

**REGIONAL MEDITERRANEAN FRUIT FLY CONTROL PROJECT
FOR NORTHERN AFRICA**

by

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ABSTRACT

The U.S. Agency for International Development (USAID) was asked to help develop and implement a medfly control program in Northern Africa. Goals were to: show that sterile male insect release techniques would work under Northern African conditions; and train personnel to carry on the program.

USAID contracted with the U.S. Department of Agriculture to conduct the project on a regional basis in Tunisia and Morocco. The regional project complemented work done previously by consultants and bilateral projects.

Three seasons' field experience and modification of procedures were needed to achieve adequate control in a Tunisian test area. Results were sufficiently promising that an economic study of feasibility and further development of technology were recommended.

The project in Morocco was prematurely terminated at the request of the Moroccan government, based on evaluations of current medfly control measures and losses, and priorities in use of resources.

KEY WORDS: Fruit, insect control, training, foreign aid, Tunisia, Morocco, medfly (Mediterranean fruit fly), sterile male insect release technique.

ABOUT THE AUTHORS

Dr. Arthur K. Burditt is presently research leader, Caribbean Fruit Fly Investigations, ARS, USDA, stationed in Miami, Florida. Dr. Burditt participated in the original planning of the Project. He has extensive research experience in detection, control, and eradication of various fruit fly species, including the Mediterranean fruit fly, melon fly, and the oriental fly; He has served in the Hawaiian Fruit Fly Investigations Unit and in various administrative positions in Washington, D. C.

Dr. E. J. Harris is research leader, Hawaiian Fruit Fly Investigations Unit, ARS, in Hawaii, where he is continuing long range research programs dealing with the detection, control, and eradication of the fruit fly species. Dr. Harris contributed heavily to the eradication of the Med Fruit Fly and the Oriental Fly on the Island of Rota and assisted and advised the Trust Territory of the Pacific Island concerning the eradication of these species.

Dr. J. Franklin Howell is a research entomologist for ARS, stationed in Yakima, Washington, working on arid deciduous fruit investigations. Dr. Howell served one year in Vienna with the International Atomic Energy Commission on insect control techniques, and is the co-author of 17 publications on insect control.

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SUMMARY

In 1967, the Government of Tunisia asked the U.S. Agency for International Development (USAID) to help them develop and implement a medfly control program. Goals were to: (1) demonstrate that sterile male insect release techniques would work under North African conditions; and (2) train necessary manpower to carry on the program without further U.S. assistance.

After evaluating facilities and interest in such a project in Tunisia and Morocco, USAID negotiated a Participating Agency Service Agreement (PASA) with the U.S. Department of Agriculture to conduct the medfly project on a regional basis in Tunisia and Morocco.

The Government of Tunisia was represented by the Institut Nationale de la Recherche Agronomique de Tunisie (INRAT). INRAT was also engaged in a U.S. PL-480 test of methods of fruit fly suppression using bait sprays and attractants. INRAT had conducted some background ecological studies that were fundamental to the sterile fly release program.

Mass-rearing and gamma irradiation facilities were completed in Tunisia in late 1969. Personnel were trained in mass-rearing and Cobalt-60 gamma irradiation at the International Atomic Energy Agency in Vienna, Austria. Local personnel were trained in techniques for handling and distributing flies by ground and airplane release. Procedures were developed for surveys to determine fly population and success of the release program. Moroccans were trained in survey and trapping techniques so the background ecological studies could proceed in Morocco.

Not enough sterile flies were produced in 1970 to gain adequate suppression in the Tunisian demonstration area. In 1971, three times as many sterile flies were released. But the release area was too large and distribution was not uniform enough.

The area was redefined and restricted in 1972, the last year of the PASA. Bait sprays were applied to the exposed perimeter of the test area to reduce migration of native flies into the release zone. The number and concentration of sterile flies was increased. During the late summer, the medfly population in the demonstration area was reduced to a level approaching complete control.

