Rev. sci. tech. Off. int. Epiz., 2006, **25** (1), 153-161

Achievements of the Soviet biological weapons programme and implications for the future

I.V. Domaradskij [1] & W. Orent [2]

(1) Moscow Gabrichevsky G. N. Research Institute of Epidemiology and Microbiology, Admiral Makarov Road, 10, Moscow 125212, Federation of Russia
(2) 4562 Club Circle, Atlanta, Georgia 30319, United States of America

Summary

The military–biological complex of the former Union of Soviet Socialist Republics was a true Frankenstein's Monster, with a powerful scientific potential – for good and for ill. This article examines both the direct scientific results of the twin biological weapons (BWs) programmes run by the 'civilian' Biopreparat and by the Ministry of Defence (MoD) and the public health benefits that sprang, despite the original intent, out of those programmes. The authors will also explore the potential for both crop and livestock destruction and for enhanced agricultural methods growing out of the parallel Soviet programme under the management of the Special Directorate of the Ministry of Agriculture.

In the last section of the article the authors discuss the situation in the military–biological complex that arose after former President Boris Yeltsin's 1992 decree abolishing all research and development on offensive BWs. The possibility is considered that expertise, technologies and materials from the former Soviet BWs programme have leaked out of Russia, because the living standards in Russia remain low and the overwhelming majority of scientists have a miserable existence.

Keywords

15th Directorate – Antiplague System – Biopreparat – Military–biological complex – Ministry of Agriculture – Ministry of Defence – State Scientific Centre of Applied Microbiology – Vector.

Introduction

The development of biological weapons (BWs) in the Union of Soviet Socialist Republics (USSR) began in the 1920s and proceeded through the next few decades until the beginning of the Second World War; by then, stocks of relatively primitive BWs were available to the Soviet military. At this point, Soviet BWs research employed only natural strains of microorganisms. But after more than 40 years of research it became clear that using only natural strains made it very difficult to achieve what the military viewed as desirable results. Some of the leading biologists of the USSR, many of them fully *au courant* with scientific developments in the West, realised that they needed an entirely new approach to the problem of making effective weapons. This new approach would incorporate the latest achievements in molecular biology and genetics. Because of the closed nature of Soviet science and society, however, Russian biological sciences lagged behind those of the West. There were few experts who were on a par with Western molecular biologists and geneticists, and there was no modern equipment.

How was Soviet biological science, crippled by decades of Lysenkoism, to overcome the advantage held by the West? In the early 1970s, the Soviet Government created a new 'civilian' branch of the BWs programme, called 'Biopreparat'. Biopreparat, established under the Main Directorate of Microbiological Industry under the USSR Council of Ministers, was designed to do whatever was necessary to modernise Soviet science and construct a suitable scientific and industrial base for the design and production of modern BWs. A specific directive from the highest levels of the Soviet Government also established the ultra-secret Interagency Scientific and Technical Council (ISTC) for molecular biology and genetics, to inspire, direct and oversee all the work performed by

Biopreparat. At the same time, the ISTC also controlled the development of a parallel line of BWs research conducted by the Ministry of Defence (MoD) (before the creation of the supposedly civilian Biopreparat the MoD had handled all BWs research). Also closely connected to the ISTC was another programme, managed by the Ministry of Agriculture. This programme directed all research on the creation and development of biological agents designed to destroy crops and livestock.

All of these organisations were, quite naturally, designated 'top secret'. At the same time, the Soviet government created another council for the study of molecular biology and genetics, this time at the Academy of Sciences of the USSR. Though this council was open, it had a dual purpose:

a) to promote the legitimate investigation of the fundamental aspects of evolutionary and molecular biology and genetics in which the USSR lagged seriously behind the West

b) to serve as a 'cover story' for the secret ISTC and the fledgling Biopreparat.

