

REPORT ON HERBICIDAL DAMAGE BY THE UNITED STATES IN SOUTH-
EASTERN CAMBODIA

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INTRODUCTION

This is a preliminary report of a study of herbicidal damage by the United States in southeastern Cambodia carried out by an ad hoc international scientific commission. It is based upon four days of intensive field investigation during the period of 25 to 29 December 1969 and upon additional detailed interviews in Phnom Penh with M. Chuon Sao-chi, the Cambodian Minister of Agriculture, M. Min Sarim, the Director General of State Rubber Plantations, M. Suon Kaset, the Director of Waters, Forests, and Game, M. Hing Un, Director of Agriculture, M. Sor Thay Seng, Chief of the Division of Agronomy, and with other government officials.

Our study was made possible by the Royal Government of Cambodia, which supplied us with all land and air transportation and other help necessary to visit the areas in question and to otherwise perform our mission. Any and all areas we wished to visit were freely open to us for purposes of inspection, interviewing, and photography.

In the field we were at all times accompanied by one or more scientists and occasionally other officials of the Cambodian government (and by an armed guard while working along the Vietnamese border). We received full cooperation and gracious hospitality wherever we went from the people at all levels of responsibility and in all walks of life. There was virtually no language barrier since French (and often English) was understood almost everywhere and since a Cambodian (Khmer) interpreter was always available to us as needed for communication with uneducated local inhabitants. M. Min Sarim, Director General of State Rubber Plantations (and a professional forester), accompanied us virtually at all times. He was most useful to us because of his close familiarity with most of the areas we visited and because of his knowledge of rubber culture, of forestry, and of agronomy. M. Min had studied for five years at the University of Quebec; he speaks Cambodian, French, and English.

It was our mission to make an independent scientific evaluation of the herbicidal damage done by the United States in April and May of 1969. One of our aims was to verify the earlier Cambodian and United States assessments of damage. We wished particularly to assess rate of recovery, extent of long-term effects, and the impact on the local inhabitants and their economy. A more general aim was to gain some preliminary insights into the ecological and economic damages

caused by herbicidal chemical warfare in the light of its massive use by the United States in neighboring South Vietnam.

We had available to us the following reports relevant to the herbicidal incursions into Cambodia:

1. "A Grave Attack on the Cambodian Economy: Ravages Caused by the Defoliants Spread by American Aircraft near the Frontier." [a popular account]
In: Kambuja, Vol. 5, No. 50, pp. 112-113, May 1969
2. "Rapport du Comité Chargé du Constat et de l'Evaluation des Dégâts Dûs aux Epanrages des Produits Défoliants par les Avions Américano-Sudvietnamiens."
By Min Sarim et al. (an ad hoc Cambodian Ministry of Agriculture committee)
Phnom Penh, 16 May 1969, 15 pp.

Plus three brief subsequent reports by this committee of 10 July 1969 (5 pp.), 17 November 1969 (3 pp.), and 9 December 1969 (4 pp.).

3. "A Report on Herbicide Damage to Rubber and Fruit Trees in Cambodia."
By C. E. Minarik et al. (an ad hoc U. S. State Department team)
Saigon, 12 July 1969, 16 pp. + 5 appendixes.
[limited distribution in November 1969]

PERSONNEL

The present study was conducted by a four-man ad hoc scientific commission, two members from France and two members from the United States:

1. Jean Lavorel (plant biophysicist)
Directeur de Recherche et Directeur du Laboratoire de Photosynthèse du Centre National de la Recherche Scientifique (CNRS)
91, Gif-Sur-Yvette, France
2. Léon Matarasso (lawyer)
Avocat à la Cour de Paris
Vice-Président du Centre International pour la Dénonciation des Crimes de Guerre
29, Rue de Tournon, Paris, 6^e, France
3. Egbert W. Pfeiffer (Ph.D.; animal physiologist)
Professor of Zoology, University of Montana, Missoula, Montana 59801, U.S.A.

4. Arthur H. Westing (M.F., Ph.D.; plant physiologist)
Associate Professor of Botany & Chairman of Biology,
Windham College
Putney, Vermont 05346, U.S.A.

