2002 Student Debates on Medical and Veterinary Entomology

Stuart C. Wooley

The Student Affairs Committee-sponsored Student Debates were established more than 10 years ago and have been well attended at the ESA annual meetings. These debates bring together volunteer student teams from around the country to rigorously present well-researched arguments on controversial but broadly relevant topics.

The 2002 Student Debates focused on issues in Medical and Veterinary Entomology. This topic was chosen for several reasons: the controversial nature of public benefits and concerns of disease control; issues of property, health safety, and economics that are often inherent in vector control; disease research and prevention.

Each team is randomly assigned a topic and position, pro or con, which they debate, despite personal opinions. To set the context for each debate, a five-minute unbiased introduction is given by an outside team. Opening arguments are then given. To encourage a more lively debate and to clarify positions, one three-minute cross-examination period was included after each of the pro or con opening arguments. This seemed helpful to each team and was useful for clarifying and focusing the debate on salient issues. The debate then proceeded with several rebuttals from each side, and a final question-and-answer session with the audience.

> In past years, under the direction of the Student Affairs Committee, debate topics were developed; invitations for participation were sent out to institutions; and teams were selected on a "first come, first served" basis. Of course, all ESA students from any institution are encouraged to participate. The process of organizing the debate begins in spring or early summer. In the summer and fall, teams research and prepare their positions, most often in collaboration with a faculty sponsor. Besides being an exercise in developing persuasive arguments, student–faculty collaboration is an excellent opportunity for both faculty and students to work together toward some resolution of a controversial topic. In addition, at some institutions, seminar credit is given to participating team members.
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> For more detailed information, contact the Chair of the Student Affairs Committee: Rodrigo Krugner, University of California, 5059 Quail Run Rd. Apt. 148, Riverside, CA 92507-6487; 909-781-8476; email, rkrug001@student.ucr.edu. Additional contact information is available at the ESA website, http:www.entsoc.org/Roster/roster.asp?name=Committee_on_Student_Affairs.

ISSUE:

Eradication of insect vectors of disease should receive priority over vector management

Introduction

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Eradication is defined as the "complete and total elimination of a group of organisms from an area" (Pedigo 1989). Under most circumstances, the goal of pest control programs is to manage pest species at acceptable levels; however, the presence of even small populations of disease vectors in an area can seriously affect human health. Consequently, the possibility of eradicating insect disease vectors has been explored. The question currently under debate is whether the socioeconomic costs associated with eradication efforts are justified when devising a control program for insect vectors.

Before undertaking a control program, the biology of each vector species must be addressed. The most appropriate control strategy will depend on the life histories of the pest and the pathogen that it harbors. The feasibility of success will be related to the ecology of vector systems. Insect-borne diseases often span large geographic areas, and controlling individual or local populations of vectors will not necessarily eliminate the target disease. Consequently, control programs must take into account the entire geographic range of the vector or anticipate the inevitable reintroduction or resurgence of the insect and the pathogen it carries.

The economic cost of control efforts is another factor to be considered (Cohn 1972). Theoretically, eradication has a larger annual cost than management programs. However, if successful, the long-term cost of eradication may be relatively less, whereas the perennial cost of managing vector populations is relatively constant. The ultimate economic cost of a decision is not always apparent. For example, costs associated with loss of human life, reductions in human health, or potential environmental impacts of a pest control program are difficult to quantify.

There must be adequate political and economic support to carry a control program through to completion. For instance, to achieve successful completion, areawide management or eradication of an insect vector requires multiple years of funding, the cooperation of property owners, and public support. After the initial stages, management strategies will require maintenance for additional years, whereas eradication will require monitoring for reinfestation. Both strategies may also require environmental clean-up and public education in order to have an appropriate level of support.

The decision to use eradication rather than vector management rests on evaluating the costs and benefits of the programs and their likelihood of success. Cohn (1972) suggests using a systems approach to this assessment—one that is systematic and comprehensive and does not overlook any major inputs or outputs. However, even under the best circumstances, the success or failure of a vector management program is difficult to predict.

▲ Pro Position

Randy M. Hamilton, Eric J. Rebek, and Kurt D. Saltzmann
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Eradication is the destruction of every individual of a species from a geographic area that is sufficiently isolated to prevent reinvasion (Newsom 1978). When considering strategies to combat insect vectors of human disease, eradication should receive priority over management. Over the long term, the social, economic, and environmental costs of managing insect vectors can far exceed the costs of a successful eradication program. Financing long-term management programs can be burdensome for developing countries and lead to accumulation of pesticide residues in the environment. Also, when a vector is managed, disease transmission may not be interrupted (many vectors have been managed for decades, yet disease transmission continues, and in some cases, is on the rise).

