

Chapter VI

PILOT PROJECT IN CHISHAN DISTRICT

A plan for an island-wide malaria control program was presented on October 17, 1951 at a meeting of representatives of the National Health Administration (NHA), the Provincial Health Administration (PHA), TAMRI, the International Cooperation Administration (ICA), the Council for United States Aid (CUSA), the Joint Commission for Rural Reconstruction (JCRR) and the World Health Organization (WHO). An agreement was then signed by the Government and WHO in November 1951 for a joint operation of a four-year malaria control program and eventually the eradication of the disease from the entire island. Under this agreement, WHO would assign an international malaria team -- composed of a malariologist, an entomologist and a public health engineer -- to the program and would provide \$34,000 to purchase certain essential laboratory equipment and supplies during the four-year period. Another agreement was signed on January 10, 1952 between JCRR and TAMRI for a grant of NT\$957,310 (US\$92,943) to supplement the operating expenses and US\$2,794 for importation of DDT and spraying equipment. Although all the assisting international and bilateral organizations agreed to support the four-year program, the budgetary provision would have to be approved on a year-to-year basis. Nevertheless, financial support was assured for the 1952 operation at the end of 1951. Similarly, the provincial government was committed to increase its financial support for the program, through TAMRI, as the program expanded. Although originally scheduled to start in January 1951, the four-year Malaria Control Program was formally launched on May 15, 1952 with the arrival of the WHO Team.

As planned, the program for 1952 was to be pilot project through which basic procedures and field techniques would be standardized. Chaochou district (Pingtung county), which had six townships with 120,000 inhabitants, was originally selected as the pilot project area. However, through a rapid reconnaissance, it was found that malaria incidence in the district was not high enough to permit an effective evaluation of the control measures. With the arrival of the WHO Team in May 1952, another survey was conducted in southern Taiwan. The Chishan district of Kaohsiung county was found to have a much higher malaria incidence and was therefore added as the second operational area. The original operational area, Chaochou district, was used as a training area for the spraying personnel, while the

Chishan operational area served for standardization for field techniques and project assessment.

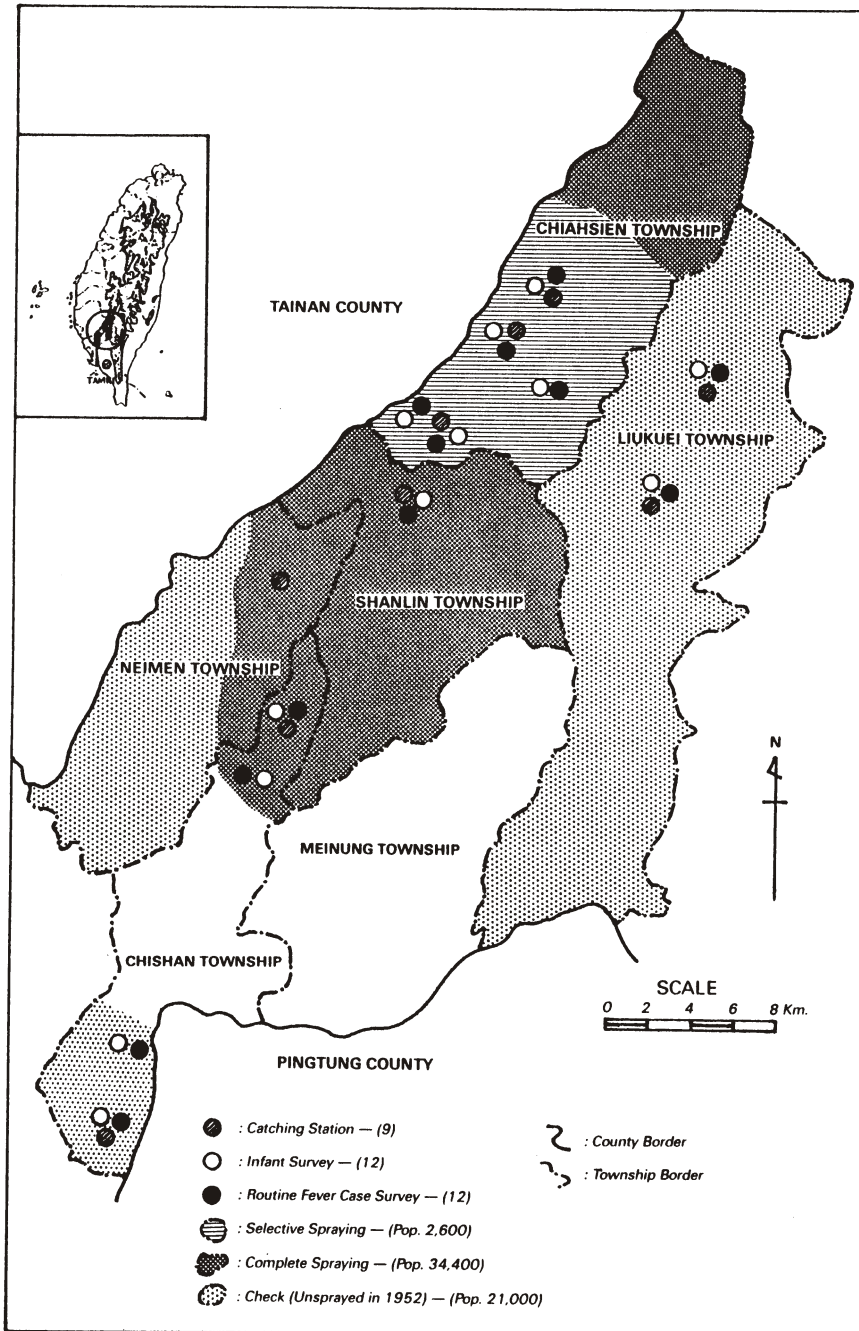
Chishan is a typical foothill district located in southern Taiwan. Administratively the district belongs to Kaohsiung county and has six "plains townships" and two "mountain townships." Only plains townships were selected for the pilot project. There were two main valleys in the district -- the western valley was used as the demonstration area, while the eastern valley, plus a part of the southern foothill area, was used as the check area. Preliminary surveys revealed that the epidemiological conditions in the two valleys were almost identical. The population in the demonstration area was 37,000 and that in the check area 21,000. In one section of the demonstration area (southern part of Chiahhsien township), selective spraying was applied. The detailed subdivisions (complete spraying, selective spraying and the unsprayed check areas) are shown on Map 5.

