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THREAT PANEL: The Threat Beyond 2000

Paper...

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I. INTRODUCTION

In March 1999, a new strain of the Hendra Encephalitis (HE) virus hit the Malaysian state of Negri Sembilan, decimating the region's pig population. The epidemic forced health authorities to cull in excess of 800,000 pigs, with officials vaccinating another 500,000 in an attempt to control the spread of the disease. The outbreak cost the Government over US\$12 million in eradication expenses, was directly responsible for plummeting pork prices, threatened social stability, led to over a hundred human deaths and undermined confidence in the Government. While the incident is not known to have been carried by a sub-state terrorist group, it does provide a good example of the type of socio-economic damage and dislocation that could be achieved as a result of the wholesale decimation of "non-human" targets with biological agents.

Compared to the attention that has been devoted to the issue of mass destruction terrorism directed against heavily populated civilian centers, particularly since the 1995 Sarin nerve gas attack in Tokyo, biowarfare against agriculture has received extremely short shrift. In large part, this is a product of a mindset in the industrialized West that has traditionally downplayed the importance of the rural sector in general. In countries such as the US, Canada, the UK and Australia, where agriculture accounts for approximately only two percent of the working population, food tends to be equated with supermarkets and the local grocery store, not farms, and is always in bountiful supply. The possibility that this highly valuable commodity might somehow be deliberately sabotaged at source is something that the majority of people simply do not consider let alone demand action against, as food scarcity has never been an issue for them. It is only in those rare cases where the daily lives of individuals have been directly affected by crop and livestock disasters, such as the "mad cow" epidemic in the UK, that we begin to see the stirrings of any public appreciation for the susceptibility of agricultural produce. However, even in these instances, the tendency has been to place the blame for catastrophes on ineptitude rather than vulnerability.

Of perhaps greater importance, however, have been the twin assumptions that terrorists tend to be pre-occupied with human targets and remain tactically conservative. The first supposition stems from a belief that the best way to achieve a general state of societal destabilization and dislocation, not to mention publicity for a cause, is by victimizing civilians with random and highly visible acts of violence. The second is based on the historical record of terrorism itself, which shows an overwhelming pre-occupation with two main weapons: the gun and the bomb. Terrorists, it is asserted, are simply not interested in experimenting with new tactics and options and will be unlikely to deviate from present modalities so long as these are sufficient to accomplish their goals. This latter argument is also often made in support of the idea that terrorists will not seek to use weapons of mass destruction (WMD) nuclear, chemical and biological - which are both technically more complex and less predictable than conventional methods.

However, there may be reason to question aspects of each of these assumptions. Although an indiscriminate bombing and shooting campaign is certainly one way to achieve a coercive

potential, it is not the only one. Infrastructure attacks, if properly executed, can be equally as effective, particularly in an era where "economics" and interdependence have become both the anchor for and soft "underbelly" of the developed world. Bombs and (especially) guns will not always be the most effective way of carrying out these types of assaults, necessitating at least some experimentation with new tactics and weapons systems. In the case of attacks directed against the agricultural sector which, despite the relative indifference shown to it, does form a critical infrastructural base for the developed world such "innovation" may well come to include biological agents. The reason for this, as will be highlighted in the report that follows, is that WMD attacks against crops and livestock are substantially easier, more predictable and less risky to carry out than those directed against civilian audiences.

The purpose of this paper is to expand the current debate on mass destruction terrorism (and terrorism in general) through an analysis of agricultural biowarfare. It specifically focuses on why it is that biological weapons represent such an attractive tactical option in regard to crops and livestock and what would motivate terrorists to target this particular sector in the first place. In addition, the report examines current US preparedness to deal with a major act of biological "agroterrorism," and makes several policy prescriptions for augmenting future response and containment strategies. The paper is organized in the following manner. Section Two evaluates the operational ease of carrying out a biological attack against agriculture in terms of the constraints that are generally held to apply with regards to "conventional" bio-terrorism. Section Three discusses the major economic, political, social and financial motivations that might encourage terrorists to adopt this form of aggression and the potential reasons for the paucity of incidents that have actually occurred. Section Four evaluates the effectiveness of current US strategies to deal with outbreaks of animal and crop diseases, before offering ways by which present emergency planning systems could be strengthened.

II. BIOLOGICAL AGROTERRORISM: ASSESSING THE ADVANTAGES IN COMPARISON TO "HUMAN-DIRECTED" BIOTERRORISM

The literature on mass destruction terrorism essentially focuses on four types of agent: nuclear, radiological, chemical and biological. At the risk of gross generalization, most commentators conclude that nuclear terrorism, while possible, is highly unlikely due to the difficulty of stealing, constructing or otherwise acquiring an effective atomic device. Even in Russia, where most analysts agree the main danger originates, nuclear weapons and fissile materials such as highly enriched uranium (HEU) and plutonium continue to be subjected to tight security and accounting controls. Radiological terrorism is regarded as a slightly more realistic danger, largely because it avoids altogether the obstacles associated with building and exploding a nuclear device. However, accessing sufficient radioactive material to carry out a mass attack is still emphasized as a major impediment that detracts most groups from considering this course of action. Chemical terrorism is apportioned a higher threat probability, largely because of the ready availability of appropriate agents and the fact that a precedent for such an incident already exists in the form of Aum Shinriyko's 1995 Sarin nerve gas attack in Tokyo. Despite this, it is again argued that organizations seriously interested in achieving mass destruction terrorism would not opt for chemical weapons largely because of the enormous quantities (and associated expense) that would be needed to affect large, open areas.

