Chapter XIII

SPECIAL STUDIES

As indicated in Chapter VII, the expansion of the DDT spraying coverage was marked by encounters with a number of serious problems which demanded general or local attention. These and similarly-challenging problems were resolved, but not without investigations which deserve more detailed descriptions. As will be seen in this chapter, these special studies carried no "publish-or-perish" trademarks, but were focused on rapid and practical resolution of difficulties encountered in field operations.

EXPLORATION OF POSSIBLE SAVINGS THROUGH SELECTIVE SPRAYING (Pletsch and Demos, 1954)

The agreements signed in late 1951 and early 1952 permitted the launching of a four-year malaria control program. Although all of the participating international and bilateral organizations promised to support that four-year program, budgetary provisions would have to be approved on a year-to-year basis, and possible thrift was not being ignored by those planning the operations. The first year's program was to be a pilot project during which basic procedures and techniques would be tested for their effectiveness in interrupting transmission by indoor spraying of DDT against the vector mosquitoes. Cost of insecticides was recognized as the major budgetary item.

During early entomological studies, the detailed recording of anopheline resting places, registered according to detailed microhabitats, had shown that some habitats were much more attractive than others (Fig. 18 in Chapter V). So marked were these differences that consideration was given to the possibility of saving insecticide and perhaps some labor if a selective indoor-spraying protocol might prove effective. The Chishan pilot project was therefore designed to include not only a complete spray area and an unsprayed "check" area, but also an area in which insecticide might be selectively applied only to indoor surfaces apparently favored by anopheline mosquitoes as daytime resting places.

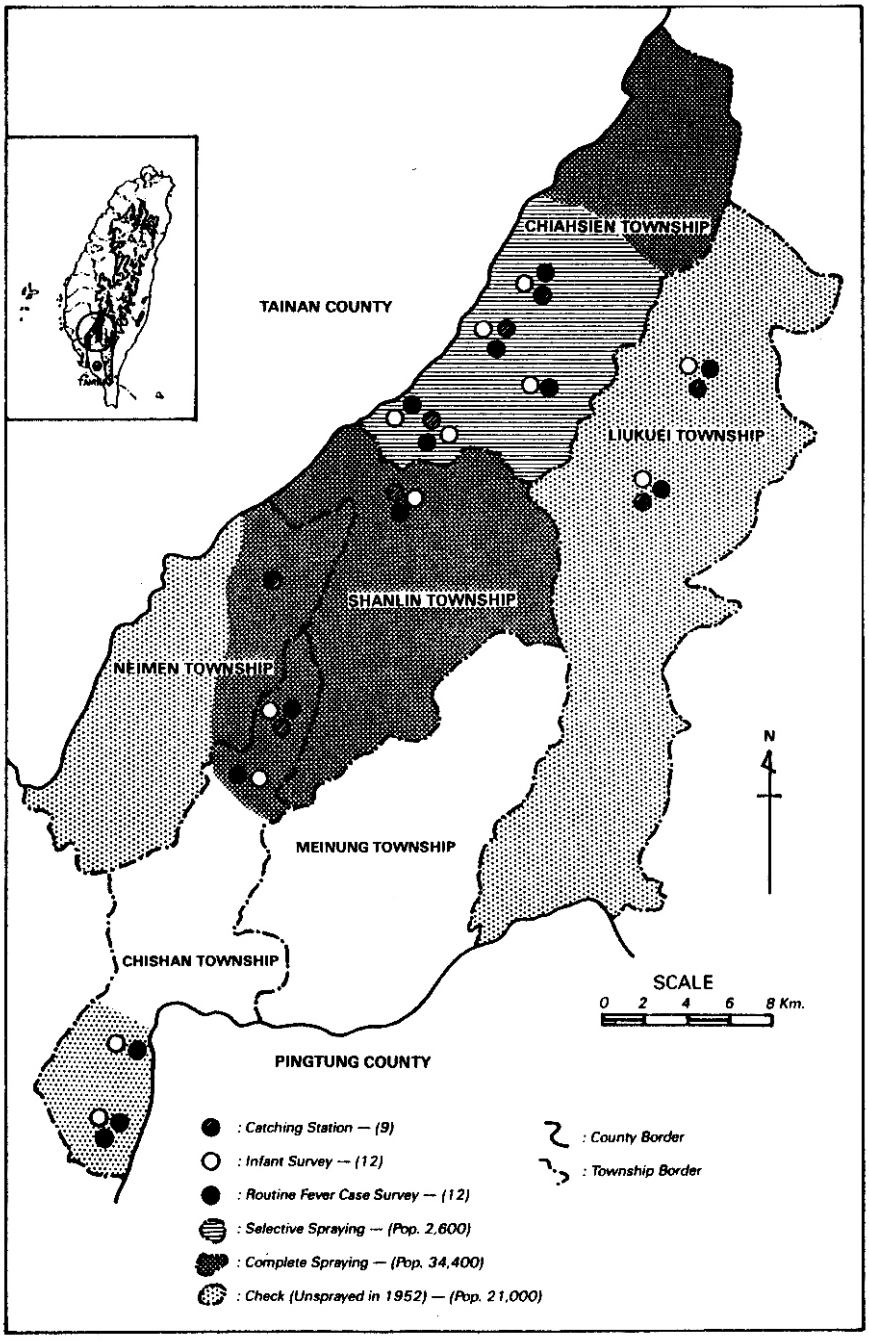
The idea of selective spraying did not originate in Taiwan. It had been attempted as early as 1946 - 1947 in the first year's spraying in the Sardinian Project in Italy, aimed not only at the eradication of malaria but also of the vector species *Anopheles labranchiae* (Logan *et al*., 1953). For unstated reasons, the Sardinian program opted for complete coverage beginning in the second year. Selective spraying was tested in Burma apparently under conditions similar to those in Taiwan, in a WHO Demonstration Project carried out in the northern Shan States from 1951 to 1954 (Weeks, 1954). *An. minimus* was considered the only vector, and indoor surveys of resting anophelines had shown a pattern similar to that in Taiwan, albeit in somewhat less detail. No cow sheds were sprayed; walls inside houses were sprayed to a height of either three feet or six feet. During the rest of the Burma Project (1952 - 1954), all selective spraying treatment included wall-spraying up to six feet. Spleen and parasite surveys, and entomological monitoring in fixed and random collections, showed satisfactory results, with once-per-year applications at a rate of 2 gm of technical grade DDT per m^2.

