction



Damage by Oriental fruit fly

In Japan, the oriental fruit fly (OFF), Bactrocera dorsalis (Hendel), had been present in the Amami, Okinawa and Bonin Islands whereas the melon fly (MF), Bactrocera cucurbitae (Coquillett), had been known in the Amami and the Okinawa Islands. These fruit flies had seriously affected fruit and vegetable production in these areas. Movement of host plants from these islands was banned by the Plant Protection Law in order to prevent their spread over to Japan mainlands. Such quarantine measures, however, posed great obstacles against the promotion of local agriculture by taking advantage of the subtropical conditions. For the dual purposes to protect the mainlands and to provide permanently free transportation of host plants from these areas, the Ministry of Agriculture, Forestry and Fisheries (MAFF) decided to launch on the eradication programs of these two fruit flies which were to be undertaken by the prefectural governments under overall subsidiary aid from the Japanese Government.

The OFF eradication program in the Southwestern Islands was initiated in Kikai Island in 1968 at an experimental scale by using male annihilation method (MAM). Based on the results of this pilot project, the program was expanded, gradually, from the Amami to Okinawa, Miyako and Yaeyama Islands. The OFF was eradicated from the Amami Islands in May 1980 and from the overall Okinawa Prefecture in February 1986.

The OFF eradication program for the Bonin Islands was introduced in 1975. By the combined use of MAM and sterile insect release method (SIRM), its eradication was achieved in February 1985.

Altogether, the eradication of OFF took 18 years with the total expenditure of 5 billion yen (excluding personnel expenses) and the labor of 192,000 man-days.

On the basis of the success of SIRM in 1978 in the experimental project on Kume Island of the Okinawa Islands, the eradication programs on the MF was implemented in the Amami Islands in 1979 and in Okinawa Prefecture in 1980. The MF was successfully eradicated from the Amami Islands in October 1989 and from the overall Okinawa Prefecture in October 1993.

The time required for the eradication of MF extended over 22 years with the net total of 20.4 billion yen excluding personnel expenses and the labor of 440,000 man-days. The number of released sterile flies reached up to 62.5 billions.

I Intrusion and establishment of fruit flies in Japan

1. Oriental fruit fly (OFF)

The OFF was first recorded in 1919 in the mid-section of Okinawa Island. Apparently, however, it had already been in the Yaeyama and Miyako Islands by that time. Thereafter, it swiftly moved up to the north and established throughout the Amami Islands by 1946.

Introduction of the OFF into the Bonin Islands is believed to be due to the bringing of infested fruit from Saipan Island around 1925. Its distribution all over the Islands was confirmed in 1968.

2. Melon fly (MF)

The MF in Japan was first discovered in 1919 in the Yaeyama Islands of Okinawa Prefecture. It was found in the Miyako Islands in 1929. After a pause of four decades, it was discoverd in the Okinawa Islands in 1972. Then, it spread rapidly northward in Yoron and Okinoerabu Island in 1973 and all over the Amami Islands in 1974.

Also, to the south of the Okinawa Islands, it was found established in the North and South Daito Islands in 1977.

Host Plants of Oriental Fruit Fly

Citrus, Peach, Plum, Fig, Bellpepper,
Tomato, Eggplant, Papaya, Mango, Banana, etc.
40 Families including more than 170 species

Host Plants of Melon Fly

Cucumber, Pumpkin, Watermelon,
Tomato, Eggplant, Sweetpepper,
Papaya, Mango, etc.
16 Families including more than 155 species

Oriental fruit flies (Adults, Left : Female, Right : Male)

Melon flies (Adults, Left : Female, Right : Male)

II Outline of OFF eradication program

1. Amami Islands

The program started in 1968 as an experimental project on Kikai Island by using MAM. Before the application of lure-toxicant, field investigations were made on the duration and range of the attracting effect of methyl eugenol, the life span and the population density of adult stage of wild flies, etc.

The control operation was commenced from September 1968 by aerial and ground application of the fiberblocks which were soaked with lure-toxicant (methyl eugenol 97% + naled (Dibrom) 3%). For the aerial application, small-sized fiberblocks ($6 \times 6 \times 0.9$ cm) were sprayed from helicopter every 10 days all over the Island at the rate of 0.5 pieces/ha. For the ground application which aimed at residential areas, larger-sized fiberblocks ($15 \times 10 \times 0.9$ cm) were manually hung on trees every 10 days at the rate of 2 pieces/ha. A remarkable decline of fly population was observed not long after the operation. However,

it never reached down to the eradication level because of the casual migration of wild flies from adjacent islets. Therefore, the pilot project was supplemented from January 1971 by the suppression control of the adjacent islands including Amami-Ohshima and Tokunoshima.