Evaluation

This project demonstrated that there are many problems associated with any effort to conduct a regional research program on insect control. Unfortunately, clear-cut, definitive results were not obtained early enough in the project in order to demonstrate, conclusively, regional control of the medfly using the sterile fly technique. However, results achieved during the final months of the project in Tunisia were sufficiently promising that an economic study of its feasibility would be justified and research on the technology should be continued.

In Morocco, medfly traps were developed that compared favorably with the standard plastic trap, at less than a tenth the cost. Population levels of medflies were determined in different regions of Morocco. Peak population of medflies occurred in August and resulted in 119 flies per trap/day. Bait spray formulations were tested in Morocco to determine their effectiveness and effects on other species of beneficial and injurious insects. The project in Morocco was prematurely terminated at the request of Moroccan government officials based on their evaluation of the extent of current losses due to medfly, current control measures required, and consideration of priorities in use of their resources.

Recommendations

The project has demonstrated that release of sterile medflies is a promising technique for control of this pest in Northern Africa. However, an economic survey and evaluation of the medfly problem is needed to determine the feasibility of a medfly control or eradication program.

The authors offer these recommendations:

- a. Conduct an economic survey of the medfly situation in Northern Africa to determine:
 - (1) Losses from medfly infestation.
 - (2) Justification for regional medfly control and/or eradication.
 - (3) Alternative methods for medfly control.
- b. Continue research and development in Tunisia to reduce mortality of medflies and make other technological improvements.
- c. Establish surveys on a regional basis to determine the distribution, presence, and density of medfly populations.
- d. Determine biological and ecological differences in medfly populations found in various parts of Northern Africa.
- e. Establish a sanitation program to reduce medfly population by eliminating host reservoirs.
- f. Determine the feasibility of establishing a quarantine program to restrict movement of infested fruit.

INTRODUCTION

The sterile male insect release technique has been used successfully to eradicate screwworm from the southeastern United States and is being used to suppress this pest and to prevent establishment of incipient infestations of

Mexican fruit fly in the southwestern United States. Experimentally, it has been used to suppress populations of a large number of insects, including several species of fruit flies.

Large-scale research programs to control the Mediterranean fruit fly (medfly) have been attempted in several locations. They were sponsored by the International Atomic Energy Agency (IAEA), Organismo Internacional Regional de Sanidad Agropecuaria (OIRSA), and U.S. Department of Agriculture (USDA), through either PL-480 programs or the U.S. Agency for International Development (USAID). Thus far, unfortunately, none of these programs has been completely successful, mostly because of logistics problems.

In 1962, IAEA proposed using the sterile male technique to control medfly in Tunisia. At about the same time, a French study mission, by M. Feron, reviewed the medfly control situation in Tunisia and recommended a pilot area for an eradication operation: The Ras-el-Djebel area, from Metline to Raf-Raf. From 1962 to 1965, F. Soria and others conducted studies in Tunisia on medfly and ecological problems involved in its control. This project was financed with IAEA support.

In 1967, the Tunisian Government asked USAID to provide technical assistance in developing and implementing a program to control medfly using the sterile insect release technique.

Dr. L. F. Steiner visited Tunisia and Morocco to evaluate their facilities and interest in such a project. USAID negotiated a Participating Agency Service Agreement (PASA) with USDA in 1968 for assistance in this project. The original project covered a period of 2 years (1968-70), but was extended another 2 years (1970-72). The medfly control program was regional in scope, although most active in Tunisia.

Tunisian participation in the project has been primarily through Institut Nationale de la Recherche Agronomique de Tunisia (INRAT). Initially, INRAT had several European scientists working on the project. They had been associated with the previous medfly research program, supported by IAEA, and a concurrent project, supported with PL-480 funds. INRAT was unable to replace these scientists when they left. Dr. Cheikh was placed in charge of the project for INRAT and provided with a support staff to carry out the project.

The principal objectives of the Tunisian project were: (1) to demonstrate use of the sterile fly release method to control the Mediterranean fruit fly; and (2) to teach Tunisian technicians the methodology and procedures required to implement the program so Tunisia could become self-sufficient.