Of all four potential varieties, it is biological terrorism that is typically seen to represent the greatest danger, given the availability, cheapness and extreme virulence of infectious bacterial and viral agents. Despite this, two major constraints are generally recognized as limiting a "natural" progression to this level. First is operational difficulty of actually transforming

pathogens and microbes into effective weapon systems. While very small amounts of bacterial and viral agents may theoretically be able to kill hundreds of thousands of people, realizing this in any meaningful operational sense is highly problematical. Unlike most chemical warfare agents, bacteria, viruses and naturally occurring toxins are neither volatile nor dermally active, meaning that they have to be dispersed in the form of a respirable aerosol (1-20 mm particles) if large numbers of people are to be infected. There are only between 10 and 20 microbial agents that possess the necessary physical and biological characteristics for this procedure, which is both expensive and technically demanding. Thus while it is possible to isolate agents of human disease from the environment, effective dissemination to ensure mass casualty results requires a highly complex process of strain selection, scale-up production, drying of the liquid agent and weaponization.

Second, is the reality that civilian attacks using biological weapons would be unlikely to serve the wider interests of the terrorist group concerned. Such an assault would almost certainly undermine both national and international political support; could conceivably have a negative psychological impact on the operatives that carried it out (in terms of moral guilt); and would definitely attract massive state reprisals. It needs to be remembered that terrorists are not irrational they act according to a clearly defined cost/benefit ratio. While there are certainly risks involved with limited terrorist actions, they are not nearly as severe as those that would be associated with a large-scale biological attack. Even fanatical religious groups - whose violence, it is often argued, comes closest to assuming a transcendental quality are unlikely to desire the consequences, alienation and utter condemnation that would result from carrying out an act of mass destruction terrorism. As Walter Laqueur has unambiguously concluded: "It can be taken for granted that [the vast majority of] terrorists existing at present will not use [the mass destruction] option, either as a matter of political principle or because it would defeat their purpose."

Although these limits may hold true for an act of biological terrorism specifically directed against a large-scale human audience, they begin to break down when the analytical focus is redirected to non-human targets.

The Operational Ease of Carrying Out Biological Attacks Against Agriculture Anti-Animal Attacks

"Weaponizing" biological agents to destroy agricultural animals is a far easier process than creating munitions designed to kill hundreds of people. Viral or bacterial warfare against human beings requires at least a limited knowledge of microbiology. However, this is not the case with livestock-disease delivery, which is, by comparison, relatively low tech. Over the years, farm animals have become progressively more disease-prone as a result of intensive antibiotic/steroid programs and husbandry changes designed to elevate the volume, quality and value of meat production as well as meet the specific requirements of potential vendors. These bio-technic modifications, which can include anything from branding and disinfectant sterilization treatments to de-horning, castration and hormone injections, have combined to dramatically elevate the stress levels of exposed livestock, lowering their natural tolerance to viral and bacterial infections.

An even more important factor facilitating the offensive use of disease among animal populations is the ease by which outbreaks tend to spread among livestock. There are far more agents that are highly infectious to animals than is the case with humans, many of which are not routinely vaccinated against particularly in states that have carried out successful eradication programs. The intensive way by which farm animals are reared, bred (particularly the widespread use of

artificial insemination) and transported only adds to the potential spread of these pathogenic organisms, especially those that are air-borne or enteric in nature. In the US alone, it would not be uncommon to find livestock feedlots containing between 5,000 and 10,000 animals at any given time. The outbreak of a contagious disease at one of these facilities would be extremely difficult to control and could easily necessitate the wholesale destruction of all the animals, a formidable and, arguably, unrealistic task. According to Dr. Tom Walton, Deputy Administrator of the US Department of Agriculture's (USDA) Animal and Plant Health Inspection Service (APHIS), an infection like Foot and Mouth Disease (FMD) could spread to as many as 25 states in as little as five days, simply through the regulated movement of animals between farm and market. If one takes into account that certain livestock movements in the US are unregulated, taking the form of either illegal shipments or the re-selling and switching of animals at market, then true rates of dissemination could be even greater than this.