A full-scale eradication program was initiated in May 1974 covering the whole area of the Amami Islands. Based on the knowhows obtained from the pilot project, aerial spraying of the smaller fiberblocks was conducted at the rate of 0.5 pieces/ha. For residential areas, the larger fiberblocks were hung on trees at the rate of 4 pieces/ha. Also, once a month, lure-toxicant cotton rope (5–10 cm long) was sprayed at 4 pieces/ha basis and/or rolled cotton (3 cm long) at 3 pieces/ha basis.

The OFF was exterminated in Kikai, Amami-Ohshima and Tokunoshima Islands in May 1979 and in Okinoerabu and Yoron Islands in May 1980 thus culminating in the freeing of the whole areas of the Amami Islands from this fruit fly.

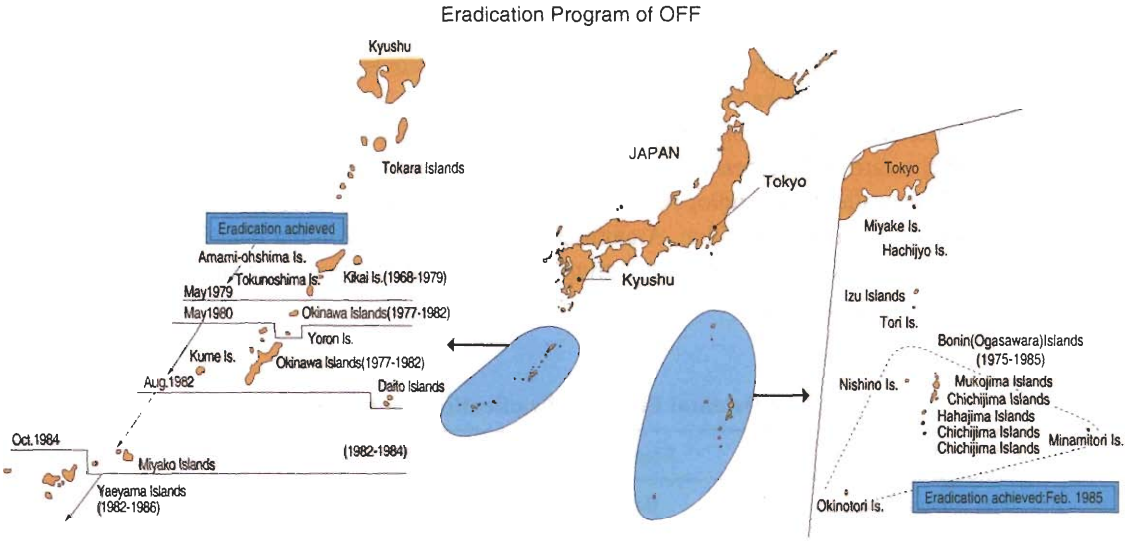
The Oriental Fruit Fly Eradication Programs

Region	Area	Period	Method
The Amami Islands	(km^2)		MAM*
Kikai Is.	56.9	Sept. 1968 – May 1979	
Amami-Ohshima Is.	819.8	May 1974 – May 1979	
Tokunoshima Is.	247.9	do.	
Okinoerabu Is.	93.6	May 1974 – May 1980	
Yoron Is.	20.5	do.	
Subtotal	1,238.7	–	–
Okinawa Prefecture			MAM*
The Okinawa Islands	1,439.2	Oct. 1977 – Aug. 1982	
The Miyako Islands	227.1	Apr. 1982 – Oct. 1984	
The Yaeyama Islands	586.0	Apr. 1982 – Feb. 1986	
Subtotal	2,252.3	–	–
The Bonin Islands	106.2	Dec. 1975 – Feb. 1985	MAM & SIRM**
Total	3,597.2	–	–

[Note] * MAM: Male Annihilation Method, ** SIRM: Sterile Insect Release Method

Oriental fruit flies (Adult)

Oriental fruit fly larvae in Mango



2. Okinawa Prefecture

The eradication program in Okinawa Prefecture started in 1977 with the Okinawa Islands (the Okinawa Island including adjacent islets and the South and North Daito Islands). At the initial stage, the MAM was aerially applied for residential area ca. 7 times a year by using lure-toxicant rolled cotton (3 cm long) at the rate of 5 pieces/ha, while, for non-residential area, rolled cotton (5 cm long) was sprayed ca. 8 times a year at the rate of 6 pieces/ha. This control was not significantly effective apparantly because of the insufficient dose of lure-toxicant coupled with the poor sustaining nature of the absorbent. A remarkable effect was obtained by testing the fiberblocks and by increasing the dose and frequency of application.