Factors contributing to failures in vector management include political, financial, and cultural difficulties in sustaining long-term management; continued disease transmission despite suppressed vector populations; opposition arising from undesirable environmental effects; increasing insecticide resistance; and the prohibitive costs of new pesticides (Collins et al. 2000, Groth et al. 2001). Opponents of eradication will cite examples of past eradication failures. However, in many cases, these programs were ill-conceived, under-funded, or lacked the technical resources necessary to achieve programmatic goals.

> Before undertaking a control program, the biology of each vector species must be addressed. The most appropriate control strategy will depend on the life histories of the pest and the pathogen that it harbors.

For small, incipient populations of exotic vectors, eradication has been very effective (Klassen 1989) and is nearly always preferred over management. Large, well-established vector populations occurring in isolated areas also have been successfully eradicated (Vreyson et al. 2000). Additionally, in certain circumstances, well-established vectors of

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disease can be eradicated from extensive mainland areas (Lindquist et al. 1990, FAO 2002).

Although eradication is not feasible for every vector in every situation, decades of experience and technological advances offer fresh opportunities for success. New technologies are generally more target-specific, less ecologically disruptive, potentially more effective, and offer improved monitoring capabilities. Technological advances include: the use of *Bacillus thuringiensis* (Bt) and biorational pesticides; the potential to introduce heritable lethal traits into wild populations; improved facilities and methods for the sterile insect technique; increased understanding of population genetics; highly sensitive pheromone monitoring; and geographic information systems and remote sensing, which permit better understanding of vector population distributions and their spatial dynamics (Kitron et al. 1996, Collins et al. 2000, Groth et al 2001).

The benefits of entirely removing a vector species from an area are too great not to give priority to this approach. By making eradication a priority, opportunities to eliminate populations and avoid costly, long-term management programs will be identified (Klassen 1989). When deemed feasible, a completely funded and well-organized eradication campaign should be carried out.

▼ Con Position

Erin J. Watson, Andrew J. MacKay, and Glenn R. Oremus
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The devastating effects of arthropod-borne diseases of humans and animals are of tremendous importance globally. Proper vector control incorporates various techniques of integrated vector management (IVM) aiming to suppress and not eradicate the insect populations. IVM is the use of all appropriate technological and management techniques to prevent or reduce human–vector contact, while remaining cost-effective and sustainable (WHO 2001). These programs are flexible, evolving with the changing biology, ecology, and behaviors of targeted vectors.

Eradication entails total and complete removal of an insect vector on a global scale so that intervention measures are no longer required at the completion of a successful program. In contrast, elimination is the suppression or removal of a pest within a defined geographical area. Elimination programs require sustained control measures indefinitely to maintain vector suppression. Thus, if continuous surveillance (e.g., of primary screwworm), barrier treatments (e.g., the tsetse fly), or other sustained control measures are necessary to maintain the absence of a vector, then eradication has not been achieved.

If eradication is feasible, then the following criteria are necessary:

1. The biology, ecology, and behavior of the vector must be comprehensively known.
2. The vector must not be well established or sporadic in occurrence.
3. The vector must cause high economic losses and/or cause negative human health impacts.
4. There must be sufficient financial support.

However, several factors complicate vector eradication:

1. complex life history of vectors,
2. presence of multiple vectors,
3. geography and topography,
4. insecticide resistance and availability of effective insecticides,
5. costly molecular techniques,
6. economics and governmental financial support,
7. community involvement, and
8. vector resurgence.

Vector resurgence often prohibits eradication and is inevitable unless the pest is eradicated globally (Gubler 1998). Reinfestation of *Aedes aegypti* (L.) in the Western Hemisphere (1947–1990s eradication campaign) and resurgence of anopheline mosquitoes following malarial eradication programs demonstrate how vector resurgence will eventually occur when surveillance and control tactics decrease or terminate completely.

