sodium chloride, the larvae and pupae detach immediately and rise to the surface of the solution where they are easily seen.

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MALARIA ERADICATION IN THE USSR

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According to the Soviets, malaria as a disease of the masses was eradicated in 1952 in the USSR. In the same year, however, malaria was fairly widespread in some of their southern Republics. Cases numbered over 180,000 in 1952—a tremendous drop from the nearly 800,000 reported in 1950 (Sergiev *et al.,* 1959). Complete eradication on a national scale was discussed and approved in 1952. Another drastic reduction in cases occurred in 1958 when only 2,504 were reported.

When I was in Moscow in 1959, I was told that total eradication of the disease was expected in 1960, despite foci which remained in several of the southern Republics.

From 1966 to 1968 almost all malaria transmission had stopped except for a few areas in the south, mainly in Georgia and Azerbaidzhan (Sergiev *et al.,* 1969). Bruce-Chwatt (1970), a well-known malariologist in England, reported that malaria had been eliminated from the whole of Europe and stated that as an indigenous disease, it had disappeared from most of the USSR. This indicated that the disease had not been eradicated from all parts of the Asian Republics of the Soviet Union.

Early history of malaria and its control in the USSR, and details on eradication up to 1959, have been published by Bruce-Chwatt (1959).

Some of the scientists involved in the malaria eradication campaign included V. N. Beklemishev, T. S. Detinova, H. H. Dukhanina, V. A. Nabokov and P. G. Sergiev.

Dr. Beklemishev, a member of the USSR Academy of Sciences, was head of the Entomology Division of the Malaria Institute (now called Martsinovsky Institute of Medical Parasitology and Tropical Medicine). He was instrumental in organizing the country-wide malaria control program. Beklemishev and collaborators introduced the principle of age-grading of female *Anopheles.* The part that this system played in eradication will be discussed under Detinova's work.

Dr. Detinova, entomologist and senior scientific worker at the same institute, has lectured on physiological age-grading of

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anophelines in London and demonstrated the technique in various other areas. She also devised a method of her own to separate nulliparous females from parous specimens. Another well-known worker is Dr. H. H. Dukhanina, epidemiologist at the same institute. She is the author of numerous articles on malaria in the Soviet Union. Dr. Nabokov worked particularly on the development of spraying equipment.

For many years Dr. P. G. Sergiev has been the Director of the Martsinovsky Institute of Medical Parasitology and Tropical Medicine and is widely known as an epidemiologist and parasitologist. He organized a network of malaria eradication stations throughout the USSR. Through his efforts in public relations, the participation of private citizens was enlisted in the malaria campaign. Prof. Sergiev was involved in the evaluation of insecticides for malaria control.

The more important vectors of malaria in the USSR are *Anopheles maculipennis maculipennis* Meig., *A. m. messeae* Fall., *A. sacharovi* Favr and *A. superpictus* Grassi.

Plasmodia recorded as causing the disease in the Soviet Union were *Plasmodium falciparum, P. malariae, P. vivax* and *P. ovale*.

In order to eradicate malaria, the Soviets used both insecticides and antimalarial drugs. The latter included chloroquine, pyrimethamine, mepacrine, quinocide, and proguanil. The insecticide of choice appeared to be DDT but BHC also was used. Laryukhin (1960) obtained good results with an emulsified suspension of technical DDT when 1 to 2 grams were applied per square meter. Beklemishev (1960) advocated the use of DDT at dosage rates of 1.5 to 2 grams at least once a year in the USSR. In addition to residual insecticides, larviciding was suggested in areas where masses of people congregated in evenings near mosquito breeding places.

The highest number of DDT residual applications was made in 1953 when over 350 million square meters of wall surface were treated. By 1958, it was necessary to treat only 239 million square meters with the same insecticide (Sergiev, 1959).