FIELD ITINERARY

Thursday, 25 December 1969: Aerial examination by small reconnaissance plane of both damaged and undamaged rubber plantations and other lands. This was primarily over the undamaged Chup area and over the damaged areas of Krek, Chalang (Chalong), Mimot (Mémot), and vicinity - all in the southeastern border province of Kompong Cham (adjacent to the South Vietnamese province of Tay Ninh).

Friday, 26 December 1969: Visit to the Cambodian Rubber Research Institute (Institut des Recherches sur le Caoutchouc au Cambodge; IRCC) at Chup and to the adjacent French rubber plantation (Compagnie du Cambodge). At IRCC we examined Institute records and interviewed the following professional staff:

Dr. W. L. Resing (chemist) (Director)
M. Gilbert Deconinck (plant pathologist)
M. Chai Kim Chun (biochemist)
M. Langlois (agronomist)
M. Tupy (plant physiologist)

We visited the adjacent plantation (the second largest in the world) in order to become acquainted with healthy rubber trees of the several major varieties at various ages.

Saturday, 27 December 1969: Visit to a moderately damaged, medium-sized, private (coöperative) plantation at Chipeang (just east of Krek) (employing ca. 500 workers), and to the associated village (population ca. 1,500). This was a typical (though somewhat larger) example of the many small plantations in the region that were damaged to a greater or lesser extent. We inspected the damage and interviewed M. Buoy San, the director, as well as several tappers and villagers at random.

Next, we visited the heavily damaged, large, private plantation at Dar (Société Khmère d'Hévéaculture de Dar; SKHD) in the company of Dr. Resing and M. Deconinck of IRCC. Here we also inspected the damage and interviewed M. Som Khom, the director, as well as several field foremen and tappers.

Monday, 29 December 1969: Visit to the rather heavily damaged, large French plantation at Mimot (Société des Plantations Réunies de Mimot; SPRM) which employs some 15,000 workers. Here we inspected the damage and interviewed:

M. E. Pellegrin (Director General)
M. C. Audureau (Assistant Director)
Dr. Charles Bosquet (M.D.; Director of the
hospital at Mimot)

as well as the five Cambodian owners of five very small nearby rubber plantations (and each living in a different nearby village).

Next, we visited a small village in the vicinity (Chalang III) to inspect in some detail the damage done to local agricultural and horticultural crops and to interview the inhabitants.

OBSERVATIONS AND FINDINGS

General: The principal period of herbicidal application seems to have occurred during April and the early part of May of 1969, and thus at the end of the dry, dormant season. Our observations were therefore carried out some eight months later and after the passing of one complete growing season (the wet monsoon season of May through November). The U.S. State Department examination had been made about two months after spraying, shortly after the onset of the growing season.

About 70,000 hectares (173,000 acres) were damaged, of which about 10,000 hectares (24,700 acres) were damaged rather heavily. This affected area contains about 15,500 hectares (38,300 acres) of damaged rubber plantations, of which about 6,000 hectares (14,800 acres) were damaged rather heavily. Of the 15,500 hectares of damaged rubber, about 11,400 hectares (28,200 acres) are over 6-7 years old and thus in production.

The herbicides used seemed to have been restricted to a mixture of 2,4-dichlorophenoxyacetic acid (2,4-D) and 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) in oil soluble formulations; this mixture goes under the U. S. Defense Department code name "Orange". We concluded that it was agent Orange because of the characteristic, dramatic, and selective effects of this hormonal class of herbicides; and because the essentially normal growth of the subsequently planted garden crops precluded the other more persistent agents also used by the U. S. armed forces. The severity and selectivity of injury suggested applications in the approximate range of 0.5 to 3 kilograms per hectare (0.4-3 pounds/acre) of active herbicidal ingredients. The lesser amount refers to the eastern and western portions of the affected area, the greater amount to the central portion.