In fact almost all civilian microbiological programmes were used as 'cover stories' to hide the top-secret BWs programmes of the MoD and Biopreparat. Of these, the programme called 'Problem Number Five' was particularly important. This odd-sounding name refers to a defensive programme designed to protect the Soviet people from BWs and infectious disease. Within the Problem Number Five programme, the Antiplague System, a vast network of institutes and stations that spanned much of the territory of the USSR, played an especially significant role. Though the Antiplague System was originally devised to fight plague and other diseases native to the region, its institutes, including the famous 'Mikrob' Institute at Saratov, came, through Problem Number Five, to serve as suppliers of strains and expertise to the Biopreparat and the MoD BWs programmes. The Mikrob Institute, for example, supplied the military programme with the most virulent available strains of *Yersinia pestis*, the plague agent. Another large antiplague institute, created in Volgograd in 1971, performed vital services for both the military and Biopreparat. At first scientists at the Volgograd antiplague institute studied pathogens that produce a deep mycosis affecting nearly all organs; later this work was extended to studies of the genetics of *Burkholderia pseudomallei* and *Bacillus anthracis* and to developing technology for the rapid diagnosis of the agents of especially dangerous infections.

After the signing (in 1972) and ratification (in 1975) of the international Biological Weapons and Toxins Convention, which prohibited the development, manufacture and accumulation of stocks of BWs and toxins, the USSR used the cover of the convention to accelerate their offensive weapons programme, though now in even deeper secrecy.

Even now, the military are doing all they can to deny or conceal the existence of the Soviet offensive programme, as evidenced by lectures delivered by the chief of the former 15th Directorate of the MoD, V.I. Yevstigneev, at the Moscow Institute of Physics and Technology in 2003 (15). His words were echoed by the retired general A. Vorob'ev (14), vice-chief of Biopreparat from 1979 until 1987. Interestingly, who or what forces them to obfuscate the issue – over 10 years after Presidential Decree No. 390 of 11 April 1992 abolished the entire offensive BWs system – is unknown.

According to all reports, the development of offensive BWs in Russia has stopped, though research using the agents of especially dangerous infections proceeds in institutions of the MoD and in facilities that were formerly under the jurisdiction of Biopreparat. Officially, all this research now falls under the rubric of biodefence.

Unfortunately, even now, little is known or understood by the wider public about the large-scale research and development carried out in the USSR as part of 'Problem Number Five'. Even data that would be helpful to scientific programmes are still classified.

The military–biological complex and socially useful activities

During the Soviet regime, the military–biological complex was created for offensive purposes and not for the common good. Still, public health benefits, in spite of the military's intent, did accrue from this work – as inadvertent by-products of research into the design and creation of BWs. Research into vaccination and treatment regimes was intended, more often than not, as a smoke-screen to reinforce the existing cover story surrounding the secret work of the military–biological complex.

The Ministry of Defence biological weapons research and development facilities under the jurisdiction of the 15th Directorate

The first important example of a public health benefit deriving from the activities of the military–biological complex is an anthrax vaccine, which was developed for human use by Nikolai Ginzburg at the Sanitary-Technology Institute (STI) of the MoD; in the late 1940s this institute became known as the Scientific Research Institute of Epidemiology and Hygiene (also known as the Kirov Institute). In 1940, Ginzburg isolated a mutant of a

highly virulent strain of *B. anthracis*, the agent that causes anthrax (5). The mutant strain had low virulence for both white mice and guinea-pigs and did not cause disease in rabbits or sheep, but it still retained its immunogenicity. Using this mutant, Ginzburg and his associates rapidly created a live vaccine known as STI (from the abbreviation of the original name of the institute where it originated). The STI vaccine was successfully used to protect the staff of the Red Army during the 1944 offensive of the Second Ukrainian Front in Romania, where anthrax was considered a threat. The STI live vaccine is still in use in Russia; it has an epidemiological efficacy of about 70%.