In May 1952 the Chishan district of Kaohsiung county, with a population of 37,000, was established as a pilot project area in which to initiate and evaluate spraying and associated evaluation operations, including manpower, equipment and logistical aspects (Map 16).

An area for complete spraying treatment was established, with a population of 34,400; an adjoining area for selective spraying was set aside, with a population of 2,600. Surrounding townships, with a combined population of 21,000, made up an unsprayed "check" area for comparison. (The latter suffered a complicating but gratifying change in 1953. The 1952 operations in both complete and selective spray areas of the pilot project had been so effective that the residents in the original check area demanded and were subsequently given the same treatment as those in the complete spray area.)

Map 16

Pilot Project Area, Chishan District, Kaohsiung County



The complete spray sectors in Chishan received the standard spraying treatment: applications were made on all walls, ceilings and the undersides of furniture at the rate of 2 gm of technical grade DDT per m^2, as a suspension of water-dispersible powder. Inner walls of all outbuildings were sprayed, with the exception of the lower half-meter of pigpens, where animal contact would remove the deposit. In the selective spray sectors, the spraying protocol was carried out as shown in Table 49.

Table 49

Spray Coverage in Selective Spray Sectors

Surfaces	Inside Houses					Stables and Other Buildings
	Bedroom	Store Room	Sitting Room	Kitchen	Toilet	
- Walls	+	+	-	-	+	-
- Roof	+	-	-	-		-
- Ceiling	+	+	-	-	-	-
- Ceiling and door of bed canopy, if present	+	-	-	-	-	-
- Underside of furniture, and window recesses	+	+	+	*/	-	-
- Underside of bed, or bed platform, incl. walls	+	-	-	-	-	-

*/ Only inside and under food cabinet.

Source: Pletsch and Demos, 1954

The correct application of the complete and the selective spraying protocols was insured by the fact that, although the spraying personnel were all recruited locally, they were trained in only one of the two procedures - either complete spray technique or selective spray technique, not both.

Effectiveness of the operations in the pilot project in Chishan in southern Taiwan was evaluated by malariometric studies (by the Parasitology Section of TAMRI) and entomological surveys accomplished by Entomology Section personnel.

Spleen and parasite surveys, infant parasite surveys, and fever case surveys showed that the selective as well as the complete treatment had produced rapid

reductions of malaria indices. In two years, the spleen rate in the completely sprayed area was down from 52.28% to 18.88%; the parasite rate declined from 23.04% to 0.13%. In the selective spraying area the spleen rate dropped from 82.95% to 30.14%; the parasite rate from 33.86% to 0.92%. Infant new infections were nil in two years in both the complete and selective sprayed areas.

A more extensive test of selective spraying was initiated in central Taiwan in 1953. Complete spray treatment was given in two townships in Nantou county with a population of 57,705; selective treatment was carried out in nine townships with a population of 244,770. Four adjoining townships, serving as the check area, received no spraying in 1953.

The malariometric survey techniques carried out in the central Taiwan trial area were the same as those used in southern Taiwan, and gave equally effective results. The explanation for these gratifying results in both southern and central Taiwan is obvious when tracing the anti-anopheline effectiveness of both the selective and complete spray applications. The story in Chungliao township in Nantou county in central Taiwan was an excellent example (Table 50). Anophelines virtually disappeared from previously infested houses following the first selective or complete spraying; adjoining unsprayed stables retained high population of *An. sinensis*, but *An. minimus* were reduced to zero or near-zero. Of great importance were the observations that in selectively-sprayed houses the anophelines were not only absent from selectively-sprayed microhabitats, but had not moved to purposely-unsprayed microhabitats.

The Engineering Section of TAMRI made a cost analysis of the extensive complete/selective trial in central Taiwan. The figure for area sprayed per capita was 43.38 m^2 in the completely sprayed houses and 26.72 m^2 per capita in the selectively sprayed premises, a difference of 16.66 m^2, a saving of 38.4%. At the existing exchange rate the cost per capita in completely sprayed areas was US$0.18 against US$0.134 in the selectively sprayed areas, or a saving of 25.6%.

Despite the significant economic attraction offered by the selective spraying protocol, there were several subtle disadvantages involved. First, although *An. minimus* adults were eliminated or reduced to near-zero levels in houses in both areas, their occasional survival in unsprayed stables in the selective spray areas might favor the possibility; albeit remote, of development of insecticide-resistant forms. Secondly, though definitely not to be ignored, was the unhappiness of farmers and their families in the selective spray areas because the unsprayed stables continued to

Table 50

Adult Anopheles Collections in Houses and Adjoining Stables
Chungliao Township, Nantou County, November 1952 - September 1955
(total number of females and males captured)

Treatment and Date	Houses				Adjoining Stables		
	An. min.	*An. sin.*	Others	Total	*An. min.*	*An. sin.*	Others
Before spraying							
(Nov. 21-26, 1952)	59	5	2	66	41	391	5
Dec. 23	20	0	0	20	44	120	4
Jan. 19, 1953	10	0	1	11	31	52	4
Feb. 5	16	0	0	16	14	42	4
Mar. 9	38	13	0	51	15	158	1
April 6	82	26	1	109	15	919	2
Selective spraying	- - - - - - Sprayed - - - - - -				- - - - - - Not Sprayed - - - - - -		
(April 9-10, 1953)							
May 6	0	0	0	0	19	222	1
June 7	0	0	0	0	20	195	0
July 7	0	0	0	0	1	172	0
Aug. 7	0	0	0	0	0	24	1
Sept. 6	0	2	0	2	0	104	0
Oct. 6	0	0	0	0	0	224	0
Nov. 5	0	0	0	0	0	160	1
Dec. 7	0	0	0	0	0	6	1
Jan. 8, 1954	0	0	0	0	0	21	0
Feb. 9	0	0	0	0	0	25	0
Selective spraying	- - - - - - Sprayed - - - - - -				- - - - - - Not Sprayed - - - - - -		
(Feb 24-26, 1954)							
March 7	0	0	0	0	0	59	0
April 6	0	0	0	0	2	372	0
May 6	0	0	0	0	0	220	0
June 7	0	0	0	0	3	89	1
July 7	0	0	0	0	0	23	0
Aug. 7	0	0	0	0	0	16	0
Sept. 7	0	0	0	0	0	53	0
Oct. 7	0	1	0	1	0	235	0
Nov. 7	0	0	1	1	0	18	0
Dec. 7	0	0	0	0	0	29	0
Jan. 9, 1955	0	0	0	0	1	8	0
Feb. 7	0	0	0	0	1	25	0
March 7	0	0	0	0	0	16	0
Complete spraying	- - - - - - Sprayed - - - - - -				- - - - - - 1st Spraying - - - - - -		
(March 24-26, 1955)							
April 9	0	0	0	0	0	0	0
May 7	0	0	0	0	0	0	0
June 7	0	0	0	0	0	0	0
July 7	0	0	0	0	0	0	0
Aug. 7	0	0	0	0	0	0	0
Sept. 11	0	0	0	0	0	0	0