Successful eradication programs must produce complete and total removal of the insect vector. Few insect vectors currently can be eradicated because of complex biological and economic factors. In addition, potential for incomplete financial support by all affected countries makes eradication impossible. However, vector suppression or local elimination from a specified area is realistic. Current control programs sponsored by the World Health Organization, such as Roll Back Malaria and Onchocerciasis (river blindness), no longer involve vector eradication, but instead rely on vector suppression, disease prevention, and therapeutic treatments to reduce the worldwide incidence of these diseases. If the world's health authorities have acknowledged that vector eradication is not the answer to disease elimination, why shouldn't we?

ISSUE:

Traditional vector control research should receive higher priority than transgenic efforts to control human and animal disease

Introduction

Stuart Wooley
University of Wisconsin

For centuries, humans have been plagued by vector-borne diseases. Many different ways to avoid or control the vectors have been proposed and tried. For example, eucalyptus was planted in parts of California where malaria was endemic in an effort to "disinfect the water and the air" so that malaria control would be aided. In early investigations (1876), Australia seemed to be "pretty free from virulent endemic or miasmatic fevers, and the latter may be said to exist only as the eucalyptus recedes" (Santos 1997).

Current practices of traditional vector control are much more scientific, and we generally know why they are successful. However, with recent scientific advancements, focus has shifted somewhat from traditional vector control measures (insecticides) to molecular strategies of vector control. Furthermore, there has been an increased focus on using molecular tools to target vectors of disease, including use of transgenic organisms that are incompetent vectors (Ito et al. 2002). A concern is that a shift in funding focus may precipitate a reallocation of funding from traditionally successful disease reduction and vector eradication or control strategies to molecular strategies that have yet to establish a successful track record.

Traditional vector control strategies and transgenic technologies have disadvantages. Insecticide resistance and the impact on nontarget organisms are among the concerns about traditional vector control. Introduction of novel gene combinations and the slow rate of progress in transgenic organisms are some disadvantages of molecular approaches to vector control. Each suffers from huge regulatory hurdles, as well as a measure of public concern and protest, but there are significant advantages to each strategy.

▲ Pro Position

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With the advent and implementation of transgenic technology, much of the funding previously earmarked for research on traditional vector control technologies has been redirected to transgenic research. Although transgenics may have a potential to reduce vector-borne disease, this shift amounts to abandoning proven technologies in favor of hypothetical solutions. A portion of the research funding currently going toward transgenic research must be redirected to researching vector and pathogen biology and ecology, developing novel and better chemistries, and determining factors affecting the development of resistance.

Understanding vector and pathogen biology and ecology is imperative for the success of vector control programs. The large number of vectors, pathogens, and ecological settings influences the intensity and duration of disease transmission, not allowing for a single control strategy for all vectors (World Health Report 1999). Recognizing the most vulnerable stage of a vector and correctly forecasting populations are important for effective vector control. Control strategy design and timing are important for all approaches to vector control.

Traditional vector and pathogen control urgently needs new pesticides and drugs. Combinatorial chemistry, DNA microarray technology, and high-throughput gene expression screening are used to synthesize and discover novel chemistries and identify potential target sites with relatively low cost and high efficiency (Freeman 2000, Hess et al. 2001). These technologies are becoming more important for selectivity and specificity of compounds. Inclusion of vector-borne diseases into pharmaceutical and agricultural protocols will help provide timely solutions as transgenics matures into a more practical option. New chemistries will provide a better opportunity to save lives in the immediate future.

Another goal of traditional vector control research is to determine the factors that cause resistance. Although insecticide resistance has been documented, it has not been a problem in all vector control programs (Hemingway and Ranson 2000). For many control programs, insecticide use is absolutely necessary, particularly when disease outbreaks require immediate control. With a limited number of public-health insecticides, the risk of resistance increases (Hemingway et al. 1997); therefore, research on resistance management is crucial for controlling vector-borne diseases. Agricultural insecticide use can cause resistance in disease vectors as well, an important consideration in endemic areas (Collins and Paskewitz 1995). Varying insecticide treatments and using thresholds might be successful; however, funding and research are needed.

> Understanding vector and pathogen biology and ecology is imperative for the success of vector control programs.

Biology, ecology, development of novel chemistries, and factors affecting the development of resistance are areas needing priority funding. An integrated pest management (or integrated vector control) approach will save lives until transgenics becomes a viable option. However, even with transgenic approaches, traditional vector control will play a major role during outbreaks and emerging vector-borne diseases. Vector control requires a multifaceted approach, and funding should be allocated accordingly.

