MALARIA RESEARCH AND ERADICATION IN THE USSR

A review of Soviet achievements in the field of malariology

by

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Little is known in the West about the past history of malaria in Russia, about the contribution of her scientists to malaria research, about the recent progress of Soviet malariology and about the achievements of the Soviet Union with regard to malaria eradication.

Any information on the latter point is of particular interest since the general strategy of malaria eradication in the USSR has many technical, administrative and socio-economic features which differ from those seen elsewhere.

The present review attempts to summarize as concisely as possible a considerable amount of information gathered from important recent books and manuals (Sergiev & Zhdanov, 1955; Sergiev & Yakusheva, 1956; Beklemishev & Shipitzyina, 1957; Nabokov, 1958), from published papers and available unpublished reports. Some appreciation of present trends and future aims of Soviet malariology was gathered during conversations with P. G. Sergiev, A. Y. Lysenko, N. A. Dombia, S. N. Pokrovskiy and E. M. Maruashvili met at the Sixth International Congresses on Tropical Medicine and Malaria (Lisbon, September 1958).

This review does not pretend to be complete and many problems mentioned in it could be greatly expanded were it not for the limitation of space. References to authors quoted from the standard books are undated. Names followed by a date indicate recent papers, included in the list of references.
History of malaria in Russia

During the nineteenth and the first quarter of the twentieth century, malaria was one of the most important endemic diseases in Russia. The disease was known to exist over the whole country but was particularly prevalent in the Caucasus, in Transcaucasia (Georgia, Armenia, Azerbeijdan), in Middle Asia and along the lower Volga.

Reports of Russian Army medical services and especially those of Turogov reveal that in the garrisons stationed during the late nineteenth century on the northern shore of the Black Sea and near the Persian frontier the annual mortality from malaria amounted to 25 per cent. of the actual strength.

The Russian malariologist Favre estimated that during the period 1890-1900 the average annual malaria morbidity in Russia was five million; this figure was much higher during the epidemic years.

A malaria commission of the Pirogov Medical Society organized in 1911-1912 by Gabrichevsky, Berestnev and Martzinovsky, reported on the dramatic effects of malaria on the Caucasus where whole areas were depopulated.

During the First World War at least 3.5 million people suffered every year from malaria in Russia. As a result of the huge movements of population and the general lowering of economic and social standards in the wake of the war, the early years following the Russian revolution saw in 1922-1923 the greatest malaria epidemic of modern times in Europe. "In the middle Volga basin there had been an almost complete lack of rain for two successive years. The crops suffered the first year and in the second year they were destroyed. All the domestic animals died, either from lack of food or because they were sacrificed to the hunger of the population. Great masses of people emigrated to more fortunate regions, where they became infected with new kinds of malaria, and in the meantime the immunity of those who stayed at home fell to a low level. The following year a great flood of the Volga inundated kilometres of plain along its left bank and the receding waters in the summer turned all the depressions in the steppes into marshes which persisted throughout the breeding

1 History of general and Soviet medicine and public health is treated in a book by Rossiyasky (1956)
season. On this physically reduced population, destitute of any biological defence either of domestic animals or of acquired immunity, descended the hordes of anophelines, and to add to the tragedy, returning emigrants who had heard that the land was again productive, brought their new parasites." (Hackett, 1937).

There were 60,000 fatal cases of malaria every year during that period and in many areas of Central Asia, the Caucasus and the Volga basin 75-100 per cent. of the population were infected. According to Dobretizer's report (quoted by Gill, 1938) the malaria pandemic in Russia in 1922-1923 involved not less than 12 million cases.

The setting-up in Moscow, in the early twenties, of the first Institute of Protozoology and Chemotherapy (today: Institute of Malaria, Medical Parasitology and Helminthology) was one of the landmarks in the development of Soviet malariology. This Institute was created by E. I. Martzinovsky, an outstanding epidemiologist and public health administrator, who introduced the idea of rural antimalaria stations and was responsible for their widespread distribution. Eight such stations were manifestly insufficient in 1921 but their number began to grow steadily after 1925.

By 1930 the situation had improved greatly because of the better execution and wider spread of public health measures generally and of malaria control in particular. The following years were devoted to country-wide planning of programmes directed against all communicable diseases and this was made possible by the setting-up of institutes of tropical medicine in several Soviet republics such as Abkhazia (1926), Armenia (1923), Azerbeidjan (1931), Dagestan (1927), Georgia (1924), Tadjikistan (1931), Turkmenia (1932), Ukraine (1923), Uzbekistan (1924). An additional tropical institute was opened in 1934 in Rostov on the Don for the benefit of the southern parts of the RSFSR.

Apart from a brief period (1934-1936) when malaria morbidity temporarily increased, especially in Middle Asia and in the Caucasus, the prevalence of this disease showed a gradual fall every year and in 1939 the malaria morbidity in the USSR was the lowest ever recorded before. The number of antimalaria stations was then 1236 without counting additional antimalaria dispensaries. In 1942-1945 the devastation and hardships brought by the Second World War were responsible for the greatly increased number of cases of malaria particularly in the Ukraine, Byelorussia and all the north-western areas occupied by the enemy.
The post-war years were devoted to the reorganization of general public health services and tightening up of malaria control. Malaria morbidity decreased from 222 per 10 000 in 1940 to 39 per 10 000 in 1950.

In 1951 the country-wide antimalaria programme proposed by Sergiev and his collaborators was approved and put on the agenda of the 1951-1956 five-year plan. The results of this programme can be appreciated by the following figures quoted after Grashchenkov (1957) and Sergiev (1958): The total number of cases of malaria in the USSR was 183,603 in 1952; in 1955 this figure decreased to 35,704; in 1956 to 13,015; and in 1957 to 5097. In 1958 the relevant figure was 4,678 according to an official report (Ministry of Health, USSR, 1959).

The concept of elimination of malaria as a mass disease was adopted in the USSR in 1952; three years later it became obvious that total malaria eradication from the country was possible by 1960.

The progress of malaria eradication in the Soviet Union will be outlined in a separate section of this review.

Research organizations and publications dealing with malaria

The main research institution devoted to problems of malaria is the Institute of Malaria, Medical Parasitology and Helminthology (named after E. I. Martzinovsky) of the Ministry of Health USSR in Moscow. (Director, Professor P. G. Sergiev, Member of the USSR Academy of Medical Sciences). Eleven other institutes of health or tropical medicine are actively engaged in work on malaria. These are situated in Ashkhabad (Turkmenia); Baku (Azerbaijan); Bukhara (Uzbekistan); Kharkov (Ukraine); Mahachkala (Dagestan); Rostov on the Don (RSFSR); Sukhumi (Abkhazia); Stalinabad (Tadjikistan); Tashkent (Kazakstan); Tbilisi (Georgia) and Yerevan (Armenia).

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1 It might be usefully pointed out here that the USSR is composed of 15 Union republics (including the Russian Soviet Federated Socialist Republic); within the full Union republics there are 17 secondary or Autonomous Soviet Socialist Republics (see map). According to the United Nations Demographic Yearbook for 1957, the mid-1956 population of the Soviet Union, including Byelorussia and Ukraine, numbered 200,200,000. The combined population of the two last-named Soviet Socialist Republics was 48,600,000.
Institutions situated in Moscow where work on subjects connected with malaria is being carried out are:

1. Institute of Pharmacology and Chemotherapy
2. Central Disinfection Institute of the Ministry of Health (insecticides and spraying equipment)
3. Central Institute of Health Education
4. Institute of General Hygiene and Urban Health
5. Institute of Epidemiology and Microbiology (named after N. F. Gamaleya)
6. Institute of Health Administration and of the History of Medicine.

Research on medical entomology is carried out at the Institute of Zoology of the USSR Academy of Sciences, at the Zoological Institutes of the Union Republics, at the faculties of several universities, and at the Academy of Military Science.¹

Most of the papers related to malaria are found in the journal "Medical Parasitology and Parasitic Diseases" (Meditzinskaya Parasitologiya i Parasitarnye Bolezni) published in Moscow every two months (Editor, Professor P. G. Sergiev). The interest devoted to malaria in the USSR can be judged from the comprehensive bibliographical index of relevant Soviet publications quoted in each issue of this journal. Thus in 1956 papers on all aspects of malaria published in the USSR numbered 119; the relevant figure for 1957 was 122 and for 1958, 172. In 1957 this journal alone published a total of 80 papers on malaria (some of them consisted of reviews of Soviet achievements during the past forty years, and were prepared for the commemorative anniversary of the October Revolution). The journal often publishes comprehensive reviews of recent work done outside the Soviet Union on some specific problems.

Papers on medical entomology dealing with systematics, genetics and physiology of malaria vectors are usually published in two other periodicals: "Entomological Review" (Entomologischeskoie obozrenye) and "Zoological Journal" (Zoologicheskiy zhurnal).

Papers referring to insecticides are published mainly (but not exclusively) in "Hygiene and Sanitary Engineering " (Gigiena i sanitaria) but also in "Pharmacology

¹ See: Pavlovsky & Gutsevitch (1957) under references. This paper was reproduced in English as a document, WHO/Insecticides/91.
and Toxicology" (Farmakologiya i toxikologiya), in the "Journal of Military Medicine" (Voenno-meditsinskii zhurnal) and "Journal of Microbiology, Epidemiology and Immunology" (Zhurnal mikrobiologii, epidemiologii i immunologii).

A description of two important Soviet scientific organizations might be of interest. Most of this information is quoted after Ashby (1947).

The Academy of Sciences (Akademia Nauk) of the USSR, one of the most powerful and distinguished scientific bodies known, was founded in 1725 by Peter the Great on the model of the Royal Society of London. The Academy of Sciences is a very select institution with 151 academicians and 325 corresponding members (in 1956). It combines the functions of an independent, high-level scientific society, of an advisory body to the Government and of a managerial department of scientific and industrial research. It has eight divisions (physics and mathematics, chemistry, geology and geography, biology, technical science, philosophy, economics and law, literature and languages). It finances and controls about 200 institutes, laboratories, museums, libraries, research stations, etc. Some of the branches of the Academy of Sciences, and particularly those in Siberia (Novo-Sibirsk), in the Far East (Vladivostok) and in the Ural (Sverdlovsk) have been prominent in carrying out pioneer research work in newly-developed areas.

The Academy of Medical Sciences (Akademia Medicinskikh Nauk) was founded in 1944. It depends directly on the Ministry of Health and controls all the relevant research institutes but not the hospitals or the pharmaceutical industry. In 1958 the Academy of Medical Sciences had 110 academicians and 150 corresponding members. It concentrates on fundamental medical research, and on high-grade applied research, while leaving the routine work to the Ministry of Health. It follows the same pattern of organization as the Academy of Sciences by bringing together the most distinguished medical scientists, who enjoy a substantial financial security attached to the title of academician; it also manages a number of institutes, a library and a publishing house. The Academy of Medical Sciences has three divisions: (1) medico-biological sciences; (2) hygiene, microbiology and epidemiology; and (3) clinical medicine. The Academy's press issues a number of medical and research journals and three of its own publications: Reports ("Doklady") for short papers, The Herald ("Vestnik") for official reports, and "Trudy" for occasional monographs.
Russian contribution to malaria research

All the Soviet writings on malaria emphasize the part played by Russian scientists in the early research on malaria. Zasukhin (1951)\(^1\) made an interesting historical study of the problem of priority of several Russian workers to the discovery of the malaria parasite and to the mechanism of its transmission. A brief, popular history of malarialogy seen from a Soviet angle was published by Plotnikov & Zasukhin (1953).

It appears that Afanasiev noticed in 1879 the presence of pigmented bodies in the brain capillaries of a fatal case of malaria and suspected that this pigment might be produced by some pathogenic protozoa.

The work of Danilevsky\(^2\) in 1884-1885 on avian malaria is universally known and recognized; he was undisputedly the first to have seen pigmented parasites in the blood corpuscles of birds and gave a detailed description of the disease produced by the avian parasite. The correct interpretation of exflagellation is one of the interesting parts of Danilevsky's work (Hewitt, 1946). In his outstanding monograph "La parasitologie comparée du sang" published in 1889 the following prophetic sentence can be found: "I believe that these researches will throw some light on the complicated questions concerning the nature of the malaria parasites of man and in so doing will enlarge and facilitate the experimental study of malaria in general."

Some Soviet authors emphasize Danilevsky's early hypothesis of the development of plasmodia in tissue cells. It is true that Danilevsky described in 1890 intra-cellular, non-pigmented parasites in the cells of avian bone marrows. These parasites might have been exo-erythrocytic forms of \textit{P. elongatum}, but as Danilevsky used the word "malaria" with regard to all Haemisporidea, the described bodies might have been

\(^1\) In this interesting book a series of factual statements are interspersed with many remarks of political character. The same could be said about the monograph by Plotnikov & Zasukhin who claim national priorities for many discoveries in the field of malaria; some of these claims are at variance with claims generally accepted elsewhere.

\(^2\) A biographical sketch of Basil Yakovlevitch Danilevsky written by Hoare (1939) is of great interest.
Leucocytozoon or even Atoxoplasma (Bray, 1957). It is interesting that the available Soviet sources do not quote Shingarev, who in 1906 described non-pigmented schizonts of *P. murinum* in leucocytes and in Kupffer cells of the liver (Bray, 1957). It is probable that Shingarev was the first author who ever recorded the tissue forms of bird malaria without however realizing their importance.

