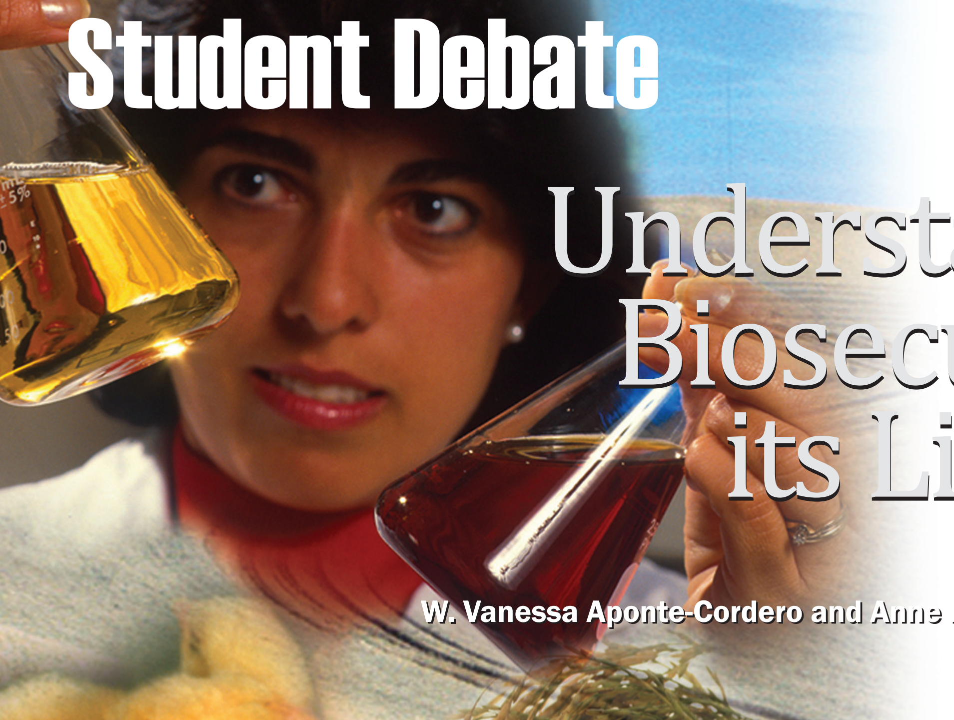

Understanding Biosecurity and its Limitations

W. Vanessa Aponte-Cordero and Anne L. Nielsen

In conjunction with the Student Affairs Committee, entomology graduate students have hosted student debates annually since 1993 (with the exception of one year) at the Entomological Society of America national meetings. The debates have focused on a variety of topics and emphasized current interests in prominent issues or subjects that shape our science. The 2007 student debate theme was Biosecurity, and debate teams consisted of graduate and undergraduate students majoring in entomology. Each team selected a faculty adviser who met weekly with them during the fall semester, often as part of a special credit course for debate preparation. Because of planned publication limitations, each debate manuscript was summarized in a 600-word narrative. Each topic includes a neutral introduction presented by an unaffiliated group (associated with neither the pro nor con teams). We invited Professor Phyllis M. Higley from the Department of Biology at the College of St. Mary in Nebraska to introduce the overall debate program this year.

What is Biosecurity?

Phyllis M. Higley
Department of Biology, College of Saint Mary

Although it is a much-talked-about concern, biosecurity is not a new idea. In 1925, the "Protocol for the prohibition of the use in war of asphyxiating, poisonous or other gasses, and of bacteriological methods of warfare" was written and then entered into force in 1928 (Geneva Protocol 1925). The concept of biosecurity has perhaps broadened since then. A simple definition of biosecurity is "the protection of the economy, environment, and health of living things from diseases, pests, and bioterrorism" (Encarta 2007).

The United Nations Food and Agriculture Organization (FAO 2003) describes biosecurity as "the concept, process and objective of managing…biological risks associated with food and agriculture." The FAO considers several areas in this concept: food safety and the introduction of genetically modified organisms, crop and livestock pests, and invasive species.

The United States has several agencies whose function it is to protect these interests (APHIS 2007, FDA 2007, FSIS 2007). The Food and Drug Administration (FDA) and the Food Safety and Inspection Service (FSIS) were created to ensure the safety of all foods in the United States. The purpose of APHIS (Animal and Plant Health Inspection Service) is to protect and promote U.S. agricultural health and to regulate genetically engineered organisms. All three agencies use surveillance and early detection to respond rapidly to food threats.