This work was divided into four main parts as follows:

- a. Develop mass-rearing techniques and facilities to produce adequate numbers of medflies for a sterile fly release program.
- b. Develop techniques and facilities to sterilize medflies and distribute treated flies throughout the experimental areas.
- c. Develop survey and detection techniques to estimate the population of native flies as well as survival of released sterile flies and to evaluate the success of the sterile fly release program in controlling the medfly population.

- d. Conduct biological and ecological studies, as needed, to assist in conducting a successful research program.

Objectives of the project in Morocco were similar. However, basic ecological studies had to be conducted in Morocco to monitor medfly population trends and determine availability of and preference for fruit hosts before a control program could be undertaken.

Differences in medfly populations in Tunisia and Morocco or other North African countries were considered great enough to require extensive ecological research prior to undertaking a large scale regional control project. The pilot test of the sterile fly program in Tunisia, based on available ecological research, required 2-3 years. During this time, necessary ecological background information on other areas was acquired.

To ensure long-term continuity of the control program, the USAID Tunisia Mission worked closely with INRAT to provide for a self-supporting, long-term program which could be continued by INRAT staff.

SITUATION

In his first two visits, Dr. Steiner surveyed the availability and potential of research facilities for the medfly control program. He found sufficient ecological research had been done to recommend a pilot sterile fly release experiment in the Metline-Raf-Raf area. He also recommended construction of a new fruit fly rearing laboratory, improved trapping methods, and use of bait sprays to reduce the fruit fly population. Research on use of bait sprays and other methods of fruit fly population suppression were to be carried out under a 2-year project, financed through the PL-480 program.

Dr. Steiner found, in these visits, that scientists in Tunisia had conducted research on medfly for several years and had considerable knowledge of its ecology, behavior, and hosts. However, this research had been conducted primarily by European scientists, most of whom had left the new project soon after its inception. He also found that available facilities and equipment were not adequate to produce and sterilize the large numbers of flies required for the project. However, plans for a new facility already were being developed.

Several suitable locations were available for a pilot test of the sterile fly method to control medfly. The most convenient sites did not appear to have the complete isolation generally considered necessary. Well isolated oases were available but were too far from INRAT for use in the initial project. Medfly hosts were available during all seasons of the year. Citrus was the primary host of economic value, followed by peaches, apricots, figs, and many other fruits of minor value but used for food or as ornamentals in the rural areas.

The medfly is a pest of citrus and other fruit throughout Northern Africa. The areas of infestation, however, are not continuous. As a result, it would be technically possible to suppress or eradicate medfly from one area or

region that was more or less isolated from others. Such an action would require either strict quarantines or continuous release of enough sterile flies to maintain suppression or eradication, and prevent reinfestation.

The Northern coast of Africa is subject to tremendous differences in climatic conditions. In many areas, adverse climatic conditions prevent survival of larvae. However, ecological studies would be required to demonstrate the effectiveness of climatic barriers to suppress medfly populations. These studies would also be used to develop models for distribution of sterile flies in a control program. As far as is known, Tunisia and Egypt are the only North African countries where such studies have been conducted.

RESOURCE INPUTS

USAID, through its PASA with USDA, has provided technical assistance, as well as commodities for conducting this project. Dr. Steiner returned to Tunisia and Morocco during the summer of 1968 to confer with local scientists and to evaluate their proposals for the project. During the spring of 1969, E. J. Harris spent 4 weeks in Morocco and Tunisia as an advisor to the project. Mr. Harris returned to Tunisia on temporary duty (TDY) for several weeks in the late fall and was transferred to Tunis early in 1970 as leader/coordinator of the regional medfly control project. In mid-1971, his headquarters were moved to Morocco and Dr. J. F. Howell was assigned to continue as technical advisor to the project in Tunisia. Mr. Harris continued as leader and coordinator of the regional project until his return to the United States in late spring 1972. Dr. Howell continued as advisor until the project was terminated in October 1972.

A Cobalt-60 gamma irradiator, as well as traps, motorbikes, trimedlure, rearing supplies, and equipment were supplied to the project in Tunisia through USAID. USAID also supplied traps and timedlure to the project in Morocco.