In 1887 Metchnikov commenced the work on systematics of malaria parasites and emphasized the part played by phagocytosis in the defence system of the organism. During the period 1888-1890 Sakharov had apparently identified the parasite of the "malignant tertian malaria" and understood the part played by the gametocytes. In 1890 Romanovsky discovered the new differential staining method which later became known under the name of Giemsa.

A long series of other Russian workers, little known outside their country, contributed to the early development of malariology in the Soviet Union. Among these pioneers the names of Toropov (1828-1884) and Favre (1874-1920) deserve special mention. Toropov's survey of malaria in the Caucasus (1864) is outstanding even today, while Favre's (1903) comprehensive review of malaria in Russia is a minor classic.¹

In 1868 Fedchenko described two species of anopheles in Russia and a few years later Favre produced a valuable report on the distribution of anopheles and on their breeding habits.

At the beginning of this century (1904) Portchinsky's pioneer work on systematics of anopheles in Russia provided the basis for all the later studies on the biology of vectors of malaria in the USSR. In 1924 Pavlovsky established under the aegis of the Academy of Sciences a permanent commission for the study of malaria vectors. The commission produced a series of entomological keys, handbooks and monographs and organized training of entomologists. Many of its publications were of particular importance, such as two manuals of entomological technique by Pavlovsky (1946, 1948),

¹ In order to verify Ross' theory of the part played by mosquitoes in the transmission of malaria, V. V. Favre while working in Kharkov infected himself with falciparum malaria, through the bite of an anopheles which was previously fed on an acute case of this disease (Plotnikov & Zasukhin, 1953).
a series of keys to the mosquitos of the USSR by Shtakelberg (1956), and two monographs on mosquito larvae by Monchadsky (1951). The physiology and ecology of mosquitos and the relationship of these studies to the epidemiology of malaria was investigated by Beklemishev (1949) whose followers (Almazova, Detinova, Kuzina, Shipitzyna, Polovodova) developed the present approach to applied entomology as a guide to malaria eradication.

Martznovsky's (1874-1935) pioneer work in organizing antimalaria measures in Russia and in the Soviet Union was mentioned before. This task was taken over on a much wider scale by Sergiev, the present Director of the Institute of Malaria, Medical Parasitology and Helminthology in Moscow.

Butlerov's early work on quinine alkaloids in 1878 was followed in the nineteen-thirties by the researches of a large group of chemists and clinicians on synthetic antimalarials. Among the clinicians the names of Tareev, Nesterov, Kassirsky, Zavadsky and Gontaeva are particularly well known. On the other hand, Moshkovsky, Magidson, Knuniantz, Tchelintzov, Grigorovsky, Bekhli, Ufimtsev, Topchiev, Braude, Stavrovskaya represent Soviet chemotherapy.

Nearly all Soviet work on the development of insecticide-dispersing equipment is linked with the name of Nabokov (1940).

It was previously mentioned that the country-wide programme of malaria eradication was adopted by the Soviet Government in 1951. In 1952 a group of distinguished Soviet malarialogists (P. G. Sergiev, V. N. Beklemishev, M. A. Buslaev, P. S. Djaparidze, L. J. Isayev, V. A. Nabokov, M. G. Rashina, N. K. Shipitzyna, A. I. Yakusheva, S. N. Pokrovsky and G. A. Pravikov) were awarded the Stalin (now Lenin) prize for their services to the country.

An outstanding and colourful personality in the field of parasitology is Professor E. N. Pavlovsky, the "grand old man" of Soviet biological science, a link between the pre-revolutionary days and the present régime. During the 55 years of his scientific activity Pavlovsky wrote over 1200 papers covering an extraordinarily wide field of biology generally and protozoology in particular. His books on human parasitology have become standard reference volumes in his own country and outside it. Pavlovsky was in charge of the permanent committee on entomology of malaria organized by the Academy of Sciences in 1924 and carried out a series of surveys in Transcaucasia.
and in South Central Asia. In 1935 Pavlovsky devoted much attention to the field study of Diptera feeding on man and animals (this group of insect pests is known in the Soviet Union under a general Siberian term "gnus"\(^1\)). He has devoted much work to the study of the general ecology of communicable arthropod-borne infections and expanded the theory of "natural foci of transmissible diseases" ("prirodnyaya ochagovost") which explains the ecological links between the host, agent and environment.\(^2\) This theory, as also the concept of the higher organism as environment of their parasites, has influenced much of the contemporary biological work in the USSR.

Professor Pavlovsky, who is 75 this year, holds probably a world record in the number of zoological genera and species linked with his name: 75 animals, from diatoms to fishes and reptiles, were named after Pavlovsky by his colleagues and pupils.

A more detailed account of Soviet research work in various fields of malariology and of their achievements in malaria eradication will be found in the subsequent sections of this paper.

**Parasitology**

*P. falciparum* was recorded mainly in parts of the USSR in Middle Asia, Transcaucasia, southern Ukraine and along the lower Volga river. Small foci were found in central Russia in the regions of Riazan, Gorky and Kuabishev, but sporadic cases of falciparum malaria were recorded occasionally (in 1936) in northern Russia, as far as Arkhangelsk. Quartan malaria was found in some regions of the Azerbeijan republic, on the shores of the Black Sea and in the Volga delta. Vivax malaria was known in all the remaining malarious areas of the USSR. Nikolaiev distinguished two sub-species of *P. vivax*.\(^3\) The southern *P. vivax vivax* has a short incubation period

\(^1\) Pronounced "g'noos", with a hard "g".

\(^2\) A summary of the theory of natural foci of transmissible diseases in relation to arthropod-borne infections of man will be found in a paper by Petrishcheva (1957).

\(^3\) The long incubation period of some European strains of *P. vivax* was observed by James and independently by Korteweg in 1920, by Martini in 1921, by Swellengrebel, Schuffner and Korteweg in 1929 (Swellengrebel & de Buck, 1938; Gill, 1938).
E. N. Pavlovsky
1884 -

P. G. Sergiev
of 14-20 days, while the northern *P. vivax* "hibernans" has a long incubation period of several months. Sergiev and Tikurskaya confirmed the varying incubation periods in several strains of *P. vivax* from Russia. Two cases of malaria due to *P. ovale* were recorded in Armenia and in Bashkiria and it is believed that both were imported from abroad by Moslem pilgrims.

The preference of *P. vivax* for reticulocytes, and the absence of such preference in *P. falciparum*, was confirmed by Voino-Yasenetzky and by Istamanian, though some exceptions were found in a proportion of patients.

Tareev agrees that recrudescences and some "early relapses" of malaria are due to a revival of erythrocytic schizogony kept at a low level in the blood, while late relapses have their origin in the exo-erythrocytic schizogony.

Blood examination for malaria parasites is carried out in the Soviet Union using the thick-drop technique and the Romanovski-Giemsa stain. Rukhadze advises that the thick film should be inclined before drying, so that the sickle-shaped thicker part of it might reveal the presence of parasites if they are scanty. The Soviet authors doubt if acute symptoms of malaria can coincide with a negative blood film but emphasize the need for repeated blood examinations. (In an interesting series of over 20 000 blood films taken in Armavir it was shown that only one-third of these slides was positive, but in the repeated series of blood slides taken from all initially negative cases, 20 per cent. were found to be positive; the same proportion of positives was found on the third examinations of blood slides found to be negative in the second examination.)

Examination of the bone marrow for the presence of malaria parasites showed that this method does not increase the number of positive findings and has no advantages over the examination of the peripheral blood.

An interesting method of diagnosis of malaria was proposed by Nesterov but not widely used. Nesterov’s method of cross-erythrocyte sedimentation (measuring the sedimentation rate of erythrocytes of a malarious subject suspended in the plasma of normal subjects and vice versa) is based on the finding that in malaria and pernicious anaemia the higher sedimentation rate of red blood cells depends on changes in those cells and not in the composition of the plasma (Sergiev & Yakusheva, 1956).
A few words should be said about some differences in terminology pertaining to malaria parasites. The Soviet sources occasionally use the term "gamont" for gametocytes and "agamont" for asexual forms of the erythrocytic cycle. Trophozoites ("rings") are frequently referred to as "young schizonts", while mature schizonts go by the name of "morula". Tissue merozoites are called "crypto-merozoites" (of the pre-erythrocytic generation) and "phanero-merozoites" (of exo-erythrocytic generation sensu stricto). The heavy stippling of erythrocytes infected with P. ovale is known as "James' granules" (Sergiev & Yaksheva, 1956).

In reporting on malaria surveys ("maliynaya razvedka") the Soviet workers use the classical indices: spleen rate and parasite rate; they also use the "endemic index" combining the two previously mentioned indices and the "anamnestic index" which refers to the past history of the disease. Ross' old index of the average enlarged spleen is also employed and the "weighting" of the proportion of the three classes of the enlarged spleen is obtained by multiplying the frequency by the factors 3, 6 and 9.

Entomology

Some methods of collection of adult mosquitoes, employed in the Soviet Union, are of interest. The assessment of the density of the vector is carried out in capture stations ("kontrolnaya dnievka") which usually number 10-15 per village. Mosquitoes are collected by pyrethrum spray catch or by hand catching. For the latter method the Soviet entomologists use either test-tubes or various suction devices. One method of hand-collecting employs a small Barraud's-type cage with a sleeve fitted with a wide glass tube. For collecting with a suction tube many workers use the apparatus ("komarolovka NZ") developed in 1940 by Nabokov and Seifert, in which suction is obtained by the pressure of rubber bulb; the air current thus produced bypasses a constriction within a wider tube and produces the suction effect. A simpler mouth

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1 The report on malaria terminology prepared by the Drafting Committee, appointed by WHO suggests the term "cryptozoite" for tissue schizonts arising directly from sporozoites. The second and succeeding generations of tissue schizonts appearing concomitantly with or later than the infection of erythrocytes are called phanerozoites. No specific names for merozoites arising from these two tissue stages have been suggested although in avian malaria the term of "cryptozoic merozoites" for the products of the first tissue schizogony was advocated (Covell, Russell & Swellengrebel, 1953).
suction apparatus known as "exhauster" is similar to the Majid's tube used elsewhere.¹

For outdoor collection of biting Diptera and quantitative assessment of their density and biting rate the Soviet authors use net traps ("uchotnyi sadok") of various designs and sizes. One of these traps consists of a bell made of netting 1 x 1.5 x 2 m ("uchotnyi kolokol") in which the observer acts as a bait; the bell unfolds when drawn down periodically and encloses the observer who collects the captured insects (Nabokov, 1958).

Some of these traps are made of dark cloth and provided with a sleeve that leads into a killing tube. Captured insects are attracted by light, fly into the sleeve and are automatically collected.

Six species of anopheles have been recorded in the USSR.

1. *A. maculipennis* complex is present over the whole Soviet Union. The distribution of separate sub-species of this complex is as follows:

   (a) *A. maculipennis messeae* was recorded in north and central Russia, in Siberia, in the Trans-Volga area and in Kirghisia;

   (b) *A. maculipennis maculipennis* is common in the European part of Russia, in western Siberia, in the Ural area, in the Trans-Volga area, in the Caucasus and in southern Turkmenia;

   (c) *A. maculipennis sacharovi* is common in the Central Asian and Trans-Caucasian republics;

   (d) *A. maculipennis atroparvus* is found only in the northern Caucasus, along the lower Dnieper and Don, and in the Kaliningrad area;

   (e) *A. maculipennis subalpinus* is found in Abkasia, Dagestan and in the Kabardin republic;

¹ Entomological survey squads are composed of auxiliary technical personnel known as "bonificators" or "malaria scouts" ("maliarinyi razvedchik").
(f) *A. maculipennis melanoon* is found in small foci along the shores of the Black Sea. Although the epidemiological importance of the six sub-species varies according to their distribution and bionomics, all of them are regarded as efficient vectors of malaria.

2. *A. superpictus* is an important vector of malaria in the Middle Asian republics, in the Caucasus and on the shores of the Black and Caspian seas.

3. *A. pulcherrimus* is common in several regions of Middle Asia and Transcaucasia (particularly in low valleys of Azerbeidjan).

4. *A. byrcanus* is widespread in the Altai area, near the mouths of the Ural and Volga river, in Moldavia, in Middle Asia and in the Caucasus. This is the only vector of malaria in the Far East of the USSR.

5. *A. bifurcatus* is common in the European part of the USSR, in western Siberia, in the Caucasus, and in Middle Asia. It is not a vector of malaria as a rule but in the foothills of the Caucasus and Middle Asia might play some part in the transmission.

6. *A. plumbeus* was recorded in North Caucasus and Transcaucasia, in Tadjikistan and Turkmenia. In exceptional conditions this species may become a temporary vector of malaria.

*A. maculipennis* and *A. superpictus* are considered as "endophilic vectors" of main importance for the transmission of malaria; the remaining four are "exophilic vectors" found mainly out of doors and only exceptionally in human dwellings or cattle sheds.

A useful taxonomic character - the spiracular structure of larvae was introduced by Mörchadsky (1936) who also suggested that the size of the larval collar can be used for the determination of the mean instar of larvae as a guide for control measures in the field. Methods of estimating the number of larvae have been introduced and the relationship between the type of aquatic vegetation and the breeding potential of malaria vectors was established in several areas. Special monographs on malaria vectors of the Transcaucasion and Central Asian republics were produced by Monchatsky & Shtakelberg (1943), by Petrichsheva (1936), Akhundov (1940) and others.