There are numerous real-life examples that can be cited to illustrate the extremely rapid way by which diseases tend to spread among animal populations. In 1983, a major outbreak of Avian Influenza (AI) occurred in the US, resulting in the destruction of 17 million chickens, turkeys and guinea fowl throughout Pennsylvania and neighboring states. In 1993, FMD surfaced in Italy, necessitating the destruction of 8,000 head of cattle, while four years later in Taiwan the disease cost the lives of 8 million hogs - spreading, at its height, at the rate of 170 new farms a day. An outbreak of Classical Swine Fever (CSF) in the Netherlands in 1997 engendered the destruction of over 8 million pigs, while "mad cow" disease in the UK almost single-handedly decimated the country's bovine industry in the late 1980s and early 1990s. Most recently in 1999, there was the Malaysian HE scare that led to the culling of over 800,000 head of swine southeast of Kuala Lumpur.

Anti-Crop Attacks

Sabotaging agricultural plants is potentially just as easy. All major food crops come in a number of varieties, each generally suited to specific soil and climatic conditions and with differing sensitivities to particular diseases. Plant pathogens, in turn, exist in different strains with varying degrees of contagion to individual crop types. A terrorist could take advantage of these properties to isolate and disseminate disease strains that are most able to damage a state's major arable food supplies. Working on the same principle that underscored the chemical defoliant programs used in Vietnam for instance, a saboteur could conceivably wreck an entire wheat growing region simply by making repeat fly-overs with a by-plane equipped to release the Karnal Bunt fungus. One commentator has suggested that a single aircraft fitted with spray tanks containing the pathogen *Puccinia Graninis Avenae*, which causes disease in oat crops, could initiate epiphytotic (plant disease epidemics) over areas in excess of 1,000 square kilometers, from a downwind distance of 30 miles. Unlike flying over cities, such pass-overs would be unlikely to arouse suspicion and probably be dismissed as legitimate crop dusting operations.

If a perpetrator was worried about the possibility of drawing attention to him/herself through such methods, however, even less conspicuous (and more basic) options are available. Crops could be destroyed from the "bottom up" by poisoning soil with root and lower stem diseases such as Bean Common Mosaic Virus or simply walking through fields with fungal-contaminated clothing and shoes (unlike bacteria and viruses, fungal spores do not require life-support cultures for their transport). Because the signs of infection are more subtle in plant life than in animals, and due to the extensive commerce in crops and their related products, it may be some time before agricultural authorities actually realized that a problem was at hand. Indeed, unless there were a number of highly visible, simultaneous outbreaks, responses could easily be delayed beyond the point required to prevent a chronic situation from developing.

Grain, wheat, tomato, corn and potato production and rice in the West has also tended to progress in conjunction with intensive cross-fertilization programs designed to increase better production yields. While the objective of these initiatives has been to create genetically modified crops that are able to perform in ways that have alluded scientists working with classical breeding techniques, they have created the equally dangerous possibility of producing highly resistant super-diseases and non-native organisms and weeds. These could conceivably be harvested and introduced by an agro-terrorist with devastating effect. This threat is not completely in the realm of the fictitious. Indeed, insurance companies are already refusing to protect transgenic plants against the possibility of catastrophic environmental damage (intentional or otherwise), precisely due to the fear that genetically modified crops could lead to the emergence of insecticide-resistant pests and weeds, viruses and fungi that may be unfazed by herbicides.

Equally as important is the fact that the prevalent practice in most of North America and Western Europe has been to grow only one or two varieties of major food crops. This is particularly true in the US where a very high degree of genetic homogeneity is found in the country's three major arable products wheat, corn and soybeans. The lack of diversity in such monocultures poses a major threat in that it makes entire crops susceptible to organisms that are pathogenic to those varieties. A terrorist could thus conceivably introduce a disease capable of unleashing a region-wide pandemic. Even if the targeted state was successful in stopping the outbreak before widespread crop destruction occurred, significant stretches would almost certainly still be destroyed. Many of the worst crop pathogens are able to move from one plant another, either on prevailing windcurrents or through propulsion as a result of raindrops splashing on leaves. This physical property effectively means that even a limited initial coverage could create considerable latent economic damage and disruption.

A Relatively Low Risk form of Aggression

Quite apart from their relative ease, bioattacks against agricultural targets are also comparatively risk free in the sense that they neither cross the threshold of mass killing (at least directly), nor, in most cases, do they represent a danger to the perpetrator him/herself. Destroying wheat or corn production or decimating a country's pig population would not attract unfettered state action in the way that a more "conventional" bioattack against humans would. Indeed in most countries, there is not even a deterrent against "agroterror" in the form of basic criminal punishment, and there has certainly been no great appreciation of the need to include agriculture in general counter-terrorism plans. Equally, because there is no large-scale loss of human life, perpetrators are unlikely to be affected by residual feelings of moral guilt or weakened by a loss of substantial political support. As Rogers, Whitby and Dando observe: "[A]n overt assault against plants may be more psychologically acceptable than attacks on people [to the extent that such action might] seem almost benign." In terms of personal danger to the perpetrator, biological agroterrorism is also more attractive than human viral or bacterial warfare as non-zoonotic diseases (which do not affect people) can be used. While these infections are lethal to ruminant animal populations, they cannot be passed on to people and, therefore, pose no risk in the form of accidental contamination.