USAID also provided training of technicians. The Government of Tunisia (GOT) through INRAT, provided entomologists, technicians, and laborers, as well as supplies, laboratory equipment, vehicles, and utilities. They also constructed and operated a new facility for mass-rearing and handling medfly populations. Arrangements for airplane distribution of irradiated sterilized flies, as well as application of bait sprays, were made through Societe National de la Protection des Vegetaux (SONAPROV).

In Morocco, local arrangements for professional, as well as sub-professional assistance and supplies, were handled through the Director of Agronomic Research (DRA).

PROJECT IMPLEMENTATION

Immediate action to utilize the research capability of INRAT was taken in 1968 when the U.S. Government and the GOT signed an agreement to conduct a research project on developing methods of suppressing medfly populations.

When the medfly program was begun in 1968, only Morocco and Tunisia were involved. Because of Tunisia's advanced readiness and determination, the program began in Tunisia. Day-to-day operations in Tunisia were conducted by INRAT personnel. An ecological study was undertaken in Morocco. The Government of Morocco sent two of their technicians to Tunisia for training in medfly survey methods. It took 2 years to fulfill the basic needs for the sterile fly release program; as a consequence, implementation of this phase of the project was delayed until January 1970.

Most of the demonstration commodities and equipment were delivered in 1968, but the radiation unit was not received until 1969. It was received in bad condition because of exposure to salt water on the deck of the ship. The GOT completed the physical plant of the rearing laboratory in May 1969, but it was not equipped and fully operational until December 1969.

Cooperation from Plant Protection and Extension personnel supplemented the research program. The ongoing program in Tunisia provided a training center for the regional program where technicians from participating countries were trained to implement the program. Most of the staff were inexperienced and learned mass-rearing methods while engaged in the ongoing program.

The most significant problem was acquiring enough personnel to implement the program. It was also a problem in getting personnel trained so they could be fully self-sufficient by the end of the project. Only short-term training was provided technicians in the use of mass-rearing (for Tunisians) and control and survey methods (for Moroccans).

The advisors, provided through the PASA with USDM, worked very closely with the USAID Agriculture Officer and Program Office in administration of the program. However, manpower ceilings and budget cuts delayed the arrival of the U.S. technical advisor in Tunisia and delayed the hiring of another advisor for the Moroccan phase of the medfly program.

ACCOMPLISHMENTS IN TUNISIA

Mass-Rearing for Release

Mass-rearing of medflies began in Tunisia in January 1970. However, production did not reach the levels needed until 2 years later. Native fly populations were very low in the winter months. Mass releases were initiated in late winter in order to overflow the entire pilot test area with sterile flies before native flies began emerging from ripe fruits in the spring.

During 1970, three Tunisian staff members were trained in mass-rearing techniques at the IAEA facility in Vienna, Austria. Procedures were established for rearing, and about 57 million flies were produced, sterilized, and released. However, production was not adequate to obtain suppression of the native medfly population in the Metline-Raf-Raf area.

In 1971, mass-rearing procedures were improved and expanded. Around 152 million flies were sterilized and released. This was supplemented by about 24 million flies obtained from the IAEA colony in Vienna.

In 1972, two additional Tunisian staff members received training in mass-rearing at Vienna. As a result of improvements in techniques (provided by IAEA personnel), rearing was further improved and production increased. About 25 million flies were sterilized and released. The Tunisian staff developed a capability of producing in excess of 50 million flies per month. However, egg and pupal mortality continued in the range of 20 percent.

Irradiation of Medflies

A Cobalt-60 source of gamma radiation was used to sterilize medflies used in this project. This source is identical to others in use by USDA entomologists to sterilize insects such as the Caribbean fruit fly in Miami, Florida. Medfly pupae were treated at a nominal dosage of 10 krad. A by-pass system was used in which the pupae were placed in a container in one room, passed into the room containing the irradiator for treatment and then passed into the packing room where the treated pupae were mixed with dye (to identify the treated adults) and placed in paper bags for emergence.