Investigation of the physiology and behaviour of malaria vectors was actively pursued particularly by Béklemishev and his colleagues; only a brief reference to their important work can be given in the present paper.
Beklemishev found that the mean mortality of anopheles during their aquatic cycle of development amounts to 90-92.5 per cent. Nevertheless, the total output of adults from a large breeding place can be very large. In areas where the transmission season does not exceed two to three months, one hectare (2.47 acres = 11 960 sq. yards) of water surface produces one to two million adult anopheles per season; naturally in areas where the transmission season is longer the figure can be several times higher.

The mean range of flight of anopheline vectors was found to be 3 km but some specimens have a flight range of 6-7 km.

Investigations on the hibernation of anopheline vectors showed that females of *A. maculipennis atroparvus*, *A. m. sacharovi* and *A. superpictus* overwintering in cattle sheds continue feeding on animals during the diapause and survive until the next spring; females of other species which fed and oviposited during the autumn cannot survive the winter.

The duration of the sporogonic cycle in malaria vectors was investigated by Nikolaiev who found that in *A. maculipennis* the period from the infective blood meal to the presence of sporozoites of *P. vivax* was 45-60 days at 16°C, 10 days at 25°C and 6-1/2 days at 30°C. The respective time at 25°C was 12 days for *P. falciparum* and 16 days for *P. malariae*.

The relationship between the gonotrophic cycle and the duration of sporogony was investigated by Shlemova and Nikolaiev who found that at 20°C the ratio is 5:1 and at 25°C, 4:1.

Investigations on the longevity of malaria vectors and the relationship with their infectivity have been carried out by Soviet entomologists and epidemiologists for several years, and their results are of great interest.

The study of the physiological age of insect vectors of disease is often the best criterion of the efficacy of control measures. Rational planning of antimalaria measures requires not only the knowledge of the general biology of the vector but also of its longevity or at least the number of blood feeds taken on the host. The malaria vector can have a "calendar age" or a "physiological age". For years entomologists have attempted to assess the "physiological age" of malaria vectors and Kozhevnikov pointed out in 1903 that the study of ovaries of female anopheles would probably be the most promising method of age-grouping (Detinova, 1957).
The method based on measurement of ampullae of the oviduct introduced in Israel by Mer in 1932 was promising and widely used in the USSR until 1941, when Polovodova showed that it distinguishes only between the nulliparous and multiparous females and has its limitations. During the forties a number of Soviet entomologists (Polovodova, Almazova, Detinova, Dolmatova, Kuzina, Lineva) devoted much attention to the assessment of the "physiological age" of blood-feeding insects. In 1942 Detinova described the morphological changes seen on the surface of ovaries in anopheles. In nulliparous females the ovarian tracheoles are tightly coiled up while in females that had laid at least one batch of eggs the uncoiled tracheoles have a net-like appearance. In 1947-1948 Polovodova found that after each oviposition by the female anopheles there remains in the follicular tube of the ovariole a round thickening; the number of those thickenings corresponds to the number of gonotrophic cycles and gives a direct indication of the physiological age of the female. It was subsequently shown by Polovodova that each thickening ("corpus luteum") is formed by the contraction of the ruptured follicular sac left by the mature egg after its passage from the site of its growth and differentiation into the oviduct prior to final expulsion. The technique of age-grouping based on the number of follicular thickenings is not unduly difficult in *A. maculipennis* and is much used in the Soviet Union.\(^1\)

These data permit the assessment of the physiological age at which the female anopheles vector becomes potentially dangerous. The mosquito can be infected during any of the gonotrophic cycles and the epidemiological importance of each individual female increases with her age, as the chances of the contact between the vector, the source of the infection and the recipient of it are greater. (It was found that *A. maculipennis* can undergo in nature up to 13 gonotrophic cycles.)

For the assessment of the mean physiological age ("vozрастnyi sostav") of the vector population, the methods of Polovodova and Detinova are commonly used by the Soviet entomologists. Comparative investigations of the mean age of the local vector

\(^{1}\) A review of the Soviet methods of age-grouping by the use of techniques introduced by Detinova and Polovodova was recently published by Gillies (1958) who also translated some of the relevant papers. These translations have been mimeographed by WHC and are available to any interested research workers.
population in two areas, one treated with residual insecticide (which increases the mortality of the vector) and the other untreated, give an estimate of the value of the residual insecticide treatment. With a good coverage of the area and an active residual deposit, anopheline females showing more than one or two gonotrophic cycles should be virtually absent and any increase of the mean age found in a reasonably good sample indicates that the imagocidal measures applied are insufficient for the interruption of transmission. These methods of entomological assessment were used during the period 1946-1956 during the malaria eradication programme in the Moscow region, in Moldavia, Azerbeijdan, Tadjikistan and other areas with much success and more recently have been applied to other insects such as houseflies, sandflies and blackflies (Dukhanina, 1957).

Much work on bionomics of malaria vectors was carried out by Beklemishev and his school. Great importance is attached to deviation of the main malaria vectors by cattle and some epidemics of malaria seen in the past (during the droughts in 1921-1922 on the lower Volga) are explained by the loss of cattle and subsequent increase of the proportion of people on which the anopheline vectors fed.

The Soviet basic and applied research on phenology in relation to the epidemiology of malaria is of exceptional interest. Much information on this subject was gleaned from a review by Shipitzyna (1957). Co-ordination of ecological observations commenced in the nineteen-twenties with the creation by Martzinovski of a network of antimalaria stations but methodical investigations of seasonal changes in the behaviour of malaria vectors were organized later by Beklemishev. Beginning with 1935 the Institute of Malaria set up a network of over 200 stations with 650 observers distributed over many ecological areas of the country. This well-planned programme produced a huge amount of records which were fully consolidated only recently.

Some of the problems investigated in the course of this large-scale programme are of special significance. The study of the timing of the diapause, its duration and

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1 Phenology: recording and study of periodic biotic events (such as flowering, breeding, migration, etc.) in relation to climatic and other factors.
degree showed that several sub-species of *A. maculipennis* have distinct patterns of their physiological changes. The seasonal trends of the density of malaria vectors were studied in relation to many ecological factors (climatic, hydrological, topographical and others). Using this method it was possible to relate the seasonal density of *A. maculipennis* in Omak to the variation in the winter table in western Siberia; similar work showed the influence of the floods of the Volga on the trend of anophele density in distant areas of the river basin.

In 1950 phenology was consecrated as a branch of science applied to the timing of malaria eradication programmes. Thus for instance the knowledge of the hibernation period, first spring flight and feeding, the beginning of oviposition, etc. permit a dynamic planning of imago-ecdal spraying and chemotherapy in each ecological zone. This adaptation of antimalaria programmes to local conditions resulted in a considerable saving of human effort and material resources.

Anophele ecology of the European part of the USSR and of much of Transcaucasia has been thoroughly investigated by the Soviet entomologists, but Siberia, the Far East, Azerbeidjan and Dagestan are relatively less known. The mass of recorded observations on seasonal bionomics of malaria vectors in the USSR has only recently been consolidated and published in a comprehensive monograph edited by Beklemishev & Shipitzyna (1957).¹

The future programme of Soviet research on phenology of malaria vectors has now been somewhat curtailed but it is proposed to carry on with observations in less known areas where *A. superpictus* is the main vector. More attention will be given to the study of other disease-carrying insects.

¹ Beklemishev, V. N. & Shipitzyna, N. U. (1957) *Seasonal phenomena in the life of malaria mosquitoes in the USSR*, Institute of Malaria, Medical Parasitology and Helminthology, Ministry of Health, USSR

This book of 527 pages contains collected papers by 36 authors and is composed of four parts: (1) Timing of seasonal phenomena in anopheles of the USSR; (2) Duration of imaginal diapause in anopheles of the USSR; (3) Phenological observations in relation to timing and duration of control methods; and (4) Seasonal periodicity in *A. maculipennis* and its importance in malaria eradication.
Epidemiology of malaria

In the northern and central parts of the Soviet Union, anopheles infected before their hibernating period die out before they become infective in the spring. The important part in the annual transmission belongs to the first generation of mosquitoes, bred out of eggs laid by the females after hibernation. This generation has its first flight in May or June and is usually the only one responsible for transmission of malaria, although during some exceptionally long and warm summers (1938 and 1948) the second generation might also be of importance. In the south of the Soviet Union the transmission of malaria is spread out over several months (peak in July and August) and several generations of the local vectors. In Middle Asia the main vector in the spring is A. m. sacharovi while A. superpictus and occasionally A. pulcherrimus take over in summer.

The greater prevalence of malaria in the south of the Soviet Union as compared with the north is explained by the concept of the "turnover of the vector" ("skorost' oborota vozbuditelsa") which depends on the basic epidemiological factors linking the infected and infective host, the agent and the environment. For vivax malaria with short incubation the "turnover of the vector" takes one month in the south and about two months in the north. Vivax malaria with long incubation has a "turnover of the vector" of 8-10 months or longer. New cases of vivax malaria with short incubation appear mainly during the third quarter of the year (in the south as late as November); new cases of vivax malaria with long incubation and delayed relapses of vivax malaria with short incubation appear mainly during the second (occasionally at the commencement of the third) quarter of the calendar year following that of the year of infection. On the other hand relapses of vivax malaria with a long incubation period are seen usually within three months after the primary attack or during the third quarter.

The curve of the monthly malaria morbidity in the USSR can be classified into three types: northern, southern and bimodal. The northern type of curve shows usually a single high peak in May or June and represents primary attacks of vivax malaria with a long incubation period. The southern type of the monthly morbidity curve shows a peak in August or September which can also be preceded by a short wave in the spring. This curve is composed of cases of vivax malaria with a short incubation period and of cases of falciparum malaria; the spring wave consists of relapses of vivax malaria
from the previous year and of a small number of vivax malaria with a long incubation period. The bimodal curve seen in the Moldavian republic, in the provinces of Kuibyshev, Saratov, Penza, Stalingrad, etc. shows two peaks - one in May-June due to cases of vivax malaria with a long incubation period and relapses of vivax malaria with short incubation; the other peak generally seen in August is due to new cases of vivax and falciparum malaria and to some belated cases of vivax malaria with long incubation. The Soviet workers use the concept of the epidemiological year which covers the period from the appearance of the first cases of vivax malaria with a short incubation period to the appearance of new cases due to the infection of vectors from relapses during the next calendar year. Thus in 1948-1949 the epidemiological year in the Moscow region ran from 1 July 1948 to 15 July 1949.

Soviet malariologists emphasize the uneven focal distribution of malaria in their country and the importance of local climatic and hydrographical conditions on the prevalence of the disease.

The transmission season covers the whole period during which the vectors are infective, from a feed obtained during the calendar year (Sergiev). This definition discounts the possibility of the vector carrying over the infection through the hibernation. In northern areas of the USSR the duration of the transmission season is limited to one to one-and-a-half months (June-July), in the central part of the Union it amounts to two to two-and-a-half months (June-August), while in the south it extends to five to six months (April-September). According to Sergiev, in the north of the country two-thirds of infections were contracted in July and one-third in August, but because of the presence of P. vivax with long incubation period the number of cases does not increase until the next May. Thus in 1948 one-sixth of all cases in the north-central part of the Soviet Union was infected in June, one-half of them in July and one-third in August (Sergiev & Yakusheva, 1956).

Antimalaria measures may change quite considerably the local curve of malaria incidence. Schizonticidal chemotherapy usually delays the appearance of primary cases, while the anti-relapse treatment decreases greatly the number of late relapses and thus the morbidity during the spring of the next year. Good imagoicidal measures will eliminate the new infections during the late summer and in consequence, the southern localities of the USSR might show the northern type of epidemiological curve with the peak morbidity during the late spring.
The relapse pattern of vivax malaria with long incubation period as seen in the northern and central areas of the USSR resembles somewhat the pattern of the well known American Chesson strain (which has a short incubation period) inasmuch as most cases have early relapses, usually in June and July. It was noted that the cases with the early primary attack have more frequent relapses. Only about 1.4-4.0 per cent. of cases of vivax malaria with a long incubation period show any relapses during the following year. Vivax malaria with short incubation, seen mainly in the south and south-east of the USSR, relapses more often and is characterized by the delayed timing (7-11 months after the primary attack).

It was noticed that in areas with intense transmission of vivax infections with a long incubation period, these "relapses" were frequent even during the spring or early summer. An investigation of the pattern of malaria morbidity in those areas where imagosidal measures were carried out thoroughly showed that the number of these early summer "relapses" greatly decreased. Thus it was confirmed that these cases are not late relapses of vivax malaria with delayed incubation period but new reinfections in individuals with a low degree of immunity acquired after the first infection.

In falciparum malaria recrudescences are not infrequent but a small proportion of "relapses" was seen during the 5-6 months following the primary attack. Sub-clinical relapses of falciparum malaria with circulating and infective gametocytes might be seen for several months in cases left without treatment.

The importance of asymptomatic parasite carriers in the epidemiology of human malaria was recognized by Berestnew in 1903 and underlined by many other authors. It is estimated by Rashina that these carriers may occasionally form as much as 30-40 per cent. of the total infective reservoir available to the vector. Two groups of asymptomatic gametocyte carriers are distinguished:

(1) primary carriers who deny ever having had any acute attack of malaria, and

(2) secondary carriers who after an overt primary attack have sub-clinical relapses, with a low gametocytaemia and yet sufficient to infect the vector. It was found by Yakusheva and Dukhanina that 14-19 per cent. of patients with falciparum malaria contracted in the autumn showed asymptomatic gametocytaemia in the spring and summer of the following year (Sergiev & Yakusheva, 1956).
These carriers are the most important link in the year-to-year maintenance of falciparum malaria in localities where the transmission period is short. Similar findings of even higher (30-50 per cent.) proportions of asymptomatic parasite carriers were recorded in vivax malaria by Sarikian and Remennikova.