PREPARATORY ACTIVITIES FOR THE PILOT PROJECT

Preparatory activities for the pilot project started with several meetings among local officials. The PHA commissioner called a meeting in Pingtung on May 24, 1952, where the officials of Kaohsiung and Pingtung county governments and county health centers were briefed on the four-year malaria control plan in general and, in particular, on the pilot project to be carried out in their counties. They expressed their serious concern about the malaria problem and their deep interest in the project. The officials of both counties pledged their support and offered whatever assistance would be needed in the course of field operations.

Two local meetings were called by TAMRI on May 30 and June 16, 1952 in Chishan and Pingtung, respectively. At these meetings, the health officers of the 10 township health stations in the two districts included in the pilot spraying program were given an orientation on the proposed work plan, and provided with detailed explanations on the types of administrative collaboration expected from the township offices and the active participation required of the health stations's personnel.

Map 5
Pilot Project Area - Chishan District, Kaohsiung County



Selection and Training of Local Health Personnel as Spraying Foremen

Upon return to their respective townships, the health officers met with their respective mayors and other township officers to discuss their participation in providing spraying personnel, financial support for local expenditures, and facilities such as storage space for equipment and insecticide. The mayor, with the help of the health officer, selected spraying foremen among township employees, giving priority first to the township malaria technician, if there was one, and then to other health personnel. In some cases, selection of the spraying foremen was made from among non-health units of the township governments.

For the 1952 pilot project, a two-week training course was organized at TAMRI headquarters for all 30 foremen (including two soldiers from the military camps in the Chishan area), starting June 23, 1952.

Recruitment and Training of Temporary Workers as Spraymen and Helpers

After the training at TAMRI, the foremen returned to their respective townships and immediately assisted the health officers to recruit temporary workers as spraymen and helpers. Although priority was given to young men of 20-30 years of age, there were 12 female helpers among the spraying crews. The spraymen and helpers were straight wage-earners who were to be dismissed upon completion of the spraying cycle, although some of them were again recruited in subsequent years.

A one-week training course was held at each of the 10 townships under the local conditions, utilizing local facilities. The TAMRI personnel participated in the training as instructors, while the local foremen served as assistants.

The pilot spraying program was initiated on July 14 and completed on September 28, 1952. About midway through the program, the field foremen met on a Saturday to discuss and resolve both administrative and technical problems.

TRIAL OF DDT RESIDUAL SPRAYING ON AN ANNUAL CYCLE

An important task in the Chishan pilot project was a confirmation of the proposed insecticide dosage and the frequency of its application. Although pioneer work in India had used dosages of 1 gm or less technical grade DDT per m² of surface, with spraying repeated at 3-4 week intervals, most of the early programs in Taiwan had applied 1 or 2 gm technical grade DDT per m², which had demonstrated residual toxicity for six months or even for a year (Table 11, Chapter III). In planning for the Chishan pilot project, it was projected that a dosage of 2 gm technical grade DDT per m², applied once a year just before the major increase in anopheline populations, would greatly reduce or eliminate vector population and interrupt malaria transmission. The problem was field confirmation of the effectiveness of this regimen and the development of a protocol for monitoring its continued usefulness. Although WHO later developed more sophisticated equipment and procedures, the bioassay tests in the pilot project and other field trials were made with locally-improvised materials. Wild female anophelines caught one day before the test were confined in Petri dishes, held in locally-made Petri dish holders (Fig. 23), exposed to DDT-sprayed (or unsprayed "check") wall surfaces for a given time (established at 15 minutes after trials varying from 5 seconds to 30 minutes), and removed to clean cages. Test mosquito mortality was recorded at intervals of 1, 2, 3, 4, 24, and sometimes 48 hours after exposure (Fig. 24).