The herbicidal mixture that was presumably used is highly (though somewhat variably) toxic to a wide range of dicotyledonous annuals and perennials, both herbaceous and

woody (including rubber, numerous fruit, and some timber trees and many vegetables). It is generally less toxic to monocotyledonous plants (including rice and other cereals, bamboo, banana, and palms). Both 2,4-D and 2,4,5-T are toxic to lethal by virtue of being absorbed and translocated by the vegetation, thence to mimic certain natural endogenous growth hormones. They cause erratic and uncontrolled overgrowth, flower, fruit, and leaf abscission, branch dieback, temporary sterility, and other ill effects; and in some instances death. Any 2,4-D that reaches the ground decomposes within a few weeks after application, any 2,4,5-T within a few months.

Damage to rubber trees: Highly accurate damage estimates can be made with respect to rubber (Hevea brasiliensis) since very precise records are kept by the IRCC and the larger plantations on a variety by variety and block by block basis with respect to tree growth, tree health, latex yield, and latex quality. The managerial plantation personnel are well trained and competent, and the methods employed by them are scientifically and technologically up to date. Latex yield per hectare in this region is the highest in the world.

Although quite a number of varieties (clones sensu stricto) are in use in Cambodia, more than 90% of all commercial production is more or less equally based upon three major varieties: "GT.1", "PR.107", and "PB.36". (The U.S. State Department report describes the three major varieties to be AVROS.50, which apparently has been confused with GT.1; PR.107; and PB.36, which is apparently a misprint of PB.36.)

GT.1, originally defoliated 90-100%, has since experienced the greatest amount of branch dieback, and has been the slowest to recover. Branch dieback of 2-3 meters (7-10 feet) or more was quite common. Young trees of this variety and those growing under adverse soil conditions have in many instances died over the past eight months. Latex production in the half year following spraying was reduced by as much as 70-80% in this variety. The current complement of leaves is somewhat abnormal in appearance and the dry rubber content (DRC) of the latex now flowing is subnormal.

PR.107 has turned out to be somewhat less sensitive than GT.1, all of the above described effects having occurred to a somewhat lesser degree. PB.36 was least affected by the herbicides and has now after one growing season recovered to a large extent.

Over-all, the IRCC has determined conservatively that the May to November 1969 latex production of the sprayed rubber trees was reduced by an average of 35-40%. This represents an economic loss so far of approximately U.S. \$11.0 million. We judge these figures to be reliable since we were impressed by the detail and accuracy of the records

kept by the IRCC and the larger plantations and by the obvious competence and integrity of the professional personnel involved. It should be added that this opinion was shared by the U.S. State Department team that had made the earlier inspection. It is also important to note that the damaged rubber trees in production represent over one-third of all the rubber trees currently in production in Cambodia. Rubber is the first or second most important export commodity of the nation, crucial to its balance of trade.

It is difficult to accurately estimate the entire extent of present and future damage since many direct and indirect factors are involved. Whereas PB.86 may be back to essentially normal production within another year, GT.1 may well level off at only 80% of normal production within another two or three years. Presumably, PR.107 will be intermediate in its rate of recovery. The death of some GT.1 and PR.107 trees will preclude full recovery of normal production per hectare until their normal time of replacement at about age 40-50. (The larger plantations have trees in blocks of about 100 hectares [250 acres] in all age classes, and follow a regular annual schedule of renewal.)

One of the serious indirect problems that has already resulted from the herbicidal defoliation is the production of a luxuriant understory of weeds throughout the affected area, resulting from greatly increased illumination of the forest floor. These weeds not only compete for the limited soil nutrients and water, but also enormously increase the fire hazard during the dry season. Indeed, we inspected the disastrous results of one 23-hectare (57-acre) fire resulting from just this situation, all the rubber trees having been killed. These weeds are being cut in part, but financial limitations preclude adequate control. The weed-associated losses may well approach the magnitude of the losses resulting from the drop in latex production.

Another problem (which applies most seriously to the many small plantations and to the entirely damaged larger ones) results from the fact that tapping of the injured trees must often be continued almost unabated for pressing financial and social reasons. Most of the families comprising the ca. 30,000 inhabitants of the affected area depend upon tapping as their prime source of income. This unfortunate situation prevents the injured trees from recovering as rapidly as they might if they were left alone for a year or two, and is likely to lead to an increased rate of mortality. Moreover, since the tappers are paid on the basis of amount of latex collected daily, they are currently earning minimal wages.