Much work was done in the USSR on the duration of the malaria infection. The results of a collective investigation co-ordinated by the Institute of Malaria indicate that the duration of infection with *P. falciparum* does not as a rule exceed one year, *P. vivax* infection - two years, and *P. malariae* infection - three-and-a-half years. In the case of mixed infections each species disappeared within its own limit of time (Sergeev & Yakusheva, 1956; Tareev, 1958).

**Clinical aspects, pathology and immunology of malaria**

Clinical aspects of malaria in the USSR were investigated by Tareev (1943), Kassirsky (1946), Zavadsky (1948), Nesterov (1953) and others. Only a few particularly interesting aspects of their findings can be mentioned here.

Soviet authors (Sergiev, Shingareva, Davidowsky) believe that during the incubation period of malaria in pregnant women, sporozoites of vivax malaria pass through the placenta into the foetal liver and may subsequently cause overt malaria in the newborn. *S* hizonts, on the other hand, do not pass through the normal placenta. During delivery there is a likelihood of direct transplacental contact between the maternal blood and that of the newborn and intrapartum infections are possible.

It was shown by Voino-Yasenetsky in Stalinabad in the early thirties that babies born from mothers with malaria weigh about 600 g less than normal babies delivered by healthy women; one-third of new-born babies from malarious mothers were premature and had a high neonatal mortality.

It is thought that the paroxysm of malaria is related not only to the rupture of erythrocytic schizonts, but also to the release of exo-erythrocytic (sensu lato) merozoites from tissue schizonts (Sergiev & Yakusheva, 1956).

The clinical periodicity of infections with *P. vivax* was thoroughly investigated. Vivax malaria with a short incubation period shows the primary attack within 14-21 days, usually in late summer; this is followed by the first series of relapses in the spring or summer of the next year and by the second series of relapses in the spring of the following year.
Vivax malaria with the long incubation period shows the primary attack in the spring or summer 8-11 months after the infective bite; this is followed in the spring of the subsequent year by a series of relapses. This series is rather longer in individuals whose primary attack was in the spring.

One of the most interesting clinical pictures described in 1945 by several Russian authors (Bystrov, Contaeva) is the "fulminant tertian malaria" which was previously not uncommon in the areas of Kuybishev, Tambov and Voronezh and occasionally seen in other parts of Russia. "Fulminant tertian malaria" was observed usually in the spring mainly in children 4-15 years of age, though in a few cases the victims were adults. The majority of the children had previously suffered from malaria; generally the fulminant attack was preceded by a rigor and accompanied by intense headache and vomiting, followed by coma, convulsions and death. Schizonts of P. vivax were found in the blood and in smears from internal organs. At autopsy there was cerebral oedema, enlargement of the spleen and liver, and pulmonary oedema.

The Soviet authors regard the cerebral oedema as an allergic reaction of the central nervous system due to a sensitization by decomposition products of the malaria parasites. The clinical picture described above has now become exceedingly rare.

Cerebral forms of falciparum malaria were previously very common in Transcaucasia and in Turkmenistan, Tadzhikistan, Uzbekistan where P. falciparum was prevalent. Contaeva and Shirokogorov believe that in addition to mechanical blocking of cerebral capillaries by parasitic thrombi, the characteristic picture of cerebral malaria is also due to an allergic (hyperergic) response of the brain tissue sensitized by the altered proteins of the affected cells.

Blackwater fever was occasionally seen during the quinine period in those areas of the Soviet Union where P. falciparum infections were prevalent. The introduction of synthetic antimalarials was followed by the disappearance of this syndrome.

The relationship between the parasite density and clinical symptoms of malaria was investigated independently by Pavlovsky, Kassirsky, Tareev, Sergiev & Tiburskaya, Ozeretskorkaya and others. It was confirmed that acute symptoms of malaria can be present with only 10-20 parasites per mm³ of blood; on the other hand, in the infection induced with very high numbers of parasites, fever does not necessarily
follow the first schizogony. The Soviet workers maintain that the classical symptoms of malaria do not depend on any "pyrogenic level" of the parasitaemia but are due to some more or less specific proteins, which gradually sensitize the reticulo-endothelial system and produce conditioned reflexes of the thermo-regulating mechanism of the central nervous system.

Tareev, Kassirsky, and other Soviet authors agree that an acute attack of malaria is accompanied by a sharp fall of neutrophils and eosinophils without any change in the number of lymphocytes or monocytes. Moshkovsky proposed the use of the differential blood count curve ("leucocyte profile") as an auxiliary method for the diagnosis of malaria.

Pathological changes in the liver were investigated by a number of Soviet workers. The frequency of hepatomegaly in malaria was described by Tareev, Miasnikov, Kassirsky, while Prokopenko recorded an exceptionally high incidence of liver enlargement in the malarious area of Pakhta-Aral in Central Asia. The well-known early degenerative lesions of the liver in malaria might occasionally lead to either acute parenchymatous hepatitis or later to cirrhotic changes.

The liver changes are due not only to the direct action of the parasites and their pigment present in the organs, but even more to local anoxia (linked with the response of the neuro-vegetative system) and to the toxic action of products released from the degenerating cells of the affected organ. Nephritis of malarious origin has been described by several authors (Tareev, Zavadsky, Kassirsky, Shakhmatov) and is accepted as a relatively common complication of the disease. Sergiev & Yakusheva (1956) do not emphasize any association of renal complications with quartan malaria.

Soviet authors believe that there is no racial or genetically acquired immunity to malaria. (This attitude is interesting as it does not fully agree with some trends of Soviet genetics, accepting the inheritance of acquired characters.) They maintain that the acquired immunity to malaria is short-lived and depends on the phenomenon of "premunition", or as Moshkovsky calls it "concomitant infective immunity". Long-lasting, post-infective immunity can be seen in highly endemic areas and is partly "anti-parasitic" and partly "antitoxic". Discussions by Soviet authors of problems of immunity in some holo-endemic areas of the world (particularly in Africa) often reveal some lack of information on this subject.
Chemotherapy

Chemotherapy plays a most important part not only in the individual treatment of malaria but also in the collective attack and prevention of this disease in the USSR. In all the early control schemes in the Soviet Union and in the more recent malaria eradication programmes, the value of chemotherapy has been fully recognized from the beginning. Antimalarial drugs have never been regarded as merely auxiliary methods. Indeed, it seems that chemotherapy has often been given more emphasis than the residual insecticides, since the available system of treatment and follow-up of individual cases offers unique possibilities of attacking the infected and infective human reservoir.

Quinine, used widely until the early thirties, is now employed only exceptionally and has been completely eclipsed by synthetic antimalarials. It was given at the daily dose of 1.0-1.2 g for 3-4 days followed by an interval of four days, after which the same treatment was repeated. Usually four treatment cycles were given. Intramuscular injections of 0.5-1.0 g are given (when necessary) twice daily.

The first synthetic antimalarial produced in the USSR, by Magidson, Strunkov, Chelintsev and Knuniants in 1931, was plasmodicid which until 1959 was much used especially in combination with other drugs.

Plasmodicid is an 8-amino-quinoline \(\beta\)-(diethylamino-1-methyl propylamino)-6 methoxyquinoline of the same general group as plasmoquine or pamaquine but more closely related to the rhodoquine (= Fourneau 710) (Field, 1939; Findlay, 1951).

Plasmodicid is produced in tablets at 0.02 g of base. The maximal daily adult dose is 0.06 g (Serüiev & Zhianov, 1955). The toxic effects of unduly large doses of plasmodicid are well known, however, and atrophy of the optic disc, ataxia, anuria, and polyneuritis have been recorded. This drug is now replaced by quinocid (see below).

Acriquine\(^1\) (= meparicine) was synthesized in the USSR in 1933 by Knuniants, Tchelintsev, Grigorovsky and Benevelenskaya, and is still very widely used. (It is

\(^1\) The Russian spelling of the root "quine" is "khin". Thus the correct names of drugs quoted in this section are: ekrikhin, ciklokhin, khinocid. The English spelling is used here.
probable that the Soviet acriquine is slightly different from the similar mepacrine type, such as atebrin, quinacrine and others (Fields, 1939).

Acriquine is produced in tablets containing 0.1 g or 0.05 g (for children). Children are also given an acriquine mixture containing 0.5 per cent. of the drug. Its advocated loading dose for treatment of adults is 0.6 g, the daily dose 0.3 g. For parenteral administration, dry powder (0.4 g per ampoule) is used in dissolving it in distilled water. Intravenous injections of acriquine are not proscribed, but caution is advocated.

Bigumal (= proguanil) synthesized in the USSR in 1947 (by Bekhli, Ufim, Topchiev) is produced in tablets containing 0.1 g and 0.05 g (for children) and is also combined tablets containing bigumal and plasmocide. Bigumal as a solution is used for intravenous treatment of cerebral malaria. The therapy of bigumal in falciparum malaria is much emphasized by the Soviet workers with prophylactic and sporontocidal effect is fully appreciated in malaria eradication programmes.

Cycloquine (= chloroquine) was recently synthesized in the Soviet Union and has been used with good results. Nevertheless cycloquine does not seem to be widely used in the USSR.

There are only brief references to this drug in the handbook by Sergiev & Yakusheva (1956) and none whatever in that of Sergiev & Zhdanov (1955) or in the works of Moshkovsky (1957) or Tareev (1958). Cycloquine is produced in tablets at a dosage of 0.3 g and the same single daily dose for the next two days. The suppressive dose is two tablets once a week.

Chloridine (= pyrimethamine) was synthesized in 1953 by Magidson and Yaroslav Yakusheva (1956) and is used as a base or as a hydrochloride in tablets at 0.025 g of base. Sergiev & Yakusheva (1956) emphasize the value of chloridine in the treatment and in prophylaxis of malaria as also its sporontocidal (= "gamostatic") effect. It was used in the Tadjikistan for collective prophylaxis at 10 mg once weekly with good effects, although relapses of vivax malaria were not prevented after cessation of administration. For treatment of malaria the dosage advocated by Abdulla was 0.025 daily for 3-4 days.
Quinocide, a Soviet 8-amino-quinoline compound, was synthesized in 1952 by Braude and Stavrovskaya and approved by the Ministry of Health in 1956 (Sergiev & Yakusheva, 1956).

It is a structural isomer of primaquine, the only difference between the two drugs being in the position of the methyl group in the side chain. In the quinocide the methyl group is in position 4\textsuperscript{1} while in primaquine it is in position 1\textsuperscript{1}.

![Chemical structures of quinocide and primaquine](image)

**Quinocide or 6-methoxy-8-(4\textsuperscript{1}-amino-4\textsuperscript{1}-methyl-butylamino)-quinoline, dihydrochloride:**

C\textsubscript{15}H\textsubscript{21}ON\textsubscript{3}, 2 HCl (78% of base)

**Primaquine or 6-methoxy-8-(4\textsuperscript{1}-amino-1\textsuperscript{1}-methyl-butylamino)-quinoline, diphosphate:**

C\textsubscript{15}H\textsubscript{21}ON\textsubscript{3}, 2 H\textsubscript{2}PO\textsubscript{4} (56% of base)

Quinocide is used as a hydrochloride in tablets containing 0.01 g or 0.005 g of the salt. Much emphasis is put on the anti-relapse value of this drug in vivax malaria with the long incubation period, and on the probable sporontocidal effect. Side-effects of this drug (nausea, cyanosis, pollakuria, microhaematuria) are seen in about five per cent. of patients, especially when any other antimalarials are administered at the same time. A course of treatment with quinocide consists of either (a) a daily adult dose of 0.03 g for ten days, or (b) a daily adult dose of 0.02 g for 14 days. Treatment is administered after the completion of the standard treatment of acute malaria as described below.

This drug gave very good results when tried out in Azerbaijan (Zhukova et al., 1958), in Kazakhstan (Lysenko & Gozodova, 1958), and in Georgia (Maruashvili et al., 1958) and the mean number of relapses of vivax malaria was never more than one per cent.
Combinations of various antimalarials have always been very popular in the Soviet Union.

The following combined drugs are quoted in the official handbook (Sergiev & Zhdanov, 1955):

(1) Acriquine 0.1 g and plasmocide 0.02 g
Acriquine 0.05 g and plasmocide 0.01 g (for children)

(2) Acriquine 0.1 g and bigumal 0.1 g, plasmocide 0.02 g
Acriquine 0.05 g and bigumal 0.05 g, plasmocide 0.01 g (for children)
This combination is called ABF or triple drug ("troichatka")

(3) Bigumal 0.1 g and plasmocide 0.02 g

The following treatment schedules with each of these three combinations are officially advocated:

1. Acriquine with plasmocide is given in three cycles (five days, three days, three days) with one week's interval between each cycle. The daily adult dose is 0.3 g of acriquine and 0.06 of plasmocide.

2. Acriquine, bigumal and plasmocide combination is administered for seven days, at the adult daily dosage of 0.3 g, 0.3 g and 0.05 g of each respective drug.

3. Bigumal (first dose 0.6 g, followed by a daily dose of 0.3 g) is given alone or with plasmocide (0.06 g daily adult dose) for five days.

The dosage for children is approximately one-quarter adult dose for the 2-4 age-group and one-half adult dose for the 6-8 age-group; infants are not given any plasmocide or bigumal.