harbor abundant populations of An. sinensis which plagued their water buffalo, the family's valuable and faithful beast of burden. Householders in complete spray areas relished the tranquility of their water buffalo in stables free of mosquitoes; the word spread to selectively sprayed areas, whose farmers promptly requested inclusion of cow sheds in their area's spraying protocol. One township even offered to provide or pay for the extra DDT from township funds. Thirdly, the selective spraying protocol, although efficiently and properly applied by well-trained spraying squads, gave some householders an impression of careless, incomplete coverage, eliciting reports that the workers were "forgetting parts of the house." Inasmuch as the campaign was enjoying excellent community cooperation, this adverse psychological reaction, along with the two factors already mentioned, led to adoption of complete spraying coverage wherever spraying was required.

BEDBUG RESISTANCE TO INSECTICIDES

While the tropical bedbug *Cimex hemipterus L.* had undoubtedly been widespread throughout Taiwan well before the four-year antimalaria program was launched in 1952, the only background data available to TAMRI were several Japanese papers dealing with the species' temperature sensitivities and cross-mating with *Cimex lectularius*. Despite the claim in some antimalaria circles that residual spraying treatment would eliminate bedbugs, TAMRI was concerned about its lack of baseline data. Bedbug surveys were therefore programmed for four townships in Taitung county in April 1953, in hopes of locating at least 100 infested houses. In effect, 322 houses in never-sprayed localities were examined, of which 112 (34.78%) were positive for bedbug nymphs and/or adults. No tests of baseline insecticide susceptibility were made at that time, but the close acquaintance of WHO and TAMRI technicians with *Cimex hemipterus* was indeed opportune. On October 7, 1953 an acute bedbug problem was reported from the Fengshan army camp in Kaohsiung county by an army medical officer. The installation had been given several DDT-formulated sprayings against malaria: one in 1950 (June); two in 1951 (March, October) and two in 1952. In 1953 several sprayings were specifically and unsuccessfully applied against bedbug infestations. Specimens *(C. hemipterus)* collected from bed nets and leather rifle maintenance boxes were subjected to continuous exposure on DDT-impregnated cloth (Chen H.H., *et al.* 1956). No mortality was recorded during the first four days of exposure, and 27.8% survival was observed after 33 days. In contrast, parallel tests with specimens from a never-

Sprayed southern Taiwan village (Kanting, Pingtung county) gave 100% mortality with less than two days' exposure. Both strains were colonized, and further tests clearly confirmed the resistance to DDT of the Fengshan strain. Brown and Pal (1971) credited TAMRI with the initial discovery of resistance to DDT of the tropical bedbug *C. hemipterus.*

Bedbugs were of primary interest in trials carried out testing the effectiveness against domestic insect pests of the traditional village house cleanings, which were practiced twice a year in Taiwan under provincial proclamation (Chen H.H., Lien, Tseng, 1956). Four never-sprayed villages in the hilly eastern part of Chingshui township, Taichung county of central Taiwan, were selected for the study. The villages had a population of 7,415 in 1,088 households. The first intensive house pest (insect) survey was a "pre-cleaning" survey carried out between February 25 and March 3, 1955. The second survey was a "post-cleaning" survey or "pre-spraying" survey carried out between April 4 and April 13. The third or "post-spraying" survey took place between May 14 and May 23.

The local type of wooden bed or raised wooden sleeping platform is covered by one or two sheets of the typical flexible woven straw mat, about 2 x 2 m. Such mats are normally the focus of bedbug infestations. To make collections, each mat was rolled and stood on one end in a large aluminum pan (Fig. 80). It was then lifted about one foot and dropped suddenly three times into the pan, shaking loose any harbored bedbugs. The mat was then reversed and again given the shock treatment. The bedbugs were collected from the pan and counted each time the mat was jarred (Fig. 81).

Bedbug specimens (all were *C. hemipterus*) were collected and counted during the examination of 529 households in the first or "pre-cleaning" survey. Bedbug eggs, nymphs or adults were found in bed mats of 116 houses (21.93%). In the "post-cleaning" examination of 310 previously-unsurveyed houses, bed mats of 67 houses (21.61%) were found infested. The semi-annual village house cleaning, carried out under supervision of the police and the subvillage headman, had

Fig. 80:

Sampling for bedbugs - straw mat was rolled, lifted and dropped suddenly into the pan.

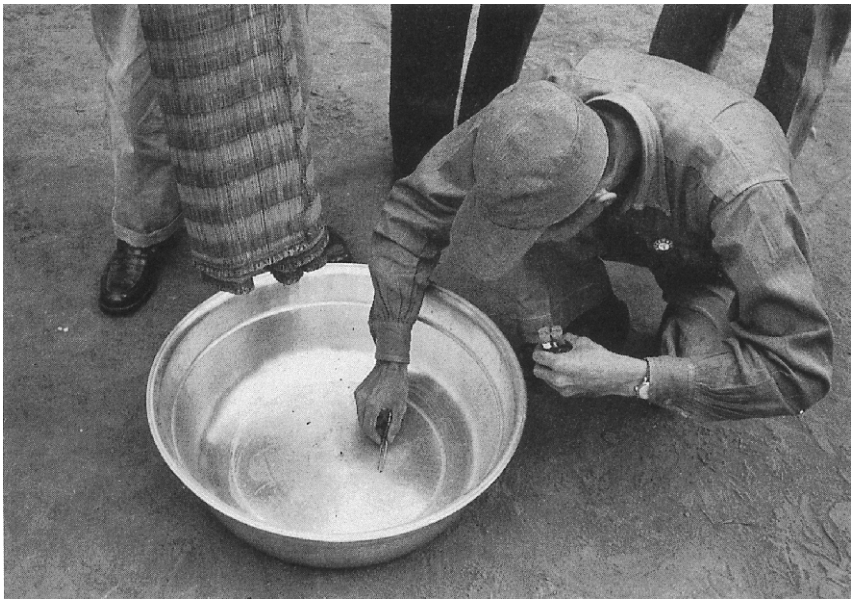


Fig. 81: Bedbugs were then collected from the pan
Source: JCRR

obviously not been effective in reduction of bedbug infestations.

