Chemical and Biological Arms Control Institute

AGRICULTURAL BIOLOGICAL WARFARE: AN OVERVIEW

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Given the tremendous economic, political, and strategic value of U.S. agricultural resources, the Washington policy community has been slow to realize their vulnerability to attack by an antagonistic state, economic or agricultural competitor, or terrorist, especially with biological weapons. With the myriad of activities currently taking place to bolster counterterrorism and strengthen critical infrastructure protection, it would be a shame to underestimate the value of, or the need to, secure better the nation's agricultural resources.

A flood of federal funding for counterterrorism activities has created new roles for various federal departments and agencies -- the Department of Defense, Department of Justice and the Federal Bureau of Investigation, the Department of Energy, the Department of Health and Human Services and the Centers for Disease Control and Prevention, the Federal Emergency Management Agency, to name the most prominent. Funding and programmatic activities to fight terrorism have burgeoned in recent years among these entities. The federal counterterrorism budget grew from $6.5 billion in FY1998 to $9.6 billion in FY1999, and over $10 billion is allocated for the current fiscal year, of which $1.8 billion is dedicated to countering terrorism with weapons of mass destruction (WMD). The Clinton Administration has requested $11.1 billion for counterterrorism in FY2001, of which $1.5 billion would be for fighting WMD terrorism.

In the rush to protect the American people and its critical infrastructure from the threat of terrorism, however, the vulnerability of the nation’s agricultural resources has been largely overlooked. Yet, historically, anti-animal and anti-plant biological warfare (BW) has been a substantial component of many state BW programs. There is also some evidence that non-state actors may be willing to attack agricultural resources. Looking to the future, the expanding global trade in agricultural products, the growing debate over animal rearing practices and genetically engineered foods, and the inevitable diffusion of biotechnology-related expertise and technology -- both to state and non-state actors -- should prompt policy makers to focus in some measure on the potential threat to the nation's agricultural resources and to identify practical measures to ensure their security.

State Programs

The history of state anti-animal and anti-plant BW demonstrates that attacks on agriculture using BW agents are certainly feasible. Livestock and crops have long been considered potential targets by military planners,

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and many countries have either pursued, actually developed, and even used offensive anti-animal and anti-plant BW agents.

The first contemporary use of agricultural BW occurred during World War I when German operatives carried out a sabotage campaign in the United States, Argentina, Romania, France, Mesopotamia, and possibly Spain and Norway. The campaign targeted draft animals, military cavalry, and food animals with anthrax and glanders in order to interrupt Allied transportation and supply lines. The German military also explored the potential of agricultural BW during World War II despite Hitler's ban on offensive BW work which he issued in the summer of 1942 (although he permitted defensive work). Germany's most extensive offensive agricultural BW work was done on foot-and-mouth disease (FMD), and during German occupation in 1942 and 1943, open-air trials were conducted on cattle or reindeer on an island in Lake Peipus in northwest Russia.[1] Potato beetle experiments were also conducted in October 1943 when 140,000 potato beetles were dropped from planes near Spreyer.[2] The Germans also experimented with turnip weevils, turnip bugs, antler moths, potato stalk rot, and potato tuber decay as well as the use of weeds for attacks on crops.[3]

The French anti-crop program was mainly directed at Germany and focused on potato beetles for use against a staple of the German food supply. In 1939, the French explored methods for intensive breeding of potato beetles, studied their behavior when released in flight at high altitudes, and conducted release trials at Cazaux.[4] Some consideration was also given to the potential of rinderpest virus to infect cattle.[5]

Japan also engaged in considerable offensive anti-crop BW work during World War II. The Japanese explored the effects of fungi, bacteria, and nematodes on nearly all grains and vegetables grown in Manchuria and Siberia.[6] Although they had limited success in developing sophisticated dissemination techniques, between 1940 and 1941 aerial dissemination was used to spread infected grains of wheat millet and contaminated cotton, and anthrax and glanders reportedly were also spread.[7]

Iraq pursued an agricultural BW capability before the Persian Gulf War experimenting with wheat stem rust and camel pox.[8] These efforts reinforced concerns that offensive agricultural BW activities still continue in some states. Such efforts are even more disconcerting considering that Iraq's work with camel pox may have been a surrogate for smallpox.