The immunoprophylaxis of plague is a second example of the considerable, if inadvertent, contribution that the Soviet military–biological complex made to public health. As in the case of anthrax, military considerations before and during the Second World War necessitated the development of plague vaccines. In the late 1930s and early 1940s, the Red Army fought the Japanese in Mongolia and Manchuria, where there were natural foci of particularly dangerous strains of the causative agent of plague; i.e. the strains found among the large native burrowing rodents known as 'tarabagan' (*Marmota sibirica*). A strain known as EV (the initials of a young girl who had died of plague in Madagascar), held at the Pasteur Institute in Paris, was sent to the USSR in the late 1930s. A highly immunogenic clone of this strain, isolated in the Sanitary-Technical Institute in 1941, formed the basis of a dry live vaccine. The creation of this vaccine was of the utmost importance, as no liquid preparations of the EV strain survived for more than ten hours at room temperature, making it impossible to use them under field conditions in wartime. The dry live vaccine proved invaluable: by the beginning of the Manchurian offensive in August 1945, millions of soldiers had been inoculated with this vaccine. Not a single case of plague was recorded among Soviet troops, whereas among inhabitants in the same period at least 500 cases were reported (10). Instructions for producing the dry live plague vaccine were transmitted in 1946 to the Ministry of Health. The technology used in the Kirov institute to develop dry live vaccines was later employed in the fight against tularaemia, brucellosis and tuberculosis.

Two other institutes, one in Sverdlovsk, now known as Ekaterinburg, and one at Zagorsk, now Sergiyev Posad, were also involved in research and development that had public health implications. The technologies required to produce anatoxins for immunoprotection from botulism, tetanus and gas gangrene, oral vaccines against smallpox and encephalomyelitis, diagnostic methods for several infectious diseases and equipment for cultivating anaerobic bacteria were all created in these two institutes.

The development of ways to protect army personnel from infectious agents, including those that might be deployed as BWs, was of major importance to the military. Military scientists investigated aerogenic methods of immunisation using dry vaccines. These novel preparations, unlike any used in the West, were administered via aerosol. The results of this research were summarised by N.I. Aleksandrov and N. Gefen (1) and then by V.A. Lebedinsky (6). As one of the advantages of this approach, Aleksandrov and Gefen emphasised the possibility of administering the vaccine to soldiers under field conditions – in tents and even in the open air. The other advantage of this dry aerosol preparation was its ability to confer a degree of pulmonary immunity that could not be achieved with traditional means of immunisation. These dry preparations protected monkeys, sheep and other animals from infection through the respiratory tract. Furthermore, aerogenic vaccination is much less reactogenic than other forms of administration and causes very few side-effects – the principal author of the present article was exposed to the aerogenic vaccination against plague without any complications.

These studies by Aleksandrov and Gefen and by Lebedinsky are of interest even today, not only from the scientific point of view but also because they provide substantial evidence that aerogenic methods of infecting people and animals have been part of the Soviet military doctrine for at least the past fifty years. Further information about certain aspects of the military's work on aerosol infections can be found in the monograph by V.I. Ogarkov and K.G. Gapochko (11), which by pure accident became available for open sale.

Though this list is by no means exhaustive, it gives a general idea of the technologies and prophylactics developed by the military that were then transferred to the Ministry of Health.

Biopreparat

As the authors related in an earlier publication (4), the designers of the modern (post-1973) Soviet BWs system established Biopreparat in order to raise the design and production of BWs to a qualitatively new level by using the latest advances in molecular biology and genetics. At first, military scientists focused on developing strains of bacteria that would be both resistant to antibiotics and have altered antigenic structures. Scientists believed that such approaches would complicate the treatment of infected people or even render treatment impossible and reduce the efficiency of vaccination. Viruses, too, were to be modified: military virologists worked to create viruses with altered antigenic structures as well as recombinant viruses that would possess other unusual properties.

At first, Biopreparat scientists had to organise the manufacture of materials that were unavailable in the

USSR: reagents, enzymes and components of media for bacterial and viral cultivation. They also needed to create banks of cellular cultures and bacteria. The Institute of Enzymology in Vilnius, Lithuania, and special directorates in the Institute for Ultra-pure Preparations in Leningrad (now St Petersburg), the State Scientific Centre of Applied Microbiology (SSCAM) at Obolensk, two hours from Moscow, and the State Research Centre of Virology and Biotechnology ('Vector'), near Novosibirsk, Siberia, were created for these purposes. As a result, in the late 1970s many scarce reagents and a number of important enzymes became easily accessible to open scientific institutes in the country.