A more intensive application of MAM was initiated from April 1979 by totally switching the rolledcotton over to the fiberblocks. For residential area, they were hung on trees 7–12 times a year at the rate of 2–4 pieces/ha. For non-residential area, they were aerially sprayed 8–12 times a year at the rate of 2–3 pieces/ha. The effect of such control was so prominent that the OFF in these islands were exterminated in August 1982.

The eradication on Miyako Islands was initiated in April 1982. For residential area, the fiberblocks were hung 10 times a year at the rate of 4 pieces/ha. For the rest, they were aerially sprayed 8–12 times a year at the rate of 2 pieces/ha. The control effect rose remarkably as expected. Partially, however, a few clustered areas where host plants were abundant and, consequently, the control pressure was relatively weaker, additional hanging of fiberblocks was necessitated. Thus, the Miyako Islands were freed of the OFF in October 1984.

On the Yaeyama Islands, the eradication started in April 1982. Similarly with the case of the Miyako Islands, the fiberblocks were hung for residential areas 10 times a year at the rate of 4 pieces/ha and aerially sprayed for the rest 6–8 times a year at the rate of 2 pieces/ha. The control effect was generally prominent except for some coastal zones and the areas with abundant host plants. Aerial application was strengthened for these areas and the eradication was achieved in February 1986.

With the completion of eradication on the Yaeyama Islands which was the last round of the programs, the OFF was totally wiped out of the whole of Okinawa Prefecture. Such an accomplishment

within relatively shorter time span had benefited greatly from the experiences accumulated in the foregoing programs for the Amami Islands which were fully made available to the campaigns in Okinawa Prefecture.

3. Bonin (Ogasawara) Islands

The past record shows that, before the reversion of the Bonin Islands to Japan, the US Army had tried an eradication of the OFF by the MAM but the attempt was not successful. Preliminary surveys on the ecology of the OFF population revealed a possible presence of a strain which was less sensitive to methyl eugenol. Hence it was decided to adopt the SIRM after reducing the fly population by the MAM.

The first step of the eradication program was undertaken between December 1975 and September 1976 by aerial spraying of lure-toxicant cotton ropes throughout the entire islands and a limited ground application of lure-toxicant fiberblocks. Then, SIRM started from November 1976 with a monthly release of 0.6–3 million sterile flies. Result of this control was not promising because the population of released flies was not sufficient. Consequently, the target areas were divided into three island groups and each group was controlled separately.

On the Mukojima Group, 3 million sterile flies were released from May 1978. On the Hahajima Group, suppression of the fly was made from May 1978 by aerial application of lure-toxicant cotton ropes. After reducing the wild fly population, the monthly release of 2 million sterile flies was commenced from November 1978. On the Chichijima Group, aerial application of lure-toxicant fiberblocks started from May 1978. Then, from February 1982, sterile flies were released at the rate of 6 millions/week. The goal was attained in February 1985 and the OFF was wiped out of the whole Bonin Islands.

III Outline of MF eradication program

1. Pilot program on Kume Island

The MF eradication was initiated in 1972 as an experimental eradication program on Kume Island by using SIRM. For the production of sterile MF, a mass rearing facility was built in the Ishigaki Island and an irradiation facility was established in Naha City, Okinawa Island.

Initial control to suppress fly population was commenced from December 1972 by aerial and ground application of fiberblocks soaked with lure-toxicant (cue-lure: 85%, naled (Dibrom): 5–5.5%, solvent: 9.5–10%). For the areas abundant with host plants, ground application was augmented with the bait spray of protein hydrolysate insecticide mixture (Amber BYF and malathion). Then, from February 1975, 1 million sterile pupae were weekly released by using specially designed plastic baskets. No appreciablly positive results were obtained apparently due to the insufficiency of released flies. Consequently, from June 1976, the released number of sterile pupae was increased up to 4 million weekly basis. Response to this modification of control was so remarkable that the final eradication of Kume Island was confirmed in September 1978.