Sterile Fly Release

- The area for sterile fly releases was selected on the basis of:
- Isolation to reduce the amount of migration into the experimental area from adjacent fruit-growing areas.
 - Amount and variety of medfly hosts for year-round production.
 - Proximity to INRAT to provide access without excessive travel time.
 - A good road through the main part of the area, with other roads and trails providing access to the fruit-producing orchards.

The area was subdivided into 3 regions along the north side of a row of 600-700 foot hills: Metline, Ras-el-Djebel, and Raf-Raf; and on the south side: Porto-Farina. During 1970 and 1971, the releases were made along the north side. In 1972, the release area was changed to the south side of the hills.

The success of the sterile fly release program in 1970 and 1971 was limited by a number of factors. The release area was too large for the number of sterile flies being produced to keep ahead of the wild population during the late spring and summer build-up. Distribution of sterile flies was not adequate to reach all areas in which wild flies were present.

Initially, the sterile fly releases were to have been made by air. However, due to problems with the airplane, most of the releases were made from the ground in areas of high host density. As a result, flies did not move out into the more remote sections where there were only occasional hosts. It is not known whether ground-released flies went beyond windbreaks surrounding citrus orchards. Generally, ground releases involved carrying flies in

paper bags to release sites, opening the bags and hanging them on various host trees, thus permitting the flies to disperse into the surrounding area. Frequently, 2 weeks elapsed between ground releases in a given area. This permitted flies to emerge, reach sexual maturity, and reproduce before the next release. Later, aerial releases were made using paper tubes instead of boxes or bags.

Survey and Evaluation Program

The survey and evaluation program developed into an efficient system in which traps were supplemented by collection of fruit.

Trap Operations: In the early ecological studies, traps were set out and moved daily from one orchard or location to another. When this program was initiated, a procedure of setting up permanent traps and checking them at 1 or 2-week intervals was adopted. Initially, plastic traps were baited with 2.5 ml. trimedlure and lindane-chlordane powder was placed in the traps to kill the flies and any ants that might be predatory on the flies. Later, this was replaced by a mixture containing 70 percent trimedlure with 30 percent naled as the toxicant.

In 1972, a system of setting out the traps for a 24-hour period once a week (instead of leaving them out permanently) was adopted. Trappers applied 8 drops of attractant to the trap wick. Primary reason for this change was that the traps recovered such a large number of flies in a week that the staff was unable to count and identify all of the marked and unmarked flies.

There was one main road through most of the area, with numerous small side roads. Much of the area was accessible only on foot or motorbike. Therefore, trapping was concentrated along the roads, trails, and the easily accessible adjacent areas. This may have distorted the sterile-native fly ratio, since ground releases of sterile flies were being made in the same areas. The traps recovered more sterile than native flies.

According to the trap records for the area from Metline to Raf-Raf, there was a slight delay in wild fly build-up in 1970 and 1971, compared to 1969. This may have been due to earlier sterile fly releases, or it may have been partially due to lower temperatures during the early spring when the overwintering larvae and pupae were completing development and adults were emerging.

Trap data for 1972 showed that the sterile release program in Porto-Farina was successful in partially suppressing the medfly population in that area. The sterile/native ratio in traps gradually declined from a high of 179/1 in April to about 93/1 in July and 48/1 in September. On the basis of trapping data, the wild fly population continued to increase from an estimated 21,500 flies in the release area in April 1972 to over 770,000 in September, in spite of releasing about 1,500,000 sterile flies per day.

It was recommended that trap operations be continued through calendar year 1973 in all experimental areas at the same level as during the past

winter and spring. This would provide a year of data without releases of sterile flies for comparison with 1972 when sterile flies had been released.

Fruit Collections: The second technique used for survey and evaluation was to collect fruit to determine the percentage of fruit infested as well as the degree of infestation present. To determine level of larva infestation, fruit were selected on the basis of punctures or other markings. However, some types of fruit did not show external indications of an infestation and were selected at random.