During World War II, both the United States and Britain had extensive anti-plant research programs. In fact, much of the United States' initial knowledge about anti-plant BW came from the British.[9] As early as March 1937, Britain's Microbiology Warfare Committee had produced its first report on anthrax and foot-and-mouth disease (as well as plague). Britain went on to develop and stockpile approximately 5 million anthrax laced cattle cakes that could be delivered through flare chutes of aircraft.[10] Yet, the British agricultural BW weapons program did not progress much beyond these capabilities.

Prior to President Nixon’s renunciation of offensive biological warfare in 1969, the United States maintained a fairly sophisticated anti-animal and anti-plant BW program. The United States developed several anti-animal and anti-plant BW agents including wheat stem rust, rice blast fungus, rinderpest, and foot-and-mouth disease. In 1944 and 1945, the United States gave serious consideration to using a fungus to destroy Japanese rice crops, but the delayed impact of such an attack made it impractical.[11]

Between 1951 and 1969 the U.S. Army carried out at least 31 anti-crop tests and stored rice and wheat blast fungus at Fort Detrick, Maryland, and at the Rocky Mountain Arsenal near Denver, Colorado.[12] The U.S. anti-plant BW program made its most significant progress in 1955 when wheat stem rust became the first anti-plant

agent standardized by the Chemical Corps.[13] Additional agents were standardized shortly thereafter[14] and around 5,000 kilograms of anti-plant BW agents were available by the early 1960s.[15]

Anti-plant BW activities were increased in the wake of American involvement in East Asia and pathogens were explored for use against opium poppy crops.[16] The U.S. Air Force anti-plant program was reestablished in 1962 and agent production was conducted at Pine Bluff, Arkansas.[17] Field tests with wheat stem rust and rice blast fungus were conducted in the Midwest and southern United States as well as in Okinawa, Japan. The Army also conducted anti-plant testing with wheat stem rust in North Dakota in 1960 and Florida in 1968 and tested anti-animal pathogens at stockyards in Texas, Missouri, Minnesota, Iowa, and Nebraska between 1964 and 1965.[18] Agricultural BW doctrine was developed by the Air Force and Army during this period, and in the mid-1970s the Central Intelligence Agency acknowledged that it had developed methods for conducting covert attacks that could cause severe crop damage.[19]

The former Soviet Union probably had the most innovative and wide-reaching offensive anti-crop and anti-animal BW programs, although the primary focus was on agents for targeting American and Western European crops. On the anti-animal side, the Soviets experimented with FMD, rinderpest, African swine fever (ASF), vesicular stomatitis virus, contagious bovine pleuropneunomia, mutants of avian influenza, and contagious ecthyma of sheep.[20] The Soviets successfully used ticks to transmit FMD, avian ticks to transmit the causative agent of ornithosis to chickens, and insects to transmit plant pathogens.[21] On the anti-plant side, work was conducted on wheat and barley mosaic streak viruses, potato virus, tobacco mosaic virus, brown grass mosaic virus (for use against barley, maize, and thornapple), wheat fungal, and brown leaf rust.[22] Viability testing in indoor chambers was conducted on FMD, and as early as 1935, tests were conducted to develop reliable methods of disseminating FMD in combat situations.[23] Lyophilization and vacuum storage experiments were conducted on maize rust, and stabilization techniques for Newcastle disease virus were also discovered.[24] The Soviets were very active in insect rearing techniques and claimed to have built automated mass-rearing facilities that could produce millions of parasitic insects per day.[25] They used radar to follow the migration and release patterns of insects to determine their anti-crop potential, and the dissemination of insect attractants was considered as a way of influencing the migration patterns of both natural and deliberately introduced insects.[26]

The experience of Germany, France, Britain, Japan, the United States, the Soviet Union, and Iraq with anti-animal or anti-plant BW agents is cause for concern. These activities have built a considerable scientific understanding of anti-animal and anti-plant BW, and although such expertise is not available in the public domain, scientists who participated in anti-animal or anti-plant military programs continue to apply their skills today in the civilian sector for peaceful purposes. The potential for former weapons scientists to sell their expertise to states or non-state actors certainly exists, especially in the former Soviet Union (FSU) where former weapons scientists are often unemployed or underpaid. Most importantly, a quick glance at the history of state anti-animal and anti-plant BW programs reveals which agents are the most promising and demonstrates the feasibility of these agents as weapons. Appropriately, the international community has recognized the potential threat of anti-animal and anti-plant BW and has responded by creating mechanisms -- the Australia Group and the Biological and Toxin Weapons Convention (BTWC) -- for restricting access to and weaponization of these agents by states.