Inadequacies in the FAO approach to biosecurity led to a proposal for biological laboratory and transportation security (BLTS) standards (Salerno and Koelm 2002). The goals of these standards are to identify high-consequence pathogens (HCPs) that inflict grave harm to humans, animals, or plants. In fact, USDA and Department of Health and Human Services have listed select agents and toxins that include primarily pathogens of humans and animals and some plant pathogens (Code of Federal Regulations 2007 a, b, c). The BLTS standards would also protect critical information that could be used to create or weaponize HCP. BLTS also would assess security threats and vulnerabilities and provide specific recommendations in balance with scientific research. Toward this end, the National Science Advisory Board for Biosecurity (NSABB) was formed in 2004 (Secretary of Health and Human Services 2004).

One of the goals of the NSABB is to develop criteria to identify biological dual-use research; that is, research that has legitimate scientific purpose that may be misused to pose a biological threat to public health or national security. Specific concerns include misuse of research to render vaccines ineffective; to confer resistance to antibodies or antiviral agents; to increase virulence, transmissibility, or host range of a pathogen; and to enable the evasion of detection or the weaponization of biological agents. Another goal of the NSABB is to develop a code of conduct for scientists and laboratory workers to ensure that bioterrorists cannot obtain materials and information.

Clearly, there are several considerations about biosecurity. Food security, or the continuous access to a safe and adequate food source, relies on the ability to produce food crops and livestock. The introduction, intentional or otherwise, of invasive and pathogenic species is a primary threat to food security. Whether current efforts against the introduction and spread of such pests are adequate is a serious concern. Another concern is the release of scientific research that has the potential for malicious use. There is resistance among the scientific community to the limitation of this information because the free exchange of information promotes scientific knowledge. A delicate balance, therefore, emerges between limiting information that could be used for ill and preventing the release of information intended to protect our health and food safety.

TOPIC

Current APHIS/PPQ regulations on imported agricultural commodities are science-based and appropriately rigorous to protect United States agriculture while facilitating global trade.

Introduction

Gregory R. Curler and Gregory J. Wiggins
The University of Tennessee

The Animal and Plant Health Inspection Service (APHIS) operates under the U.S. Department of Agriculture and is responsible for developing and enforcing regulations governing the import and export of agricultural products. These regulations protect agriculture and natural resources through the development and implementation of inspection protocols for imported products and deal with established invasive and/or economically important pest organisms (USDA 2007). The Plant Protection and Quarantine (PPQ) division of APHIS is responsible for preventing entry into the United States of organisms that pose a threat to agricultural crops and native plants; these include invasive insects, noxious weeds, and plant pathogens. The PPQ regulations also abide with the World Trade Organization's Sanitary and Phytosanitary Agreement, under which the United States is required to provide the least trade-restrictive phytosanitary measures necessary to ensure the appropriate level of protection (WTO 1994).

To reduce the likelihood of harmful introductions, permission is granted to import new commodities only after a risk assessment is conducted. Risk assessments identify potential pests and pathways by which the pests can enter the United States. They determine which pests are likely to become established and economically important and help to develop plans to manage the pest in the event that risks are realized (USDA 2000). The information considered in these risk assessments is based largely on data from scientific literature about the pests and crops being evaluated. The Risk and Pathway Analysis team conducts risk assessments and other research activities that identify measures to reduce the risk of pest introductions. Results of risk assessments give program managers and policy makers a basis for their operating procedures and import standards (USDA 2004). The actual process of risk analysis, however, is not always clear, and the level of risk established for pests has been formally questioned by some stakeholders (Simberloff 2005).

Many challenges face PPQ; for example, implementing thorough and timely inspections of imported commodities, developing protocols to prevent harmful introductions, managing scientific research and data from inspection stations, and distributing information to the public to promote responsible travel and international shipping. National security concerns, emerging trade issues, government initiatives, and political influence also may periodically hinder APHIS and PPQ from realizing their goal of using a science-based approach to protect agriculture while facilitating global trade (APHIS–PPQ 1993).

▲Pro Position

Jessica M. Jennings, Patricia L. Mullins, and Joel D. Keralis
Texas A&M University

APHIS, the USDA Animal and Plant Health Inspection Service, creates and enforces regulations governing the import and export of agricultural commodities. With this task comes the responsibility of providing sound, scientifically based importation guidelines to protect domestic agriculture and promote trade in the global market. To execute these guidelines, APHIS designs and carries out its policies using a scientific basis that protects U.S. agriculture (APHIS–PPQ 1993).

The scientific basis of USDA policies is mandated by international agreements, the foremost being the agreement on the application of Sanitary and Phytosanitary Measures (SPS). This international treaty requires that a science-based risk assessment be completed before implementing any policies governing importation of foreign goods (WTO Legal Affairs Division 2007). The agreement also mandates the fair and universal application of any policy to all countries importing a specific good, which balances the international trade market and prevents trade concessions from being used as foreign policy weapons (Campbell 2001). Under SPS, the United States has agreed to use a scientific basis for its policies to avoid potential international trade sanctions. This agreement makes it difficult for the USDA to create blanket policies restricting the importation of goods from any country or countries without a thoroughly documented risk assessment. These agreements also delineate acceptable forms of quarantine treatment and provide details of application (FAO 1999).