Similarly, although the development and manufacture of devices and instruments used in biomedical research was spurred on by the needs of the BWs facilities of Biopreparat and of the MoD, autoclaves, instruments for lyophilisation, reactors, chromatographs, samplers and so forth were also delivered to the open research institutes. All of this design and manufacture – for both BWs facilities and open institutes – was carried out by the research and design institutes in Moscow and by factories in Yoshkar Ola, Kirishi, Berdsk and Penza.

During the construction phase of Biopreparat's own scientific centres, Biopreparat carried out joint research projects in different areas of biology with open scientific research institutes and universities. Biopreparat provided financial assistance and supplied the institutes with imported equipment and reagents. Furthermore, Biopreparat trained research fellows at the Antiplague System in microbiology. In three of the antiplague institutes Biopreparat also created departments of molecular genetics, which worked under the cover of Problem Number Five. The results of some research from that period were published in the open press and reported at conferences on the Plasmid Programme, which was also financed by Biopreparat. The Plasmid Programme served as yet another cover story: officially, the Plasmid Programme was created by the open Council for Molecular Biology and Genetics at the Academy of Science. The programme existed for 14 years and helped to introduce modern biology to the young employees of many institutes. Besides this programme, the principal author of the present article organised the Laboratory of Extrachromosomal Heredity of Microbes, the first in the USSR. The laboratory, which was well equipped, closely connected to scientists in the outside world and located at the Moscow Research Institute for Protein Synthesis (an open institute), was completely financed by Biopreparat. These international connections allowed the development and organisation of a bacterial culture collection, which was necessary for genetic research. Furthermore, the laboratory carried out, on a contract basis, joint research projects with open institutes in Krasnodar, Saratov, and Tartu in Estonia.

The discovery that the plague microbe had plasmids, or rings of extrachromosomal DNA, was particularly significant both for the military and for the wider scientific world. This discovery was made at the Laboratory of Extrachromosomal Heredity of Microbes, during research carried out jointly with the military. This laboratory dealt only with vaccine strains – work with highly pathogenic microbes was forbidden in Moscow and other major cities – while parallel research was carried out with virulent strains in the Kirov Institute. The same open Moscow laboratory also developed methods of transferring foreign genetic information into *Y. pestis*. This discovery allowed the subsequent creation, at the Kirov Institute, of a virulent *Y. pestis* strain with the particular characteristics, including antibiotic resistance, necessary for the development of a new, more refined, kind of BW.

The discovery of plague plasmids, which enabled the study of the plague germ's pathogenicity and the development of a more effective plague weapon, was made several years before the publication of the same discovery in the West.

Collaboration between military and open laboratories also produced work with public health benefits, even at the heart of the secret BWs system. At the Biopreparat facility SSCAM, researchers explored the creation of biological means of protecting plants against plant pests as well as against the insect vectors of human and animal diseases. The basis for these explorations was the microbe *Bacillus thuringiensis*, whose cells contain a toxin ('delta endotoxin'). Commonly known as 'Bt', *B. thuringiensis* is an insecticidal bacterium marketed worldwide for the control of many important plant pests, principally Colorado beetle and Lepidoptera (butterflies and moths) caterpillars but also mosquito larvae. *Bacillus thuringiensis* products represent about 1% of the total agrochemical market – fungicides, herbicides and insecticides – across the world. Commercial Bt products consist of powders containing a mixture of dried spores and toxin crystals.

Factories in Berdsk (near Novosibirsk) and Stepnogorsk (in Kazakhstan) manufactured Bt preparations. The Stepnogorsk facility had been built to produce BWs, particularly the anthrax agent, *B. anthracis*. Nevertheless, the manufacture of Bt products also served the interests of Biopreparat. First, it provided a cover story for the large-scale cultivation of *B. anthracis*. Second, it enabled technology to be modernised and new equipment to be tested using an agent that would not subject factory personnel to the risk of infection, because Bt products are harmless to humans. The second factor was extremely important. Despite stringent safety precautions, the risk of infection and possible epidemic outbreaks from working with the causative agents of dangerous infections remains. In addition to the sensational and tragic events in Sverdlovsk in 1979, when an accidental release of *B. anthracis* spores killed at least 68 people (8), there were

other less well-known incidents, illustrating the lethal dangers of working with highly pathogenic agents. Manufacturing failures resulted in several laboratory workers becoming infected with *Brucella abortus* in one of the open Moscow institutes in the 1970s, and a number of laboratory researchers at Vector died from haemorrhagic fevers – Marburg in 1988 and Ebola in 2004. Experimental work with *Burkholderia mallei* killed a researcher at SSCAM in 2004.