▼ Con Position

Jason L. Rasgon, Linda M. Styer, and Sharon L. Minnick
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Worldwide, vector-borne diseases cause considerable mortality and morbidity in humans and domestic animals. Because of economic issues, lack of infrastructure, and failure to sustain control efforts, traditional vector control techniques have failed to halt the reemergence and spread of these diseases. It is unlikely that the situation will improve in the future because of the loss of effective insecticides caused by resistance and new regulations, and by the lack of a public health infrastructure in many affected countries. Therefore, in the past decade, high-profile efforts have been made to develop novel disease control approaches based on genetic manipulation of arthropod vectors (Beaty 2000).

Transgenic research has reinvigorated vector biology, drawing in scientists and funding from diverse areas. As a result, enormous strides have been made in the molecular biology of vector insects, culminating in the recent publication of the full genomes of *Anopheles gambiae* (Holt et al. 2002) and *Plasmodium falciparum* (Gardner et al. 2002) and the announcement of transgenic anopheline mosquitoes that are impaired in their ability to transmit *Plasmodium* parasites (Ito et al. 2002).

Transforming vectors to create pathogen-refractory strains is only one of several possible transgenic vector control strategies. Others include transgenic improvements to the sterile insect technique (Alphy 2002), recombinant strains of *Bacillus thuringiensis* (Park et al. 2001), and the genetic manipulation of symbionts (paratransgenesis). Significant progress has been made in paratransgenesis; field trials will soon be conducted to control Chagas disease using paratransgenic kissing bugs (Beard et al. 2002).

Spreading a desired trait into natural populations may be challenging, but potential strategies do exist, including the use of an autonomous transposable element or *Wolbachia* symbiont to drive a trait to high frequency in the population (Beaty 2000).

Whereas transgenic research thus far has focused on developing molecular tools and techniques, future work needs to address vector population biology and safety concerns. Spreading a desired trait into natural populations may be challenging, but potential strategies do exist, including the use of an autonomous transposable element or *Wolbachia* symbiont to drive a trait to high frequency in the population (Beaty 2000). Safety issues can be addressed through laboratory experiments, trials on remote islands, and trials using vectors of animal diseases.

A key benefit of transgenic strategies is their specificity, thus limiting undesirable non-target effects. Transgenic strategies also reduce reliance on environmentally harmful insecticides that are the mainstay of traditional vector control. Although transgenic techniques require large resources initially, they have the potential to be self-sustaining. This provides an advantage over traditional vector control techniques that require large investments from developing nations and adequate infrastructure to implement control measures.

The effectiveness of traditional vector control has been tested and has failed to provide lasting solutions. Transgenic efforts should continue to receive higher priority because they have the potential to provide sustainable relief from the burden of vector-borne diseases.

ISSUE:

Publicly Funded Mosquito Control Efforts in Urban Areas Should Take Precedence over Private Concerns regarding Pesticide Exposure

Introduction

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Pestiferous and disease-carrying mosquito species are a persistent problem in urban areas. The primary mandate of mosquito control organizations is to protect their constituents from exposure to mosquito-borne pathogens and the nuisance aspect of large populations of mosquitoes. Urban mosquito control often involves the use of synthetic insecticides on public and private land. Many groups and individuals are opposed to pesticide use within their community because of concerns about exposure to real and perceived risks to human health and the environment.

The U.S. Environmental Protection Agency (EPA) requires that all new insecticides be subject to a rigorous registration process to identify any potential risk to human health or the environment. The EPA considers insecticides used for mosquito control in the United States as posing no “unreasonable” threat to human health when applied according to label restrictions (EPA 2000). However, concerns have been expressed that there is insufficient information on the long-term effects of exposure to these chemicals. Most toxicological studies are short-term tests that are theoretically extrapolated to assess long-term effects (Cantelli-Forti et al. 1993).

Most mosquito control programs place an emphasis on reducing mosquito populations by source reduction and the use of larvicides. However, the ues of adulticides may be required when populations reach a high enough level to constitute a major nuisance problem or public health risk. Much of the opposition to urban mosquito control is focused on the widespread application of adulticides, which has been shown to be effective in reducing adult mosquito populations (Gratz 1991). However, improper application may result in ineffective control, a waste of money, and negative public relations.