Since the Kume Island project was designed as an experimental one, special emphasis had also been placed on the research aspects toward the establishment of eradication methodology. Throughout the project, many innovating techniques were developed including the estimation of population density of wild MF, the mass production and sterilization of MF, etc. These technical developments provided sound basis for the full-scale eradication programs that were to follow on the Amami and Okinawa Islands.

The Melon Fly Eradication Programs

Region	Area	Period	No. of released sterile flies/week	Total no. of released sterile flies
The Amami Islands	(km^2)		(millions)	(millions)
Kikai Is.	56.9	Jan. 1981 - Oct. 1985	4	890
Amami-Ohshima Is.	819.8	Feb. 1985 - Nov. 1987	30 - 40	4,380
Tokunoshima Is. Okinoerabu Is. Yoron Is	362.0	Dec. 1986 - Oct. 1989	25 - 33	4,100
Subtotal	1,238.7	–	–	9,370
Okinawa Prefecture				
Kume Is.	60.0	Dec. 1972 - Sept. 1978	1 - 4	360
The Miyako Islands	227.1	Dec. 1977 - Nov. 1987	30 - 48	6,340
The Okinawa Islands	1,379.2	May 1986 - Oct. 1990	80 - 185	30,940
The Yaeyama Islands	586.0	Oct. 1989 - Oct. 1993	83 - 90	15,440
Subtotal	2,252.3	–	–	53,080
Total	3,491.0	–	–	62,450

Melon fly (Adult)

Melon fly larvae in balsam pear

2. Amami Islands

Based on the results of the experimental eradication project on Kume Island, the eradication program for the Amami Islands was designed for each major constituent island under a series of annual projects. The program began with the two year preparatory project (1979–1980) in which the mass rearing and irradiation facilities being capable of producing 4 million sterile insects/week were constructed in Naze City.

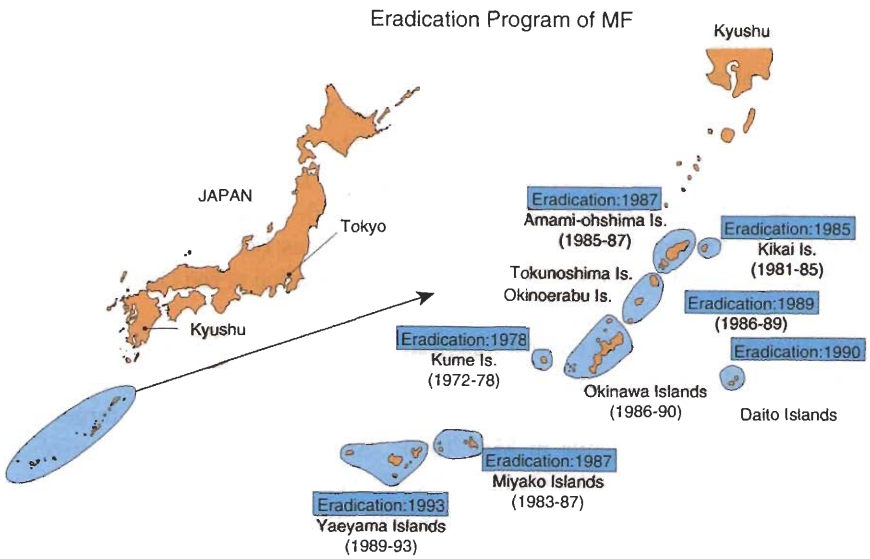
The first eradication control of MF was launched on Kikai Island. Before the application of SIRM, suppression of wild fly density was attempted during January to July, 1981 by aerial spraying of lure-toxicant fiberblocks which was coupled with the ground application of bait spray. Then, from August 1981, 4 million sterile pupae/week were released from the ground by using plastic release baskets. Eradication of MF was accomplished in October 1985.

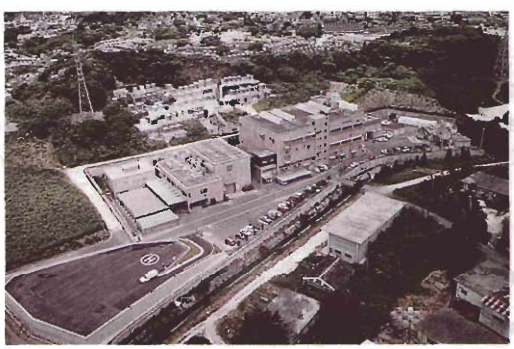
Along with the progress of eradication in Kikai Island, a three year project (1982–1984) got underway in order to reinforce the supply of sterile insects. Thus, an annex mass production facility with a weekly output of 40 million sterile insects was made available.