The most important aspect of chemotherapy of malaria in the USSR is the attention paid to the shortening of clinical attacks due to relapses and to the prevention of secondary cases. The drug administration is carried out by the medical and paramedical personnel of a very wide network of hospitals, polyclinics, health centres, dispensaries, antimalaria stations, factory medical units, etc., and based on the early diagnosis, reliable notification, good record-keeping and regular surveillance through the medium of house, school or factory visits or by periodical convocation of the former patients to dispensaries or health centres. All the former patients are repeatedly and emphatically reminded of the importance of reporting whenever they have any clinical symptoms even remotely resembling malaria.
Three types of chemoprophylaxis are known to exist:

1. Individual chemoprophylaxis based on the seasonal administration to the whole population exposed to malaria of two tablets of bigumal, or two tablets of acriquine once a week. It was confirmed by Tiburskaya, Lysenko and Bobkova that in vivax malaria with the long incubation period bigumal delayed the primary attack; in vivax malaria with the short incubation period the primary attack was prevented, but not the following relapses.

Since 1952 chloridine was given in some areas at the dosage of 0.05 g (50 mg) once a week with very good results. More recently cycloquine was given at 0.5 g once a week. Individual prophylaxis of malaria is now used less frequently, because of the general decrease of malaria in the USSR.

2. Collective prophylaxis concentrates on the prevention of relapses and of the subsequent infection of vectors by gametocyte carriers. Ten days after the completion of schizontocidal treatment ("kupirovanye") of the acute attack each case of malaria undergoes an anti-relapse treatment. Subsequently during the transmission period of malaria which is assessed on the basis of local climatological conditions and phenological observations of entomologists, each previous case of malaria is given gametocidal and sporontocidal drugs. Generally two tablets of acriquine with plasmoxide, or bigumal with plasmoxide are given for two days every week during the summer. Today the introduction of quinocide has changed this regimen and those who, after the schizontocidal treatment of acute malaria, had a full course of anti-relapse treatment by quinocide do not undergo any further "collective prophylaxis" and are considered as cured.

3. Finally, there is the pre-epidemic chemoprophylaxis employed in northern areas of the USSR where vivax malaria with a long incubation period is common. In these areas, attacks of malaria may be expected in the spring and can be prevented. Bigumal or acriquine alone or with plasmoxide are administered at the dosage given for collective prophylaxis. Recently quinocide is also given 2-3 weeks before the probable epidemic at 0.03 g daily for ten days.

The duration of the follow-up of cases of malaria depends on the type of the infection: one year for falciparum malaria, two years for vivax malaria and three years for quartan malaria. The schedule of this follow-up is quoted after Sergiev & Yakusheva (1956):
During the first calendar year of the diagnosed malaria the patient has a course of treatment followed by anti-relapse collective prophylaxis, which commences ten days later and lasts throughout the transmission period. During that period (June to August or September) he is examined by the medical unit once a month and during the remaining 8-9 months once every quarter. In case of clinical relapse or asymptomatic parasitaemia, focal insecticide spraying of his house and those of his neighbours will be carried out. During the second year the same schedule is applied with special attention to anti-relapse treatment of vivax malaria with long incubation period.

General anti-mosquito measures

Mechanical protection of the population from mosquito bites by screening of houses ("zasetchivanye") and individual mosquito nets ("polog") is used in several areas of the country; in these localities the shelters for domestic animals are sited so as to take advantage of possible zoophilic habits of mosquitoes. Among the repellents dimethyl phthalate is the most popular although it seems that some other unspecified repellents (SK-9) have also been used, with varying success. The use of wide-mesh netting impregnated with naphthalene and phenol compounds was introduced in 1939 by Pavlovsky and Pervomaisky. The value of this method for individual protection was greatly increased when dimethyl phthalate and dibutyl phthalate jellies (made up in acetyl cellulose solution) became available. These impregnated nets are known in the Soviet Union as Pavlovsky’s nets.

An interesting characteristic of mosquito control measures in the Soviet Union is their comprehensiveness and wide prevalence. Classical methods, such as drainage, filling ("bonification"), intermittent drying, naturalistic control, afforestation, water management in large-scale hydrotechnical projects, are actively carried out. The larvivorous fish, Gambusia affinis, was brought from Italy in 1925 by Rukhadze and used in Transcaucasia, South-Central Asia and Ukraine with conspicuous success (Sokolov, 1958). (In Abkhazia 80 per cent. of all potentially dangerous waters have been seeded with larvivorous fish.)

Larvicidal methods have nowadays decreased in importance but are still widely used in urban areas close to large mosquito breeding places. Methods of larvicidal control do not greatly differ from those used in other parts of the world. Two types
Poster showing the use of DMP impregnated nets (Pavlovsky's nets) and bed-nets
of larvicidal oils are employed: petroleum oil and "green oil"; the second is more active as it contains five per cent. of naphthalene compounds. These oils are applied by means of various drip cans, oil pillows (Indian "gudas") or knapsack sprayers. The application rate is approximately 20-40 ml per m² of water (roughly, 18-36 gallons to an acre) and the dosage of the "green oil" is half of that of petroleum oil. There is no information on the use of larvicidal oils with addition of chlorinated hydrocarbons.

There are various larvicidal dusts such as Paris green, calcium arsenite, "Arsmal" (an orthoarsenite of copper), thiodiphenylamine, hexachloran (= BHC); the inmean application rate to one hectare of water surface is between 0.8 to 3 kg of the toxicant, (approximately 0.8-1.8 lb. per acre) mixed with an inert diluent in the proportion 1:24 to 1:9. Some larvicidal dusts are also used as suspensions in a mixture of kerosene, water and soap.

The dusting and spraying equipment ranges from sifter cans, hand-operated, front carried or knapsack type rotary dusters (RV-1, "Tip-top") or the latest "Serna-4", to power-driven dusting apparatus such as "Serna-2" and its later more powerful model, "Serna-3" which can be carried in a trailer, truck or in a motor boat (Nabokov, 1957).

Much "space-dusting" using "Serna-3" is now being used in Siberia near Krasnoyarsk where the biggest Soviet hydro-electric plant is being built on the Enisey river and where winged insect pests and ticks abound. "Cloud-dusting" is being tried out using high explosives (Detinova, 1958).

Before the Second World War pyrethrum concentrates made up into solutions or emulsions ("Flicid") or as fumigants were widely employed in the Soviet Union.

Most of the Soviet pyrethrum comes from the Crimea, southern Ukraine and Azerbaidjan. A survey of species of chrysanthemums ("romashka") growing in the USSR was carried out in 1934 (Nabokov, 1958) and some high-yield new species were found. Pyrethrum dusts and concentrates (five per cent. and twenty per cent.) have been used for control of many arthropods since the value of pyrethrum in malaria control was emphasized by Nabokov in the early thirties. At the present time pyrethrum is used mainly for space spraying as solutions (such as "Flicid" containing 0.06-0.07 per cent. of pyrethrins I in white spirit), as emulsions or as fumigant candles. Recently a pilot plant started the production of allethrin - a synthetic analogue of cinerin.
Space spraying is carried out in areas where there are many winged pests. In houses pyrethrum solutions (0.03-0.045 per cent. of pyrethrin extract) are used at a dosage varying between 6 and 12 ml per 1 m³. Fumigant candles made of pyrethrum dust, sawdust, saltpetre, starch and water are also employed. For large-scale treatment, aerial spraying is carried out or DDT and pyrethrum aerosols are dispersed at the ground level from liquid concentrates, or released by fumigation. High pressure Freon 12 propelled insecticide aerosols are produced from cylinders (type VMA contains up to 500 g of DDT or BHC), mechanically created aerosols - from power-driven aerosol generators (type DASH-16 or AO-I61). Portable pulsating thermal generators made in Czechoslovakia are now being introduced.

DDT and BHC fumigant canisters ("shashki") and candles are now increasingly used for control of mosquitos and other pests. Candles of the "D20" type are used mainly for indoor fumigation; they contain 20 g of DDT and are sufficient for one medium-size room; larger canisters ("D-17" or "G-17") contain 1 kg of DDT or BHC and burn for 20 minutes. They are much used for the treatment of warehouses and such, as also for outdoor fumigation; the open-air dosage is four canisters to a hectare every ten days.

An interesting method is the indoor use of fumigant paper, prepared by impregnating blotting paper with a solution of saltpetre and then with a 25 per cent. solution of DDT or BHC. The dry paper is hung on wires and produces, on burning, insecticidal fumes sufficient for indoor control of winged pests. About 1 g of fumigant paper is sufficient for 1 m³ of space.

Much use has been made of aerial dusting and spraying of insecticides ("aviaopylenye", "aviaopryskivanye") since 1929 when the first trials of aerial spraying commenced near Moscow. The early PO-2A planes with a speed of 100-110 km/hour were used for many years and later changed to heavier LI-2 and AN-2 planes with a bigger payload and capable of a speed of 155-160 km/hour. According to Sergiev & Yakusheva (1956) the area treated annually from the air averaged during the past years 3-4 million hectares (7.5-10 million acres). Entomologists together with their auxiliary staff ("bonificators") prepare the plans for aerial insecticide dispersion and check on the results. A new trend favours the use of helicopters ("vertelet") for
Обезвреживайте места выплода комаров

Постер, показывающий различные методы борьбы с личинками комаров (наливание, обливание и воздушное опрыскивание)
aerial spraying and the helicopter MI-4 first tested in 1955 is being used with
success (Nabokov, 1957).\(^1\)

The aerial insecticide-dispersing equipment developed in the Soviet Union is
unconventional, reliable and rugged. The equipment developed recently by Popov (1955)
can be easily converted for dusting and spraying. For spraying, a 20-30 per cent.
solution of DDT is used, while DDT dusts have a five per cent. concentration. The
application rate varies between 0.1 and 0.4 kg of BHC and 0.5-1.0 kg of DDT per
hectare, depending on the topography of the area. In the northern areas of the USSR
pre-flood ground or aerial dusting of DDT and BHC is also increasingly used against
the culicine mosquitoes (\textit{A. communis}, \textit{A. intrudens}, \textit{A. vexans}, \textit{A. exorucians}, etc.)
and against \textit{Ixodes persulcatus}, the vector of virus encephalitis.

DDT and BHC\(^2\) have been used on a large scale since 1950 and considerable
quantities of both insecticides are now produced by factories working for the State
Chemical and Pharmaceutical Industry ("Glavchinfarmprom").

The Soviet technical DDT complies with the following specifications (Nabokov,
1958):\(^3\)

---

\(^1\) The early (1931-1939) reports by Nabokov on aerial spraying and dusting in
the Soviet Union are quoted by Covell (1941).

\(^2\) BHC is known in the USSR as hexachlorocyclohexane or hexachlorane and
abbreviated as HChCH. The gamma isomer content of the technical product is 13
per cent.; the proportion of other isomers is: alpha - 7\% per cent., beta -
6 per cent., delta - 6 per cent. New formulations are produced with much higher
gamma isomer content (Nabokov, 1958).

\(^3\) These requirements fully correspond to the specifications approved by WHO
(WHO Specifications for Pesticides, 1956).
Total organic chlorine content % by weight 51.0
Hydrolysable chlorine content % by weight 9.5-11.0
p,p'-Isomer content % by weight not less than 68.0 (usually 70.5-72.9)
Setting point not less than 78°C
Chloral hydrate content % by weight 0.025
Acidity calculated as H₂SO₄ % by weight 0.3
Solid material insoluble in water % by weight 0.5
Solid material soluble in water % by weight 0.25
Solid material insoluble in acetone % by weight 1.0
Alkalinity calculated as Na₂CO₃ % by weight 0.5
Water content % by weight not more than 0.5

A number of chlorinated insecticides such as "chlorten" (= a chlorinated alpha pinen), "chlorinalan" (= chlordane), "hexaten" (a mixture of chlorinated terpenes and isomers of BHC) and others are being tested, as also heterocyclic carbamates (pyrolan, pyramat) and many organic phosphorus insecticides, among which "mercaptos" (= diazinon), "karbos" (= malathion), "chlorfen" (= toxaphene), "chlorofos" (= Disterex), "pyrophos" (tetra ethyl-monothio-pyrophosphate) and "ditio" (tetra ethyl-dithio-pyrophosphate) should be noted (Nabokov, 1958; Korovin, 1958).

DDT and BHC formulations used in USSR are wettable powders, dusts, emulsions and pastes. Dusts generally contain five per cent., 10 per cent. and 12 per cent. of the active principle, water miscible emulsions ("Detoil") contain 20-25 per cent. of DDT or 15 per cent. of BHC, wettable powders contain 15 or 25 per cent. of the toxicant, pastes contain 30 per cent. of DDT or BHC. Highly concentrated pastes containing 66 per cent. of DDT and BHC were recently used in Tadzikistan by Lariukhin (1957) and showed a longer residual action. A new type of formulation is the highly stable "emulgo-suspension" of a semi-solid consistency and yet easily suspended in water. It is obtained by mechanical homogenization of the mixture in mineral oil and water. It is composed of 40 per cent. DDT, 10 per cent. mineral oil, 15 per cent. emulsifier and stabilizer (ether polyethylene glycol) and 35 per cent. of water (Nabokov, 1958). (When no other formulations are available, a suspension of technical DDT in water with soap as an emulsifier is used.) The usual dosage for complete coverage and barrier
Цель - уничтожение комаров в рабочем поселке.

Обработка рабочего поселка препаратами DDT или гексахлорана уничтожает комаров, клещей, москитов, клопов и прочих насекомых-наездников.