Urban mosquito control is a very controversial subject. Proponents for proactive mosquito control programs often cite the risks posed by exposure to mosquito-borne pathogens, and the discomfort experienced when adult populations are high. Opponents to the use of pesticides for mosquito control stress that human morbidity and mortality associated with mosquito-borne pathogens is very low in the United States and Canada. They suggest that the known and unknown costs of widespread pesticide use in urban areas may be greater than the benefits of reducing mosquito populations. Both groups are often vocal and may exert considerable pressure on state and local governments. With the recent introduction of the West Nile virus into North America, the debate over the validity and safety of urban mosquito control is likely to increase.

Pro Position

Stuart Wooley
University of Wisconsin

Urban mosquito control is directed at alleviating the nuisance of mosquitoes and other pest insects and at preventing disease. In areas where vector-borne diseases are not a serious health threat, nuisance pests are the primary targets, but this has caused concerns regarding the safety of pesticide applications in urban centers. Because of the rapidity with which vector-borne diseases can spread through urban communities, it is important that publicly funded mosquito control efforts take precedence over private concerns about pesticide exposure.

Historically, vector control has involved spraying pesticides, most famously DDT, among the populace with little regard for human exposure. Today, this practice has been discontinued, and issues of exposure are more prominent. When vector control involves insecticides, many precautions are taken to reduce exposure to humans and nontarget organisms. These precautions include using ultra-low volume (ULV) sprayers (220 ml/ha) and spraying when humans are indoors (Rose 2001), thus reducing the negative effects of spraying (i.e., health concerns) to generally acceptable levels.

Urban mosquito control is a very controversial subject. Proponents for proactive mosquito control programs often cite the risks posed by exposure to mosquito-borne pathogens, and the discomfort experienced when adult populations are high.

Alternative methods of vector control also can be used. For example, introduction of dragonfly nymphs, mosquito fish, and other biological control methods are receiving deserved attention. But these are costly enterprises; and for many communities that lack the resources, pesticides are the only cost-effective alternative (Rose 2001). Additionally, in areas where mosquitoes are abundant, biological control agents are often ineffective when compared with pesticide applications (Rupp 2001). In areas where insect populations are high, especially following storms or droughts (Chase and Knight 2003), vector-borne diseases may be more likely to spread, especially if the disease is already widespread in the population. Public health concerns (e.g., avoiding encephalitis outbreaks) should take precedence over concerns about pesticide spraying.

With increasing globalization and introductions of new pests into novel areas, we have seen the emergence of new vector-borne diseases (e.g., West Nile virus). Increasingly, pesticide use must continue to control the spread of disease in a previously unexposed population (Goddard 2002). While pesticide is currently widely used to control nuisance pests (Rose 2001), the potential health effects of an introduction of a competent vector of disease could be serious, especially if there were no potential to launch a major chemical control effort. Moreover, with the loss of effective pesticides for controlling vector-borne disease for several reasons (e.g., loss of registration), public funding to research safe, effective chemical control methods is urgently needed (Zaim and Guillet 2002).

Finally, the significant concerns of the few must be taken into account when possible, but they cannot be allowed to override the public health needs of the many. Indeed, if there is a significant public health concern, as determined by a competent scientific and medical authority, the vocal minority should not be allowed to trample the needs of the majority. Unfortunately, in the United States, there is a strong tendency for government to respond to the squeakiest wheel even if it isn't the one needing the most grease. Even though scare tactics and pseudoscience often seem to hold sway, public concerns should outweigh private concerns, particularly when public health is at stake.

Con Position

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Clemson University

Urban mosquito control is directed at vector management and biting fly control. Because there are laws that override private and personal freedoms to control a real disease epidemic, we will not debate that issue. Pesticide application often is seen as the primary method to control mosquitoes. In an urban situation where mosquito-borne disease agents are not posing a serious threat to humans or domestic animals, publicly funded mosquito control efforts should not take precedence over private concerns about pesticide exposure.

Although it is true that malaria killed more than 20,000 people in one epidemic in 1880, there is a relatively low risk of mosquito-borne illness in the continental United States. West Nile virus has captured media attention as a ravaging epidemic, but serologic surveys of Romanian and U.S. outbreaks indicate that neurological symptoms occur in less than 1% of the infected individuals; mortality occurs in only 5–14% of these same individuals (Petersen and Roehrig 2001). Under these circumstances, the possible allergic responses and hazards of pesticide applications outweigh the risk of vector-borne disease.