The scientific basis of USDA policies is mandated by international agreements, the foremost being the agreement on the application of Sanitary and Phytosanitary Measures (SPS). This international treaty requires that a science-based risk assessment be completed before implementing any policies governing importation of foreign goods.

We believe that the pest risk assessment protocol developed and used by the USDA is one of the most important science-based tools used to ensure the security of imported agricultural commodities. The risk assessment process determines the potential for species to become invasive (Venette and Gould 2006) by focusing on the likelihood and consequences of establishment. Risk assessment includes evaluating climate–host interaction, host range, dispersal potential, economic impact, environmental impact, the quantity of substance imported, and the likelihood of surviving post-harvest treatment or shipment, escaping detection, or finding a suitable habitat or host.

An expert panel of 15 scientists conducts the risk assessment. Each factor is given a score of low, medium, or high, based on the panelist's assessment of the gravity of establishment likelihood and consequences. The panelists then assign a separate, independent confidence value of low, medium, or high to each of their assessments, based on the amount and reliability of available data. Thus, the USDA pest risk assessment uses the professional judgment of multiple experts and provides a reliable decision-making tool that minimizes assessment bias.

There are five national science programs or divisions under which Center for Plant Health Science and Technology (CPHST) work can be classified: Agricultural Quarantine Inspection and Port Technology (AQI&PT), Molecular Diagnostics and Biotechnology, Response and Recovery Systems Technology, Risk and Pathway Analysis, and Survey Detection and Identification (APHIS–PPQ 2007). These programs use services such as methods development, quality assurance, training, and education to protect U.S. agricultural resources and facilitate international trade. The AQI&PT program, for example, develops quarantine inspections and mitigation treatments to protect agricultural imports into the United States. To conduct risk assessments, the Risk and Pathway Analysis program collects, interprets, and prioritizes scientific evidence about plant pest risks. The USDA uses numerous tools that allow officers to make adequate risk assessments and equip them to make sound regulatory decisions (National Plant Board 2006).

Biosecurity encompasses the measures taken to protect the public from bioterrorism. The National Science Advisory Board for Biosecurity advises the U.S. government on potentially hazardous research, termed "dual-use" (NSABB 2007).

▼ Con Position

Amanda C. Bachmann, Christina M. Harris, Kerry E. Mauck and Ezra G. Schwartzberg
The Pennsylvania State University

APHIS uses several core procedures that are not science-based and have the potential to negatively impact global trade and U.S. agriculture. These procedures include risk assessments, interception protocols, and treatment protocols. Problems within these procedures result in the creation of regulations that are not science-based and do not encourage global trade.

APHIS uses risk assessment procedures to determine which pests pose significant threats to U.S. agriculture (National Research Council 2002). For these assessments, qualitative, subjective scores are assigned to different risk elements for a pest, such as likelihood of survival or density of suitable hosts (National Research Council 2002). The qualitative scores assigned to each risk element are summed to produce one score for that element. These element scores are summed to produce a final risk estimate. Performing risk assessments in this way is not valid for several reasons. Relying on subjective assessments reduces repeatability and inhibits peer review. In many cases, there are few ways to critique the scores, and a score for each risk element is considered to be independent when summed (National Research Council 2002). In reality, one risk element may affect a subsequent risk element. To ensure accuracy, scores should be viewed as the likelihood of events in a sequential chain (National Research Council 2002). Regulations based on the current method for risk assessments are therefore not science-based.

These flaws in risk assessment are exacerbated by poor pest interception protocols. Pest interception is critical for identifying non-native species and their country of origin. Since 1984, APHIS has recorded pests found during inspections in the Port Information Network (PIN) database (McCollough et al. 2006). Currently, the database can be used only within APHIS, and it is not designed for research analysis. Limitations include haphazard sampling protocols, recording only positive detections, and identification issues (depending on the stage, insects may only be identified to order) (McCollough et al. 2006). Improvements to this database are necessary for statistical-analysis of agricultural regions and their potential pest risks.

Compounding the inadequacy of risk assessment and pest interception records is the unsupportable standard of Probit 9 (99.9968% mortality of insects; Baker 1939), which defines the effectiveness of quarantine treatments by APHIS. Flaws in this standard include the excessive time and money it requires, as well as the inability to test this treatment standard, which requires mortality of more than 90,000 conspecifics for a 95% confidence level (Follett and McQuate 2001). Probit 9 has never been adequately validated as an effective quarantine standard, and more recent literature suggests alternative treatment programs that may more effectively facilitate global trade (Landolt et al. 1984, Follett and McQuate 2001).