Немецкий дом должен быть обработан препаратами DDT или гексахлорана.

Внутренние поверхности помещений обрабатываются препаратом DDT.

Постер иллюстрирует способы опрыскивания с использованием DDT и BHC.
spraying (see below) is 1 g of the technical DDT per m$^2$ and 2 g of technical BHC per m$^2$. This dosage is doubled in the case of focal spraying (see below). The necessary dilution rate of the formulations used is calculated on the basis of a mean delivery rate of 3-10 litres per 100 sq. ft. (5.1 per 100 sq. ft. corresponds to the delivery rate of one gallon to 1000 sq. ft.).

Home-made whitewash containing five per cent. BHC or ten per cent. DDT is also used in some areas as, for instance, in the Ukraine, as it was shown that there is little decomposition of DDT in the ordinary whitewash.

DDT is used for residual spraying of human dwellings while BHC is generally preferred for cattle sheds, stores and other unoccupied premises.

Chemical assessment of insecticide deposits is carried out in some special projects. The samples are collected by scraping or swabbing. Several chemical tests are used. The simplest employs the method of Merkulova & Kambur (1951), based on the decomposition of DDT by hot potassium hydroxide and formation of white precipitate of chlorides on addition of silver nitrate solution. A more precise nephelometric test proposed by Pomicheva (1952) is based on the partial dehydrochlorination of DDT by alcoholic potassium hydroxide. The colorimetric method introduced by Kulberg & Shima (1949) is based on the nitration of DDT by potassium nitrate in the presence of sulphuric acid; to the resulting tetranitro compound lead chloride is added which converts the diamine into a red diazo compound soluble in sulphuric acid and quantitatively assessed in a colorimeter against a set of standards. This method has a sensitivity range of 5-50 microgrammes. For the chemical estimation of BHC Koliakov (1956) proposed a method based on the dehydrochlorination by alkali and fast potentiometric titration.

The duration of residual effect of BHC being much shorter than that of DDT, the official manual (Sergiev & Zhdanov, 1955) advises that repeated spraying with BHC should be carried out every 1-1/2 months, if necessary.

The duration of the residual effect of DDT depends naturally on climatic conditions of the area but it is stated (Sergiev & Yakusheva, 1956) that in the south the residual effect lasts for several weeks, and in the central and northern areas for several months. In some parts of the Soviet Union (Orekhovo-Zuevo) it was found that DDT deposits remain active for 12-14 months. Only one DDT spraying cycle a year is used in the USSR as a
rule though sometimes two cycles might be needed in the south. Normally about 15-25 per cent. of houses in southern parts of the USSR are treated twice a year.

The timing of spraying cycles depends on the transmission season and on local conditions of the area. In the north and in central parts of the USSR the spraying cycle begins in March or early April, while in the south in May or June.

The following table quoted after Nabokov (1958) illustrates the dosage and spraying schedules used in the USSR:

<table>
<thead>
<tr>
<th>Area</th>
<th>DDT technical</th>
<th>BHC technical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dosage</td>
<td>Cycles</td>
</tr>
<tr>
<td>North and central part of the USSR</td>
<td>1 g/m²</td>
<td>One</td>
</tr>
<tr>
<td>Northern Caucasus, southern Ukraine, Moldavia</td>
<td>1.5 g/m²</td>
<td>One</td>
</tr>
<tr>
<td>Middle Asia, Transcaucasia</td>
<td>2 g/m²</td>
<td>One</td>
</tr>
</tbody>
</table>

There are three methods of residual spraying: complete coverage ("sploshnaya obrabotka"), barrier spraying and focal spraying ("ochagovaya obrabotka"). The latter, introduced by Sergiev, is used whenever the malaria morbidity is less than three per cent.

The method of complete coverage is used in all highly malarious rural areas or in localities where the anopheline density is high and the risk of introduction of malaria from immigrants is considerable. The complete coverage comprises not only
human dwellings but also all the outhouses, cellars, hay lofts, etc. Barrier spraying is carried out in some urban areas, close to large mosquito breeding grounds and the width of the sprayed zone depends on local conditions. With the decrease of malaria morbidity during recent years the method of focal spraying has become much more common and is used for the treatment of a group of houses whenever a case of malaria is discovered in the course of surveillance.

In conditions when "exophilic" vectors, such as A. pulcherrimus, might be involved in the transmission of malaria, residual spraying might be carried out also outside the inhabited houses, under the eaves, in caves, around trees and bushes, etc.

Spraying of cattle and domestic animals, as a complementary method of malaria eradication in areas where the vector shows zoophilic tendencies, was tried out on a small scale in 1948 but widely used since 1952 by Bandin (1957). In the Stalingrad and Altai area it gave very good results, confirmed in Tadjikistan by Lysenko et al. (1957) against A. superpictus. The method is particularly valuable in areas with silkworm industry and its main drawback is the short duration (about ten days) of the residual effect. The formulation consists of ten per cent. DDT dust mixed with colophonium for better adherence. Water suspensions or water emulsions are also used at an approximate dosage of 1 g of the active compound to a m^2 of the surface of the animal.

Two main groups of spraying equipment are used for residual spraying: (1) Hand-operated medium capacity sprayers, and (2) Power-driven high capacity wheeled or vehicle mounted spraying machines. In the first group there are three types: the hydraulic stirrup pump bucket sprayer ("hydropult-Vulcan"), the pneumatic compression sprayer ("Kraskopult O-11", "Tremas") or the knapsack pneumatic sprayer ("Automax", "ORP").

Recently the hand-operated compression sprayers were provided with Schrader valves and the task of compression was mechanized using portable petrol-driven compressors of the NLS-1 type (Nabokov, 1957).

In the second group there are several types of heavy sprayers, such as the "OMP-A" ("Pioneer"), the electrically-operated DASH-23, and others (Nabokov, 1958).
An interesting type of spraying equipment is the "DUK" high capacity sprayer mounted on a Soviet type of cross-country motor vehicle (GAZ-51) and driven by the engine of the motor car.

Spraying is carried out by squads ("brigades") composed of 4-6 spraymen ("bonificators") and a supervisor ("rukoviditel"). The recommended standard distance between the sprayer nozzle and the wall is 1 m; this is twice the standard distance used elsewhere. Protective clothing used by the spraymen is composed of an overall ("kombinezon") and a respirator ("protivogaz") when necessary.

Large-scale residual spraying is normally carried out by the regional, provincial, district and urban health centres ("sanitarno epidemicheskaya staneya"). These centres are provided with their permanent spraying personnel and necessary transport although other non-medical organizations, such as industrial estates and agricultural "holkhoves" are usually requested to assist with transportation. The total area of walls and ceilings sprayed in the USSR was 267 million $m^2$ in 1957 and 239 million $m^2$ in 1958 (Ministry of Health, USSR, 1959).

Resistance

References to insecticide resistance ("ustoichivost'") of arthropod vectors are surprisingly few in the available Soviet writings. Resistance of houseflies to DDT and BHC was recorded several years ago by Derbenieva-Ukhova and Morozova (Nabokov, 1958) and reported more recently from Moscow, from the Crimea and from some southern Soviet Republics (Derbenieva-Ukhova, 1957; Olenev, 1958).

A special technical meeting devoted to the problem of arthropod resistance to chlorinated hydrocarbons was convened in February 1957 at the Moscow Institute of Malaria and Medical Parasitology. Most of the original papers read at this meeting dealt with the resistance in the housefly but experimental DDT resistance in lice was also mentioned. The meeting agreed that the problems of arthropod resistance to insecticides should receive more attention, recommended the setting-up of a co-ordinating centre for studies on resistance and drew up a detailed programme of basic and applied research work.

No resistance of mosquitos generally and anopheles in particular has been reported from the Soviet Union (Sergiev, 1958; Nabokov, 1958). Data on susceptibility levels
are not quoted in the available Soviet sources, even though a series of tests of anopheline susceptibility were recently carried out in Gurzia (Georgia). The response of some arthropod vectors to the contact with insecticide deposits has been investigated however and a few types of bioassay chambers have been described. One of the early bioassay kits is that of Korovin & Mironova (1949) for sandflies. A recent device designed mainly for bioassays but usable also for susceptibility testing is the "Exposimetre NLZ-3", developed by Nabokov, Lariukhin and Zhukova (Nabokov, 1958). It can be used for mosquitoes or for flies and its design is based on the principle of forced contact of the insect with the toxic surface, by the action of a plunger in a wide glass tube applied to the toxic surface through an intermediate plastic plate provided with a metal slide. A smaller bioassay chamber similar to a slide-rule and used for single insects was recently described by Turich (1958).

In his recent book Nabokov (1958) discusses briefly the problem of resistance of arthropod vectors to chlorinated hydrocarbons. He mentions that the results obtained by Soviet workers (Derbenieva-Ukhoa & Morozova, 1950; Derbenieva-Ukhoa & Lineva, 1953) disagree with the recent foreign work on the inheritance of the resistant gene according to Mendelian genetics. The Soviet authors claim that the adaptation to the environment is inheritable as taught by Michurin and that the inheritance of specific resistance follows this pattern.

Nabokov (1958) discusses the mechanism of the biochemical action of DDT and doubts that the resistance of flies can be explained solely by the faster conversion of the toxicant into DDE through the action of the specific enzyme.

The Soviet authors do not believe that DDT has a true irritant effect on mosquitoes; they admit, however, that the contact with DDT increases temporarily the phototropism of poisoned insects (Nabokov, 1958).

The susceptibility of mosquitoes to insecticides depends on the stage of their gonotrophic cycle, freshly blood-fed females being less susceptible than those that are empty. The most susceptible are those which are on the wing after the hibernation, while the period of relatively high tolerance coincides with the diapause, as shown by Vinogradskaya, Nabokov & Shmeliova (1949).
Malaria eradication

A comprehensive programme for the country-wide elimination of malaria as a mass disease was prepared by Sergiev in 1949 when the use of residual insecticides (mainly DDT) began to gather momentum. This programme was adopted in 1951 and carried out with an impressive drive and determination.

There is little doubt that the extensive programme of public health activities generally and of antimalaria work in particular could not have been accomplished by the Soviet Union without adequate medical, scientific and auxiliary personnel. A few figures quoted below give some relevant information.

The number of medical officers in the USSR (excluding the Armed Forces) was 140,769 in 1940 and increased to 329,442 in 1956. Of these, 24,058 (about seven per cent.) employed by the Ministry of Health are specialized in public health work. The annual output of qualified medical men and women was 14,500 in 1953-1954, and the ratio of the population to one physician decreased from 715 in 1950 to 625 in 1955. The number of qualified paramedical personnel, such as dentists, pharmacists, feldshers, sanitarians, midwives, nurses, laboratory technicians, etc., was 386,740 in 1940 and 858,497 in 1956. Of the latter figure, 22 per cent. were feldshers and two per cent.

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There are two equivalent Russian terms for malaria eradication: "liquidatsia" or "isokorenene" (taking out with the roots). The first term is more commonly used; the second, occasionally encountered, is synonymous.

The following relevant figures were quoted recently by two different sources:

<table>
<thead>
<tr>
<th></th>
<th>Austria</th>
<th>Federal Germany</th>
<th>France</th>
<th>Italy</th>
<th>Switzerland</th>
<th>United Kingdom</th>
<th>USSR</th>
</tr>
</thead>
<tbody>
<tr>
<td>World Directory of Medical Schools (1957)</td>
<td>628</td>
<td>745</td>
<td>1093</td>
<td>828</td>
<td>976</td>
<td>1149</td>
<td>784</td>
</tr>
</tbody>
</table>

"Feldshers" are auxiliary medical officers with limited rights and responsibilities. Their training in special schools takes approximately half the time needed for training a medical graduate.
ПРОВЕРЯЙТЕ СВОЕ ЗДОРОВЬЕ У ВРАЧА

"Обследование врачом каждого нового прибывающего строителя предупреждает занос болезней на стройку."

"У каждого прибывающего строителя проверяется кровь на малярию."

"Больной мальярией дает авангард армии."

Poster illustrating the follow-up of a malaria case by consultation, blood examination and administration of antimalarials.
sanitarians and epidemiological assistants (Ministry of Health, USSR, 1957). These figures do not comprise the auxiliary technical staff, such as supervisors, drug distributors ("akriquinizers"), mosquito collectors ("bonificators") and others. It might be added that in 1956 not less than 2,780,000 persons, or about 1.3 per cent. of the entire population of the Soviet Union, worked in one way or another in the field of public health (Ministry of Health, USSR, 1957; Gunther, 1958).

From the very beginning the planning of the programme was based on the existing wide network of dispensaries, health centres, polyclinics, epidemiological stations and antimalaria stations. It might be usefully pointed out that in 1956 the Ministry of Health, USSR (1957) listed over the territory of the Soviet Union 24,105 hospitals, 33,854 polyclinics, 16,400 dispensaries, 5,230 health centres with a MCH ("sanitarno-epidemicheskaya stancya"), 19,979 health units ("zdravpunkt"), 46,966 maternity and child welfare units and 68,300 auxiliary medical units ("feldshersko-akusherskiy punkt").

In 1955 the number of scientific workers in the USSR was 223,893, of whom 9,460 were Doctors of Science and 77,961 were Candidates of Science (Central Statistical Board, USSR, 1957).