Some, although not all, of the molecular biology and genetic research by Biopreparat scientists became public knowledge – and therefore available to open scientific research laboratories – after the break-up of the USSR. Attention was focused on studies of *Francisella tularensis*, a bacterium whose genetics were little known in open academic circles at that time. As a result of Biopreparat research into tularaemia, a means of transferring heterologous genetic information into *F. tularensis* had been developed. Adding novel and alien genetic material to *F. tularensis* was necessary to create altered strains and, less ominously, to elucidate its pathogenicity. Also of singular importance is the extensive research conducted at Obolensk on *B. anthracis*. Some years ago Andrei Pomerantsev, one of the principal anthrax researchers at SSCAM, developed a method for introducing haemolytic genes from *Bacillus cereus* into *B. anthracis* (12) – this experiment had real significance for BWs research because, theoretically, the addition of heterologous genes to *B. anthracis* could make its strains more virulent. Furthermore, such a trait in a pathogenic *B. anthracis* strain would prevent its ready identification: virtually all diagnostic laboratories look for non-haemolytic *B. anthracis* and would discard a haemolytic colony as just another bacillus, thus delaying the strain's identification. While it is hard to see a public benefit from this research, it is worth noting that the research at Obolensk on anthrax has facilitated the development of a new vaccine to replace the STI live vaccine currently used in Russia. Andrei Pomerantsev now works in the United States of America at the National Institute of Allergy and Infectious Diseases.

As far back as the 1980s, the former Soviet BWs programme created a demand for recombinant organisms, specifically *Y. pestis* and species of *Francisella* and *Brucella*, that were engineered to express mammalian beta-endorphin, a form of neuropeptide. Three of Biopreparat's institutes took part in this work. Beta-endorphin was synthesised at the Leningrad Institute for Ultra-Pure Preparations; the chemical synthesis of the gene that produces beta-endorphin was carried out at Vector, and the actual introduction of the gene into the bacteria, followed by experiments on live animals using those recombinant bacteria, was performed at SSCAM. This chain of research and experiments proved that mammalian genes can be expressed even in highly pathogenic bacteria (3).

This research was critically important for the so-called 'Problem Factor', a programme first proposed to Biopreparat by Major General Igor Ashmarin in the late 1970s. He had the idea that germs expressing neuropeptides might be used to disable people, rather like biochemical agents such as tear gas, 'intoxicant' or other 'inoffensive' gases are supposed to do, without causing death. It was a highly original idea, whose realisation – at least in Ashmarin's original conception – could have produced a more 'humane' weapon than one using deadly disease agents by themselves. Furthermore, this research opened the way for the inexpensive production of neuropeptides in large quantities, using bacteria as 'biochemical pumps'.

If we attempt to estimate the contribution of Biopreparat to the Russian national economy, we must especially note that it created a modern scientific and technological infrastructure for continued research in the life sciences, which simply did not exist before Biopreparat was established. Despite drastic changes in the Russian economy, a drain in manpower, particularly at the highest levels of scientific expertise, and the general decline of governmental support for advanced molecular and genetic research, this scientific and technological base has survived and continues to function. The most salient example of this survival is the transformation of Vector, which still includes seven scientific research institutes, four affiliated enterprises and a number of other separate structural divisions, and which figures prominently in joint public health research projects with American scientists.

The Special Directorate of the Ministry of Agriculture of the Union of Soviet Socialist Republics

The Special Directorate of the Ministry of Agriculture of the USSR had a fine scientific and industrial base. It included at least three veterinary institutes (Vladimir City, Pokrov in Vladimir Oblast and Otar in Kazakhstan) as well as the Institute of Phytopathology, based in Galitsino near Moscow with branches in Uzbekistan and the Far East.