Hudson Model 710-S hand compression sprayers were used in carrying out the conventional antimalaria spraying in all houses of the four villages, involving application of approximately 2 gm of technical grade DDT per m^2 to the bed mats and to the beds or sleeping platforms.

A total of 351 houses which had been examined in the "pre-spray" survey were re-examined in the third or "post-spray" survey. Only two cases of bedbug infestations were found, of which one was clearly due to faulty DDT spraying. The single application of antimalaria residual DDT to houses had given very acceptable control of extensive bedbug infestations. Despite evidence that the traditional semi-annual housecleaning operation had failed to control bedbugs, TAMRI did not discourage the practice - which included wiping of walls - if the event took place before the annual antimalaria spraying, with instructions prohibiting any post-spraying wipe-off of DDT deposit.

Although alerted in late 1953 by the bedbug problem in the Fengshan army camp where DDT resistance had followed several years' use of DDT, TAMRI had received only favorable reports following first-round applications of the insecticide.

However, in late 1955, a spray squad foreman reported that bedbugs were not being killed in parts of some sea-coast villages in Pingtung county. Investigations revealed heavy infestations in houses sprayed one to two months earlier:

Township	Houses Examined	Infestation Rate
Hengchun	47	97.8%
Checheng	23	100%
Fangshan	20	80%

In November 1955 the houses in Woulanpi and Haikou, Pingtung county, were experimentally sprayed with mixtures of DDT and gamma-BHC (Liu, 1958):

Wuolanpi: DDT 2 gm + gamma-BHC 17 mg per m^2
Haikou: DDT 1.5 gm + gamma-BHC 45 mg per m^2

Satisfactory control was observed, but a follow-up survey showed some recovery, although to lower-than-pretreatment levels. Subsequent tests of susceptibility to BHC gave no signs of development of physiological resistance.

During May 1956 TAMRI technicians checked a number of army barracks and found bedbug infestations in 6 of 33 rooms examined. At about the same period, TAMRI initiated the use of a combination of insecticides, 2 gm technical grade DDT + 17 mg gamma-BHC per m^2, in all spraying operations.

In 1964, tests of bedbug susceptibility to seven insecticides were made by non-TAMRI personnel (Chen M.Y., Wang R.C., 1965) using *C. hemipterus* from a local colony already resistant to DDT and dieldrin. Test results which used the protocol of Busvine and Lien (1961) indicated that diazinon was the insecticide of choice for use on the more common local substrates. The local tests of diazinon against *C. hemipterus* also supported its effectiveness against *C. lectularius*, as reported by Lofgren, Keller, Burden (1958).

SILKWORM INTOXICATION

Shortly after the initiation of the expanded spraying program in 1953, TAMRI received a letter and report from the Provincial Silkworm Improvement Farm concerning DDT intoxication of silkworms in the Chishan district of

Kaohsiung county. Contact was made with a branch sericultural station in Chaochou, which coordinated silkworm-culture matters in Pingtung, Kaohsiung and Taitung counties as part of a provincial movement toward establishing a sericultural "cottage industry." The Chaochou station reported that 12,200 kg of cocoons, worth NT$20.50/kg, had been produced in its area of coordination from the 1953 spring brood of silkworms, but that serious losses attributed to the antimalaria spraying had been reported from Chishan. Nineteen affected silkworm raisers were visited, and their rearing rooms, rearing equipment and surviving silkworms (then in the fifth larval stage) were inspected. To obtain uniform data, 21 questions were used in interviewing each silkworm program participant. The answers permitted the following conclusion: that efforts made to receive pre-spraying information concerning farmers intending to raise spring or fall broods of silkworms were only partially successful for the following reasons:

1. The sericultural branch station may distribute egg sheets (each sheet with approximately 10,000 eggs) in bulk to a single farmer in a community. After the eggs have hatched, the farmer may subdivide his allocation among many neighbors, some of whose decision to participate may be made at a very late date.
2. Participation is highly variable from season to season, reflecting current economic conditions as well as the farmers' involvement in other types of agricultural ventures.

When the squad foremen had been furnished lists of local sericulturists, they were able to give special attention to the farmers who were listed. Such farmers were advised of possible adverse effect of spray coverage; spraying of their premises was subsequently carried out only at the farmer's request.

Fig. 82: Silkworms after incubation in a rural household

The extent of silkworm mortality confirmed during the interviews differed considerably from the original reports. Among raisers originally reporting 100% losses, current observations showed mortalities ranging from 0% to 100%. Silkworm mortality attributed to DDT may have resulted from DDT intoxication, or to one or more of the following factors:

* careless handling (for many of the raisers, this was their first experience with silkworms);
* inadequate food supply (wild mulberry was not always seasonally available);
* poor ventilation; and
* disease(s) of unknown nature.

Some of the mortality originally attributed to DDT actually occurred one to five days before spraying, according to two silkworm raisers in one village.

A number of tests were carried out on a laboratory basis. Using paper sprayed the day prior to tests, silkworms were placed in contact with the paper for 10, 20 and 60 seconds. Specimens with 10-second contact continued to feed for as

long as 20 minutes, then showed tonic paralysis of head and thorax portions similar to the stiff neck of cases of human meningitis. The majority of the worms recovered, molted, and spun cocoons as though they were healthy worms. Some worms with 20- and 60-second contact with sprayed paper also recovered after showing various degrees of paralysis.

A series of worms exposed to a wooden substrate, sprayed with 2 gm technical grade DDT/m^2 twenty months earlier, showed no symptoms of intoxication and produced normal cocoons.