On the Amami-Ohshima Island, bait spray was applied from February to September 1985 to suppress the fly population in residential areas as well as in the areas of cucurbit production. Then, from September 1985, 30–40 millions of sterile pupae were weekly released by aerial and ground application. Eradication was attained in November 1987.

On Tokunoshima, Okinoerabu and Yoron Islands, bait spray for suppression control was made from December 1986 to May 1987 at or around farming areas and wild plantings where cucurbit and other host plants were present. Aerial and ground releases of sterile pupae started on May 1987 at the level of 25–33 millions/week. Eradication on the three islands was achieved in December 1989. Accordingly, the MF was completely wiped out of the whole Amami Islands and the restrictions on the movement of host plants from these islands were totally lifted.

The achievement of eradication in the Amami Islands took 10 years and 7 months. The total net cost for control (excluding personnel expense) was 3.41 billion yen (national fund: 3.32 billion yen). It took the labor of 122,000 man-days and 9.4 billions of sterile flies for releasing.





Sterile fly mass-rearing facility, Okinawa Prefecture

Loading release apparatus onto a helicopter

3. Okinawa Prefecture

In drawing up the MF eradication program for Okinawa Prefecture, a critical review was made on various factors such as the size and topography of constituent islands and the construction schedule of facilities for mass production of sterile insects, etc. In the annual projects, the eradication campaign was decided to start with the Miyako Islands which were to be followed in series by the Okinawa and the Yaeyama Islands. As a first step of the program, a large scale mass-production and sterilization facility was built in Naha City during the period of 1980–1986.

On the Miyako Islands, suppression control was carried out from December 1983 by aerial spraying of lure-toxicant fiberblocks. After reducing the fly density, the weekly release of 30–40 million sterile flies was commenced on August 1984. A new release technique developed by Okinawa Prefecture was introduced for the operation. Instead of sterile pupae, newly emerged sterile adults were immobilized by chilling (2–5°C) and discharged directly from helicopter using a special equipment for releasing. This method was adopted widely as a standard procedure for the aerial applications in other islands of Okinawa Prefecture. Eradication of the MF on the Miyako Island was achieved in November 1987.

On the Okinawa Islands (Okinawa Island including adjacent islets and South and North Daito Islands), suppression control was initiated on May 1986 in the central and southern areas by aerial spraying of lure-toxicant fiberblocks. This control was switched over to SIRM from November 1986 whereby 80–110 million sterile adults were aerially released weekly. For the mountainous northern areas and neighborhood islets, suppression control started from November 1986 by the aerial application of lure-toxicant fiberblocks. The SIRM was commenced on March 1987 whereby 20–79 million sterile flies were weekly released from helicopter. In South and North Daito Islands, SIRM was initiated on May 1988 by ground application of sterile adults at the basis of 6–10 millions/week. Everywhere, the number of released flies was steadily increased later on. As many as 185 million sterile flies/week were released at a peak time over all the Okinawa Islands. Thus, eradication of the Okinawa Islands resulted in October 1990.

In the Yaeyama Islands, suppression control was firstly undertaken on Ishigaki and Taketomi Island from October 1989 by aerial spraying of lure-toxicant. This was followed by SIRM from January 1990 whereby 40–44 million sterile adults were weekly released from helicopter. The target area was expanded to Iriomote and Yonaguni Islands in May 1990. After the suppression control, SIRM was aerially applied from November 1990 at 43–50 million weekly basis. The number of released sterile flies reached up to 90 millions/week at a peak time throughout the Yaeyama Islands. Eradication was achieved in October 1993.

By the succesful eradication of Yaeyama Islands, MF was completely wiped out of Okinawa Prefecture and the ban and restrictions on the movement of host plants of MF were totally abolished.

The eradication campaign against MF in Okinawa Prefecture took 22 years. The total net cost for the control excluding personnel expenses amounted to 17 billion yen (national fund: 15.14 billion yen). It required 318,000 man-days and the total of 53 billion sterile flies for releasing.

Since the first discovery of MF in 1919 in the Yaeyama Islands which happened to be the final target of the eradication programs, MF was successfully rooted out of Japanese territory after as many as 74 years.

IV. Prevention of reintroduction

The OFF and MF have been eradicated from Japan at a huge cost of time, labor and expenditures. The successful ending of the eradication program immediately posed an important new task, i. e. prevention of reintroduction and maintenance of zero condition against these fruit flies.