Many of the blocks established during the past several years were decimated regardless of variety, so that the larger plantations in the affected area will largely lack these

several age classes. This and the possible need for earlier replacement of mature blocks (owing to possible earlier senility, *i.e.*, earlier drop in latex production) will unbalance the normal rotational cycles for decades to come. An added aggravation is that some of the budwood gardens (the source of the clonal material for the reestablishment of the clonal varieties) were badly damaged.

The dead branch stubs and the weakened condition of the trees may result in future increases in fungal or insect depredations, although there are as yet no indications of this.

Finally, it is of physiological interest to note that a very high proportion of two rubber varieties, TR.1600 and BD.5, have died during the interval since the spraying. It is most fortunate that these two highly sensitive varieties are essentially not in commercial use in the affected area.

Damage to other vegetation: A large variety of garden crops (both agricultural and horticultural) were devastated in the seemingly endless number of small villages scattered throughout the affected area. Virtually all of the ca. 30,000 local inhabitants are subsistence farmers that depend for their wellbeing upon their own local produce. These people saw their crops then growing literally wither before their eyes. Indeed, it was the widespread death of the vegetables that heralded the rest of the damage to the area. Their then current crops of vegetables of numerous kinds, of pineapples (Ananas comosus), of guavas (Psidium guajava), of jack fruit (Artocarpus integra), of papayas (Carica papaya), and of many, many more were simply destroyed.

Some of the other more important food crops that were largely wiped out at the time included durian (Durio zibethinus), manioc (Manihot esculenta and M. ultissima), tomato (Lycopersicum esculentum), several types of beans (Phaseolus vulgaris, Glycine max, Vigna sesquipedales, etc.), cauliflower (Brassica oleracea), and custard apple (Annona diversifolia? reticulata?).

Food plants that seemed to be only little or moderately damaged by the herbicides included taro (Colocasia esculentum), ginger (Zingiber officinale), banana (Musa sapientum, etc.), orange (Citrus sinensis), longan (Nephelium longana), mango (Mangifera indica), sapodilla (Achras zapota), sugar palm (Borassus flabellifera), and coconut (Cocos nucifera). Of these, coconuts are now showing a moderate measure of delayed injury not originally expected. A number of annual crops were largely spared because for the most part they had not yet been planted. Rice (Oryza sativa), although moderately resistant to the herbicides, falls into this category.

At the time of our visit, the annual plants that had been planted subsequent to the spraying for the most part seemed to be normal in appearance. On the other hand, pineapple plants look healthy but are to date refusing to bear. The new papaya crop is small and the fruits and leaves are somewhat distorted on a number of the plants. Some guava trees have died in the interim, and none of those that have persisted are as yet bearing. The custard apples are for the most part not yet bearing either. Lychee trees (Litchie chinensis), apparently not an important crop locally, suffered severe dieback and are not yet bearing. The important jack fruit trees (anticipated by the U.S. State Department team to largely recover) are unfortunately now for the most part dead. Indeed, the dead jack fruit trees stand as grim reminders of the "poison from the sky" beside virtually every home in the area. (The Cambodian Ministry of Agriculture estimates that some 45,000 of these were killed or severely damaged.) The banana plants seem completely normal again and the manioc trees seem to be recovering well (although some of the new fruits are abnormal in shape).

Kapok trees (Ceiba pentandra), whose fibers provide a small cash crop for the local inhabitants, were largely killed in village after village. The few surviving trees are not yet bearing their fiber-producing fruits. We inspected two small plantations in the area, one of coffee (Coffea arabica) and another of teak (Tectona grandis), neither of which seemed to have been damaged by the herbicides.

The forested portions between the plantations and villages in the affected area presently support only a scattering of commercially usable timber trees of a variety of species. Although many of the few tall timber trees had been initially defoliated, most now seem to be slowly recovering (largely through the production of adventitious shoots). We did observe some dead individuals of two commercial species of dipterocarp: lumbar (Shorea hypochra) and phdiec (Anisoptera cochinchinensis).