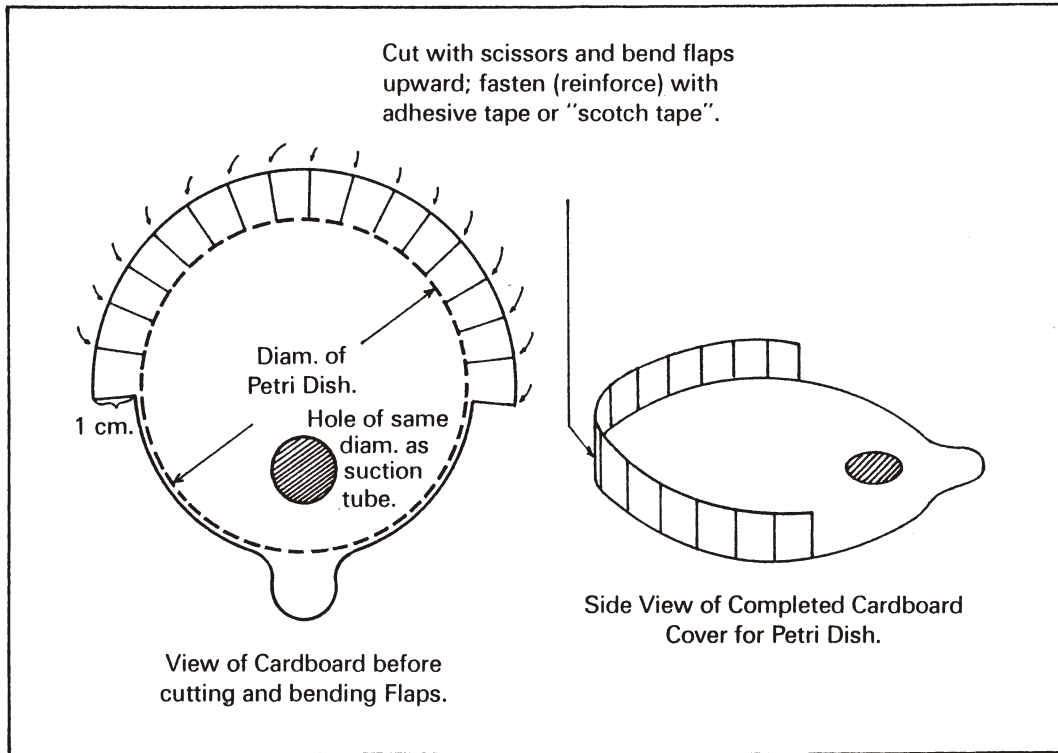


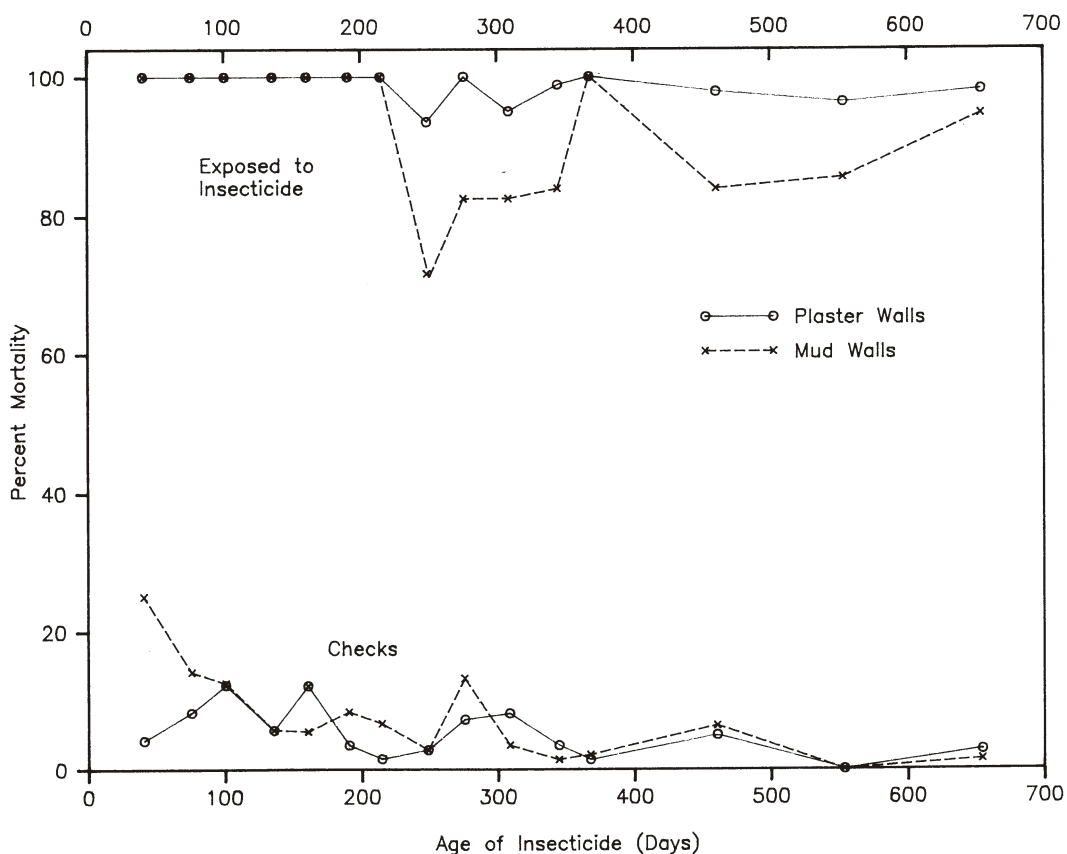
Fig. 23: Improvised Petri dish holder



Fig. 24: Entomology technician preparing equipment and mosquitoes for bioassay test

A near crisis occurred upon encountering the publication of data from studies in Mexico (Downs, Bordas and Navarro, 1951) indication that DDT residues on some mud (adobe) building blocks, reddish in color from high ferric content, may have short periods of effectiveness. Inquiries were made of agricultural specialists in Taipei as to the existence and distribution of such soils in Taiwan. Inasmuch as soil survey charts were not complete for many malarious areas, the sites for bioassay trials were selected to give wide coverage, and always included houses with mud walls and other houses with plaster walls. Initial bioassay trials were made using both *An. minimus* and *An. sinensis* females. The specimens of *An. minimus* were not only small and more difficult to manipulate, but were obviously more fragile than the larger *An. sinensis*. Preliminary test showed rapid, high mortality even among the "check" specimens of *An. minimus*. In comparative testing, exposures which produced intermediate or high mortalities among specimens of *An. sinensis* invariably resulted in earlier, complete mortality of *An. minimus*. Additionally, *An. minimus* often disappeared from localities after one or two spraying cycles, making it impossible to obtain wild specimen for the tests. *An. sinensis* were therefore used

for all field tests. Fig. 25 illustrates the progressive results, on both mud and plaster walls, with tests carried out in central Taiwan from 40 to 655 days.



Bioassay tests, exposing wild-caught *An. sinensis* females to deposits of DDT (2 gm/m^2) on plaster and mud walls. Exposure period - 15 minutes. Mortality readings made 4 hours after removal from wall. First readings - April 20, 1 9 5 3 ;

Fig. 25: Bioassay tests with *An. sinensis* exposed to DDT deposit

Anopheline mortality upon exposure to DDT-sprayed walls was far from instantaneous, although the great majority of anophelines were dead by the time of a 4-hour reading, while the "checks" were still doing well. By the time of the 24-hour

reading, the "check" anophelines had begun to succumb to heat, confinement or other factors to the extent that the protocol opted for a reading after 4 hours (Table 23).

Table 23
*Mortalities (percentages) of An. Sinensis Exposed for
15 Minutes to Sprayed (DDT) and Unsprayed Plaster and Mud Walls
Nantou Town, Nantou County, Taiwan*

No. of Days After Surfaces Were Sprayed	4-Hour Mortalities				24-Hour Mortalities			
	Plaster Walls		Mud Walls		Plaster Walls		Mud Walls	
	Expos.*	Checks	Expos.*	Checks	Expos.*	Checks	Expos.*	Checks
38-41	100	4	100	25	100	56	100	56
75-77	100	8	100	14	100	97	100	61
97-99	100	10	100	12	100	88	100	84
135-137	100	6	100	6	100	79	100	63
159-160	100	12	100	5	100	48	100	41
187-189	100	4	100	8	100	91	100	87
215-216	100	2	100	7	100	85	100	92
245-247	93	3	74	3	100	52	100	68
275-278	100	8	82	14	100	38	100	55
307-309	95	8	82	3	100	50	98	40
343-345	98	3	84	1	100	54	98	51
364-366	100	2	100	2	100	50	100	51
458-461	97	5	84	7	100	88	100	92
553-555	96	0	86	0	100	14	98	4
652-655	98	2	95	1	100	23	100	18

* Adjusted with check mortality, using Abbott's formula.

COMPLETE VERSUS SELECTIVE RESIDUAL SPRAYING

Previous studies (Tseng, Chen H.H. and Pletsch, 1956; and Pletsch, Tseng, and Chen H.H., 1956) clearly indicated that *An. minimus* was endophilic and anthropophilic, and that it showed a marked preference for daytime resting places inside human dwellings, such as bedrooms (especially underneath beds), storerooms, and underneath furniture and shelves. Based on this knowledge, the houses in one part of the Chishan pilot project area (with 2,986 inhabitants) were selectively sprayed in

1952. In the part so-designated for selective spraying, surfaces not preferred by *An. minimus* for resting were not sprayed. Stables were also left unsprayed. In 1953 the same selective spraying technique was further extended to cover nine townships in Nantou county with a population of 244,770. The results indicated that there was a 25% saving in insecticides but no significant saving in labor. Although the selective spraying was as effective as the complete spraying in interrupting malaria transmission, it was not practical in Taiwan because of serious objections by residents of communities receiving selective rather than complete spraying coverage. The details of the selective versus complete spraying study are presented in Chapter XIII.