APHIS treatment protocols that are intended to prevent the introduction of pests have been found to have problems. In the past, APHIS has failed to comply with required efficacy treatment trials. This inefficiency can permit the entry of pests into the United States if treatments or methods are not adequately researched. This ineffectiveness becomes costly and time-consuming to remedy if challenged in court by parties outside the government.

These examples suggest that APHIS requires improvement. Current risk assessments fail to satisfy the criteria for being science-based and the PIN database inhibits access to information that could improve these assessments. Furthermore, some APHIS treatment protocols are based on outdated standards and poorly researched efficacy tests. Thus, many APHIS regulations are not science-based and incorporate standards and practices that do not protect U.S. agriculture or facilitate global trade.

Acknowledgments

We thank Norman Barr, Raul Ruiz, Owen Thompson, Kelli Hoover, Michael Saunders, and the Department of Entomology at Penn State for their contributions toward this endeavor.

TOPIC

Scientific journals and government agencies should review papers for biosecurity concerns and refrain from publishing information that may be helpful to bioterrorists.

Introduction

Amanda C. Bachmann, Christina M. Harris, Kerry E. Mauck and Ezra G. Schwartzberg
The Pennsylvania State University

Bioterrorism is defined by the Centers for Disease Control and Prevention (CDC) as "the deliberate release of viruses, bacteria, or other germs used to cause illness or death in people, animals, or plants" (CDC 2007). Biosecurity encompasses the measures taken to protect the public from bioterrorism. The National Science Advisory Board for Biosecurity advises the U.S. government on potentially hazardous research, termed "dual-use" (NSABB 2007). Dual-use research provides information that is of benefit to science, but is also potentially useful to terrorists. If co-opted by violent extremists, this information could threaten public health and safety. As a result, censorship has been proposed as a means of limiting dissemination of dual-use research.

The main concern with the censorship of sensitive material is that it will likely affect our work as entomologists and researchers by altering how we access and share scientific information. Because science builds on the knowledge of others, sharing information is critical. Censoring publications could also inhibit collaboration. Publishing dual-use research, however, could increase the risk of a bioterrorist attack.

It is uncertain whether current checkpoints, such as publication editors and grant panels, are adequate to identify and handle dual-use research. Publications generally require enough detail in the methods section to allow the experiment to be replicated by another scientist, even if these methods deal with diseases or organisms of potential interest to bioterrorists. Some people propose that new safeguards should be integrated into the current peer review process to prevent dual-use research from reaching potential terrorists. Granting agencies that follow a government framework on biosecurity issues could also limit funding for dual-use research by requiring applicants to indicate what level of threat their research could pose if co-opted for malevolent purposes. Others argue that this would impede progress and further hamper efforts to understand and anticipate potential threats (Atlas 2002, Gaudioso and Salerno 2007).

Whether or not current safeguards are adequate to protect our country against potential bioterrorism threats is debatable. The extent to which terrorists access and use scientific literature is unknown. However, implementation of review processes targeting sensitive research may affect the dissemination of scientific knowledge.

▲ Pro Position

Waseem Akbar, Jessica Brauch, Julien M. Beuzelin, and Jason C. Hamm
Louisiana State University

Bioterrorism can be defined as "the deliberate release of viruses, bacteria, or other germs to cause illness or death in people, animals, or plants" (CDC 2007). The use of bioterrorism as a war tactic is not a novel concept. In the past, acts of bioterrorism generally have been simple in nature. The rapidly growing field of biotechnology has the potential to open more doors for terrorists looking for new means to cause harm on a large scale. Thus, scientific publications with inherent benefits can also be costly, and this fact has been widely recognized in the scientific community (Atlas 2002, APHIS–PPQ 2003, Alberts 2005).

The use of bioterrorism as a war tactic is not a novel concept. In the past, acts of bioterrorism generally have been simple in nature. The rapidly growing field of biotechnology has the potential to open more doors for terrorists looking for new means to cause harm on a large scale.

With the creation and ubiquitous use of the Internet, anyone can easily access various sources of knowledge such as electronic journals and databases. Under these circumstances, the scientific community needs to be much more prudent about the material being published. Self-regulation out of responsibility can be the right attitude to adopt. This idea of self-regulation has already been accepted by editors of several journals, scientists, authors, and government officials. On 10 January 2003, a group of professionals met to discuss the issue of self-regulation and determined that when the potential harm of a publication outweighs the potential societal benefits, the paper should be modified or not be published at all (APHIS–PPQ 2003).