Moreover, biological attacks against crops and livestock can be carried out in such a way that they mimic natural disease occurrences, thereby delaying suspicion and possibly allowing the perpetrator to avoid detection altogether. A mass outbreak of Bovine Spongiform Encephalopathy (BSE) or Wheat Smut, for instance, is less likely to arouse suspicion (at least initially) of intentional contamination than a sudden epidemic of people-borne anthrax or plague. Because plant and animal life is especially susceptible to the rapid spread of viral, bacterial and

fungal epidemics (see above), there is a higher probability of such instances being "dismissed" as natural disasters than would be the case had they had occurred among human populations. Of course, too many simultaneous outbreaks might (eventually) generate suspicion of foul play and nefarious purposes. However, by this time those responsible would have had ample opportunity to depart the targeted country and re-establish in a safe, or at least distant location.

Compounding all this is the fact that agroterrorism is simply not something that the majority of the farming community actively thinks about, let alone prepares for. In terms of contingency planning most concern centers around changing market and consumer trends and how to safeguard against high probability events (such as adverse weather conditions), not how to protect livestock and crops from the deliberate introduction of diseases. As the President of Hitch Enterprises Inc., one of the largest cattle and hog feeding operations in Oklahoma, somewhat dismissively (though not unreasonably) points out: "Its like being in a flock of a thousand ducks and having someone down there with a shotgun. If there's someone out there who wants to let loose that kind of thing, the chances are, its not going to be in my feed yard."

Such attitudinal traits are not confined to farmers. Awareness of the potential threat posed by biological terrorist attacks against agriculture is equally lacking within the mainstream bureaucratic community of most countries. In the US, the agricultural sector is still to be officially designated as a critical infrastructural node that is vulnerable to sabotage and disruption. Equally, it was not until October 1998 that the words "terrorism," "agriculture," and "biological weapons" were officially strung together by the USDA and used in the same conceptual sense when assessing potential vulnerabilities to the industry.

In essence, a concerted biological attack against an agricultural target offers terrorists a virtually risk free form of assault, which has a high probability of success. This is important as one of the main factors that appears to have limited terrorist experimentation with weapons of mass destruction is lack of predictability, defined in terms of both state/popular reaction and perceived ability to effectively carry out the operation in question. Moreover, like most ordinary people, terrorists tend to shy away from using dangerous substances, which, if handled incorrectly, could pose as much of a risk to themselves as their intended targets. Terrorists are obsessed with managing events and, like war planners, remain pre-occupied with controlling the outcomes of what they start. Biowarfare against agricultural as opposed to human targets is sufficiently risk-averse that it is certainly possible to achieve this level of operational assuredness with a relatively high degree of self-confidence.

Notwithstanding its operational ease, there would be little point in investing time and effort in carrying out attacks against animals and crops if the impact of such action was not likely to be that great. However, this is where the real threat of agroterror comes in. The ramifications of a concerted bio-assault on a country's meat and food base would be far-reaching and could easily extend beyond the immediate agricultural community to affect other segments of society.

III. TERRORIST MOTIVATIONS FOR CARRYING OUT BIOLOGICAL ATTACKS AGAINST AGRICULTURE

Economic Destabilization

One of the most alluring reasons for carrying out a major act of biological agroterrorism would be to create economic destabilization. The cost of containing and eradicating a severe outbreak of animal or crop disease would be exorbitant and would almost certainly be passed on to the consumer in the form of higher food prices. Between 1983 and 1984, for instance, the US poultry

industry was hit by a particularly pathogenic strain of AI. Eradicating the disease cost the Government US\$63 million, contributing to a US\$349 million rise in chicken, turkey and egg prices in the first six months of the outbreak. Fusarium Head Blight has cost Canadian farmers millions of dollars in destroyed crops, including estimated losses of US\$90 million to Manitoba's wheat and barley industry. A study carried out by the United States Department of Agriculture (USDA) similarly concluded that if African Swine Fever (ASF) were ever to become established in the country, the cost over a 10 year period would be US\$5.4 billion, with most of that being attributable to consumer losses. Losses brought about by natural occurring plant diseases suggest that attacks against crops would be equally as costly. In 1970 Leaf Blight in the southern US was instrumental in destroying US\$1 billion worth of corn. Epidemics of cereal smuts throughout the world periodically consume hundreds of millions of dollars worth of crops, while Leaf Rust in coffee plantations has remained a pressing problem in Latin America for the past two decades.