ORGANIZATION OF SPRAYING SQUADS AND FIELD OPERATIONS

The composition of a basic spraying squad, the size of population to be directly protected by a squad during a two-month period, the most practical pattern of squad management, basic procedures and patterns of actual spraying, standard methods of assessment, etc., were tested and established in the pilot project of 1952.

A spraying squad consisting of a foreman, four spraymen, two helpers and five hand compression sprayers was assigned to spray in 60 working days the premises inhabited by 7,000 people. A total of 28 squads were organized in the 10 townships included in the Chishan project (Fig. 26). One TAMRI technician was assigned to each township as supervisor/coordinator. The functions of the spraying squad members were as follows.

The foreman called on each household to explain the purpose of the work, the pre-spraying preparation of rooms, and the post-spraying precaution against wiping off DDT deposit. He then allocated to the spraymen the houses which were ready for spraying. He checked the speed and quality of work of each sprayman at least twice a day. He was responsible for inspecting every house that was sprayed and, following the inspection, marking the house with a label indicating "DDT" and "Date" sprayed (Fig. 27). The foreman was also responsible for the maintenance of the spraying equipment and for keeping a daily record of DDT consumption, population directly protected, number of structures sprayed, and time spent on the project.

Spraymen did the actual spraying. Helpers fetched water, helped prepare DDT suspension and, when necessary, assisted residents in preparing the rooms for DDT spraying.



Fig. 26: Spraying squad
(one foreman, four spraymen and two helpers)

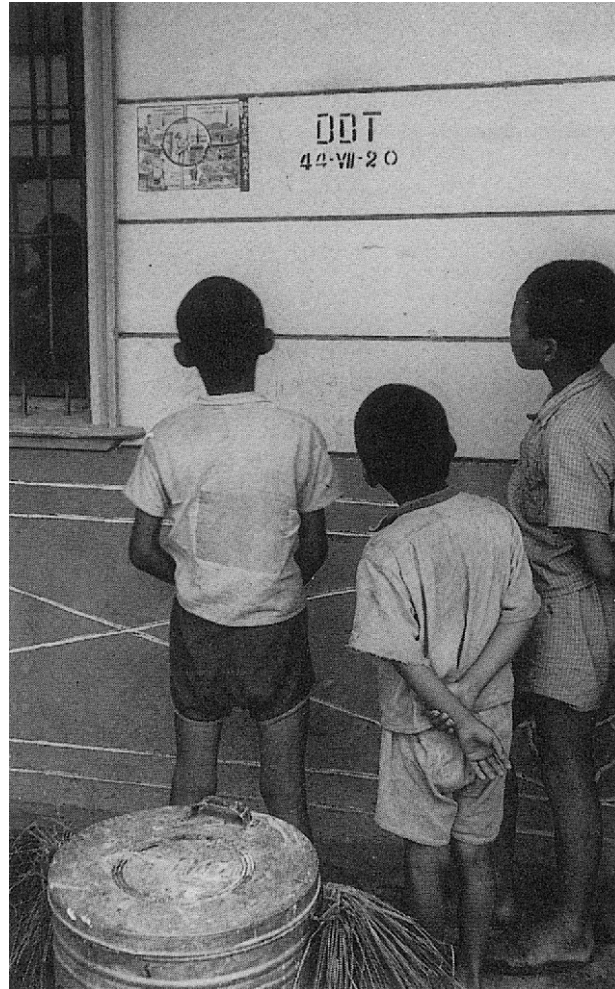


Fig. 27: House marked with "DDT" label
after foreman's inspection

After spraying one village, the "spraying squad" moved to the next village on foot or on bicycle, carrying with them all the equipment and the remaining insecticides (Figs. 28 and 29).



Fig. 28: Spraying squad moving from one village to another, on foot



Fig. 29: Spraying squad moving from one village to another, by bicycle

Two modes of operation were tried, side by side, during the pilot spraying in seven townships, to compare efficiency in terms of output and manageability. The composition of each spraying squad was the same -- one foreman, four sprayers and two helpers.

Mode 1-4-2: In this mode, all four sprayers were engaged in spraying, but they also had to spend a certain amount of time to prepare DDT suspension and to pump sprayers (Fig. 30).

Mode 1-3-1-2: In this mode, one of the four sprayers took turns, working with the two helpers, in preparing the DDT suspension, pumping sprayers and helping local residents prepare rooms for spraying. The other three sprayers concentrated solely on spraying, with minimum interruption.

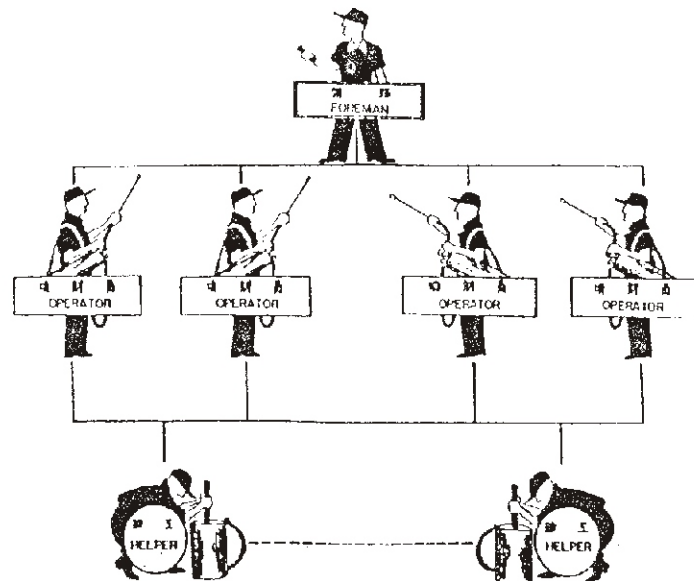


Fig. 30: Squad organization, 1-4-2 mode

On the average, the sprayers working in the 1-3-1-2 mode were able to spray 589.51 m² of surface area per sprayer-hour, compared to 356.71 m² of surface area sprayed by those working in the 1-4-2 mode. When computed for the entire spraying squad of seven persons, the output of the 1-3-1-2 mode was 238.40 m² of surface area sprayed per man-hour, which compared favorably against the 211.43 m² achieved by the 1-4-2 mode. However, the 1-3-1-2 mode did not work well in sparsely populated areas, especially on the hillsides -- the prevailing feature in the more malarious areas. The 1-4-2 mode proved to be more practical and was adopted as the basic pattern for spraying operation.