In areas where silkworms were reared on a large scale, DDT was applied to farm animals during the entire malaria season for the first year (Ilyashenko, 1959). Then in the fall, treatment of buildings with DDT (at the rate of 2 grams per square meter) was accomplished after silkworm rearing had ceased. In the second year, Ilyashenko concluded that farm animals should be treated with DDT only in August and September and buildings treated when propagation was over. This system proved effective in controlling mosquitoes without harm to silkworms in Tadzhik SSR. The technique was modified to meet conditions in other areas of the Republic where few silkworms were being reared.

In the Azerbaidzhan Republic, Nabokov *et al.* (1964) sprayed a DDT emulsion in rooms where silkworms were maintained, without harm to these insects.

An account of spraying buildings with DDT has been given by Nabokov and Laryukhin (1960). Houses on both sides of narrow streets were treated simultaneously by means of extremely long hoses carried on a truck. The truck proceeded down the street until all houses were sprayed. When the streets were wide, the houses were treated by one crew which went from one side of the street to another or from one farm to another.

On farms where the buildings were far from the street, treatment was made from the truck in the farmyard. In these cases both hoses were used at once to treat the living quarters and the animal sheds. During this type of treatment, the mechanized crews did not have to carry heavy knapsack sprayers. This made it possible to employ many women in mechanized crew work.

The long hoses were used to treat apartment buildings as well. Treatment began on the top floor when the hose would be pulled by a rope through the window. The hose was then transferred on the same floor through other open windows. Following treatment of the top floor, the hose was lowered by a rope to the floors below. The insecticide could not be supplied above the third floor, because of lack of sufficient pressure.

To help speed up eradication, the Soviets offered prizes to physicians, nurses and other malaria workers for the detection of malaria foci.

The Russians are aware of the detrimental effects of DDT and BHC sprayed on cattle. Detinova (1962) suggested that ". . . where endemic malaria is weak cattle should not be treated. . . . However, in very serious foci of malaria, provided that the main vectors are exophilic species, it must be remembered that the serious consequences of the disease may many times outweigh the damage resulting from treating cattle with these insecticides."

At this point I wish to show how the work of Detinova fits into the malaria eradication picture. The Soviets considered it important to know the precise physiological age of a mosquito in order to estimate the effectiveness of residual insecticides used in malaria control, and they introduced this technique to the rest of the world. Physiological age is determined by the number of gonotrophic cycles through which a female mosquito has passed. A gonotrophic cycle consists of a blood meal, formation of eggs, and oviposition. The number of cycles a female undergoes represents her physiological age, not her actual age in days. According to Detinova (1962) the cycles are rather easily identified. V. P. Polovodova found that each oviposition left a tiny thickening or sac-like structure in the follicular tube. By counting the number of these structures, called dilatations, one may determine through how many gonotrophic cycles the mosquito has passed. Individuals of some species of *Anopheles* have as many as 13 or 14 cycles. The more gonotrophic cycles through which a female has passed, the more dangerous she becomes because the more likely she is to infect with malaria the person she bites.

Large scale dissections of *Anopheles maculipennis messeae* and *A. sacharovi* were carried out to determine the physiological age in limited areas during the campaign. Soviet workers believe that when residual sprays have been applied effectively and the deposit is still active, anophelines which have passed through one or more gonotrophic cycles should be virtually absent. Increased mean physiological age indicates that spraying operations are not efficient enough to interrupt transmission.

Dr. Detinova is an expert in the technique of determining the physiological age of a female mosquito by this method. She (1968) also has demonstrated the Russian technique with *Anopheles* spp. in Africa in areas she visited.

Although the idea of counting dilatations in the follicles apparently originated with the Russians, Lebied (1959) working in Africa arrived at practically the same conclusions, independently. He worked with *Anopheles gambiae* Giles, *A. funestus* Giles and *Aedes aegypti* (L.).

Some workers in different parts of the world agree with the Russian technique, others find the method impracticable for routine use in the field. In some areas, particularly the tropics, the cycles appear so fast that it becomes difficult to detect the dilatations.