During the period of the autumn brood of silkworm-rearing in Pingtung county, six raisers rearing 22,000 to 29,000 silkworms were selected for a practical trial. The premises of three raisers were kept unsprayed as controls; the premises of the other raisers had been sprayed one day, two weeks, and one month before the trial. All larvae reared in the unsprayed premises suffered only the lightest mortality, and only in the fifth instar. In premises sprayed the day of the trial, larvae introduced into the rearing rooms one or five hours after the spraying showed high mortality (71.04% and 67.26%, respectively). Larvae introduced into rearing rooms which had been sprayed two weeks or one month previously showed very low mortality (1.33% and 4.39%, respectively), and cocoons of surviving larvae showed no abnormalities nor reduction of weight. These results indicated that silkworm rearing might be safely carried out in premises sprayed at least two to four weeks earlier. Information provided by TAMRI to those promoting and coordinating or engaged in silkworm-rearing was as follows:

1. DDT residual spraying of premises used for silkworm rearing can but need not, need not, cause mortality among the larvae;

2. DDT damage to silkworm reared in multiple-room houses of the plains type may be avoided or minimized if these rules are followed:

   (a) Adjust the spraying and rearing schedules so that spraying follows rearing, if possible. If the local malaria situation will not permit delaying the spraying, advance the spraying, or delay the rearing, or both, so that the spraying is completed 2-4 weeks before the initiation of rearing;

   (b) Do not spray the rearing room;

(c) Remove all silkworm-rearing equipment, including racks, trays, paper, nets, etc., at least 25 meters to the windward side of the house during the actual spraying; and

(d) Avoid contamination from sprayed parts of the house. Do not wipe or brush residues from sprayed surfaces, as the dust will be toxic (Fig. 83).

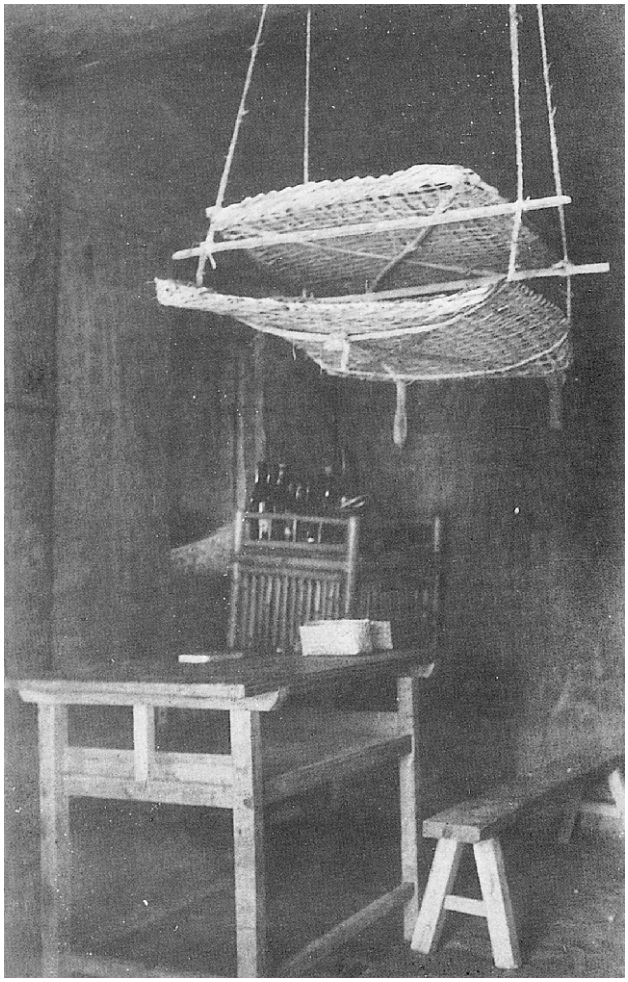


Fig. 83:

Trays of silkworm larvae suspended in rearing room

DDT INTOXICATION IN A FAMILY OF SOUTHERN TAIWAN (Hsieh, 1954)

July 15 of the lunar calendar is a festival day widely celebrated throughout Taiwan. The Taiwanese people call this special occasion "PO-TO." On that day, the people prepare a sacrifice in the form of a big dinner offered to their ancestors and to other deceased persons who have no descendants.

On one particular PO-TO, a housewife, during the course of preparing pork dumplings, accidentally mixed in approximately 40 gm of 50% DDT water-dispersible powder with the ingredients. The combined ingredients yielded roughly 1,533 gm of mixture, from which 70 meat balls were made, each containing approximately 286 mg of technical grade DDT.

All eleven members of the family ate the dumplings; within 2-6 hours, eight of them showed symptoms of intoxication, *i.e.*, excessive perspiration, nausea, vomiting, convulsions, headaches, increased salivation, tremors, accelerated heartbeat, and cyanosis of the lips. The estimated dosage of technical grade DDT ingested by those manifesting such symptoms varied from 16.3 to 120.5 mg/kg of body weight, except for one 29-year old male who, because he was ill and did not eat much, ingested only approximately 6.0 mg of technical grade DDT/kg of body weight. Three family members who showed no symptoms were a 23-year old pregnant woman who ingested 10.3 mg technical grade DDT/kg body weight, a 17-year old male who ingested 6.7 mg/kg, and a 25-year old male who ingested 5.1 mg/kg. A two-year old girl who ingested 120.5 mg/kg manifested the most serious symptoms. The intoxicated persons were given enemas of saline solution and magnesium sulfate during the toxic manifestations. All recovered within two days after the appearance of symptoms.

According to William J. Hayes Jr., eminent industrial toxicologist, the details of this isolated, involuntary ingestion of DDT were unique; their publication constituted a classic reference.

"MILK-FISH" AND ASSOCIATED MALARIA PROBLEMS

In August 1955 a belated attempt was made to assess the possible effects of spraying operations on a small-scale -- but important and interesting -- fishing activity in eastern and southern Taiwan. During May and June, and to a lesser extent in July and August, hundreds of people invaded the beaches of eastern and southern

Taiwan to fish in shallow coastal waters with fine-mesh nets for the miniscule stages of *Chanos chanos* Forskal (often known as "milk-fish"). The tiny fish were transferred to holding basins -- usually scooped out of the sand just above the high tide mark -- where the salinity was gradually decreased until the survivors could be transported to western Taiwan by bus, truck or plane. There the fish were placed in ponds of fresh or slightly-brackish water of individual farmers and were reared to maturity.

During the east coast spraying operations there were significant numbers of migrants who refused to permit the spraying of their substandard, improvised shelters along the beaches, because they were adjacent to their relatively lucrative milk-fish operations. In some instances emergency adjustments of the spraying schedules had been made to delay spraying until the fresh-water-conditioned fish had been transported to western Taiwan. However, heavy fish mortality had been reported where spraying had been done near the temporary rearing ponds. A TAMRI study was attempted along the beaches at Panliao village of Pingtung county, but the season was already over. Nevertheless, it had been reported that there had been fish killed in a few of the western Taiwan fish ponds to which they had been taken to be raised to maturity. Resulting from careless spraying under the eaves of permanent housing, fish kills were occurring in some down-wind fish ponds.