At Pokrov researchers studied African swine fever and rinderpest, which is caused by a virus belonging to the *Morbillivirus* genus; at Vladimir City scientists investigated foot and mouth disease (FMD), and researchers at Otar worked on African horse sickness. In the area of phytopathology, the Special Directorate studied, for example, plant diseases caused by fungi, including rice blast (which is caused by *Pyricularia oryzae*), yellow rust, leaf rust and potato late blight (which are caused by various *Phytophthora* species).

The principal efforts of the Directorate were devoted to developing genetically enhanced bioagents and BWs

technology directed against crops and domestic animals. But, so far as we know, Directorate scientists never achieved much in this arena. It is doubtful whether this Special Directorate contributed much to the national economy at the time. But the Special Directorate left a legacy of sound scientific and technical research, much as Biopreparat has done. Science-based agriculture – far removed from the disastrous agricultural policies of Trofim Lysenko – was vital for the rise of sophisticated animal husbandry and agriculture in Russia.

The Antiplague System

The venerable Antiplague System, which dates from before the Russian Revolution, cannot truly be considered as a branch of the Military–biological complex. Nevertheless, for many years their research institutes were involved tangentially in the activities of the military–biological complex, mainly through Problem Number Five – a code-name for biodefence activities focusing on the prevention, treatment and urgent prophylaxis of dangerous infections. Antiplague researchers also worked to develop rapid diagnostic methods and new approaches to the development of vaccines, including 'chemical vaccines' – using only isolated antigens – as well as new live vaccine strains for plague and other diseases. The disease treatment protocols were approved by the Ministry of Health and then employed by the MoD and Biopreparat, which also obtained various diagnostic tests from the Antiplague institutes. These institutes also manufactured large quantities of the live plague vaccine EV, which was stored mainly for civil defence.

One of the significant achievements of the Antiplague System researchers in the field of immunology was the creation of a novel 'chemical' plague vaccine. This new 'chemical' vaccine consisted of two antigens, one isolated from *Y. pestis* and one from the related but less virulent *Y. pseudotuberculosis*. This new vaccine is especially effective for revaccination after an initial injection of the live EV vaccine. The chemical vaccine represents an advance over the original live strain because it is less reactogenic and thus less potentially dangerous.

Antiplague System researchers also developed techniques for introducing resistance to the most widely employed antibiotics into the live EV strain. This altered strain was used to develop a dry vaccine to be administered simultaneously with the antibiotics; in this way, someone being treated for plague exposure could be vaccinated with a live strain at the same time as receiving antibiotics to treat an incubating infection. Though these techniques have clear public health significance, they also held great interest for the MoD and Biopreparat: adding antibiotic resistance to a vaccine strain proved that resistance could be added to virulent strains – one of the goals of the Soviet BWs programme.

The Antiplague System also played a major role in the professional training of personnel for the MoD and Biopreparat.

What now?

The enormous scale of BW-related activities in the USSR raises an important question: what happened to the military–biological complex after the country's disintegration and President Boris Yeltsin's decree of 11 April 1992?

The MoD lost its testing area on Vozrozhdenie Island in the Aral Sea and was radically restructured. According to General Yevstigneev, the 15th Directorate (in 1992 it became known as the MoD Biological Defence Department) focused on 'ensuring the country's biological security', which he interpreted as 'protection of people, farm animals and plants, and the environment from dangers that were or are caused by a source of a biological–social emergency' (15). However, P.I. Melnichenko (7), the MoD's Chief Epidemiologist, stressed that 'at present neither the public nor the government is fully prepared to adequately respond to the threat of bioterrorism in Russia or to take timely and effective steps to mitigate its consequences'. Coming from such a source, this statement can be taken at face value despite the implicit irony: according to the government's official pronouncements, the military have always concentrated on developing defences against BWs, and prevention has always been at the heart of all public health measures.