A still different method to evaluate malaria control was devised by Detinova (1945). She found a way to distinguish anophelines which have deposited eggs from those which have not. In newly emerged females the tracheae in the ovaries are tightly coiled and branch off in many directions. Following oviposition, the tracheoles gradually straighten out and become uncoiled. She found that the uncoiling process could not be reversed.

Most workers in mosquitoes find Detinova's tracheole technique to be very effective. Of all the literature I have read

TABLE 1.—Statistical summary of the status of the malaria eradication program in the USSR, 1962–1968.

Year	No. Blood Smears		Consolidation Phase				Maintenance Phase				
	Examined	Positive	% of original malarious area	No. of malaria cases Total	Indigenous*	Other	% of original malarious area	No. of malaria cases Total	Indigenous*	Imported	Other
1962	?	340	1.00	114	78	36	99.00	196	44	133	19
1963	3,598,327	250	0.35	92	84	8	99.65	158	14	133	11
1964 (Jan–Sept. only)	2,278,480	89	0.28	31	?	?	99.72	58	0	42	16
1965	?	357	0.30	88	36	52	99.70	269	8	219	42
1966	?	297	0.25	19	7	12	99.75	278	74	155	49
1967	4,891,560	289	0.20	52	37	15	99.80	237	19	172	46
1968	?	262	0.20	47	23	24	99.80	215	21	141	53

* Including introduced cases.

on the subject, I have found none to date to disagree with her method.

Following practical eradication of malaria from the USSR, the Soviets had to cope with several problems. One major item was imported malaria. This meant a delay in the final eradication date. They felt that the high rate of malaria in countries adjacent to theirs was particularly disturbing. Sources of infection arrived constantly from mainland China and these cases had remained partially undisclosed, according to Dukhanina (1960). As many as 101 cases were registered, chiefly in Kazakh SSR from mainland China in 1958 (Sergiev *et al.*, 1959). Also, individuals arriving from Africa brought in malaria. Soviet citizens traveling in tropical and subtropical countries became infected and a number returned with the disease.

Another difficulty consisted of individuals who suffered from mild attacks of malaria but who took insufficient drugs, and remained sources of infection. Another grave concern was the failure of laboratory technicians to detect malaria parasites in blood samples.

Malaria cases following blood transfusion added to their problems. From 1958 to 1964, a total of 47 cases of malaria resulted from blood transfusions. According to Dukhanina and Zhukova (1965) only 8 cases were adults. The rest were children, many of whom had been given blood from their parents as a method of therapy. Maternal blood was given to a number of children to protect them against measles.

Administrative difficulties, rather than technical failure, seemed to be the reason for some cleared areas becoming reinfested.

Imported malaria still concerns the Soviets since they border on countries where the disease has not been eliminated. In addition, visitors from other malarious areas present a threat. The Russians are continuing surveillance and planning for better methods to detect imported malaria cases.

Statistics on malaria cases in the Soviet Union from 1962–1968, presented in Table 1, are taken from the World Health Organization annual summaries of the status of malaria eradication campaigns in all countries having such programs (WHO 1963–1969). Total figures for 1969 are not available to me at this time.

At the end of 1962 the USSR reported that 99 percent of the originally malarious area of the country was in the maintenance phase of operations, meaning that malaria had been eradicated from such areas. The remaining one percent was in the consolidation ("clean-up") phase, with malaria transmission continuing in some residual foci. [At the start of malaria eradication operations in a country all the work is defined as being in the attack phase. By 1962 no part of the USSR remained in that phase.] In Table 1 it may be seen that the total number of blood smears positive for malaria each year has fluctuated but little—from 250 to 357—in the 7-year period under review. It is assumed that each positive blood smear is from a different case of malaria, but this is not necessarily true.

By 1968 the area in consolidation had decreased to 0.2 percent, indicating that the remaining foci of transmission were more restricted than they were in 1962. According to a map (WHO 1970) these foci are all in the Caucasus and Kazakhastan, which borders on mainland China.