Therefore, a set of preventive measures have been taken for the respective island as soon as the eradication was confirmed. At present, a forecasting system to detect the possible invasion of fruit flies has been established throughout these regions. The system consists of a network of regular trapping surveys for the fruit flies.

The number of lure-bait traps placed throughout the regions are 838 Steiner traps for OFF (Amami Islands: 219, Okinawa Prefecture: 559, Bonin Islands: 60) and 778 Steiner traps for MF (Amami Islands: 219, Okinawa Prefecture: 559). These traps are checked biweekly through the year around.

In addition to the trapping surveys, host fruits are regularly collected twice or three times a year and checked for the presence of fruit flies. Further, in Okinawa Prefecture, preventive control for OFF is carried out by spraying lure-toxicant fiberblocks 6 times a year and, for MF, the SIRM is still continued at 70 million weekly basis throughout the year.

Besides these regions, the regular monitoring surveys are conducted systematically throughout Japan for 8 species of fruit flies of quarantine concern including the mediterranean fruit fly, OFF, MF, etc.

Conclusion

The eradication program for OFF and MF in Japan started in 1968, took a long span of 26 years and ended in 1993. The program was promoted step by step on the basis of carefully planned annual projects and finally succeeded. The course of events, however, has not always been smooth and without problems. It was especially so at an early stage of the program. Although there was a successful case of small scale eradication program on fruit flies which had been conducted by U. S. Department of Agriculture, available data and information were so scarce for the first big undertaking ever tried in Japan. Within the framework of the program, therefore, researches on basic and applied aspects of eradication had to be made in order to break through a number of technical difficulties. The eradication of OFF and MF could only be accomplished by resolving the technical issues such as the followings.

① Clarification and improvement of duration and effective range of attractants.
② Development of lure-toxicant application techniques.
③ Development of rearing techniques for MF.
④ Establishment of sterilization techniques.
⑤ Improvement and maintenance of quality of sterile insects.
⑥ Improvement of sterile fly release boxes.
⑦ Development of equipment for aerial application of sterile flies.
⑧ Clarification and control measures for sporadic local outbreak of fruit flies which resisted the eradication.

The Southwestern Islands (The Amami and Okinawa Islands) and the Bonin Islands lie geographically close to the Southeast Asian regions where OFF, MF and other fruit flies of economic importance are widespread. These areas are constantly exposed to a high risk of reinfestation and establishment of fruit flies, additionally, in terms of the accomodating climate and plant flora. Therefore, it is vitally important to maintain the best possible measures to prevent reinfiltration of these fruit flies.

References

Department of Agriculture, Forestry and Fisheries, Okinawa Prefectural Government (1979) The report of the experimental eradication project of the melon fly from Kume Island, Okinawa, Japan,

130pp. (in Japanese).

Department of Agriculture, Forestry and Fisheries, Okinawa Prefectural Government (1994) Special edition commemorating the eradication of fruit flies from Okinawa Prefecture, Japan, 349pp. (in Japanese).

Department of Agricultural Policy Planning, Kagoshima Prefectural Government (1980) The history of eradication of Oriental Fruit Fly (*Dacus dorsalis* Hendel) from Amami Islands, Kagoshima, Japan, 296pp. (in Japanese).

Department of Agricultural Policy Planning and Office of Melon Fly Control in Ohshima Branch, Kagoshima Prefectural Government (1991) Special edition commemorating the eradication of melon fly from Amami Islands, Kagoshima, Japan, 122pp. (in Japanese).

ISHII, S. *et al.* Ed. (1985) Eradication of Fruit flies —Theory and Practice—, Japan Agricultural Aviation Association, 391pp. (in Japanese).

Plant Protection Division, Ministry of Agriculture, Forestry and Fisheries. (1986) Oriental Fruit Fly Wiped Out of Japan —Outline of the Eradication Campaign—, 12pp.

Plant Protection Division, Ministry of Agriculture, Forestry and Fisheries (1993) Eradication of Melon Fly from Japan —Outline of Eradication—, 12pp. (in Japanese with English summary).

Research Council, Ministry of Agriculture, Forestry and Fisheries and Okinawa Prefectural Agricultural Experiment Station. (1995) Researches and technical development for the eradication in the melon fly and oriental fruit fly, 98pp. (in Japanese).

YOSHIZAWA, O. (1993) Successful eradication programs of fruit flies in Japan. Plant Protection 47 (12): 527–533. (in Japanese).

YOSHIZAWA, O. (1996) Eradication programs of fruit flies in Japan. Agrochemicals Japan 68, 2–8.