Among the long series of administrative measures introduced in connexion with this programme, some deserve special mention. The compulsory notification of cases of malaria has been in force in the RSFSR since 1921; it was extended to other areas of the Soviet Union in 1947-1948 and the tightened-up registration ("uchot bolnykh") of all cases of malaria covered the whole of the USSR since 1951.

The training programme was not less comprehensive and by 1954 the professional staff available in the USSR numbered about 2,000 medical officer-malariologists, 500 entomologists and 350 malaria engineers (Sergiev & Rashina, 1957).

An interesting table illustrates the intensity of the training programme of the Institute of Malaria of the Ministry of Health (Pokrovsky & Leiserman, 1957).
<table>
<thead>
<tr>
<th>Year</th>
<th>Malarialogists</th>
<th>Medical parasitologists</th>
<th>Entomologists</th>
</tr>
</thead>
<tbody>
<tr>
<td>1946</td>
<td>32</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1947</td>
<td>18</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1948</td>
<td>71</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1949</td>
<td>54</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1950</td>
<td>65</td>
<td>-</td>
<td>27</td>
</tr>
<tr>
<td>1951</td>
<td>25</td>
<td>-</td>
<td>21</td>
</tr>
<tr>
<td>1952</td>
<td>54</td>
<td>-</td>
<td>25</td>
</tr>
<tr>
<td>1953</td>
<td>27</td>
<td>-</td>
<td>25</td>
</tr>
<tr>
<td>1954</td>
<td>-</td>
<td>26</td>
<td>30</td>
</tr>
<tr>
<td>1955</td>
<td>-</td>
<td>25</td>
<td>37</td>
</tr>
<tr>
<td>1956</td>
<td>-</td>
<td>21</td>
<td>52</td>
</tr>
<tr>
<td>Total</td>
<td>346</td>
<td>72</td>
<td>217</td>
</tr>
</tbody>
</table>

In addition to chemotherapy and residual insecticide spraying, other available methods were not neglected, and drainage, water management, larvicidal oils, zooprophylaxis, mechanical protection, etc. were widely used. The overall technical guidance was given by the Institute of Malaria and Medical Parasitology of the Ministry of Health, as also by the regional institutes previously quoted.

The thorough planning of antimalaria measures in relation to general socio-economic development and to some specific aspects of it (hydro-electric or irrigation schemes, colonization of new areas) is perhaps the most obvious characteristic of malaria eradication in the USSR.

Public health education ("sanitarno prosvetitelnaya rabota") received much emphasis and is actively carried out using all the available and well-tried methods of political indoctrination by meetings, discussion groups, pamphlets, posters and films.

It might be of interest, at this point, to outline briefly the administrative organization of malaria eradication in the USSR. The whole of the malaria eradication programme in the Soviet Union is directed now by the Division of Communicable Diseases
(Protioepidemicheskiy Otdel) of the Department of Public Health and Communicable Diseases (Glahvnoe Sanitarno-Protioepidemicheskoye Upravlenye) of the Ministry of Health. (Until recently the Ministry of Health, USSR, and the respective ministries of Soviet republics had a special malaria division.)

The Division of Communicable Diseases, advised by the Institute of Malaria of the Ministry of Health, USSR, is responsible for the administrative and technical planning of all antimalaria measures and for training of personnel. The epidemiological follow-up of cases of malaria is organized jointly with the Division of Medicine of the Ministry of Health, USSR; the organization of research is vested in the Institute of Malaria of the Ministry of Health and the regional Institutes of the respective republics; public health education in malaria is organized by the Institute of Health Education of the Ministry of Health.

Apart from hospitals, polyclinics, dispensaries, and health centres, there were in the Soviet Union special strategically-situated antimalaria stations linked with the general national health service and with the medical service of railways and waterways. There were 2150 antimalaria stations in 1952 and 2000 in 1954; today most of them have been merged with the general public health units.

On the basis of general directives sent by the Ministry of Health, the planning of antimalaria measures within each district is prepared by the District Medical Unit ("Vrachebnyi Uchastok") with the advice of the corresponding Health Centre ("Sanitarno-epidemicheskaya Stancya"). A preliminary survey is carried out by the village medical and health unit ("Selskiy Vrachebnyi Uchastok") and by the District Health Unit. This plan is submitted to the higher authority, viz. the Regional Health Centre whose MOH (Glahvnyi Vrah Sanitarno-epidemicheskoy Stancyi) adopts it after consulting such local collective farming units, or industrial organizations as are relevant. The plan, after its approval by the Regional Health Department ("Raizdравотдел") is submitted to the Executive Board of the region ("Rayonniy Ispolkom") and then to the Provincial Health Department ("Oblizдравотдел") which consolidates the programme for the whole province.

The medical follow-up and drug administration are carried out by the network of provincial, regional, district and other hospitals, polyclinics, dispensaries, school
medical services, crèches, nurseries and other health units. Insecticidal measures on a small scale are carried out by the local health units with the co-operation of other collective organizations if necessary. Large-scale spraying is always carried out by the District Health Centre. ¹

In the practice of passive surveillance much attention is paid to the blood examination for malaria of all fever cases reporting for medical attention. The medical and paramedical personnel are often reminded of the possibility of malaria in cases of obscure fevers; the population is encouraged to avail themselves of medical aid centres for diagnosis and treatment of even minor ailments.

All cases of clinical malaria (whether primary attacks or relapses) and all persons found to be positive for malaria in the course of active surveillance are registered. These records are sent monthly to the provincial health authority.

In addition to passive surveillance, active surveillance is in force during the transmission season in all areas where malaria was common. This surveillance ("podvornyi obkhod") is carried out by district health visitors or voluntary drug distributors ("akriquinisators") and its frequency varies between five and ten days depending on the size of the district. All local inhabitants and visitors with fever or vague general symptoms have their blood examined for malaria parasites but no immediate treatment is given. This work of active surveillance is often carried out by non-medical personnel such as members of the Red Cross or Red Crescent, delegates of collective units, etc. Mass surveys of the population ("obsledovanye naselenya") are carried out occasionally in localities where the malaria morbidity was significant. Some surveys are limited to those individuals who are known to have had malaria during

¹ Regulations dealing with methodology of malaria surveys, chemotherapy, anti-mosquito measures, entomological investigations, etc. approved by the Ministry of Health, USSR, have been collected in the manual edited by Sergiev & Zhdanov (1955).
the previous years, who had undiagnosed fevers, or who came from malarious areas; in smaller localities the whole population is examined.¹

The results of this intensive programme were spectacular. Figures quoted by Pokrovsky & Leiserman (1957) for the largest single administrative unit, namely the Russian Socialist Federal Soviet Republic, are particularly interesting. The trend of malaria morbidity in that part of the Soviet Union can be assessed by taking the 1940 figures as 100 per cent. After the peak figure of 103 per cent. in 1945, the year 1948 gave the comparative malaria morbidity of 55 per cent., 1949 - 42 per cent., 1950 - 19 per cent., 1951 - 8 per cent., 1952 - 4 per cent., 1953 - 3 per cent., 1954 - 1.5 per cent., 1955 - 0.7 per cent., and 1956 - 0.25 per cent. The changing geographical pattern of malaria morbidity in different regions of the RSFSR is well brought out in Table 1.

¹ The extent of surveillance activities carried out in the Soviet Union can be judged from the figures available through the Ministry of Health, USSR (1958). During the year 1957 the number of mass survey blood examinations for the presence of malaria parasites amounted to 5,769,463 of which 1318 were found to be positive. The highest percentage of positive blood slides was recorded in Armenia (0.13 per cent.) and in Azerbeidjan (0.13 per cent.); there followed Tadjikistan (0.045 per cent.) and Gruzia (Georgia) (0.026 per cent.). It should be pointed out that in the RSFSR out of 2,203,325 slides 130 were positive (0.006 per cent.) while in the Ukraine the respective figures were 1,259,137 and 5 (0.0004 per cent.). In 1958, about 6.5 million slides were taken during mass surveys and 2378 were found to be positive. Most of these were P. vivax with only 68 P. falciparum and 6 P. malariae.
TABLE 1. REGIONAL MALARIA MORBIDITY AS PERCENTAGE OF THE TOTAL MALARIA MORBIDITY IN RSFSR DURING THE PERIOD 1940-1955 (after Pokrovsky & Leiserman, 1957)

<table>
<thead>
<tr>
<th>Regions of RSFSR</th>
<th>Regional malaria morbidity as percentage of total malaria morbidity in RSFSR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1940</td>
</tr>
<tr>
<td>Northern</td>
<td>1.5</td>
</tr>
<tr>
<td>Western</td>
<td>1.0</td>
</tr>
<tr>
<td>North-western</td>
<td>1.0</td>
</tr>
<tr>
<td>Central</td>
<td>40.0</td>
</tr>
<tr>
<td>Volga-Kama</td>
<td>30.0</td>
</tr>
<tr>
<td>Northern Caucasus</td>
<td>8.0</td>
</tr>
<tr>
<td>Ural</td>
<td>10.0</td>
</tr>
<tr>
<td>Western Siberia</td>
<td>6.0</td>
</tr>
<tr>
<td>Eastern Siberia</td>
<td>2.5</td>
</tr>
<tr>
<td>Far East</td>
<td>-</td>
</tr>
</tbody>
</table>

The Tables 2 and 3 show the trend of malaria morbidity during the period 1940-1956 in the RSFSR and in 14 Soviet republics quoted after Sergiev & Yakusheva (1956) and Sergiev & Rashina (1957).


<table>
<thead>
<tr>
<th>Republic</th>
<th>Peak year</th>
<th>Number of cases</th>
<th>Number of cases in 1954</th>
</tr>
</thead>
<tbody>
<tr>
<td>Georgia (Gruzia)</td>
<td>1943</td>
<td>131 841</td>
<td>2 874</td>
</tr>
<tr>
<td>Moldavia</td>
<td>1948</td>
<td>155 924</td>
<td>447</td>
</tr>
<tr>
<td>Kirghizia</td>
<td>1945</td>
<td>67 552</td>
<td>468</td>
</tr>
<tr>
<td>Armenia</td>
<td>1943</td>
<td>86 206</td>
<td>160</td>
</tr>
<tr>
<td>Turkmenistan</td>
<td>1943</td>
<td>62 248</td>
<td>365</td>
</tr>
<tr>
<td>Karelo-Finnlandia</td>
<td>1948</td>
<td>7 057</td>
<td>41</td>
</tr>
<tr>
<td>Ukraine</td>
<td>1945</td>
<td>471 479</td>
<td>568</td>
</tr>
<tr>
<td>Byolorussia</td>
<td>1946</td>
<td>234 357</td>
<td>295</td>
</tr>
</tbody>
</table>
### TABLE 3. MALARIA MORBIDITY IN RSFSR AND 14 UNION SOVIET REPUBLICS* IN 1940, 1946 AND 1956 (after Sergiev & Rashina, 1957)

<table>
<thead>
<tr>
<th>Republic</th>
<th>1940 Cases</th>
<th>Prevalence per 10 000</th>
<th>1946 Cases</th>
<th>1956 Cases</th>
<th>Prevalence per 10 000</th>
</tr>
</thead>
<tbody>
<tr>
<td>RSFSR</td>
<td>1,924,899</td>
<td>175.3</td>
<td>1,604,925</td>
<td>5,616</td>
<td>0.5</td>
</tr>
<tr>
<td>Armenia</td>
<td>57,887</td>
<td>420.5</td>
<td>60,179</td>
<td>68</td>
<td>0.4</td>
</tr>
<tr>
<td>Azerbeijan</td>
<td>238,145*</td>
<td>743.0</td>
<td>244,830</td>
<td>3,071</td>
<td>0.04*</td>
</tr>
<tr>
<td>Byelorussia</td>
<td>21,258</td>
<td>21.7</td>
<td>234,357</td>
<td>46</td>
<td>0.06</td>
</tr>
<tr>
<td>Estonia</td>
<td>-</td>
<td>-</td>
<td>527</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Gruzia (Georgia)</td>
<td>102,818</td>
<td>290.3</td>
<td>78,604</td>
<td>808</td>
<td>2.0</td>
</tr>
<tr>
<td>Kazakhstani</td>
<td>128,368</td>
<td>208.9</td>
<td>227,366</td>
<td>1,103</td>
<td>1.2</td>
</tr>
<tr>
<td>Kirghizia</td>
<td>18,927</td>
<td>129.7</td>
<td>52,412</td>
<td>69</td>
<td>0.34</td>
</tr>
<tr>
<td>Latvia</td>
<td>-</td>
<td>-</td>
<td>1,590</td>
<td>6</td>
<td>-</td>
</tr>
<tr>
<td>Lithuania</td>
<td>-</td>
<td>-</td>
<td>1,632</td>
<td>10</td>
<td>-</td>
</tr>
<tr>
<td>Moldavia</td>
<td>59,368*</td>
<td>-</td>
<td>64,528</td>
<td>51*</td>
<td>0.19*</td>
</tr>
<tr>
<td>Tadjikistan</td>
<td>72,224</td>
<td>486.7</td>
<td>80,020</td>
<td>1,305</td>
<td>7.3</td>
</tr>
<tr>
<td>Turkmenistan</td>
<td>27,237</td>
<td>217.2</td>
<td>29,361</td>
<td>58</td>
<td>0.34</td>
</tr>
<tr>
<td>Ukraine</td>
<td>230,648</td>
<td>54.9</td>
<td>335,930</td>
<td>184</td>
<td>0.04</td>
</tr>
<tr>
<td>Uzbekistan</td>
<td>203,552</td>
<td>324.0</td>
<td>348,282</td>
<td>645</td>
<td>0.74</td>
</tr>
<tr>
<td><strong>Total USSR</strong></td>
<td>3,164,522</td>
<td>222.1*</td>
<td>3,517,199</td>
<td>13,015</td>
<td>0.65</td>
</tr>
</tbody>
</table>

* This indicates figures which were corrected by Professor Sergiev in 1958 (in litt.)