Of more importance to TAMRI than occasional fish mortality were the results of parasite surveys in Chiupen village in Manchou township, Pingtung county, where more than 300 migratory milk-fishermen had stayed while collecting and conditioning fish during the 1956 season. Two *P. vivax* cases (0.29%) were found among 687 smears taken in Chiupen in March 1957. Attempts to follow up migrant fish collectors who had stayed in Chiupen for several weeks led to 49 persons in Wansa village in Hengchung township in Pingtung county. Examination of blood smears from these "fish collector-migrants" yielded two more cases (4.08%) of *P. vivax*. By July 1957 Chiupen had achieved a dubious reputation in TAMRI as a malaria hot-spot in which migratory milk-fish collectors had become far more important than the migratory fish. The village of some 700 residents had produced ten malaria cases in 1956 and six additional cases by July 6, 1957 (blood smears were still to be made from a small detachment of coastguardsmen). Moreover, another positive case of a milk-fish hunter from Fangliao, Pingtung county, had been added to the two migrant cases picked up in Wansa village.

On July 6 one malariologist, one entomologist and one microscopist from TAMRI, and one Pingtung health center employee had descended on Chiupen to apply quarantine measures on the fish-collecting and fish-conditioning migrants and

to initiate monthly case-finding and treatment among the natives. Only by immediate and intensive application of control measures did Chiupen avoid the dubious distinction of receiving early recognition as a malaria "focus."

FELINE FATALITIES

During the January 1955 training of county malaria supervisors in Chaochou it was reported by one supervisor, and confirmed by many others, that notable mortality of cats had occurred in rural Taiwan since the beginning of the antimalaria program, and that the price of cats in sprayed areas had gone up significantly. Without question there had been some undocumented attrition in feline as well as rodent populations. The rodent populations had evidently been recovering more quickly, creating a demand for cat replacements.

Cat mortality received at least passing attention at the Provincial Assembly on January 1955, when the malaria eradication program was in the spotlight. Attention was called to alleged inefficacy of the insecticide and to DDT-killing-cats problems. The Provincial Health Commissioner used pre- and post-spraying malaria endemicity figures to counter the insecticide inefficacy complaints, but the feline fatality issue was left unanswered.

With cat mortality the subject of such attention, a TAMRI-organized cat survey was arranged by checking 96 households scheduled for their first residual spraying on August 2, 1955. Immediately following the spraying, the 19 households which had cats were checked daily for 10 days, every other day for another 10 days, and once per week for another three weeks. Complete records as to cat mortality, and to the weight of the deceased felines, were obtained from only four households:

Days Lapsed After Spraying	No. of Dead Cats	Weights (in gm) of Dead Cats
1	2	400
		450
4	2	1,000
		1,050
14	2	1,400
		3,100

Among the 19 households originally having cats, 10 reported having seen 11 dead rats, three shrews and three small dead chickens. A somewhat different survey was carried out in late 1955 in villages near TAMRI headquarters in southern Taiwan. Previously-sprayed villages with 586 houses included 141 households with one or more cats (average number of cats in those households = 1.5). In other villages which had never been sprayed, there were 408 households, among which 103 had cats (an average of 1.76 cats per cat-house). Both previously-sprayed and never-sprayed villages were sprayed during July, August and September of 1955. All of the households originally harboring cats were visited daily up to the 20th day after spraying. In the resprayed village, 16 of the initial 141 "with-cat" families (11.35%) had lost their cat(s); 64 dead rats were recorded. In the newly-sprayed villages, 21 of the initial 103 "with-cat" households (20.39%) had lost their cats; 84 dead rats were recorded.

Squad foremen and spraymen had frequently suggested to householders with cats that they isolate them (along with young ducks or chickens) during, and for several days after, the spraying (Fig. 77 in Chapter XI). There was little evidence that this advice was taken seriously. Cat mortality remained a problem and was often cited as the principal reason for refusal of house spraying.

SPLENOMEGALY (Chen C.T., Wu, Hsieh, 1954)

A special study was made of the differences in detectability of minor splenomegaly through variation in the recumbent position of the patient. In Taiwan, Hackett's classification has been followed in the spleen surveys since 1946. The normal or non-palpated spleen is given the numerical value "zero" (0). Any spleen which becomes palpable when the subject draws a deep breath is given the number "I." The larger spleens are numbered successively as 2 and 3 if above the level of the umbilicus, or 4 and 5 if below it (Hackett, 1944).

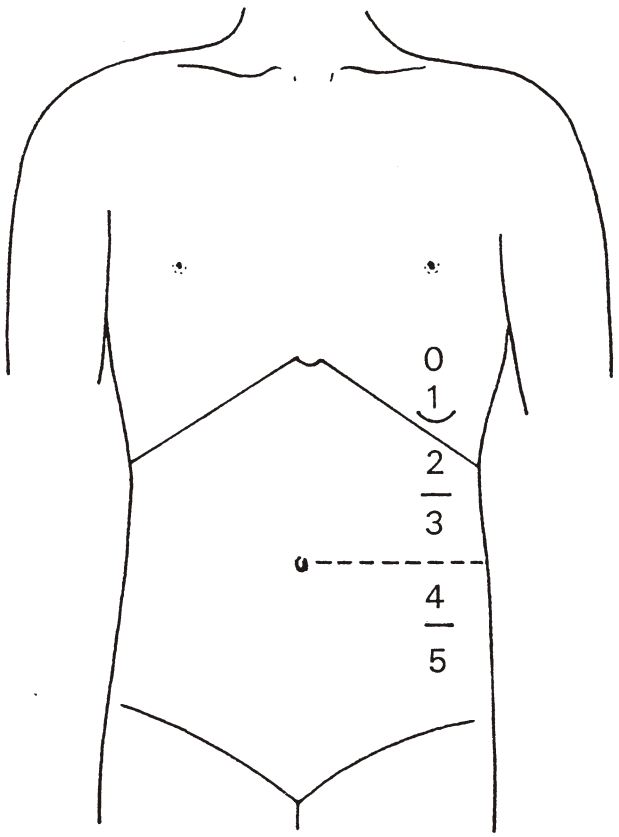


Fig. 84: Diagram showing classes of splenic enlargement
(after Hackett)

The degree of splenic enlargement may be measured with the subject standing up, sitting or lying down. Some differences have been observed in the results obtained by such Methods, the higher values being in the recumbent position. Small spleens, especially those belonging to the class one, are apt to be missed when the subject remains erect or seated. In the recumbent position, two alternatives were recognized. The first alternative was to have the subject lying down on his or her back with thighs and legs flexed; the second with the subject lying down on his or her right side, knees flexed and the left arm extended. These two positions will be referred to herein as the first and the second recumbent positions, respectively (Figs. 85 and 86).