When the goal of mosquito control is pest management, the nuisance properties of pesticide application must be considered. Thermal foggers produce clouds of hot, rancid pesticide fog and in some situations can cause explosions, cover vehicles with grease, and even temporarily blind drivers (Rose 2001). Pesticide labels state that the chemicals used are not considered a risk when applied according to the label by a trained applicator. In some locales, children on bicycles have been observed chasing the fogging vehicles (Rose 2001). That is certainly not indicated on the label. Many pesticides impact nontarget species (Rose 2001), and even "environmentally friendly" alternatives can affect nontarget species (Batzer and Resh 1992).

Pesticide application can itself cause economic damage. The application of pesticides to control biting flies is expensive. For example, at a South Carolina golf course, a biting fly control program cost more than $12,000 per year (Gray et al. 1996). In situations of mosquito attacks, DEET works well and instantly for the few golfers present and reduces the costs of control to the facility. Unless the economic damage outweighs the cost of application, private concerns should outweigh the need to spray.

Pesticides are not always effective as mosquito control agents. In Florida, for example, Curtis and Carlson (1990) determined that naled applied as a thermal fog was ineffective in controlling some daytime-biting mosquitoes. Citizens should object to the waste of public funds if the pesticide applications do not work, but instead potentially expose them to dangerous or noxious chemicals.

Pesticide labels state that the chemicals used are not considered a risk when applied according to the label by a trained applicator. In some locales, children on bicycles have been observed chasing the fogging vehicles

A final aspect for consideration is that ignoring public concerns to pesticide application and exposure may further strengthen the already strong aversion to publicly funded mosquito control efforts among some segments of the population. When a major public health threat emerges, a well-organized group of pesticide-opposing citizens and new laws could actually delay needed control efforts.

ISSUE:

The Federal Government Should Support the Use of Pesticides Previously Banned in the United States to Fight Vector-Borne Diseases in Developing Countries

Introduction

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Each year vector-borne diseases such as malaria, dengue, and leishmaniasis kill millions of people worldwide. Although a few of these diseases have clinical cures or vaccines, most are controlled by insecticides directed at vectors. Currently the World

Health Organization (WHO) lists 36 insecticides that are specified for public health use, including carbamates, organophosphates, pyrethroids, and DDT (WHO 2003).

DDT has a long history of use for vector-borne disease control. During WWII, DDT was used to protect troops against typhus (Ritter et al. 1995), and in the 1950s and 1960s, DDT was widely used during the global initiative to eradicate malaria (Attaran et al. 2000). Our understanding of DDT and other insecticides changed dramatically in 1962 with the publication of Rachel Carson's *Silent Spring*, which linked indiscriminant and irresponsible use of this pesticide with the disappearance of songbirds and raptors. Within 10 years, most developed countries, including the United States, banned the use of DDT primarily because of its presumed harmful effects on wildlife and the environment (Curtis 1994). The realization that pesticides could harm humans and the environment led to further pesticide bans and higher safety standards for new pesticides. In 2001, a worldwide ban of DDT and other Persistent Organic Pollutants was established at the Stockholm Convention (United Nations Environment Programme 2002). Because of DDT's importance in controlling vector-borne diseases, an exception has been made to allow continued production and use of this chemical for vector control until safe, affordable, and effective alternatives are in place.

The current debate centers on whether the United States should support the use of pesticides previously banned in this country to fight vector-borne diseases in developing countries. Pesticides, such as DDT, are known to persist in the environment and become biomagnified as they move through the food chain. However, the quantities used in public health in developing countries constitute a fraction of worldwide pesticide use and thus environmental effects should be minimal (Attaran et al. 2000). DDT also has been linked to various human cancers and lower sperm counts. However, negative health effects due to pesticides should be weighed against the benefits of fewer cases of vector-borne disease (Curtis and Lines 2000). Alternative, environmentally friendly pesticides have been used for vector control; however, they are often more expensive and not as effective as DDT (Walker 2000).

The realization that pesticides could harm humans and the environment led to further pesticide bans and higher safety standards for new pesticides. In 2001, a worldwide ban of DDT and other Persistent Organic Pollutants was established at the Stockholm Convention (United Nations Environment Programme 2002).

If the United States bans a chemical because of safety concerns, is it ethical to encourage other countries to use it? Should developing countries be forced to abandon DDT, one of the few affordable methods effective in preventing malaria, when malaria rates are increasing? The debate surrounding banned pesticides will likely continue until affordable and effective alternatives to vector-borne disease control are found.