Non-state Agricultural Sabotage

Why might a non-state actor attack plants, animals, or agricultural products? Some actors may be motivated for the same reasons as other terrorist actions -- to attract attention to a cause, incite fear, disrupt society, or demonstrate a capability with the intent of exacting political concessions. Other actors may be prompted by different motives -- economic interest, sabotage, or revenge. Biological attacks against agriculture could serve these interests for a number of reasons. First, although many pathogens are zoonotic and could pose a public health

threat, an attack against agriculture could be conducted without causing human casualties, making it an attractive option for a perpetrator that does not want to kill. It also frees a perpetrator of many of the moral constraints that may be involved in directly targeting human populations with violence. Second, it may be very difficult to distinguish a deliberate agricultural attack from a naturally occurring outbreak of disease. A perpetrator who wants to disguise an attack as a natural event could covertly use plant or animal pathogens to cause considerable disruption, or environmental and economic damage, with little risk of detection. Likewise, a futures trader or commercial agricultural entity could carry out a covert agricultural attack to capitalize on the resulting market shift or to discredit a competitor's product. Third, agricultural resources are largely exposed and unprotected, and thus vulnerable to attack. Fourth, the technical and operational barriers associated with agricultural BW are relatively limited compared to anti-personnel BW given that many animal and plant pathogens rapidly reproduce and are easily disseminated. An attack with karnal bunt would require little more than acquisition and introduction of the fungus into a wheat crop. Likewise, FMD or avian influenza are highly contagious animal diseases that could spread rapidly from a single infected animal. In addition, agricultural resources are part of the food chain and a hoax or even a mere threat against them can have a substantial impact if perceived as either a threat to agriculture or public health.

Non-state actor or terrorist interest in targeting agricultural products are not unknown in history. Examples include the 1978 Arab Revolutionary Army Palestinian Commandos use of mercury to contaminate Israeli citrus exports heading for Europe; a 1985 letter to the U.S. embassy in Sri Lanka claiming that Sri Lankan tea exports bound for the United States had been contaminated with cyanide; and a series of anonymous telephone calls to the U.S. Embassy in Chile claiming to have laced Chilean grapes heading for the United States with cyanide. In each case shipments of the agricultural products were detained and inspections were conducted to determine whether contamination had actually occurred. In the meantime, confidence in the suppliers of these products plummeted as did the value of their products over the long-term. In the case of the Chilean grapes incident, it is estimated that $333 million in revenue was lost by Chilean growers and exporters as a direct result of the incident and much more when the longer-term market impact is factored in.[27] Although these incidents involved the use or threatened use of chemicals against agricultural products, the use of pathogens could have a similar economic impact.

In 1952, Mau Mau insurgents in British colonial Kenya used toxin derived from an African milk bush to poison 33 head of cattle, in what the British believed was a concerted campaign against livestock.[28] In 1989, a group calling itself the Breeders announced that they had bred and released Mediterranean fruit flies to protest the use of pesticides in southern California. Subsequently, a USDA study identified peculiar patterns of Mediterranean fruit fly infestation in southern California that year.[29] These cases suggest some degree of non-state interest in agricultural sabotage or terrorism.

Vulnerability of U.S. Agricultural Resources

Agriculture represents a significant portion of the U.S. economy. It accounts for 13.1% of the gross domestic product and 16.9% of domestic employment.[30] Agricultural exports alone account for $140 billion in revenue and are responsible for 860,000 domestic jobs.[31] With the application of new agricultural technologies, the United States has commercialized and economized agricultural production generating an inexpensive source of food that allows consumer wealth to be invested in other areas. Scientific advances in agriculture have produced greater crop yields and allow animals to be raised with greater efficiencies and in much larger concentrations. Eighty-four percent of the U.S. cattle population is concentrated in the southwest, approximately 60% of the swine population resides in the Midwest, and 78% of the chicken population can be found in the southeast Atlantic region.[32] Today cattle are fattened on large feedlots sometimes holding as many as 150,000 to 300,000 head of beef,[33] with approximately 78% of the U.S. beef stock passing through just 2% of the feedlots.[34] Similarly, swine farms will often hold more than 10,000 hogs, and chicken farms will pen 100,000 birds together.[35] Furthermore,

today's animal rearing practices are highly mobile. Animals are often born in one place, transported to another as they mature, and then transported again for slaughtering. These practices could facilitate the spread of both natural as well as deliberate outbreaks of disease. For example, the introduction of FMD could devastate large populations of cattle, sheep, swine, and deer. FMD is an extremely contagious airborne disease with seven variants and 70 sub-variants that can spread upwards of 150 miles in the wind.