The preservation of public trust and support is critical to the future of scientific progress and freedom. Even though scientists may approach research with a conscientious attitude about conduct, the knowledge and products or technologies derived from research can be misused by others to deliberately pose a threat to public health or human resources (Jackson et al. 2001, Wein and Liu 2005). Scientists involved in any aspect of life sciences research have an ethical obligation to avoid or minimize the harm that could result from malicious use of their research.

The recommendations of the National Science Advisory Board for Biosecurity (NSABB) about dual-use research can serve as a guide to determine what information could be of potential use to bioterrorists (Anon. 2007). This board suggests weighing risks and benefits and developing a comprehensive communication plan for dual-use research. According to the board, information may be considered dual-use if it enhances harmful consequences, disrupts effectiveness of immunization, confers resistance to biological agents, increases ability to disseminate biological agents, alters host range, enhances the susceptibility of a host population, and generates a novel pathogenic agent.

The overall message of the board's recommendations is that research found to have dual use should be given careful consideration for biosecurity concerns. Depending on the risks associated, either a modified version of the contents should be published, or the research should not be published at all. Because scientific review is a routine process conducted by researchers with expertise in the specified field and is a multi-individual task at several levels, its integrity should not be in question. If conducted correctly, the review process will ensure that any specific information taken out of the publication will not hinder development of science. Another possible way of disseminating dual-use findings is through communication on a "need to know" basis through secure lines of communication without public access. This approach will ensure the dissemination of individual scientists' findings without compromising the public's well-being. To summarize, identifying and regulating dual-use research by following guidelines set by the NSABB will reduce the risk of bioterrorism arising from the dissemination of scientific research and maintain public trust in the scientific community.

Acknowledgments

The Louisiana State University team thanks their advisors, Gene Reagan and Gregg Henderson, for manuscript suggestions and advice and support throughout the student debate.

▼ Con Position

Dagne Duguma, Godshen R. Pallipparambil, Cesar D. Solorzano, Robin M. Verble, and Tara N. Wood
University of Arkansas

"The age of engineered biological weapons is neither science fiction nor suspense thriller…it is here today" (Aken 2006). Ethical attempts are being made to increase security wherever possible. However, in the scientific community, ethical questions are raised when not only scientific journals, but government agencies, can prevent publication of papers containing information that may (or may not) be helpful to bioterrorists.

Completed research should not be halted at the level of publication regardless of the results. By preventing publication, the most significant step in scientific research is violated. Furthermore, there are currently no concrete definitions or systematic cost-benefit analyses to establish what information could be considered helpful to terrorists (Atlas 2002). Government and industry regulations already keep sensitive information from being disseminated to the public (Shea 2003). Finally, coordinating restrictions on publication would require impossibly complex logistics.

Communicating results is the final and arguably most significant step in the scientific method, and occurs most effectively through journal publications (Anon. 2003a). Charles Vest, president of the Massachusetts Institute of Technology, wrote, "The advanced education of scientists depends on the critical openness of the scientific process, publication and participation within science institutions, in and out of the United States" (Vest 2001). Publishing is not only a time-honored tradition of science; it allows peer scrutiny (Salyers 2002).

If government agencies gained legal authority to restrict publishing scientific research, decisions would have to be "based on a scientifically sound assessment of risks and benefits" with concrete definitions and regulations (Aken 2006). Current terms used to describe dual-use research are ambiguous and questionable.

If systematic risk assessments are devised, they must be implemented before potentially dangerous research is conducted; moreover, refraining from publishing completed results may create greater dangers to our society (Anon. 2003a). Trust and confidence are key elements of international cooperation in arms control and security. Therefore, only complete transparency will allow nations to determine the intentions of others and build confidence in multilateral compliance. A report by the U.S. National Academies (1982) concluded "greater security would be achieved by the open pursuit of scientific knowledge than by attempts to curtail the free exchange of scientific information". Who will reject scientific papers based on biosecurity concerns is also unresolved (Fallow et al. 2003).

It is imperative that science not be impeded by political ideology. If science hinges upon unfounded risk assessments and ambiguous definitions, the quality and progress of science is endangered.

Dual-use research will not cease if it is not published. We can compound the problem by limiting science and, in the end, cause more societal harm than the harm we are trying to prevent. Limiting science proved unsuccessful in Galileo's time; and it is imprudent, let alone impossible, today.

Existing protocols keep sensitive information from being widely disseminated. The Classified Information Act restricts publishing selected government research and grants corporations confidentiality contracts to maintain industry secrets (Shea 2003). Numerous projects have been conducted behind closed doors, suggesting that existing protocols are sufficient to maintain security without further suppression of publication.