Male figs, brought into the sterile fly release area to pollinate female figs, were found to be infested. This resulted in introduction of fertile flies from outside into the release area.

Some fruit was dissected to locate eggs and determine if they were fertile or sterile. Eggs were more easily found in some kinds of fruit (such as green citrus) than in others (such as ripe citrus, figs or peaches). Young, recently hatched larvae may have been overlooked, along with the eggs from which they have hatched. In general, this technique was easier to use when working with fruit where egg punctures could be easily located.

Biological and Ecological Aspects

Much information was collected on biology and ecology of the medfly in Tunisia. The recent finding of medfly larvae infestations in male figs was of special interest. Also of interest was finding numbers of immature fruit flies surviving the winter as larvae in fruit or pupae in soil. As a result, trap data were poor indicators of the potential fruit fly carry-over from one year to the next. Emerging adults in the early spring undoubtedly account for the rapid build-up of flies in late spring and early summer. Similarly, the hot, dry conditions of midsummer result in an apparent decline in the adult fly population during August, with a resurgence in September.

ACCOMPLISHMENTS IN MOROCCO

The Moroccan phase of the regional project was terminated prematurely, at the request of the Government of Morocco based on their evaluation of current losses due to medfly, the effectiveness of chemical control methods currently in use, and consideration of their priorities in use of their resources. Consequently, only preliminary stages were completed. The full regional intent of the program would have necessitated medfly control in both countries, including effective quarantines to prevent reintroduction of the fly.

Research on distribution, biology, and ecology of medfly in various parts of Morocco was undertaken. Survey data showed wide fluctuations in medfly populations from location to location and week to week. A resident population of flies existed throughout the year, rapidly increasing in the spring to a maximum in late summer.

A low-cost, locally made trap was developed that compared favorably with the U.S.-made plastic trap.

Two Moroccans were sent to Tunisia for short-term training in survey as well as control methods.

No control program was attempted in Morocco.

PROBLEMS ENCOUNTERED

Numerous problems were encountered during the conduct of this regional project on medfly control. These involved, chiefly, problems of logistics and cooperative relationships and were quite similar to problems that have been encountered in the United States, Costa Rica, the Western Pacific, and elsewhere. Coordination of a project involving scientists and subprofessionals speaking different languages is difficult. Although these problems were frustrating, none were insurmountable.

Some other problems which delayed or limited accomplishments were: breakdowns and lack of service or parts for the irradiator, motorbikes, and other equipment; delays in ordering and delivery of supplies; airplanes not being available for distribution of flies; and establishing contacts, through channels, with other agencies whose cooperation and assistance in the project were required.

EVALUATION OF PROGRAM EFFECTIVENESS

In Tunisia, the major objective of demonstrating the suppression and control of medfly using the sterile male technique was, to all intents and purposes, achieved during the final months of the project. During the first 2 years of the control experiment, fly production was not adequate for overflooding the native fly population during the late spring build-up of flies. However, reducing the area of the experiment and increasing fly production resulted in partial suppression of medfly during the summer of 1972. Over 1.5 million sterilized medflies were produced and released per day between March and October 1972. In April 1972, releases were being made in Porto-Farina area at a ratio of over 1700/1 sterile/native flies. This ratio steadily declined to 49/1 in September, indicating that the released flies were unable to maintain their initial advantage over the native population. This was partially due to migration of wild flies into the area, spotty distribution of sterile flies, excessive mortality of sterile flies, and possibly reduced competitiveness.

To have achieved the full regional intent of the program would have required demonstration of effective medfly control and quarantine in all participating countries.

The secondary objective of developing Tunisian self-sufficiency, through training and teaching their staff the methodology and procedures required for the project, was successful only to a limited extent. The original staff

included several foreign scientists who left the project and went elsewhere. Several of the Tunisian technicians also left to accept better paying positions. Two Tunisians were sent to the United States and five to Vienna, Austria, for short periods of training in rearing and handling insects in a sterile insect release program. However, the Tunisian Ministry of Agriculture was unable to nominate technicians for longer term advanced training.