Fig. 85:

A child lying on his back
(first recumbent position)

Fig. 86: A child lying on her right side (second recumbent position)

In Taiwan, the subject is always placed in the first recumbent position for spleen examination. If the spleen is palpated with normal or deep breathing, the size is registered accordingly and the subject is dismissed. However, if no spleen is palpated, the subject is asked to take the second recumbent position and to breathe deeply for at least five times before a "negative" spleen is registered. Very frequently, small spleens are palpable only in the second recumbent position. The size of the enlarged spleen detected only while the subject is in the second recumbent position is not necessarily smaller than the class one spleen detected in the first recumbent position. It may simply be due to personal variation in the position to the apex, or of the point of further projection of the spleen which may be detected in the second recumbent position but not in the first recumbent position. To evaluate the epidemiological significance of the small spleens palpable in the two different recumbent positions, a field study was organized in December 1953 in the pilot project areas with 3,546 school children of 6-12 years of age. The results are presented in Tables 51 and 52.

Table 51

Difference in Spleen Rate and AES Obtained from Two Different Recumbent Positions

Position	Total Exam.	Spleen Size					Total Pos.	Spleen Rate	AES*/
		0	1	2	3	4			
1st	3,546	2,622	391	437	89	7	924	26.1	1.69
1st &2nd	3,546	1,990	1,023	437	89	7	1,556	43.9	1.41

*/ AES = Average enlarged spleen

Table 52

Percentage of Blood Positives in Each Spleen Class

Spleen Size	No. Exam.	Malaria Parasite						
		Neg.	*Pv*	*Pf*	*Pm*	Mix	Pos.	%
0	1,990	1,980	5	5	0	0	10	0.50
1(A)	391	386	1	4	0	0	5	1.28
1(B)	632	624	4	4	0	0	8	1.27
2	437	409	10	16	1	1	28	6.41
3	89	81	4	3	1	0	8	8.99
4	7	6	0	1	0	0	1	14.29
Total	3,546	3,486	24	33	2	1	60	1.69

1 (A) = Class 1 spleens detected in the first recumbent position.
1 (B) = Negative in the first recumbent position, but positive at the second recumbent position.

The area under this study already had been sprayed twice with DDT (1952 and 1953); therefore, both spleen and parasite rates were already very low, and monthly infant survey revealed no new infection. In this epidemiological situation,similar to that of a hypoendemic area, the class one spleen represents a considerable portion of the total splenomegaly. Therefore, if the survey is made without using the second recumbent position, the overall spleen rate is lower and the Average Enlarged Spleen (AES) higher, giving a biased epidemiological value for the assessment of the control program.

Another aspect of interest is the correlation between palpable spleen and malaria parasites. As reported by Wu and Chuang (1956), the parasite rates increase as the spleen becomes larger. According to their analyses of 90,336 school children examined during the 1953 island-wide malariometric survey, the parasite rates in the spleen positive groups were about five times as high as those in the spleen negative groups. In Table 52, it is noted that the parasite rates of class one spleens detected at the first and second recumbent positions are practically identical (1.28% and 1.27%), while those of the negative spleen group are much less (0.5%).

STAINING TECHNIQUE

The slides from the parasite surveys, except those of the monthly infant parasite and fever case surveys, were generally stained *en masse*, using staining jars. The slides were arranged with their smeared surfaces face to face. A piece of dry cardboard paper in between the slides (on the unsmeared half sides of the slides) permitted a separation space between them. A study was conducted using 108 blood smears taken in duplicate during the December 1952 survey in a highly malarious village in the Chishan district. One set of 108 blood smears was stained *en masse*, while the other set was stained individually. The smears had been taken on December 22 and stained on December 25,1952. They had been carefully numbered and there was no confusion in their identification. Four more positives were found in the set stained *en masse* than in the set stained singly (70 positives versus 66 positives). Three of these additional positives were *P. falciparum* (one ring), *P. vivax* (one ring), and *P. vivax* (one ring). The fourth positive was a mixture of *P. falciparum* and *P. vivax*, the corresponding slide of the set stained *en drop* was positive for *P. falciparum* only.

To confirm this finding, one of the malariologists of TAMRI (Hsieh) repeated the trial and stained *en masse* two different sets: (a) 100 slides collected from the fever case survey and (b) 100 slides from his own blood. Hsieh's blood was checked negative for malaria parasites. Positives among the 100 slides from the fever cases totaled 57. Three slides from Hsieh's blood were found to be positive, being *P. vivax* (one ring), *P. vivax* (one ring), and *P. falciparum* (one ring).

Following this study, staining blood smears *en masse* was discontinued at TAMRI; since early 1953, only individual slide staining technique has been used (Fig. 87).

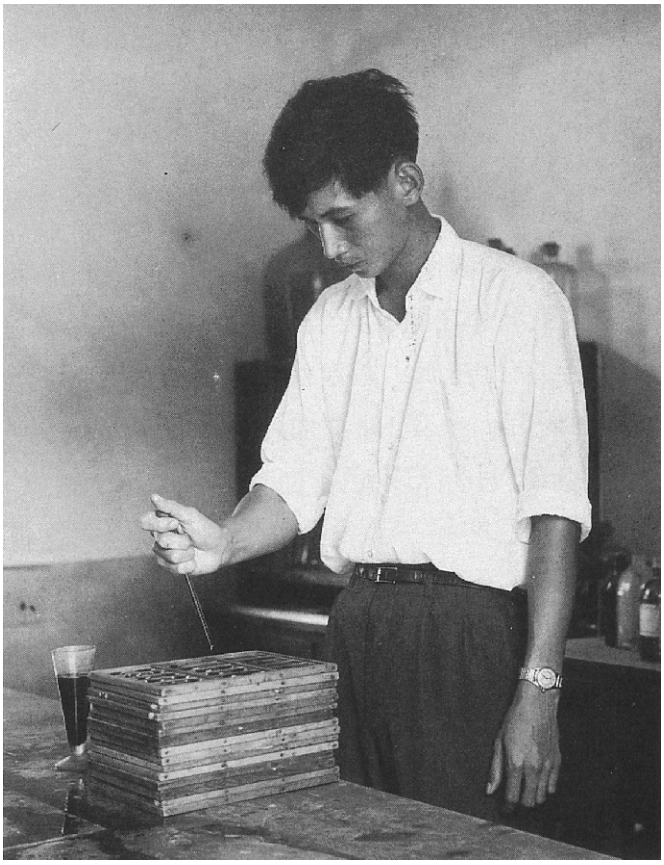


Fig. 87: Staining individual blood smears

A MALARIA EPIDEMIC AND ITS ECONOMIC IMPACT

A malaria epidemic was detected in southern Taiwan in October 1953 by a TAMRI malariologist while making a general malariometric survey in the area. On the one hand, the explosiveness of this malaria outbreak was an indication of inefficiency in the malaria reporting system. On the other hand, the outbreak provided a good opportunity for TAMRI to better understand the epidemiology and the impact of a malaria epidemic on a community.