Finally, the logistics of limiting publication are impossible (Editors and authors group 2003). The research community is global; therefore, review and regulation processes must be global. "Failure to harmonize biosecurity measures on an international scale will create gaps in security and might hamper legitimate scientific research" (Aken 2006). Worldwide agreement on anything, much less an issue of security, is improbable. There will always be objections to guidelines, regulations, and wording—consider the Kyoto Protocol. Banning journal publication does not stop dissemination of research via personal letters, the Internet, or other communication. No regulation or governing body can dictate what cannot be published.

Dual-use research will not cease if it is not published. We can compound the problem by limiting science and, in the end, cause more societal harm than the harm we are trying to prevent. Limiting science proved unsuccessful in Galileo's time; and it is imprudent, let alone impossible, today.

TOPIC

Research on potential insect invasive species that can transmit animal diseases should take precedence over invasive crop pests and diseases

Introduction

Waseem Akbar, Jessica Brauch, Julien M. Beuzelin, and Jason C. Hamm
Louisiana State University

Invasive species can be broadly defined as "species that have a demonstrable ecological or economic impact" (Lockwood et al. 2006). The ecological or economic impacts of invasive species vary in nature and importance: Some species become invasive intentionally for agricultural or economic gains or for bioterrorism purposes; some become invasive accidentally due to introductions because of increasing international trade and tourism; and some are invasive naturally because they interact with human affairs (e.g., disease vectors or crop pests).

There are several examples in which invasive species have been proven beneficial or devastatingly harmful. Non-native species such as rice, wheat, cattle, or poultry provide as much as 98% of the food supply in the United States. European honeybees contribute several billion dollars to the agricultural economy (Pimentel et al. 2005). Invasive alien species also cost an estimated $120 billion annually in the United States (Pimentel et al. 2005). The gypsy moth, although intentionally introduced into the United States for silk production in 1869, escaped from rearing facilities, eventually causing a record 12.9 million acres of forest defoliation by 1981 (Anon. 2003b). Africanized honeybees were introduced in Brazil in 1956 to help revive the Brazilian beekeeping industry. The accidental release of this bee has caused economic, social, and ecological problems throughout South and Central America and now in the southwestern United States (Anon. 2003b).

Biosecurity in a comprehensive sense covers "strategies to assess and manage the risks of infectious diseases, quarantined pests, invasive alien species, living modified organisms, and biological weapons" (Meyerson and Reaser 2002). In this era of globalization and the increased risk of terrorism, the potential for the introduction or malicious use of invasive species and their subsequent spread is more likely. Regardless of their origin, insect invasive species affecting animals or plants can interfere with the well-being of the affected areas' agricultural and have the potential to cause considerable damage. Thus, biosecurity programs require research on invasive insect species that transmit animal diseases and are crop agricultural pests.

For invasive insects in animal and crop systems, the debating teams will address the perspective on the priorities relating to economic losses, prevalence, human impacts, and prevention and management strategies.

Because of modern farming practices, crop diseases are generally well managed. Technological advances have made it possible to engineer plants for higher yields and resistance to pests and diseases. Resistant varieties can be developed in a relatively short period of time.

▲ Pro Position

Elizabeth A. Alexander, Sarah E. Alexander, Anaïs S. Castagnola, Kelly L. Felderhoff, Andrew D. Haddow, Jason A. Hansen, Amanda J. Jacobson, and Michelle E. Rosen
The University of Tennessee

Invasive insect species transmit animal disease organisms, cause veterinary and public health problems, and contribute to economic losses. Occurrence of disease outbreaks abroad and subsequent domestic invasions demonstrate the need to prepare for future incidences of disease. Determining the impact of vector-borne diseases in the United States is aided by research on endemic diseases in foreign countries (Bram et al. 2002, Mackenzie et al. 2004).

Recent geographic expansion of Bluetongue virus (BTV) by *Culicoides* spp. in Europe puts the United States at risk for the introduction of exotic serotypes. BTV causes significant economic losses in sheep and cattle. To prevent spread to disease-free countries, strict trade embargoes prohibit exportation of animals and animal products with evidence of infection (Bram et al. 2002).

Research on invasive species that transmit animal disease organisms is necessary because of the high probability of their introduction. For example, *Aedes albopictus,* the Asian tiger mosquito, has spread to 28 countries including the United States. It is considered the most invasive mosquito in the world and can transmit 22 viruses (Benedict et al. 2007).

In 2005, gross farm receipts for the United States exceeded $200 billion, with crop and livestock production each comprising half that amount (Breeze 2004). While both commodity types contribute equally to the economy, the potential impact of zoonotic disease on human and animal health is of greater concern.

Because of modern farming practices, crop diseases are generally well managed. Technological advances have made it possible to engineer plants for higher yields and resistance to pests and diseases. Resistant varieties can be developed in a relatively short period of time. In addition, Integrated Pest Management practices maintain most plant pests and diseases at acceptable levels (Owens 2002). Animal disease control is seldom so straightforward.