Over and above direct economic costs, national multiplier effects need to be considered. In the UK, for instance, the outbreak of mad cow disease in the 1990s cost London between US\$9 and US\$14 billion in compensation costs to farmers affected by the slaughter of their cattle and employees laid off in the 500,000-worker dairy and beef industries. This increased national expenditure dramatically widened the budget deficit, forcing the Government to sell off more state-owned bonds in an attempt to raise capital. The combined knock-on effect on the public sector borrowing requirement (PSBR) and the retail price index ensured under-performance in gilt options, higher inflation and a reduced ability to implement long term interest rate and tax policies. In commenting on a similar occurrence taking place in the US, Corrie Brown, an expert on animal diseases and Head of the Department of Pathology at the University of Georgia, has observed:

If an exotic disease entered the United States, rendering the raising of animals unprofitable and causing the failure of individual farms, the effects would ripple to the nearby community, including equipment dealers, the local tax base, and so on. The lending industry might become incrementally a bit more concerned about the next farmer who wanted an operational loan, so lenders would begin to charge more interest on subsequent loans to other similar operations. A disease that has a direct impact on livestock could thus indirectly affect many sectors of the economy.

Biological agroterrorism would also have substantial international ramifications, further exacerbating the economic and financial costs to the affected country. Foreign traders would almost certainly be less willing to buy exported produce and in extreme cases, such as the UK "mad cow" outbreak, could be encouraged to impose full economic embargoes as protective measures. This would have a severe economic impact, particularly on countries that rely on agricultural exports as a principal source of foreign currency. Following the 1997 outbreak of FMD in Taiwan, for instance, an indefinite ban was imposed on the country's pork exports, causing Taipei's GDP to drop by a full two percent almost overnight. Conservative estimates assume that Taiwan will not be able to fully re-enter the market for at least 10 years, representing a substantial loss of national revenue for a country, which has traditionally accounted for over 15 percent of world exports. The outbreak of mad cow disease in the UK provides an equally pertinent case in point. Worldwide bans imposed on British beef products contributed to the curtailment of export markets worth at least US\$2.4 billion, adding further strain to a trade deficit that was already standing (at that time) at US\$16.5 billion.

A study undertaken by Canadian veterinarians in 1987 provides a very good example of how international repercussions can work to considerably exacerbate the national economic impact of a large-scale disease outbreak. Projections based on containing the spread of a major outbreak

FMD in the central prairie provinces concluded that eradication costs could be limited to US\$2 million, assuming effective counter-measures and contingencies were immediately put in place. However, once the ramifications of international embargoes, canceled overseas purchasing contracts and reduced international consumer demand were factored in, the veterinarians estimated the true economic cost of the epidemic at US\$2 billion, a staggering one thousand times greater.

Product contamination by sub-state groups and individuals provides an additional indication of the potential economic damage that can be achieved by deliberately targeting food products. Two cases stand out - both of which have involved substantial losses. The first occurred between 1977 and 1979 when over 40 percent of the Israeli European citrus market was curtailed by a Palestinian plot to inject Jaffa oranges with mercury. The second took place in Chile in 1989 and involved an anti-Pinochet movement lacing grapes bound for the US with sodium cyanide. Subsequent suspensions of Chilean fruit imports by the US, Canada, Denmark, Germany and Hong Kong cost the country over US\$200 million in lost revenue earnings. Although in each of these instances chemical agents were used with the specific intent to cause civilian casualties (and as such do not fit with the typology of agroterrorism presented here), they do provide an insight into how "food terrorism" can serve equally well as a highly effective economic weapon.

Undermine Support and Confidence in Government

A second, equally important, motivation for carrying out a biological attack against agriculture would be to undermine government confidence and support. Successfully releasing contagious agents against crops and livestock would undoubtedly cause people to lose confidence in the safety of the food supply and could lead them to question the effectiveness of existing contingency planning against weapons of mass destruction in general. Although agricultural attacks are far easier to execute than civilian-directed assaults (as is pointed out above), such nuances are almost certainly going to be lost on publics who tend to cast simple assertions on complex events. People may begin to equate the ability to infect crops and animals with a capacity to target humans, calling for greater emergency planning in heavily populated cities, more stockpiling of vaccines and increased surveillance of "high-risk" groups (which carries its own risks in terms of civil liberties and xenophobia). Critics (unfairly and with the benefit of hindsight) will demand why the intelligence services failed to detect the attack in and why the agricultural sector was left exposed. Graphic images of diseased cows and sheep would be aired by the media and taken as evidence of the extreme susceptibility and vulnerability of all animal life, including human beings, to deadly pathogens. Certain commentators may take matters one step further, arguing that yet another precedent had been set in the use of biological weapons, warning "that it is just a matter of time before attacks are directed against civilians." The combined effect would be to undermine public confidence in the ability of the government to carry out one of its most basic tasks, security of the individual, quite possibly initiating a chain of political and legal reactions that fundamentally alters the relationship between citizen and state.