In all 10 townships, the spraying operation began on the same date -- July 14, 1952. The spraying squads started in the outer, most sparsely-populated area in each township, working toward the center of each village within the township, and finally toward the center and most populated area of the township. A day or two before a squad began its work in any village, the foreman called a village meeting, usually in the evening, to explain his mission, to solicit the cooperation of the households, and to emphasize to the local residents the importance of not wiping off DDT deposits from the surfaces sprayed (Fig. 31).



Fig. 31: Village meeting

The squad worked eight hours a day, six days a week. Workers hired as spraymen and helpers received only daily wages, without other remuneration such as uniforms, transportation, over-time pay or compensatory leaves. On each working day, the foreman placed a directional squad-flag at the nearest access road or trail, with an arrow pointing in the direction where his squad was working. This arrangement helped the supervisor locate the squad and facilitated communication, official and otherwise, with the township office (Figs. 32 and 33).



Fig. 32: Squad flag



Fig. 33: Dr. Paul Q. Peterson (MSA Health Officer) visiting a spraying squad and interviewing a Chishan Resident

Each township provided a bulletin board at the health station to display a map of the township, a chart and a statistical table, which graphically showed the weekly progress of the spraying operation. The geographical area covered in the spraying operation was shaded on the map; the chart and table showed the number of structures sprayed, the population directly protected, the surface area (m²) sprayed, consumption and balance of DDT, etc. The location of each squad was marked on the map by a small pin bearing a small flag. Posters, handbills and written instructions were also posted on the bulletin board for public information.

Each foreman submitted a daily report to the TAMRI supervisor who, together with the foreman, reviewed the report and prepared weekly summaries to be submitted to TAMRI. All weekly summaries were consolidated at the TAMRI headquarters for overall evaluation.

The spraying squads and TAMRI supervisors moved on foot from place to place within their respective townships. Although there were 28 squads, only seven bicycles were used for daily transportation of supplies and equipment. TAMRI had only one 1947 Dodge pick-up truck (one ton) and two 1947 Willys jeeps for the entire pilot project, namely the spraying operations and malariometric and entomological surveys in the same general area (Figs. 34 and 35).



Fig. 34: 1947 Dodge pick-up truck
(courtesy of the Rockefeller Foundation)



Fig. 35: 1947 Willys jeep (courtesy of UNRRA)*/
crossing a suspension bridge in
Liukuei, Kaohsiung county

* / United Nations Relief and Reconstruction Administration

EVALUATION OF EPIDEMIOLOGICAL RESULTS IN THE CHISHAN PILOT PROJECT

Four types of surveys were conducted to evaluate the effectiveness of the DDT spraying program in both the demonstration and check areas. All the pre-spraying surveys were completed between June-July 1952. The spraying operations were carried out during the period July 14-September 28. All surveys were repeated periodically in the same manner, in the same localities, and by the same groups of technical personnel.

Spleen and Parasite Surveys

Samples were taken from three age groups, *i.e.*, 2-5, 6-9 and 10-14 years old, of pre-school and school children. The household registration system maintained at the township office normally provided updated demographic information by villages. Before the survey, lists of pre-school children were prepared. Forms, each bearing the name and age of a child, were delivered to the village heads for distribution to the respective households. The time and place where the examinations were to be made were indicated in these forms. The majority of the children usually appeared at the specified time and place, but house-to-house surveys were sometimes required to complete the work. For school children, the surveys were done through visits to schools and sometimes to villages to search out absentees. Surveys were conducted twice a year -- once in June and once in December. The peak of transmission was usually from October through December in the Chishan district and therefore the rates in December would have been higher than those in June, if the control measures were not applied or were ineffective.



Fig. 36: Taking blood smears at school

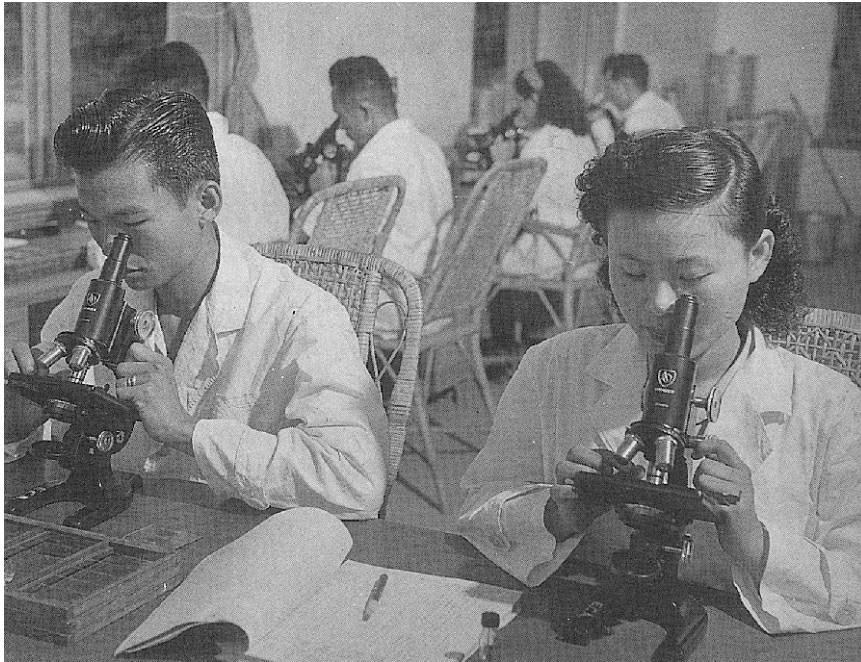


Fig. 37: Examination of blood smears

The pilot project in Chishan district confirmed the effectiveness of DDT spraying once a year at 2 gm technical grade DDT per m². (Actually, the dosage as calculated later was 1.86 gm per m².) In the complete spray area, the parasite rate fell from 23.0% to 1.9%, and the spleen rate fell from 52.3% to 24.7% in less than 18 months. Similar results were obtained in the selective spray area. In the check area, where no DDT was applied, no measurable change was obtained during the same period. In 1953 the check area had to be sprayed because the people protested strongly for having been left out from the DDT spraying program in 1952. Nevertheless, the objective as check area had been served, and the area was included in the regular spraying program beginning in 1953.