Some definitions are pertinent. An *indigenous* case of malaria is one that is infected in the place at which it is discovered. An *imported* case is one that is brought into a country from a foreign country whereas an *introduced* case is one that is infected from an imported case.

The total number of cases of malaria in the consolidation area decreased irregularly from 114 in 1962 to 47 in 1968, and in the 7 years all except one of the cases were *Plasmodium vivax* infections.

In the maintenance area the total number of cases increased slightly from 1962 to 1968: from 196 to 215, the majority being imported cases. However, each year many of the cases were determined as introduced or indigenous, and some that were apparently not classified epidemiologically are shown as "other." *Plasmodium falciparum* cases were diagnosed less often than *P. vivax*.

The country of origin of the imported cases is not routinely noted in the statistical summaries. In the USSR many imported cases are in African visitors who suffer relapses from their falciparum malaria (otherwise known as tropical malaria). Vivax malaria is the predominant type in the USSR and rest of the temperate zone.

The statistical reports from which the data in Table 1 are extracted pertain to entire countries, regardless of their population and area. The population of the originally malarious area of the USSR was estimated to be 181,000,000 (Bruce-Chwatt, 1959). It is evident that malaria has been eradicated from a huge population that was formerly at risk to the disease.

Summary. The year 1952 marked the period when the Soviets accomplished malaria eradication as a disease of the masses in the USSR. From that year on, a drastic reduction in cases was reported. By 1968 almost all malaria transmission had stopped except for small areas in Georgia and Azerbaidzhan. It is evident from a World Health Organization map for the early part of 1969 that only a few foci were left in the Asian part of the Soviet Union at that time. Other aspects of the malaria campaign included data on mosquito vectors, plasmodia, antimalarial drugs, use of residual insecticides (mainly DDT), Russian techniques for physiological age-grading of mosquitoes, and problems confronting the Soviets following practical eradication of malaria.

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EVALUATION OF ULTRA LOW VOLUME GROUND EQUIPMENT IN BRAZORIA COUNTY, TEXAS [1]

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Brazoria County Mosquito Control District, Angleton, Texas, May 15, 1970

INTRODUCTION. Mount *et al.* (1966) demonstrated that nonthermal aerosols and thermal aerosols were equally effective when malathion, fenthion, and naled were used as toxicants. Mount *et al.* (1968) concluded that U.L.V. nonthermal aerosols of malathion were at least as effective as high volume thermal aerosols against caged mosquitoes. These authors also indicated that U.L.V. aerosols of malathion and naled were more effective than high volume aerosols against caged and free-flying mosquitoes. In both of the above tests, the nonthermal aerosols were produced by a modified Curtis aerosol generator (Model 55,000).

Recently, Lowndes Engineering Company manufactured a conversion unit for the Leco 120 thermal aerosol generator. This conversion unit replaces the combustion chamber and operates at a pressure of 3 p.s.i. on the insecticide container and has a flow rate ranging from ½ to 1 gallon per hour. At the higher flow rate, the mass median diameter of the droplets is expected to be in the range of 10 microns.

The many advantages of ground application of U.L.V. aerosols have been reported by Mount *et al.* (1968): (1) Reduce to a minimum the need for carriers, solvents, and additives; (2) reduce drastically the amount of spray solution that has to be carried; (3) lessen greatly the amount of insecticide placed in the biosphere; (4) reduce size of equipment; (5) no dense fog to obscure traffic or roads.

METHODS AND MATERIALS. The tests were conducted during the summer and fall of 1969 to obtain performance data on malathion and Dursban [3] using an ultra low volume ground application. All treatments were applied with a U.L.V.

[1] Presented at the 26th annual meeting of the American Mosquito Control Association, Portland, Oregon, February 22–25, 1970.

[2] Agricultural Department, The Dow Chemical Company, Lake Jackson, Texas.

[3] Registered trademark of The Dow Chemical Company, Midland, Michigan.