Today's Biopreparat is officially a public corporation. It has been deprived of its major research and production base in Stepnogorsk (now in Kazakhstan) and the institutes directly involved in the development of BWs (SSCAM and Vector are now under the Ministry of Health).

It is important to note that retired General Yevstigneev has become the first deputy of Biopreparat's current Director General, perhaps because Biopreparat is on the list of institutions allowed 'to carry out independent expert examination of goods and technologies for the purposes of export control'; this includes binary (or dual-use) products – in other words, those suited for both military and peaceful purposes (13). The authors are unable to explain why Biopreparat is allowed to do this, since the research centres formerly owned by Biopreparat are now directly controlled by the State Health Inspectorate (one of the departments of the Russian Ministry of Health). A strange situation!

The alliance of the Antiplague System and the MoD is also worthy of note. It may have been caused by the need to pool their efforts in the fight against terrorism. Be that as it

may, the Antiplague System is much more closed, in particular to foreigners, than in the past.

As far as the authors are aware, the Special Directorate of the Ministry of Agriculture of the USSR was liquidated and its facilities are now used for civilian purposes. For example, the Federal Centre of Animal Health Protection – descended from the Institute for FMD at Vladimir – pursues multi-faceted research and is also engaged in the manufacture of many biological products for the prophylaxis and treatment of diseases in animals. The Centre also produces medical products for the treatment of human diseases.

In conclusion, it should be noted that living standards in Russia remain low, and the overwhelming majority of scientists have a miserable existence. In general, this is also true of scientists who work for military facilities and those who receive direct grant support from ISTC, the USA or other funding body for research at former Biopreparat institutes. This contributes to a Russian brain drain, to the possible export of BWs from Russia (if any remain in storage) and to the concern over the potential leaking of expertise, technologies and materials from the former Soviet BWs programme. It is therefore appropriate to mention the 1998 accounts of a very small group of researchers, mainly from academic institutes, but not from Biopreparat, who went to Iran to teach genetics and molecular biology (9). The authors also remind the reader of a public suggestion by N. Kislichkin, formerly of Obolensk, to sell the Soviet 'weaponised' strains of *F. tularensis* (2).

■

Résultats du programme soviétique en matière d'armes biologiques et conséquences pour l'avenir

I.V. Domaradskij & W. Orent

Résumé

Le complexe militaro-biologique de l'ex-Union des Républiques socialistes soviétiques était un véritable monstre de Frankenstein, doté d'un puissant potentiel scientifique – au service du bien et du mal. Le présent article examine d'une part les résultats scientifiques directs des programmes jumelés en matière d'armes biologiques gérés par le Biopreparat « civil » et par le ministère de la Défense et, d'autre part, les bienfaits pour la santé publique qui ont découlé de ces programmes, en dépit de leur visée originale. Les auteurs explorent également les possibilités de destruction des cultures et des élevages et d'amélioration des méthodes agricoles qui résultent du programme soviétique parallèle exécuté sous la conduite de la Direction spéciale du ministère de l'Agriculture.

Dans la dernière section de l'article, les auteurs examinent la situation au sein du complexe militaro-biologique à la suite du décret de 1992 de l'ex-Président Boris Yeltsin abolissant la recherche et le développement en matière d'armes biologiques offensives. Ils envisagent la possibilité d'une fuite hors de Russie de l'expertise, des technologies et du matériel issus de l'ancien programme soviétique relatif aux armes biologiques, fuite qui s'expliquerait par le niveau de vie qui reste faible en Russie et par l'existence misérable de l'écrasante majorité des chercheurs.

Mots-clés

15e Direction – Biopreparat – Centre scientifique d'État de microbiologie appliquée – Complexe militaro-biologique – Ministère de l'Agriculture – Ministère de la Défense – Système de lutte contre les fléaux – Vecteur.