Currently, no vaccines are stockpiled in the United States to protect livestock against vector-borne disease organisms (Breeze 2006). Development of such vaccines could take years and may come too late. Many diseases likely lack an effective vaccine altogether. In some cases, animals have become seropositive after vaccination and are indistinguishable from those that are infected (Bram et al. 2002, Purse et al. 2005, Perry and Stones 2007). This makes disease management difficult. Some vaccines may revert to virulence, which may lead to disease spread (Bram et al. 2002, Purse et al. 2005).

Intensive methods of rearing and processing agricultural animals lead to increased risk of rapid disease organism spread within a population. In the United States, 2% of feedlots produce more than 75% of the nation's cattle. Livestock industries are concentrated in only a few states (Breeze 2004, 2006). This creates high-density populations of susceptible individuals and increases vector-borne disease organism transmission rates. These same diseases can be transferred by transporting infected animals to other facilities.

It is essential to increase research on vectors of livestock disease to protect U.S. agriculture and human health from vector-borne disease organisms (Bram et al. 2002). Seventy-five percent of emerging infectious diseases are zoonotic, having the potential to infect livestock and wildlife as well as human populations (Vorou et al. 2007). Examples include Venezuelan equine encephalitis, African horse sickness, Rift Valley fever and West Nile virus. Competent vectors for all four diseases exist in the United States.

Insect invasive species that transmit animal diseases directly impact livestock, wildlife, and humans (Bengis et al. 2002, USAHA 1998, LaDeau et al. 2007). Their ability to cause veterinary and public health problems, in addition to economic and trade sanctions, will have significant immediate and long-term consequences. Research on invasive insects that transmit animal disease organisms is paramount and must take precedence to prevent future disease and to safeguard human health.

▼ Con Position

Anne L. Nielsen, Joe Ingerson-Mahar, and Jessica L. Ware
Rutgers University

The U.S. agricultural system, comprising animal and crop production, is a vital and sustainable part of the economy. Grain and forage crops such as small grain, rice, alfalfa, soybean, and field corn grown in the United States are the primary elements for livestock feed. Much of the world's protein consumption (80%) is derived from cereal crops (Pimentel 1991). Invasive crop pests threaten this sustaining food supply. To protect these vital food sources, research efforts should remain focused on invasive crop insect pests and pathogens, as they negatively impact the lives of humans and livestock.

Currently, U.S. research funding on animal diseases is less than 10% of the annual federal budget. This level of funding is a logical response to recent conditions in U.S. agriculture. Damage caused by invasive species is estimated at $120–138 billion each year (Evans 2003, Pimentel et al. 2005). Crop losses and control costs due to invasive insects and pathogens were estimated at $25 billion in 2005 (Pimentel et al. 2005). In California alone, invasive insects caused $257.6 million in crop damage in 2003, approximately 67% of the state's annual crop losses (Pimentel et al. 2005, Sumner et al. 2006). California spent $65 million more to control invasive crop pests than to manage animal diseases in the same year, emphasizing the economic importance of invasive crop pests (Sumner et al. 2006). European corn borer costs $1 billion annually in damage and control in the United States (University 2006). The red imported fire ant, a scourge of crops, livestock, and humans, annually causes more than $700 million more in crop damage losses than costs associated with medical and veterinary losses (Flanders and Dree 2007).

With the exception of screwworm, no catastrophic livestock pest has entered recently the United States. Although animal disease management efforts must focus only on potential introductions of foreign species, crop protection involves the monitoring and control of foreign species and the range expansion of established and endemic pests. Glassy-winged sharpshooter has expanded its range in California and vectors the plant disease pathogen *Xyella* to grape and other crops. There have been more than 500 invasive insect crop pests and more than 20,000 invasive crop pathogens introduced thus far into the United States (Pimentel et al. 2005). Research into the establishment of foreign invasive species and range expansions of established and endemic pests must be maintained as a top priority in the United States.

When discussing other areas for research focus, zoonotics are often referred to as a rising concern for human health. Zoonotics are diseases communicable from animals to humans under natural conditions, and in this sense must be insect-vectored. Although zoonotics are a realistic concern, public awareness and agencies outside of agriculture are already confronting these problems. With the exception of West Nile virus, zoonotics have been more of a hypothetical threat, compared to the reality of invasive crop pests. The introduction of animal disease vectors is frequently mediated through anthropogenic transport and is best controlled through port-of-entry inspection, quarantine, and education. Thus, research efforts on plant pest detection and pathways of invasive crop pests should take priority, with the goal of protecting livestock feed and human dietary requirements. Focusing research on invasive crop pests has proven successful in the past and must be continued into the future.