Table 24
Spleen and Malaria Parasite Surveys Among Children Ages 2 - 14
in Chishan District, 1952 - 1956

Area	Survey Date	Spleen Survey			Parasite Survey		
		Total Exam.	Spleen Rate (%)	AES	Total Exam.	Para. Rate(%)	Gamet. Rate(%)
Completely Sprayed Area	June 1952	1,687	52.28	2.24	1,953	23.04	11.32
	Dec. 1952	1,875	31.63	1.96	1,884	11.52	4.25
	June 1953	1,705	24.22	1.87	1,705	5.10	1.06
	Dec. 1953	1,823	24.73	1.66	1,830	1.86	0.33
	June 1954	2,071	18.88	1.16	2,277	0.13	0.00
	Dec. 1954	2,096	15.31	1.40	2,100	0.86	0.43
	May 1955	2,235	11.45	1.37	2,235	0.40	0.09
	June 1956	2,292	6.88	1.17	2,292	0.13	0.04
Selectively Sprayed Area	June 1952	651	82.95	2.67	762	33.86	19.55
	Dec. 1952	682	54.40	1.91	684	17.84	7.46
	June 1953	732	38.25	1.96	730	4.52	0.82
	Dec. 1953	732	42.95	1.82	738	2.30	0.81
	June 1954	773	30.14	1.53	870	0.92	0.34
	Dec. 1954	846	20.14	1.50	846	1.18	0.59
	May 1955	917	15.27	1.49	917	0.22	0.11
	June 1956	838	11.42	1.34	860	0.35	0.00
Former Check Area	June 1952	1,419	44.47	1.99	1,452	20.32	5.23
	Dec. 1952	1,396	53.58	2.09	1,465	25.73	14.69
	June 1953	1,486	43.47	2.04	1,476	15.79	5.32
	Dec. 1953	1,532	38.51	1.68	1,532	8.55	2.74
	June 1954	1,526	26.75	1.62	1,663	2.41	1.14
	Dec. 1954	1,974	22.70	1.46	1,775	1.69	0.62
	May 1955	1,765	18.98	1.42	1,767	0.47	0.34
	June 1956	1,893	9.24	1.13	1,900	0.21	0.05

Note: DDT spraying was carried out each year between August through September from 1952 - 1956 in the completely and selectively sprayed areas and from 1953 - 1956 in the former check area.

Monthly Infant Surveys

In order to observe if malaria transmission had been interrupted or reduced by DDT spraying, monthly surveys of infants were conducted in 12 selected villages, eight in the demonstration area with a population of 8,333 and four in the check area with 4,847 inhabitants. Before the surveys were initiated, lists of infants were prepared at each township office; mothers were notified through the headman of each village to bring their babies to a designated public place in the village or to the headman's residence for blood examination. Those infants found to have malaria parasite in their blood were properly treated and then excluded from subsequent surveys. Also, those infants whose age exceeded the 365-day mark were eliminated from the list (Fig. 38).



Fig. 38: Infant survey

From June to September 1952, there were 118 positives among 1,233 infants examined in the demonstration area, while in the check area 39 positives were found among 491 examined. All these positive cases were infected within 12 months prior to the day of examination. From October 1952 to September 1953, there were six positives found in the selective spray area and 10 in the complete spray area, making a total of 16 cases in demonstration area within 12 months following the first spray.

These cases were believed to have contracted malaria infection before their respective villages were sprayed for the first time. New infections had practically ceased in 12 months after the first DDT spraying. The results of the monthly infant surveys in the Chishan district are shown in Table 25.

Fortnightly Fever Case Survey

It is generally accepted that in a highly malarious area, a good proportion of fever cases can be attributed to plasmodial infections. Therefore, a successful malaria control measure applied to said area is bound to reduce the number of fever cases among the local population. At the same time, there should be a lower malaria positivity rate among the fever cases examined.

In the Chishan district, fever case surveys had been carried out since July 1952, being conducted fortnightly during the period from July to November 1952 and monthly thereafter. The results of the surveys are shown in Table 26 in terms of the number of fever cases per 10,000 inhabitants visited and the positivity rate for malaria among the fever cases seen at the time of the visits. The number of fever cases declined in the entire Chishan district, but the malaria positivity rate dropped sharply only in the demonstration area, whether completely sprayed or selectively sprayed.

Table 25
Monthly Infant Parasite Surveys in the Chishan District
June 1952 - June 1954

Survey Period	Selective Spray Area			Complete Spray Area			Check Area		
	No. * Exam.	Total Pos.	Para. Rate(%)	No. * Exam.	Total Pos.	Para. Rate(%)	No. * Exam.	Total Pos.	Para. Rate(%)
June - Sept. 1952	400	38	9.50	833	80	9.60	491	39	7.94
	----- 1st spray completed -----								
Oct. - Dec. 1952	314	2	0.64	564	7	1.24	515	34	6.60
Jan. - Mar. 1953	369	2	0.54	596	1	0.17	432	9	2.08
April - June 1953	396	0	0	551	1	0.18	447	2	0.45
July - Sept. 1953	422	2	0.47	574	1	0.17	454	5	1.10
	----- 2nd spray completed -----								
	----- 1st spray -----								
Oct. - Dec. 1953	378	2	0.53	446	0	0	471	2	0.42
Jan. - Mar. 1954	370	0	0	528	0	0	440	0	0
April - June 1954	392	0	0	587	0	0	490	0	0

Pos. = Positive; Para. = Parasite

* Total number of infants examined in the period indicated.
 On an average, 90.4% of all infants in the area were examined every month.

Table 26
Consolidated Data from Fever Case Surveys in the Chishan District
July 1952 - May 1954

Survey Period	Selective Spray Area			Complete Spray Area			Check Area		
	Persons Visited	FC Per 10,000	Pos. Rate (%)	Persons Visited	FC Per 10,000	Pos. Rate (%)	Persons Visited	FC Per 10,000	Pos. Rate (%)
July '52 - Sept. '52	13,539	744	31.8	18,914	502	30.5	16,075	529	31.1
Oct. '52 - Mar. '52	21,776	607	24.7	36,087	327	19.4	33,933	433	40.8
April. '53 - Sept. '53	17,065	425	13.0	26,381	350	11.8	25,961	335	24.5
Oct. '53 - Mar. '54	22,228	305	4.0	39,883	198	4.2	36,385	184	24.7

Note: FC per 10,000 = Fever cases per 10,000 inhabitants.