Kaoshu township had 18 villages with a population of 21,000, of whom 80% were engaged in agriculture. It consisted of a triangular-shaped, flat terrain bounded

on the northeast by the principal mountain chain, on the west by the Laonung river and on the south by the Wulo river. The township was partially isolated at the time because the bridges normally handling traffic to and from Kaoshu had been washed away.

The area was recognized as malarious, but was considered to be mesoendemic and was therefore given low priority in the spraying program. The township was surveyed once in May 1952. The spleen rate recorded at that time was 10.2%, based on 157 school and pre-school children examined. There was a health station and, according to its record, only 26 cases of malaria were registered during the period 1948 - 1952. From January through June 1953 the number of malaria cases went up to 102; in July alone there were 90 cases. Thereafter, the epidemic became explosive, reaching more than 1,000 cases in October, when the epidemic was accidentally uncovered. The situation was acute in five villages, with a total population of 5,256. Among this population, 3,005 persons contracted new infections during the four-month period (July - October). Emergency DDT spraying was immediately organized and the affected area was placed under special observation, with monthly infant surveys and periodic malariometric surveys. The results are shown in Tables 53 and 54.

Table 53

Monthly Infant Parasite Surveys in the Five Epidemic Villages in Kaoshu Township October 1953 - April 1955/*

Survey No.	Month/ Year	No. Exam.	Number of Positives					Parasite Rate
			Pv	*Pf*	*Pm*	Mix	Total	
1	Oct.'53	220	20	26	0	9	55	25.00%
2	Nov.	137	6	8	0	0	14	10.22
3	Dec.	113	1	0	0	0	1	0.88
4	Jan.'54	107	1	0	0	0	1	0.93
5	Feb.	99	0	0	0	0	0	0
6	Mar.	115	2	0	0	0	2	1.74
7	Apr.	131	2	1	0	0	3	2.29
8	May	129	1	1	0	0	2	1.55
9	June	146	0	3	0	0	3	2.05
10 - 19	July '54 - April '55: Average monthly examination = 105: All negative							

*/ Sprayed in November 1953 and September 1954.

Table 54

Spleen and Malaria Parasite Surveys Among School Children Ages 6-15 from Five Epidemic Villages in Kaoshu Township, October 1953 - April 1955

Date of Survey	Spleen Survey			Malaria Parasite Survey							
	No. Exam	Spleen Rate	AES	No. Exam	*Pv*	*Pf*	*Pm*	Mix	Total	Para. Rate	Gam. Rate
Oct. ' 53 (1)	461	60.5	2.17	463	40	93	0	9	142	30.7	19.40
Apr. ' 54 (2)	458	45.2	1.98	458	72	34	1	9	116	25.3	7.64
Apr. ' 55 (3)	527	20.3	1.62	211	2	2	1	0	5	2.4	0

Note: (1) = Before DDT spraying
(2) = 5 months after the first DDT spraying
(3) = 6 months after the second DDT spraying
AES = Average enlarged spleen
Gam. Rate = Gametocyte rate

The experience of this epidemic clearly indicated that an efficient reporting system was very essential, especially in the mesoendemic area where malaria was unstable and the epidemic was apt to occur whenever favorable conditions were present. All health centers and health stations were alerted.

Taking this opportunity, an intensive survey was made to measure the economic impact of the epidemic on individuals or on the community (Plelsch, Chen C.T., 1954).

A total of 854 individual household units, with family members totaling 5,256 (99.4% of the people in the five villages), were visited by the TAMRI staff and questions were asked as to primary cases of malaria, expenses of treatment, work days lost by the patients, labor hired from outside directly or indirectly associated with the sickness. The findings were summarized as follows:

* *Primary malaria attack.* 3,005 persons contracted new infections during the four months from July - October 1953. This represented 57.2% of the population of 5,256.

* *Expenses of treatment of malaria cases.* The total amount spent by subject population (5,256) in the five villages on malaria treatment from July - December was NT$96,333.90. Breakdown: NT$87,560.90 for doctors' fees, health station charges and cost of antimalaria drugs; NT$8,773.00 for herbal doctors' treatments and temple visitations to obtain relief.

* *Loss of work days of patients during acute febrile stage and convalescence.* Excluding children under 10 years of age and all children registered for school attendance, the total period of incapacitation in the five villages amounted to 17,680 man-days during July - October. For those interested in calculating potential monetary losses, the lowest local wage for unskilled labor was NT$8.00 per day.

* *Outside labor hired to compensate for labor loss.* The epidemic period coincided with autumn rice crop harvest. Families affected by the epidemic engaged outside labor totalling 2,284 man-days.

* *Miscellaneous expenses.* Included were costs of special food commonly prepared for invalids, charges for religious acts prescribed by local superstition, and funeral expenses of two persons whose deaths were caused or aggravated by malaria attacks. The total expenditures in this miscellaneous category amounted to NT$17,015.

The above study revealed that malaria could greatly affect the economy of the individual, even to a catastrophic degree. Suffering from the disease is an important health problem to the individual, but death, should that occur, is a tragedy for the family. Interpretation of the impact on the economy of the community is more complex, however, and cannot be based merely on the factors documented in this study. For example, despite the suffering and tragedy of individuals, there was no loss because of non-harvesting of rice, inasmuch as it was gathered by only 2,284 man-days' of hired labor needed to replace the 17,680 man-days lost during the harvest season. The malaria-stricken farm family which paid wages to outside workers might have ill-afforded such payments, but the outside hired workers enjoyed more income than otherwise, and harvested the crop without serious effect on the community's gross crop production. However, the insidious effects of malaria on the community, whether epidemic, catastrophic or perennial debilitation, were obvious and could not be measured in terms of dollar value alone.