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Debate Moderator and Organizer

W. Vanessa Aponte-Cordero is a Ph.D. candidate working with Gary Felton and Shelby Fleischer in the areas of Chemical Ecology and Pest Management. In 2007, she worked as the ESA-Student Affairs Committee Chair.

Acknowledgments

Special thanks to Gene Reagan for his guidance with the student debate and manuscript review. Thanks to the student debate teams for their manuscript contributions.

Debate Participants

Louisiana State University

Waseem Akbar is a Ph.D. student studying biochemical bases of sugarcane resistance to the sugarcane aphid with Gene Reagan.

Julien M. Beuzelin is a Ph.D. student studying the effects of non-crop hosts and selected cultural practices on population dynamics of stem borers on rice and sugarcane with Gene Reagan.

Jessica Brauch is a Masters of Science student studying ecology of West Nile virus with Wayne Kramer.

Jason C. Hamm is a Ph.D. student studying host plant resistance and induced resistance in rice with Michael J. Stout.

The Pennsylvania State University

Amanda Bachmann is a Ph.D. student researching the population phenology of introduced crop pests under the direction of Shelby Fleischer.

Christina Harris is a Ph.D. student researching plant volatile-mediated interactions between crop pests and parasitoids under the direction of James H. Tumlinson.

Kerry Mauck is a Ph.D. student researching plant-pathogen-vector interactions under the direction of Mark Mescher and Consuelo De Moraes.

Ezra G. Schwartzberg is a Ph.D. student working under the supervision of Jim Tumlinson on the chemical ecology of tritrophic interactions.

Rutgers University

Joe Ingerson-Mahar is a Ph.D. student researching the correlation of morphology and feeding habits of carabid beetles with Jim Lashomb.

Anne L. Nielsen Ph.D. research focus was on the population ecology of an invasive stink bug species, providing basic biological information and monitoring methods to evaluate the potential agricultural impact with George Hamilton. She is currently a post-doc at UC Davis.

Jessica L. Ware Ph.D. project focused on dragonfly systematics, convergence in morphological datasets, wing venation and flight behavior, dictyopteran outgroup selection in molecular datasets, and the influence of model selection on divergence estimation with Mike May and Karl Kjer. She is currently a post-doc at the American Museum of Natural History.

Texas A&M University

Jessica M. Jennings' main interests are public health and vector-borne diseases. She is an avid runner and enjoys training for marathons.

Patricia L. Mullins' main interest is taxonomy of parasitic Hymenoptera, particularly of the family Agaonidae. She enjoys all aspects of Entomology, and outside of school loves to backpack, rock climb, and play volleyball.

Joel D. Keralis' primary interest lies in taxonomy. He also enjoys cooking and traveling, especially backpacking in Europe.

University of Arkansas

Dagne Duguma is a Masters of Science student working on biological control of an invasive species. His research interests are applied and integrated management tactics including biological control, habitat manipulation, cultural practices and insecticide resistance.

Godshen R. Pallipparambil is pursuing his doctoral degree in entomology with a minor in cellular and molecular biology. His interests include plant–insect interaction studies.

Cesar D. Solorzano is a Ph.D. student working on population genetics of the flood water mosquito *Aedes vexans* and its effect on vectoring *Dirofilaria immitis*.

Robin M. Verble is completing a Masters of Science degree in entomology researching the effects of prescribed fire on populations of *Camponotus pennsylvanicus* in oak hickory forests and ants as predators of forest insect pests.

Tara N. Wood is a Masters of Science student working on Japanese beetle oviposition behavior and the effects that various entomopathogenic nematodes and turfgrass species have on beetle larval survival and development.

University of Tennessee

Elizabeth A. Alexander is a Masters of Science recipient that specialized in molecular systematics and plans on pursuing Ph.D. studies.

Sarah E. Alexander is a Masters of Science recipient from the College of Veterinary Medicine and specialized in Public Health.

Anaïs S. Castagnola is working on her Masters of Science degree with Juan Luis Jurist-Fuentes and is focusing on identifying novel midgut growth factors from *Halitosis* viruses.

Kelly L. Felderhoff received her Masters of Science degree and worked on her Ph.D. with Fred Hain at North Carolina State University studying hemlock resistance to the adelgid.

Andrew D. Haddow is a Ph.D. student working with Reid Gerhardt and Carl Jones to determine the epidemiology of La Crosse encephalitis in eastern Tennessee.

Jason A. Hansen is a Ph.D. student studying insect systematics under the direction of John K. Moulton.

Amanda J. Jacobson is a Ph.D. candidate working with John K. Moulton on the systematics of Blephariceridae and black fly suppression.

Michelle E. Rosen is a Masters of Science candidate studying *I. scapularis* and Lyme disease in Tennessee under the direction of Graham Hickling.

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