Damages to crops other than rubber have been estimated by the Cambodian Ministry of Agriculture to amount to approximately U.S.\$1.2 million. The extent of privation caused the local inhabitants cannot be estimated.

Damage to land and soil: We observed no evidence of increased erosion or of soil hardening via laterization and no evidence of change in the level of the water table or of any other physiographic factor. Nor did we find any evidence of weather modification.

Damage to livestock and other animals: All of our interviews with the local inhabitants consistently disclosed that village livestock became ill for a period of several days soon after spraying. Whereas the larger animals (water buffaloes, cattle, and mature pigs and sheep) became only mildly ill and all recovered, some of the smaller ones

(chickens, ducks, and young pigs) suffered more severely and in some cases were reported to have died. The domestic mammals were described as having had digestive problems, whereas the domestic birds became partially paralyzed for a time. Apparently many wild birds became similarly disabled and could be captured easily. There were also a number of small dead birds found at the time in the woods and fields.

It is interesting to note here that eastern Cambodia in general has experienced quite a substantial increase in a variety of wildlife, apparently driven out of Vietnam by the defoliation and other ravages of the war. Included are muntjacs and other species of deer, wild cattle (gaurs, bantengs, and some koupreys), elephants, a number of monkey species, and wild pigs.

Effect on humans: Many of the local inhabitants we interviewed spoke of widespread temporary diarrhea and vomiting, particularly among infants and to a lesser extent among the general adult populace. At one location (Chipeang) water was trucked in for a time following spraying to provide uncontaminated water for the children. In those instances where the people depended largely upon deep wells for their water supply we received no report of human digestive problems.

We had a lengthy interview with the physician who directs a hospital in the affected area (at Mimot) that serves some 15,000 people, and which handles about 200 local patients a day. (The doctor speaks not only French and English, but Cambodian and Vietnamese as well.) We also inspected his detailed hospital patient records for 1968 and 1969. This investigation revealed no increase in the incidence of any malady during or subsequent to spraying. Owing to the known abortive and teratogenic effects of 2,4,5-T in laboratory animals and its similar suspected effects amongst the South Vietnamese population, we gave particular attention to this possibility. However, there has been no increase discernible in recent months. (There are about fifty local births per month and the birth of one malformed infant about every two months.)

SOURCE OF THE HERBICIDAL SPRAY

There is, of course, no question that the responsibility for the extensive herbicidal damage we have observed in Cambodia rests upon the United States. Only the United States has the ability and matériel locally to carry out such operations. By its own admission, the United States has in South Vietnam carried out extensive aerial spraying with a variety of herbicides. Indeed, over 10% of the entire surface of South Vietnam has been heavily sprayed over the past eight years. The U.S. State Department report enumerates the spray missions in some detail that were carried out in the neighboring

Cambodia - 10

Tay Ninh province of South Vietnam between March and June of 1969.

Some of the Cambodian damage, perhaps as much as one-third of it, certainly appears to be the result of drift from some of these operations. Indeed, such drift is unavoidable given the type of herbicide used, the method of application, and the existing topographical and meteorological conditions.

Although denied by the U.S. Defense Department, the U.S. State Department report concluded that a significant portion of the damage was virtually certain to be the result of direct overflight. We have concluded even less ambiguously that the evidence for direct overflight is incontrovertible. The total amount of damage, the areal extent of damage, the distance of damage from the South Vietnamese operations, the prevailing wind direction during the period in question, and the spatial pattern of severity (in the central portion of the affected area severity essentially the same near the border as 18 kilometers [11 miles] in) have forced us to the conclusion that at least two-thirds of the actual damage in Cambodia was the result of direct overflight. Moreover, a number of the local inhabitants we interviewed reported to have seen spray planes in operation overhead. M. Buoy San, director of the plantation at Chipeang, described to us a low-flying plane spraying his plantation at about 9 a.m. on three separate occasions in April and May.

Some 70,000 hectares (173,000 acres) were at least slightly injured. If one makes the conservative assumption that this entire area was damaged by a dose rate averaging as little as 0.5 kg/hectare (0.4 pound/acre) of active herbicide, a total application of some 35,000 kilograms (77,000 pounds) would have been needed. How much of this could have resulted from drift over the border arising from the U.S. military operations in adjacent South Vietnam?