An interesting account of the results of the malaria eradication programme in Byelorussia, home of the famous Prypet marshes and Polesie — a notorious malarious area of eastern Europe — was given by Beliatsky & Rubinstein (1959).

The amount of malaria in Byelorussia was imperfectly known during the first quarter of this century but can be estimated at approximately 150 per 10 000 of the population. The subsequent trend of malaria morbidity in Byelorussia during the period 1924-1957 (excluding the years 1941-1944) is shown in Table 4.
TABLE 4. ANNUAL MALARIA MORBIDITY PER 10 000 OF THE POPULATION IN THE BYELORUSSIAN S.S. REPUBLIC DURING THE PERIOD 1924-1957 (after Beliatzky & Rubinstein, 1959)

<table>
<thead>
<tr>
<th>Year</th>
<th>Cases per 10 000</th>
<th>Year</th>
<th>Cases per 10 000</th>
<th>Year</th>
<th>Cases per 10 000</th>
</tr>
</thead>
<tbody>
<tr>
<td>1924</td>
<td>19.6</td>
<td>1934</td>
<td>17.6</td>
<td>1948</td>
<td>147.5</td>
</tr>
<tr>
<td>1925</td>
<td>29.1</td>
<td>1935</td>
<td>55.6</td>
<td>1949</td>
<td>98.3</td>
</tr>
<tr>
<td>1926</td>
<td>10.4</td>
<td>1936</td>
<td>42.2</td>
<td>1950</td>
<td>25.8</td>
</tr>
<tr>
<td>1927</td>
<td>18.0</td>
<td>1937</td>
<td>63.4</td>
<td>1951</td>
<td>4.4</td>
</tr>
<tr>
<td>1928</td>
<td>28.4</td>
<td>1938</td>
<td>53.6</td>
<td>1952</td>
<td>1.4</td>
</tr>
<tr>
<td>1929</td>
<td>11.3</td>
<td>1939</td>
<td>55.7</td>
<td>1953</td>
<td>0.5</td>
</tr>
<tr>
<td>1930</td>
<td>6.7</td>
<td>1940</td>
<td>23.8</td>
<td>1954</td>
<td>0.4</td>
</tr>
<tr>
<td>1931</td>
<td>4.7</td>
<td>1945</td>
<td>324.0</td>
<td>1955</td>
<td>0.25</td>
</tr>
<tr>
<td>1932</td>
<td>6.8</td>
<td>1946</td>
<td>344.6</td>
<td>1956</td>
<td>0.05</td>
</tr>
<tr>
<td>1933</td>
<td>13.6</td>
<td>1947</td>
<td>266.3</td>
<td>1957</td>
<td>0.02</td>
</tr>
</tbody>
</table>

According to the recent information supplied to WHO by the Ministry of Health, USSR (1958, 1959) the total number of cases of malaria over the whole territory in the Soviet Union was 5097 in 1957 (3652 primary infections and 1445 relapses), and 4673 in 1958 (the latter figure is provisional).

The figure of ten cases of malaria per 10 000 population was accepted as the limit, above which malaria was regarded as a mass disease. Table 5 shows the annual trend of malaria morbidity in the USSR for the period 1950-1956.

According to the criterion mentioned above, malaria was eliminated as a mass disease from wide areas of the USSR about five years ago. The greatest decline was noted during recent years in the Uzbek, Moldavian, Tadjik and Kirghiz republics.
### TABLE 5. MALARIA MORBIDITY PER 10 000 POPULATION IN RSFSR AND 11 UNION REPUBLICS OF USSR DURING THE PERIOD 1950-1956
(after Sergiev & Rashina, 1957)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>RSFSR</td>
<td>31.5</td>
<td>12.8</td>
<td>6.2</td>
<td>4.1</td>
<td>2.4</td>
<td>1.3</td>
<td>0.5</td>
<td>In 1935 - 1948.8</td>
</tr>
<tr>
<td>Armenia</td>
<td>91.0</td>
<td>35.1</td>
<td>10.7</td>
<td>3.0</td>
<td>1.1</td>
<td>0.5</td>
<td>0.4</td>
<td>In 1940 - 743.0</td>
</tr>
<tr>
<td>Azerbeidjan</td>
<td>181.0</td>
<td>118.5</td>
<td>87.1</td>
<td>57.4</td>
<td>52.6</td>
<td>24.4</td>
<td>9.0</td>
<td>In 1945 - 813.0</td>
</tr>
<tr>
<td>Byelorussia</td>
<td>25.2</td>
<td>4.3</td>
<td>1.4</td>
<td>0.56</td>
<td>0.36</td>
<td>0.25</td>
<td>0.06</td>
<td></td>
</tr>
<tr>
<td>Gruzia (Georgia)</td>
<td>43.5</td>
<td>32.8</td>
<td>23.8</td>
<td>14.5</td>
<td>7.5</td>
<td>4.5</td>
<td>2.0</td>
<td></td>
</tr>
<tr>
<td>Kazakhstan</td>
<td>84.0</td>
<td>45.0</td>
<td>20.0</td>
<td>10.9</td>
<td>6.6</td>
<td>3.2</td>
<td>1.2</td>
<td></td>
</tr>
<tr>
<td>Kirghizia</td>
<td>60.7</td>
<td>26.0</td>
<td>10.7</td>
<td>6.6</td>
<td>2.9</td>
<td>1.2</td>
<td>0.34</td>
<td></td>
</tr>
<tr>
<td>Moldavia</td>
<td>115.7</td>
<td>34.8</td>
<td>10.5</td>
<td>3.3</td>
<td>1.6</td>
<td>0.5</td>
<td>0.18</td>
<td></td>
</tr>
<tr>
<td>Tadjikistan</td>
<td>164.1</td>
<td>118.5</td>
<td>81.5</td>
<td>62.5</td>
<td>50.3</td>
<td>25.9</td>
<td>7.3</td>
<td>In 1940 - 486.7</td>
</tr>
<tr>
<td>Tukmenistan</td>
<td>55.8</td>
<td>18.7</td>
<td>7.7</td>
<td>2.9</td>
<td>2.7</td>
<td>2.1</td>
<td>0.34</td>
<td>In 1945 - 530.0</td>
</tr>
<tr>
<td>Ukraine</td>
<td>10.9</td>
<td>2.4</td>
<td>0.6</td>
<td>0.2</td>
<td>0.15</td>
<td>0.08</td>
<td>0.04</td>
<td></td>
</tr>
<tr>
<td>Uzbekistan</td>
<td>172.0</td>
<td>90.0</td>
<td>47.1</td>
<td>27.7</td>
<td>12.1</td>
<td>4.1</td>
<td>0.74</td>
<td></td>
</tr>
<tr>
<td><strong>Total USSR</strong></td>
<td><strong>39.0</strong></td>
<td><strong>17.5</strong></td>
<td><strong>9.2</strong></td>
<td><strong>5.8</strong></td>
<td><strong>3.6</strong></td>
<td><strong>1.7</strong></td>
<td><strong>0.7</strong></td>
<td><strong>In 1940 - 222.1</strong></td>
</tr>
</tbody>
</table>

**Note:** The relevant figure for the whole territory of the Soviet Union was 0.25 per 10 000 in 1957 and about 0.23 per 10 000 in 1958.

In 1955 the USSR Ministry of Health prepared a plan, the aim of which is to achieve the complete eradication of malaria by 1960. As a result of this plan a number of specialists in charge of "spraying brigades" were sent on detachment to some difficult areas in Azerbeidjan, Georgia, Kazakhstan, Tadjikistan, Uzbekistan and Yakutsk republics. Moreover the Ministry of Health convened in 1956-1957 two regional technical meetings on malaria eradication: one in Baku for Transcaucasia and the other in Stalinabad for Middle Asia.

As quoted above the number of notified cases of malaria in the Soviet Union fell from 3-1/2 million in 1946 to 4678 in 1953. The present geographical status of malaria...
eradication in the Soviet Union can be assessed from the following information lately provided by the Ministry of Health, USSR (1959). By the end of 1958 not a single case of malaria has been recorded for the past three years over an area of 7 723 000 km\(^2\) of the Soviet Union with a population of 158 050 000. This amounts to about 60 per cent. of the total potentially malarious area of the USSR and to 83 per cent. of the population inhabiting this area. A total area of 3 496 000 km\(^2\) with a population of 25 170 000 is in the consolidation phase ("faza ukreplenia") and under surveillance even though only a few and sporadic cases of malaria were recorded within this area during the past three years by mass surveys. An area covering 1 504 000 km\(^2\) with a population of 6 780 000 is still in the attack phase ("faza nastuplenya") under the regular residual spraying combined with the system of follow-up described previously. The following zones of the Union Republics are in the latter phase of malaria eradication: RSFSR (population in the malarious zones - 4 000 000), Kazakhstan (population - 400 000), Kirghizia (population - 400 000), Uzbekistan (450 000), Tadjikistan (150 000), Turkmenistan (50 000), Armenia (50 000).

Thus one would be justified in saying that malaria eradication has already been attained or is about to be completed over 88 per cent. of the total potentially malarious area of the Soviet Union, comprising 96.5 per cent. of the total population inhabiting this area. Judging by this achievement there can be little doubt that the few remaining foci of malaria, mainly in Transcaucasia and in Middle Asia, will be eradicated within the next few years.

According to Sergiev & Rashina (1957) the undeniable success of malaria eradication in the USSR was due to three simultaneously executed measures (note the order of priority):

1. Early discovery of individual cases of the disease, intensive treatment and careful follow-up of each case for not less than two years;

2. Use of residual insecticides such as DDT and BHC for the total coverage of an area or for barrier, village or focal spraying depending on local conditions;

3. Widespread prevention of mosquito breeding by the use of all available methods.

Plans prepared for the post-eradication period of 1959-1965 were outlined in the representative journal of the Institute of Malaria of the Ministry of Health (Edit. 1958).
These plans refer to public health activities and to the research programme. First, attention will be concentrated on the prevention of the introduction of malaria from the outside and on the improvement of mosquito control, preferably by anti-larval measures. Secondly, it is proposed to develop new methods of early recognition of symptomless parasite carriers, to improve the anti-relapse treatment, to discover the best measures for prevention of epidemics from imported cases, to develop the use of old and new insecticides, to adopt the insecticidal methods so that they could be used in areas with silkworm industry, and, finally, to study the epidemiology and eradication of malaria in other countries.

During the next few years the main aims of the health services of the USSR in areas where malaria is still present are: continuation of insecticidal spraying with complete or focal coverage, treatment of cases including the administration of anti-relapse drugs (quinocide), and follow-up of each case for at least two years.

Wherever there is any possibility of the introduction of malaria from outside the USSR, chemoprophylaxis of the population near the frontier will be maintained. One of the most important tasks is the tightening up of the reporting of suspected cases, their correct diagnosis, treatment and subsequent follow-up.

Active surveillance is satisfactory only if every inhabited area can be visited not less than three times a month and this might be difficult in some circumstances. There is a good case for adding special squads to improve the frequency and completeness of the local surveillance activities and to develop new methods to discover not only all the clinical cases of malaria but even more so the asymptomatic carriers (Timofeeva, 1957).

The notification of malaria should not be accepted unless the diagnosis is based on a positive blood examination. Each proved case of malaria should have a thorough epidemiological investigation by a specialist and the speeding up of the notification procedure is of great importance (Edit. 1957).

Measures to be taken in conditions when malaria is nearly eradicated have been described by Sorgiev (1958). The object of the compulsory epidemiological investigation is: (1) to determine the origin of the notified case of malaria, (2) to decide
if there is a likelihood of secondary cases and (3) to determine the necessary counter-measures. The type and extent of these measures depend on many factors (origin of the case, number of persons affected, species of the parasite, coincidence with the transmission season, bionomics of the prevalent vector). As a rule the greater the number of cases the more extensive are the protective measures.

In the present conditions of near-eradication of malaria in the USSR, the following epidemiological points are of interest: (1) sharp decrease of the overall incidence of malaria; (2) absence of any sizeable foci of malaria, even though small foci are still to be found and present a potential danger; (3) great rarity of falciparum malaria, most of the cases of disease being only vivax malaria; (4) prevalence in all areas, including the south, of the northern seasonal type of tertian malaria so that most of the attacks are in spring and summer; and (5) annual appearance in some areas of the USSR of a very small number of foci. Over the whole potentially malarious area of the Soviet Union there are now three groups of communities (1) those (by far the most common) where eradication has been achieved and where cases of malaria are totally absent or exceptionally imported; (2) those where malaria persists as a small focus of infection; and (3) those where after an absence of malaria cases for one to three years a few local cases have appeared.

From the point of view of an epidemiologist the latter cases are particularly important and have been carefully investigated. The results of this investigation showed that population movements were occasionally responsible for the reinestation of a small area but the main cause was linked with a premature cessation of antimalaria measures or with gaps in the system of surveillance. The problem of importation of cases of malaria from outside the country is now investigated. On the other hand the leading Soviet malariologists gave a warning that the present success of malaria eradication in their country should not lead to a casual attitude to the problem and to a premature weakening of the whole organization geared to the complete and permanent elimination of malaria from the Soviet Union.
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