Pos. Rate = Slide positivity rate for malaria among the fever cases.

Entomological Surveys

Without question the spleen and parasite surveys, the monthly infant surveys, and the fortnightly fever case surveys provided the most definitive measurement of the effectiveness of indoor residual spraying in the pilot project area. Nevertheless, the parallel measurement of anopheline populations was considered essential in monitoring the spraying coverage, the duration of effectiveness of DDT deposits applied only one per year, and the possible development of anopheline resistance to the insecticide.

In order to insure parallel coverage by malariometric and entomologic means, the selection of mosquito collection stations was delayed until the epidemiological survey areas were chosen. However, pre-spraying baselines were obtained before the spraying began on July 14, 1952. During June, collections were made in 11 localities in the demonstration-area-to-be and in four localities in the check-area-to-be. Exhaustive collections in 36 not-yet-sprayed houses yielded 1,130

anophelines, of which 1,063 were *An. minimus* and 43 were *An. sinensis*. Of 251 anophelines found in unsprayed stables, 116 were *An. minimus*, 128 were *An. sinensis* and 7 were other species.

Long-term collection stations were established in July -- three in the complete spray area, three in the selective spray area, and three in the check area. Potential breeding places for larval collections were chosen in association with each adult anopheline collection station.

Routine fortnightly collections began in late July/early August (July 26-30 and August 9-13). Use of window traps was attempted but was found to be impractical because of irregularities in the house construction materials (Fig. 39).

The usefulness of the fortnightly collections was immediately apparent. Although seasonal anopheline populations were still rising in the check area in October (one unsprayed house yielded 849 specimens of which 846 were *An. minimus*), the stations in the completely sprayed area and in the sprayed portions of the selective spray area yielded no anophelines. Larval collecting stations were giving irregular results, *e.g.*, rice-field stations were reflecting seasonal rice-cultivation changes, irrigation canal stations suffered occasional flushing effects during heavy rains.

During continued entomological monitoring of the pilot project, the collection stations in the complete spray area and the sprayed stations of the selective spray area showed zero or near-zero anopheline population, while populations in the unsprayed check area reflected seasonal effects of agricultural practices and variable weather phenomena.

Due to popular demand, the Chishan check area was sprayed in 1953. Larger complete/selective spray areas were established and maintained in Nantou county during 1953, monitored by monthly rather than fortnightly collections.



Fig. 39: Window trap

CALCULATION OF MANPOWER NEEDS, DDT AND SPRAYER REQUIREMENTS

At the end of 1951 an extensive island-wide survey of different types of houses was carried out. This survey had the objective of assessing house design, construction material, division of rooms, furniture and sprayable superficial areas. In June 1952, before the initiation of the spraying operations in the pilot project areas, another survey was carried out in the Chishan and Chaochou districts to estimate the average superficial area per capita in the two districts. In the Chishan district, 97 households with 704 persons were selected from different villages, and measurement of sprayable superficial area was made. The results indicated that the average sprayable surface area per capita was 52.6m^2 , and that on the average bedrooms occupied 34.2% of the surface in the house, the sitting room 17.1%, the store room 16.1%, the kitchen 15.7%, and others 16.9%. A similar survey in the Chaochou district showed an average of 42.6m^2 of sprayable surface per capita and more or less the same proportion of surfaces for different types of rooms.

The results of the above-mentioned house surveys and the operational output experienced in the DDT house spraying programs during the Rockefeller Research Center period constituted the base for estimating manpower needs, insecticide, sprayers, operational period, basic composition of a spray squad, and other operational requirements and expenses.

In the pilot project area, including both the Chishan and Chaochou districts, the spraying operations started on July 14 and were completed on September 28, 1952. Data for the entire pilot project area (Chishan and Chaochou districts) follow:

Summary of Spraying Operations (1952)

Number of villages sprayed	119
Number of houses (or structures) sprayed	21,682
Number of rooms and compartments sprayed	148,163
Population directly protected	156,217
Superficial area sprayed (m ²)	6,617,660
DDT (technical grade) used (kg) */	12,270
DDT (technical grade) sprayed (gm per m ²)	1.86
No. of workers, incl. squad leaders, spraymen and helpers	205
Man-hours spent, all squad members	42,443
Man-hours spent, spraymen only	29,905
Total number of working days employed	49.8

Analysis of Operational Output

Ave. number of rooms & compartments sprayed per structure	6.83
Average superficial area sprayed per structure (m ²)	305
Average number of inhabitants per structure	7.2
DDT (technical grade) used per structure (gm)	566
Average superficial area sprayed per capita (m ²)	42.4
DDT (technical grade) used per capita (gm)	78.5
Proportion of time spent for travel to total time of operation	32.0%

*/ DDT actually used was 5,671 kg of 50% water-dispersible powder (wdp) plus 12,579 kg of 75% wdp.

Cost Analysis

<u>Item</u>	<u>Cost in NT\$</u>	<u>% of Total</u>
DDT, technical grade	233,273.00	63.54
Labor	76,414.00	20.81
Supervision	33,865.95	9.22
Depreciation and repair of equipment	5,376.27	1.46
Transportation	8,147.20	2.22
Training	8,079.00	2.20
Printing	2,000.00	0.55
TOTAL:	367,155.42	100.00

Cost per capita protected = NT\$2.35 (equivalent to US\$0.23)

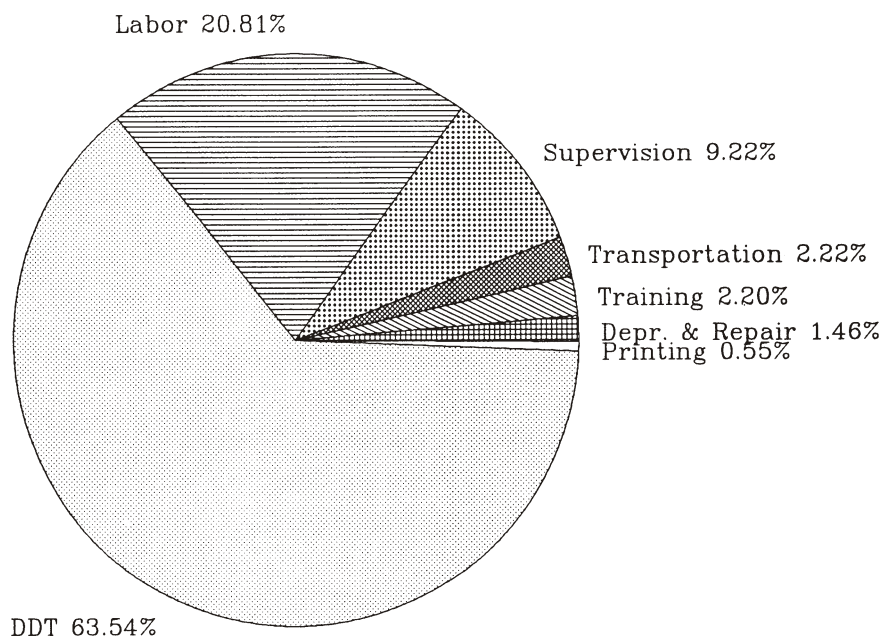


Fig. 40: Cost analysis - first year operation

SUMMARY OF THE PILOT PROJECT

The 1952 pilot project was intended to confirm the effectiveness of DDT house spraying on a large scale, to test the practicability of conducting field operations by the local health workers and the community members, and to assess the cost and applicability of the proposed malaria control measure.