■

Éxitos del programa soviético de armas biológicas y consecuencias de cara al futuro

I.V. Domaradskij & W. Orent

Resumen

El complejo militar-biológico de la ex Unión de Repúblicas Socialistas Soviéticas era un verdadero monstruo de Frankenstein, dotado de un enorme potencial científico, para bien y para mal. Los autores examinan los resultados científicos directos de los programas gemelos de armas biológicas, dirigidos por la entidad 'civil' Biopreparat y por el Ministerio de Defensa, así como los beneficios que de ellos se siguieron para la salud pública pese a sus objetivos originales. También estudian las posibilidades de destrucción de cultivos y ganado y de mejora de los métodos agrícolas que podían derivarse del programa soviético paralelo que estaba a cargo de una dirección especial del Ministerio de Agricultura.

En el último capítulo los autores exponen la situación en que quedó el complejo militar-biológico después del decreto promulgado en 1992 por el Presidente Boris Yeltsin por el que se abolían todas las actividades de investigación y desarrollo de armas biológicas ofensivas. Después consideran la posibilidad de que los expertos, la tecnología o determinado material del programa soviético de armas biológicas hayan salido de Rusia, dado el bajo nivel de vida que sigue imperando en el país y la misérrima existencia a la que se ven abocados los científicos.

Palabras clave

15ª Dirección – Biopreparat – Centro Científico Estatal de Microbiología Aplicada – Complejo militar-biológico – Ministerio de Agricultura – Ministerio de Defensa – Sistema antiplagas – Vector.

References

1. Aleksandrov N.I. & Gefen N. (1962). – Active specific prophylaxis of infectious diseases and its improvement [in Russian]. Ministry of Defence Publishing, Moscow.

2. Alibek K. & Handelman S. (1998). – Biohazard: the chilling true story of the largest covert biological weapons program in the world – told from inside by the man who ran it. Random House, New York, 272-273.

3. Borzenkov V.M., Pomerantsev A.P., Pomerantseva O.M. & Ashmarin I.P. (1994). – Study of nonpathogenic strains of *Francisella, Brucella* and *Yersinia* as producers of recombinant beta-endorphin [in Russian]. *Biull. Eksp. Biol. Med.*, **117** (6), 612-615.

4. Domaradskij I.V. & Orent W. (2003). – Biowarrior: inside the Soviet/Russian biological war machine. Prometheus Books, New York.

5. Ginzburg N.N. (1969). – Live vaccines [in Russian]. Meditsina, Moscow.

6. Lebedinsky V.A. (1971). – The inhalant (aerogenic) method of vaccination [in Russian]. Meditsina, Moscow.

7. Melnichenko P.I. (2001) – Bioterrorism and bioaccidents: the prevention, problems of protection and safety [in Russian]. *Bulletin 'Vaccination'*, **3** (21), 2-3.

8. Meselson M., Guillemin J., Hugh-Jones M., Langmuir A., Popova I., Shelokov A. & Yampolskaya O. (1994). – The Sverdlovsk anthrax outbreak of 1979. *Science*, **266**, 1202-1208.

9. Miller J. & Broad W.J. (1998). – The Germ Warriors: a special report. Iranians, bioweapons in mind, lure needy ex-soviet scientists. *New York Times*, December 8.

10. Nikolaev N.I. (1968). – Plague [in Russian]. Meditsina, Moscow.

11. Ogarkov V.I. & Gapochko K.G. (1975). – Aerogenic infections [in Russian]. Meditsina, Moscow.

12. Pomerantsev A.P., Staritsin N.A., Mockov Y.V. & Marinin L.I. (1997). – Expression of cereolysine AB genes in *Bacillus anthracis* vaccine strain ensures protection against experimental hemolytic anthrax infection. *Vaccine*, **15** (17-18), 1846-1850.

13. State Customs Committee of Russia (2003). – Letter No. 07-56/41346, 17 October 2003.

14. Vorob'ev A. (2001). – Problems of microbiological security at this juncture [in Russian]. *Bulletin 'Vaccination'*, **3** (21), 6-7.

15. Yevstigneev V.I. (2003). – Biological weapons and problems of ensuring biological security. Theses of lectures read on 25 March and on 8 April in the Moscow Institute of Physics and Technology for students of the course: The WMD Non-proliferation and Reduction Regime and National Security [in Russian]. Available at: http://www.armscontrol.ru/course/lectures03A/viye30325A.htm (accessed on 9 February 2006).