The actual mechanics of dealing with an act of agricultural bioterrorism could also generate public criticism, particularly if it was aimed against livestock. Containing a major disease outbreak would almost certainly necessitate the slaughter of hundreds to thousands of animals. The 1999 HE epidemic in Malaysia, for instance, led to over 800,000 pigs being shot, while the 1997 FMD outbreak in Taiwan resulted in excess of 500,000 tons of pork meat being destroyed. Dealing with volumes of these magnitudes in a politically acceptable manner poses a significant challenge on at least two levels. Actually culling large numbers of animals, despite being a scientifically justifiable method to contain viral and bacterial dissemination, would be sure to generate vigorous opposition from affected farmers and animal rights movements, particularly if such operations involved the destruction of high-risk but non-disease showing livestock. In the

US, for instance, there has not been a major cattle or sheep epidemic in the era of television; as such, no visual point of reference has been available to prepare the public for the consequences of containing such an occurrence. The use of Government marksmen, armed with high velocity assault rifles to massacre half a million head, including those that exhibited no clinical signs of infection, would simply not be endorsed as a legitimate form of disease containment.

Even in the unlikely event that large-scale culling operations were accepted, the actual removal of carcasses would be just as challenging. The quickest and easiest way to dispose of contaminated animal waste is either by burying corpses in landfills covered with quicklime or by incinerating them in pits lined with burning tires. However, utilizing such methods in an ecologically "friendly" manner is only feasible if a small number of bodies need to be dealt with. Burning thousands of carcasses with rubber tires, for instance, would create a huge, smoldering open fire as well as a highly visible atmospheric pollution problem, both of which would attract widespread popular criticism. Mass burial is likely to be just as contentious, not least because of the risk it would be seen as posing to ground water supplies and the fact that it would render large areas of land essentially unusable for many years (of particular concern to heavily urbanized states). On the other hand, the longer a government prevaricates and leaves diseased carcasses out in the open, the higher is the probability that they will act as a source for future infection epidemic spread an equally unacceptable outcome.

APHIS has attempted to come to grips with the problem of mass carcass disposal by looking at the rendering system as a possible way to deal with livestock slaughtered from quarantined farms. To test the viability of this alternative, the Service simulated an outbreak of FMD in 1998 in which destroyed animals were exposed to extreme heat, reduced and re-processed into feed meal as part of the emergency containment process. However, within one week the test system had been completely overwhelmed and could no longer deal with the volume of animal protein that was coming in. Following the exercise, APHIS officials concluded that the rendering system was ineffectual in terms of mass carcass disposal and that, in the event of a major disease outbreak, the only realistic way of quickly dealing with animal corpses would be through burning or burial. USDA officials have since conceded that gaining public and political acceptance of these methods, or conceptualizing viable alternatives to them, remains one of the most challenging issues currently facing the Department in terms of future emergency contingency planning. The potential for agricultural disasters (and the failure to deal with them) to seriously damage a government's credibility and standing should not be underestimated. The 1997 FMD outbreak in Taiwan (which some still believe was a deliberate act) undoubtedly contributed to the general sense of dissatisfaction with the Lee Presidency and is regarded, by some, as marking the true beginning of the Island's economic and political reversal in the late 1990s. The BSE epidemic in the UK unleashed a storm of political protest against the Government of John Major, while the 1999 pig dioxin scandal in Belgium was directly responsible for the fall of the Christian Democratic Socialist Coalition led by Jean-Luc Dahaene. In this light, Colonel Robert Kadlec, an expert working with the US Air Force's biowarfare program, has commented that agroterrorism "offers an adversary the means to wage a...subtle yet devastating form of warfare, one which [could] impact [on] the political...sectors of society and potentially national survival itself."

Undermine Social Stability and Create Mass Panic

Beyond immediate economic and political motivations, terrorists may also carry out an act of biological agroterrorism to undermine social stability and create mass panic. A major disruption to a state's agricultural base would impact on the lifestyles and welfare of those that depend on this industry for employment. Infected farms would have to be quarantined and, possibly, permanently closed, impacting not only on the agricultural workers themselves, but also the

employees of businesses that rely on their produce. A University of Maryland study, for instance, has estimated that a mere four percent drop in the state's poultry production would immediately wipe out 1,000 jobs in the state, affecting industries as diverse as construction, banking, rendering, transportation, and fast food.

Bioattacks against agriculture could also be used to undermine a state's food supply, particularly in poorer countries that are dependent on a single crop (such as rice) and lack a concerted ability to import from overseas. Such assaults would not only cause malnutrition; they would also lower immune resistance to a wide range of common illnesses, possibly leading to an increase in disease incidence and placing greater strains on what may already be overburdened medical and health infrastructures. History provides an indication of how extensive these problems could be. The Irish disaster of 1845-46, which was brought about in large part by late Blight in potatoes, killed one million, driving another million from the country. Nearly a century later, Brown Spot Disease decimated rice crops throughout Bengal, contributing to a famine in which more than two million people eventually died of starvation and/or illness.