DDT residual house spraying applied once a year at 2 gm technical grade/m² was outstandingly effective, to an extent not previously achieved in Taiwan. As indicated in previous paragraphs, the parasite rate in school children was reduced from 23.0% to 1.9% in 18 months, the infant new infections were greatly reduced after the spraying and were eventually eliminated, and the slide positivity rate among fever cases declined from 30.5% to 4.2% in the same period. Entomologically, the effects of the insecticide were equally striking. The adult anopheline density in the sprayed premises dropped to zero or near-zero levels after the first application of DDT and remained so through the second application.

Each spraying squad, whose composition was tested out in the 1952 pilot project, was expected to spray houses of 7,000 people within 60 working days, using seven squad members (one foreman, four sprayers and two helpers) with five hand-sprayers (four active and one spare). This calculation proved to be generally sound. When a squad worked in an area where housing was concentrated, spraying proceeded swiftly. In contrast, under working conditions in remote villages with scattered houses requiring excessive traveling, the spraying took more time. However, averages on a township basis showed that with very few exceptions, 60 working days were more than enough for a complete round of spraying in a township. In effect, the 1954 statistics later revealed the following average working days on a regional basis: 50.4, 51.1, 53.6 and 51.6 days for northern, eastern, southern and central Taiwan, respectively. Nevertheless, an allowance of a working days was considered appropriate for meeting contingencies such as heavy rainstorms, floods or typhoons.

It was believed that a spraying cycle of 12 weeks, including two weeks of training and other preparatory works and 10 weeks (or 60 working days) for spraying, would not constitute undue distractions in the normal activities of the health centers and health stations and could be repeated once a year for several years.

Based on 45 m² as the surface area per capita requiring spraying and 2 gm of technical grade DDT per m² as the prescribed dose, pre-spraying allocation of insecticide (namely, 75% water-dispersible DDT powder) at 120 gm per capita was sufficient for complete house spraying. Beginning with the 1953 island-wide

spraying, 110 gm per capita were forwarded directly to individual townships, while the remaining 10 gm per capita were retained in respective health centers to be dispensed at a later time, if and when needed. This logistical arrangement resulted in reducing allocation errors to a minimum.

The 1952 field operations showed that local health personnel could, with adequate training, organize and perform an efficient malaria control program. Furthermore, the community could be promoted to participate in the program by assisting the spraying squads and survey teams when needed, and the local government could be convinced to share the labor costs. The experiences of the pilot program provided a sound basis for island-wide DDT spraying in successive years.

PREPARATION OF OPERATIONAL MANUALS

The valuable experiences gained by working closely, from May to September 1952, with 28 spraying squads in 10 townships in the pilot project were used to refine and reinforce operational and administrative techniques. Two instructional manuals were developed for field use by the spraying crews. Additionally, an implementation guide was prepared for use by county and township personnel.

A 31-page (8" x 6") *Foremen and Operators' Manual* and a 44-page (8" x 6") *Foremen and Operators' Guide* were prepared in English and Chinese. The former manual had the Chinese text with the corresponding English on the facing pages; the latter had alternating Chinese and English instructions on the same pages with relevant illustrations on the opposite pages. The first and second editions of these useful field workers' "best sellers" were distributed freely to all spraying personnel in February 1953 and December 1953, respectively. These two editions were mimeographed. The third edition was printed and issued in January 1954; it was professionally presented and was even more attractive. The two manuals were further improved in January 1955 by adding material for the convenience of foremen in rating spraymen, *e.g.*, tabulation to eliminate tedious calculations and not infrequent errors.

These manuals explained: (a) the action of DDT in mosquito and malaria control, (b) the proper use of compression sprayers and accessory equipment, (c) where to spray, (d) how to spray, (e) spraying practice, (f) cleaning of the sprayers, (g) measurement of surface areas sprayed, (h) how to rate spraying speed, (i) proper and accurate recording of data collected, and (j) other details of basic spraying methods.

Copies of the manuals were sent to local program-associated agencies, to malaria advisory committee members, to county and township health officers, and to international support organizations. Overseas recipients included the American Society of Tropical Medicine and Hygiene, which kindly mentioned these manuals in the *Tropical Medicine and Hygiene News*, Vol. 3, No. 3, page 11 (June 1954), and referred readers to the WHO malaria team in TAMRI as a source for copies. As a result, copies were distributed to universities, libraries and individuals, upon request.

The first edition of a third manual, *A Guide for Implementation of the DDT Spraying Program* (in Chinese), was a 10-page, mimeographed pamphlet issued on June 25, 1953. It was updated year after year and, by January 1956 it became an encyclopedic 70-page (10½" x 8") booklet, printed professionally and distributed to county health officers, county malaria supervisors, township mayors, township health officers and township malaria supervisors, as well as TAMRI personnel. The guide was intended to provide assistance in the administration of the spraying operations at county and township levels. Its 14-page text included short chapters covering: (a) the objectives of the spraying, (b) outlines of training courses for county supervisors, township supervisors, foremen and spraymen, (c) selection or recruitment of trainees, (d) general plan of operations in a township, (e) daily working hours, (f) publicity campaign, (g) outlines of the responsibilities of local officials, including county and township health officers and township mayors, (h) matters requiring special attention during the spraying of houses, (i) post-spraying precautions, (j) care of insecticides, sprayers and other equipment, and (k) personnel management.

The manual-guide then offered numerous appendices covering a wide variety of otherwise hard-to-find information, ranging from descriptions of mosquito daytime resting places to a consolidation of scattered but extremely pertinent regulations from the *Taiwan Provincial Gazette*. In summary, it was a veritable "book of knowledge" for the DDT spraying program in Taiwan.