The swift and devastating effects of FMD were demonstrated by an epidemic in Taiwan in March 1997. The first two suspected cases were reported on March 14 in the Hsinchu Prefecture and within two weeks 1,300 pig farms in 15 western prefectures were infected.[36] All susceptible animals in that area were destroyed and the premises disinfected. It is believed that the Central Mountain Range that runs lengthwise throughout Taiwan initially prevented the disease from spreading throughout the eastern prefectures of Taiwan. Although some cases of FMD were discovered in the eastern prefectures, they were quickly contained and destroyed.

The Taiwanese example demonstrates the pace at which FMD could take hold in a livestock population as well as the severe economic impact of disease outbreaks. As a result of the FMD outbreak, Taiwan lost its principle export markets for pork, particularly the Japanese market. Within one week of the outbreak, swine prices had prices had dropped by 60% and estimates project that 50,000 people became unemployed and $6.9 billion was lost in export revenue.[37] Three years later Taiwan has yet to fully regain its exports markets. Such outbreaks of disease raise serious concerns about the current lack of preparedness in the United States to deal with such an outbreak. Little capability exists in the United States in terms of procedural responses for dealing with such a crisis, stocks of vaccine to limit the spread of disease, carcass disposal capacity, or even psychological preparedness to accept such an event whether natural or intentionally introduced.

Most of the crops in the United States are largely concentrated in the Midwest, completely accessible, and potentially vulnerable to deliberate manipulation using plant pathogens. In 1997, the American position in the international wheat market was jeopardized by the discovery of two spores of karnal bunt in Arizona. Karnal bunt causes black discoloration and an odor in flour milled from infected wheat making it commercially useless. It is an extremely feared plant pathogen because it can contaminate the soil for as long as five years after it infects crops. Upon discovery of karnal bunt in Arizona, U.S. wheat exports to 30 trading partners were automatically halted by international law until the United States was able to demonstrate that the karnal bunt had been isolated and contained and that storage and transport centers were free of additional spores. In addition, all shipments of U.S. wheat en route were required to go directly to mills to ensure that replanting of infected wheat would not result in soil contamination. Estimates of the economic impact of this discovery range from tens to hundreds of millions of dollars. Although this event was apparently a natural occurrence, a deliberate attack on U.S. agricultural resources could have a similar, or potentially worse outcome. Given the central role that agriculture plays in the U.S. economy, the United States must be better prepared to deal with both natural and deliberately introduced plant and animal diseases.

USDA's New Role

By and large, the United States Department of Agriculture (USDA) only plays a role in addressing naturally occurring plant and animal disease outbreaks. Very little of the department's efforts are dedicated to protecting U.S. agricultural resources from deliberate attacks using disease, and no funding has been specifically dedicated for these purposes. USDA was a latecomer to the interagency process set into motion by Presidential Decision Directive-62 (PDD-62), the directive that defined federal roles and activities for addressing WMD and critical infrastructure terrorism, largely because agriculture and the food supply system were not included as part of PDD-62. USDA has also made little if any contribution to the Biological Weapons Convention Protocol negotiations

despite the numerous plant and animal agents that are included in the Protocol Rolling Text as "listed agents" with biological warfare potential.

On the positive side, the USDA and the agricultural community are now beginning to participate in the mesh of activities to combat terrorism and protect critical infrastructure. USDA has recently appointed representatives to the seven National Security Council (NSC) interagency Working Groups established by the NSC's Coordinator for Counterterrorism, and an eighth Working Group was created to deal specifically with Protection of Agriculture and the Food Supply. In 1999, USDA also formed the policy-level Special Interagency Programs (SIP) Office, as well as an agency-level Biosecurity Committee, and has created many partnerships with agencies that have a stake in CBW issues.[38] In the proposed FY2001 budget, USDA is slated to receive an estimated $10 million for internal R&D activities for addressing threats to agriculture. This funding is a potential improvement from zero funding for these efforts in FY1999 and FY2000, but alone it is not sufficient to meet the challenge.