▲ Pro Position

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Extensive effort is being put into controlling vector-borne diseases with environmental, biological, and immunologic methods. However, the fact remains that in many cases chemical pesticides are the only available alternative. Although there is much speculation on the effects of DDT, the high financial cost involved in the research, development, testing, and required registration for a single alternative pesticide is approximately $50 million (Gratz and Jany 1994). In countries where DDT has been banned, the cost of alternatives consumes a much greater portion of the already limited budget dedicated to the control of vector-borne diseases. In addition, new chemicals may not prove to be as effective or as safe as DDT.

Insecticides used in vector-borne disease control programs are primarily used as residual sprays indoors, resulting in little environmental impact. Research has shown that a large house can be treated with a surface concentration of 2 g/m^2 once a year with 0.5 kg DDT (Attaran et al. 2000). This application rate translates financially to $1.44/house/year. An inverse correlation was shown linking the number of malaria cases directly to the number of houses sprayed. Also, discontinued spraying resulted in an elevated level of reported cases (Roberts et al. 1997). Even though resistance to DDT has been documented, the vector populations carrying this resistance are still low in most cases. As for the use of DDT in malaria control programs, even the Director General of WHO stated "indoor spraying of DDT in routine antimalarial operations does not involve a significant risk to man and wildlife" (World Health Organization 2002).

Although the United Nations Environment Programme (UNEP) headed the charge to ban the use of DDT and other persistent organic pollutants, almost 400 scientists signed a letter to the diplomat stating simply "The scientific literature is unpersuasive of the need to withdraw DDT; on the contrary, it is

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clear that doing so risks making malaria control ineffective, unaffordable, or both" (Attaran et al. 2000). Even the environmental group, Physicians for Social Responsibility, conceded that DDT is "highly effective" in malaria control (Attaran et al. 2000). Eliminating DDT, possibly the most cost-effective chemical, for use in vector control without better supporting evidence, would carry a heavy toll on the lives of millions of people in the endemic countries of these diseases.

▼ Con Position

Kelly Cook, Lauren Kent, Jonathan Lundgren, and Erin Marlow
University of Illinois

The U.S. Environmental Protection Agency (EPA) has banned the application of several organochlorine insecticides previously used in vector control because of their persistence in the environment, harmful effects on wildlife, adverse effects on human health, and the availability of cost-competitive alternatives that pose fewer risks (Anon. 2002). Despite the U.S. ban on organochlorines, DDT is still approved for use in vector control in some countries (World Wildlife Fund 1995).

DDT has a stable chemical structure that is highly persistent and subject to little biodegradation. Its half-life can be as long as 22 years in water, and its metabolite, DDD, has a soil half-life of approximately 190 years (World Wildlife Fund 1995). DDT is fat-soluble and can accumulate in animal tissues quickly, even at low concentrations. In addition to its invertebrate toxicity, DDT is harmful to many vertebrates, including fish, birds, mammals, and amphibians (Extension Toxicology Network 1996).

DDT and other banned pesticides are associated with a number of human diseases and disorders. DDT is passed from mothers to infants via breast milk, and is linked to human breast and pancreatic cancer, depressed nervous system function in children, increased rates of preterm births, and decreased birth weights in infants (Curtis 1994, World Wildlife Fund 1995). Other banned pesticides are acutely toxic to humans, and human fatalities have been reported from exposure to aldrin, endrin, and dieldrin.

Alternative vector controls that are more compatible with environmental and human safety are now cost-competitive with DDT, which is viewed as inexpensive. Furthermore, it is assumed that substitute insecticides are more expensive and require more frequent application. In reality, some organophosphate, carbamate, or pyrethroid insecticides applied as residual sprays, ultra-low volume mists, and in impregnated bednets can be more efficient and cheaper than DDT residual sprays (Curtis 1994, Schiff 2002). The comparative effectiveness of these alternatives is made even greater by resistance to DDT in populations of about 85% of mosquito species that transmit malaria (Metcalf 1989).

DDT and other banned pesticides were valuable when few means of control for disease vectors existed. However, alternative control strategies have been developed that are less expensive and more efficient than organochlorines. These alternatives eliminate our dependence upon the use of DDT. In light of the availability of effective alternatives and the harmful effects that banned pesticides have on human health and the environment, the United States should not support the use of banned pesticides.

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The Pennsylvania State University team also participated in the oral arguments of these debates.