Terrorists could equally carry out a biological attack against livestock to create panic and stimulate a socially disruptive rural-urban exodus. Several animal diseases are zoonotic in nature, meaning they have the ability to "jump" species and affect human beings. Principal among these are AI, BSE, Glanders, HE, Japanese Encephalitis, Rift Valley Fever (RVF), Screworm Myiasis, Swine Vesicular Diseases (SVD) and Vesicular Stomatitis (VS). An outbreak of any of these infections would be likely to have severe repercussions in terms of creating a mass public scare, especially if human deaths actually occurred. Terrorists could use this to their advantage, allowing them to create a general atmosphere of fear and anxiety without actually having to carry out indiscriminate civilian-oriented attacks (and all that this entails in terms of alienating actual and potential support). The 1999 HE epidemic in Malaysia provides a good example of how zoonotic animal diseases can stimulate mass panic in a potentially susceptible population. The virus, which killed over 117 villagers in a little over a month, caused thousands of people throughout the state of Negri Sembilan to desert their homes and abandon their livelihoods, with many fleeing as internal "environmental refugees" to the shanty towns on the outskirts of Kuala Lumpur.

Generation of Finances and Coercive Blackmail

The low probability of detecting intentional biological assaults against agriculture additionally makes this form of aggression an ideal, and largely risk-free way for terrorists (and other criminals) to raise capital for logistical and operational purposes. An attack that severely crippled the US sheep industry, for instance, would result in an immediate increase in demand, and corresponding rise in price for the products of America's major lamb, mutton and wool competitors. An astute terrorist group could take advantage of this by simply investing in appropriate European and Australian stock shares on the futures market before carrying out an attack against US sheep producers. All they would then have to do is wait for the "natural" economic laws of supply and demand to take effect before "cashing-in" on their elevated dividend premiums. This procedure could be repeated, targeting other major agricultural industries such as wheat, corn, beef and pork.

The Taiwanese 1997 FMD outbreak provides a good example of the type of financial opportunities that could be made available through this type of financial speculation. The Food and Agriculture Policy Research Institute (FAPRI) has estimated that world pork prices will rise by an average of five percent over the next several years as a direct result of the disease epidemic. Most benefit is expected to go to US hog producers who, due to their cost advantage and

available processing capacity, are projected to capture nearly 78 percent of the export opportunities made available. Anyone with dividends in US pork shares prior to the 1997 FMD outbreak would have thus have been virtually guaranteed of making a substantial profit on their initial investment.

Agroterrorism would serve just as well as a form of coercive blackmail, either for extortion or to force a change in political opinion and policies. Unlike human-directed biological threats, terrorists would have the advantage of definitively establishing the credibility of their resolve by actually carrying out a large-scale attack without encouraging massive retaliation from a state that feels it no longer has anything to lose. Moreover, given the enormous damage that could be inflicted on a state's economic and political base by repeated attacks, a targeted government would have a strong incentive to negotiate - a key consideration in any blackmail attempt.

USDA officials have postulated several fictitious, but entirely plausible, scenarios involving the use of agricultural terrorism as a form of coercive blackmail. One of the most interesting revolves around a political extortion attempt by Colombian guerrillas designed to force Washington into reducing its counter-narcotics and insurgency cooperation with Bogota by threatening multi-focal animal and plant pathogenic attacks throughout mainland US. Disease specialists maintain that the Government would have little option but to conduct "behind-the-scenes" negotiations, particularly if a "demonstration" assault was first carried out highlighting the potential damage and disruption that could be caused through such a course of action.

A Form of Indirect Surrogate Warfare

Finally, attacks against livestock and crops could be used as a form of indirect form of surrogate warfare, with a state sponsoring a third party to undermine an adversary's diplomatic relations and war fighting capacity by targeting its agricultural base. As pointed out above, an outbreak of a contagious disease would almost certainly result in an embargo against the affected state as major importers struggle to protect their own livestock industry and public health systems. Such affects can have a particularly damaging impact on interstate diplomatic relations, especially if the targeted government believes it has put in place effective containment and eradication measures. The ban imposed on British beef by European Union (EU) states following the outbreak of BSE in the UK, for instance, severely strained London's relations with its major European allies, exacerbating existing tensions in bilateral and multilateral negotiations over closer EU integration. A similar embargo imposed on Belgian pork exports in the wake of the current dioxin scare has had an equally pernicious effect on Brussels-European partnerships.

Agroterrorism would be equally as effective in terms of undermining a state's war fighting capacity. During hostilities, food carries a priority rivaling ammunition, with most military forces relying on animal products for up to 40 percent of their rations and as much as 70 percent of the calorific value of their diet. History has shown that programs designed to reduce an enemy's food supply have been an integral component of major war plans in the past (see below). In an age where "twilight battlefield" tactics have increasingly come to surpass more conventional state-state exchanges, sponsoring groups to destroy an adversary's food and fiber at their source could be a highly effective way of prosecuting wars that are not decided with push-button speed.

Why Have Not More Acts of Agroterrorism Actually Taken Place?