Engagement of the private sector is essential for addressing nearly all dimensions of the issue. Establishing a national strategy to address threats to agriculture as well as developing contingency plans for dealing with agricultural attacks will have to rely heavily on the participation of the private sector. For example, thorough disease surveillance systems rely on reporting from a range of private sector entities -- local and commercial farmers or practicing veterinarians -- and much of the R&D work conducted in the private sector is applicable to the agricultural BW issue. Genetic analyses conducted by university research laboratories and professional societies enhance understanding of disease etiology, industry ventures to develop genetically engineered vaccines may be effective against the broad-range of animal diseases including BW, and genetically enhanced disease resistance plants can protect crops from both natural and deliberate disease outbreaks. The private sector harbors a pool of expertise and knowledge, and their active engagement in conjunction with government entities is essential to effectively meet the challenges posed by threats to agriculture.

Recommendations

Federal activities to address the vulnerability of agriculture are growing, but the following capabilities should be stressed as crucial aspects of effective preparedness:

- *Strategy:* The USDA should take the lead on formulating a strategy that begins with a threat analysis as the basis for defining requirements. Such a strategy should stress deterrence and prevention as well as crisis and consequence management, and enumerate the potential roles of other federal departments and agencies, states, locales, industry, and the public.
- *Contingency Plans:* Federal, state and local emergency outbreak response plans and procedures have not been developed. Some level of planning should take place to establish procedural mechanisms for dealing with a crisis and to define roles and jurisdictions.
- *Surveillance:* Improved global surveillance of disease outbreaks, whether natural or deliberate, will allow for early intervention and containment of outbreaks of disease and will increase understanding of emerging threats to the food supply.
- *Diagnostics:* Improved diagnostic capabilities for determining the specific pathogen and strain is an important aspect of initiating an appropriate response. Advanced microbial forensics and comprehensive databases of foreign animal and plant diseases will help determine the origin of a pathogen and aid in attribution and prosecution of a perpetrator in the event of a deliberate attack.
- *Biosafety Level 4 (BSL) Laboratory Capacity:* USDA does not currently have a BSL 4 laboratory facility. A BSL 3 laboratory should be upgraded to ensure safe handling of dangerous zoonotic animal pathogens that also pose a public health threat.

- *Training:* The first to notice an unusual agricultural event will likely be either farmers noticing sick animals or malformed plants or veterinarians and local USDA extension agents. Very few farmers, veterinarians, or extension agents in the United States are experienced with the range of plant or animal diseases associated with BW. Some level of awareness training is necessary to alert these communities to the characteristics and ramifications of unusual disease outbreaks.

- *Cooperation:* USDA should continue to be more thoroughly integrated into counterterrorism and threat reduction activities encompassed by the interagency process. USDA should also be given greater input into the BTWC Protocol Ad Hoc Group negotiations, especially given the list of restricted plant and animal pathogens in the Protocol Rolling Text. USDA's input should also be sought for the BTWC Review Conference scheduled every fifth year in Geneva, with the next conference to be held in 2001.
- *Research & Development:* Potential cooperation between government, industry, scientific entities on R&D should be explored and strengthened where possible.
- *Security:* A government-private sector commission should be established to assess the vulnerabilities of agricultural facilities as well as business practices that may enable an attack.

Conclusion

The feasibility of agricultural BW is evident in a number of state BW programs. Despite inconclusive evidence that non-state entities pose a greater threat to agriculture, there is a growing awareness that agriculture is vulnerable to BW attack. Natural disease outbreaks have clearly demonstrated the devastating impact that disease can have on plants and animals as well as the economic damage that often results. Policy makers must be sensitive to the possibility that agricultural BW may well be exploited in the future, and must continue to take actions to ensure that the agricultural sector is well prepared to deal with any future challenge.