Each spray plane carries a payload of about 3,600 kilograms (7,900 pounds) of active herbicide. If one can assume that no more than about 10% of the herbicide in each aircraft could have drifted onto the affected area, this would mean that of the order of 100 planes had to have been flying missions rather near to the Cambodian border during April and early May of 1969. Actually (according to the U.S. State Department report) only about half that number of planes flew defoliation missions in the adjacent Tay Ninh province during that time. Moreover, meteorological conditions and other considerations led the U.S. State Department team to conclude that drift could only have originated from five missions apparently totalling 29 planes.

Thus, even assuming a conservative over-all average dose rate of 0.5 kg/hectare (0.4 pound/acre), drift could have accounted for as much as one-third of the total injury

that occurred. Our examination of the affected area suggested that its eastern and western portions may have received about 0.5 kg/hectare. However, there is a large central block of perhaps 10,000 hectares (24,700 acres) in which the extent and selectivity of damage suggests a fairly uniform application rate of the order of 2-3 kg/hectare (2-3 pounds/acre). This more heavily damaged zone extends about 20 kilometers (12 miles) from north to south and about 5 kilometers (3 miles) from east to west. It includes the rubber plantations at Dar, Chalang, and Prek Chhlong. The damage on this central block can only be explained on the basis of a direct overflight. It could be accounted for by some seven planes flying at a higher than usual altitude.

We conclude that it is highly likely that the overflights were a deliberate violation of the frontier. The border is recognizable from the air and both United States air and ground forces seem to be intimately familiar with its location. Although U.S. aircraft violate Cambodian territory daily for purposes of reconnaissance, the daily military combat activities in the region (a number of which we observed at rather close hand) are for the most part strictly limited to the South Vietnamese side. The fact that rubber plantations (which are readily distinguishable from the air) were so heavily hit (one-third of all of this major Cambodian crop), suggests an attempt at punitive action on the part of the United States. That U.S. pilots are, we are told, under routine standing orders in South Vietnam to avoid the spraying of rubber adds further support to the hypothesis that this particular action was deliberate.

CONCLUSION

Our mission was a sad one, a mission whose *raison d'être* we wish had never occurred. The loss in rubber production will be relatively easy to ascertain over the next year or two, and restitution will hopefully be made by the United States. (We concur with the U.S. State Department report that a fairly reliable evaluation of damages should be possible following one more growing season, *i.e.*, toward the end of 1970; we concur with the Cambodian Ministry of Agriculture report that an economist should be included in the next visiting team.) The damages to rubber that we have observed are certain to result in a significant setback in Cambodia's slow but promising struggle to strengthen its economy. Therefore, the sooner the United States makes restitution the better.

We feel particularly grieved about the innumerable direct and indirect losses suffered by the innocent local populace. The extent of these losses can never be determined satisfactorily and will never be compensated adequately. We have seen at first hand how particularly drastic this type of military action is for people whose very existence is so closely tied to the land.

Cambodia is a small nation attempting to remain neutral toward all nations and at peace with its neighbors despite enormous external pressures. We cannot understand and we cannot condone the violations of Cambodian territory by the United States, for which the present report furnishes but one example. Despite a week of free and unhampered travel by automobile, on foot, and by low-flying aircraft along hundreds of kilometers of the border, we could find no evidence of Viet Cong activity in Cambodia; nor did our repeated conversations with Cambodians and Europeans living along the border suggest any such activity.

We therefore urge that the United States adopt an iron-clad policy of respect for the rights of the Khmer people and of the Royal Cambodian Government. Only in this way will we be able to bolster the deteriorating amity between the peoples of the United States and Cambodia.

Finally, we cannot help but mention the United States' herbicidal activities in neighboring South Vietnam. We have witnessed the devastation caused by this relatively minor incursion into Cambodia. How much worse it must be for the hapless peoples of South Vietnam whose lands are being sprayed so much more heavily and systematically. Theirs is a long-term legacy of economic and ecological devastation whose full enormity is difficult to grasp.