Despite the ease and potentially severe implications of carrying out agricultural bio-attacks, to date only a few instances of this type of terrorism have actually occurred. In his exhaustive study on biocrimes and bioterrorism in the Twentieth Century, which is widely recognized as the best currently available, Seth Carus notes only three cases involving the terrorist use, or threatened use

of biological agents against crops and livestock. The first took place in 1952 when the Mau Mau used plant toxin (African Bush Milk) to infect steers at a Kenyan mission station in areas reserved for the Kikuyu tribe. According to Carus, the cattle poisonings were part of a concerted campaign directed against livestock throughout Kenya. The second instance involved a threat by Tamil militants in the early 1980s to infect rubber and tea plantations in Sri Lanka with non-indigenous diseases as part of a total biological war strategy designed to cripple the Sinhalese-dominated Government in a few years. The third incident occurred in 1981. In this case a group called "Dark Harvest" threatened to contaminate "appropriate places" throughout the UK with Anthrax-laced soil to raise public awareness of the ecological dangers inherent in chemical and germ warfare research.

Does the lack of supporting empirical data suggest serious impediments into employing biological agents against agriculture? As Section Two argues, technical, operational and psychological constraints against use are minimal. Weaponizing and disseminating bacterial, viral or fungi infections is neither a difficult, complex or risky task and, in contrast to human-oriented attacks, might seem almost benign. The interest that several state actors have shown in developing biological agents for mass use against crops and livestock readily underscores this potential viability. As far back as World War II, the British were experimenting with "cattle cakes," cow snacks laced with anthrax, as a way of crippling the German beef industry. Before terminating its biological warfare program in the early 1970s, the US had standardized several anti-crop agents, including Potato Blight, Rice Seedling Blight and Brown Spot Disease, Rice Blast Pathogen, Cereal Mildew, and Bacterial Soft Rot (which infects carrots, potato, cabbage and onion). According to DIA officials, a key component of the USSR's biowarfare program focused on anti-agricultural agents, with at least seven facilities known to have been devoted solely to plant and animal pathology.

South Africa is similarly known to have conducted research into agricultural biowarfare during the Apartheid years. The program had both an anti animal and (likely) anti crop component, with most experimentation occurring at the central Onderstepoort facility. According to the DIA, the principal focus of Pretoria's efforts revolved around weaponizing African Swine Fever and FMD for use in neighboring countries, including Namibia (then known as Southwest Africa), Zimbabwe and Angola. Most recently, were revelations that the Iraqi regime had developed naturally occurring fungal plant pathogens to cause disease and the large-scale destruction of food and cash crops. The main emphasis in this case was on the *Tilletia* fungus, which has been responsible for wheat losses in many parts of the world. The UN has since listed ten internationally significant crop diseases as having a high biological warfare capacity, including Wheat Smut as well as other diseases that affect coffee, pine and fruit trees, root vegetables and various kinds of beans.

If there are no real technical or psychological constraints to employing biological weapons, why haven't terrorists made more use of this modus operandi, especially given its potential to cause significant economic, political and social upheaval? One reason could be that terrorists simply haven't thought through the full ramifications of deliberately targeting agricultural livestock and produce. According to this interpretation, it may only be a matter of time before we see more instances of this type of aggression taking place. As Stefan Wagener, a US microbiologist, observes, the ingredients and recipes for an agroattack are already in place; the willingness and realization to actually use them is bound to increase sooner or later.

Another possibility may be that deliberate sabotage is traditionally not something health officials have actively looked for when investigating crop or animal disease outbreaks. The implication here is that more acts may have actually taken place than we know about. Animal and plant

health officials in Washington concede this as a possibility, acknowledging that in most countries (including the US) the tendency is to automatically assume disease outbreaks are naturally occurring events. The inevitable consequence has been epidemiological investigations that seldom consider the possibility of deliberate pathogenic introduction. While this line of reasoning would obviously hold little relevance for possible attacks carried out by publicity-seeking groups (who would engender more criminal-focused investigations by claiming responsibility for their acts), it could have some validity for the anonymous terrorist whose only goal is to cause mass disruption and chaos.

Finally, it could be that terrorists consider this form of aggression too "dry" in comparison to traditional bombings in the sense that attacks against crops and animals do not produce immediate, visible effects. The impact, while significant, is delayed, lacking a single point for the media to focus on. Such disruptive terrorism, as Brian Jenkins has observed, lacks drama: "No lives hang in the balance. There is no bang, no blood. They satisfy neither the hostility nor the publicity hunger of terrorists." In this light, the fact that biological agroterrorism has not emerged as more of a problem is, perhaps, understandable. However, it would be wrong to assume that this negates the possibility of a switch to this form of violence. As the Introduction points out, infrastructure attacks, if carried out effectively, can be just as devastating as more traditional terrorist actions, something that is especially true with regard to agriculture. The mere ability to drive a state's economic and public management resources toward stemming incipient epidemics give both anti-crop and anti-animal assaults considerable clout that would be of considerable benefit to any group faced with significant power asymmetries. Moreover, as the HE epidemic in Malaysia readily demonstrates, a disease outbreak that kills human beings and requires the slaughter of hundreds of thousands of animals does have the potential to make a marked visible impression and certainly can attract considerable media interest, locally, nationally, regionally and even internationally.