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[1] Geissler, Erhard. "Biological Warfare Activities in Germany, 1923-45," Geissler, Erhard and Moon, John Ellis van Courtland, eds. *Biological Warfare from the Middle Ages to 1945,* (New York: Oxford University Press, 1999), pp. 120.
[2] Ibid., pp. 121.
[3] Ibid., pp. 111, 117.
[4] Lepick, Olivier. "French Activities Related to Biological Warfare, 1919-1945," in Geissler and Moon, pp. 83.
[5] Ibid., pp. 86.
[6] Harris, Sheldon. "The Japanese Biological Warfare Program: An Overview," in Geissler and Moon, pp. 139.
[7] Ibid., pp. 143-144.
[8] Eighth UNSCOM Report to the Security Council, S/1995/864, 11 October 1995. http://www.un.org/Depts/unscom/sres95-864.htm.
[9] Bernstein, B.J. "The Birth of the U.S. Biological Warfare Program," *Scientific American,* 1987, 256: pp. 116-121.
[10] Choffnes, Eileen. "The Environmental Legacy of Biological Weapons Testing," (unpublished manuscript).
[11] Harris, R. and Paxman, J. *A Higher Form of Killing: The Secret Story of Chemical and Biological Warfare,* New York, NY: Hill and Wang, The Noonday Press, 1982).
[12] Department of the Army, *Textbook of Military Medicine,* (Falls Church, VA: Office of the Surgeon General, 1997), p. 461.
[13] Ibid., p. 51.
[14] Ibid.
[15] SIPRI, *The Problem of Chemical and Biological Warfare, Volume II: CB Weapons Today* (Stockholm: Almkvist and Wiksell, 1973), pp. 234.
[16] See Department of the Army, 1997, p. 60.
[17] Ibid.
[18] Ibid.
[19] Livingston, NC and Douglass JD. "CBW: The Poor Man's Atomic Bomb," *National Security Papers,* Vol. 1, Cambridge, MA: Institute for Foreign Policy Analysis, Inc., 1984).
[20] Defense Intelligence Agency, *Chemical and Biological Warfare Capabilities -- USSR,* March 1977, DST-1600S-034-76-SUP 1, Unclassified, pp. 245-7.
[21] Ibid., pp. 236.1.
[22] Ibid., pp. 240-245.
[23] Bojtov, Valentin and Geissler, Erhard. " Military Biology in the USSR, 1920-1945," in Geissler and Moon, pp. 159.

[24] See Defense Intelligence Agency, March 1977, pp. 238.
[25] Ibid., pp. 240.
[26] Ibid., pp. 241.
[27] Ban, Jonathan. "Chilean Grapes: A Case Study," presentation *Assessing Motivations and Patterns of Behavior Associated with Nuclear Biological and Chemical Weapons Terrorism*, Authors Workshop, Monterey Institute for International Studies, Washington, DC, (in forthcoming volume edited by John Parachini).
[28] Carus, W. Seth. *Bioterrorism and Biocrimes: The Illicit Use of Biological Agents in the 20th Century*, (Washington, DC: National Defense University, August 1998), pp. 78.
[29] Root, RS. "Infectious Terrorism," *Atlantic Monthly*, May 1991, pp. 44-50.
[30] Horn, Floyd. "Agricultural Bioterrorism," in Roberts, Brad. *Hype or Reality: The "New Terrorism" and Mass Casualty Attacks*, (Alexandria, VA: Chemical and Biological Arms Control Institute, 2000), pp. 109-110.
[31] Ibid.
[32] Horn, Floyd. Presentation to *NBC Industry Group*, March 16, 2000.
[33] Brown, Corrie. "Agro-Terrorism: A Cause for Alarm," *The Monitor: Nonproliferation, Demilitarization, and Arms Control*, Vol. 5, No. 1-2, Winter-Spring 1999, pp. 7.
[34] Horn, Floyd. "Emerging Aspects of Biological Warfare Terrorism: Agriculture," presentation at CBACI seminar series, *Responding to the Biological Weapons Challenge*, September 14, 1999.
[35] See Brown, Winter-Spring 1999.
[36] Shieh, Happy K. "Update on the Foot-and-Mouth Disease Outbreaks in Taipei China," http://www.ss.niah.affrc.go.jp/FMD/taiwan-e.html.
[37] Wilson, Terrence M. and Tuszynski, Carol. "Foot-and-Mouth Disease in Taiwan -- 1997 Overview," U.S. Animal Health Association 1997 Committee Reports -- Committee on Epizootic Attack. http//:www.usaha.org/reports/taiwanfmd.html.
[38] See Horn, September 14, 1999.

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