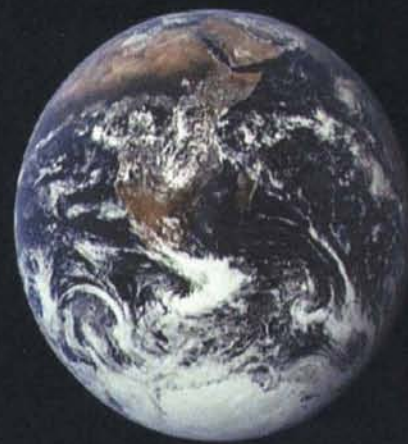
International Issues in Entomology: A Student Debate

Leslie L. Allee, Editor



The graduate student debates at the Entomological Society of America's Annual Meeting encourage graduate students to become active participants in the broader scientific and policy debates that affect entomology and provide a forum to raise the awareness among all entomologists of timely issues affecting science and society. Initiated in 1993 by Doctors George Kennedy and Fred Gould, the debates are now organized for the annual meeting by the Student Affairs Committee. Summary statements from previous debates on such topics as environmental issues associated with enhancing the impact of biological control agents (Gould et al. 1996) and on issues in ecologically sound integrated pest management (Whitaker 1998) have been published in this forum. Other debates have addressed issues related to pesticidal transgenic plants, conservation of insect biodiversity, and professional ethics.

Each annual debate consists of a collection of statements related to a broad topic. The specific format for the debate evolves each year in response to suggestions from participants. For each debate statement, students present an objective background statement describing the historical development of the issue (10 minutes), one team argues the statement is true (pro position), and one team argues that the statement is false (con position). After the pro and con statements (10 minutes each), each team has two rebuttal opportunities (3 minutes each), taken in turns, to respond to the opposing position. The remainder of the hour allotted for each statement is used for questions and lively discussion with the audience.

This article contains summaries of background and position statements presented during the debate on International Issues in Entomology at the 1997 Annual Meeting in Nashville, TN. Each pro or con position statement, although authored by the students noted below, was assigned randomly and might not represent the actual opinions of the individual authors. For each statement, information is presented to support only the position assigned; a balanced view may be gained by reading both the pro and con statements.

Participation in the debates is open to all students from entomology and related university departments. Teams are organized and debate topics generated during the spring or early fall. Departments commit to sending a team of one or more students to the ESA Annual Meeting and to providing a faculty advisor. Participation is encouraged through invitations sent to the chair of every department, announcements in the *ESA Newsletter,* and personal contacts. Preparation for the debates occurs during the fall. Through formal seminars or informal discussion groups, students research and study the issues, debate the pro and con positions, and prepare presentations of randomly assigned positions. If you are interested in participating in these debates as a student, faculty advisor, or department, or have suggestions for future debate topics, please contact the ESA Student Affairs Committee.

Acknowledgments

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pact of biological control agents: a student debate. Am. Entomol. 42: 160–173.
Whitaker, P. 1998. Important issues in ecologically sound integrated pest management. A student debate. Am. Entomol. 44: 148–165.

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Topic:

Certain Pesticides Banned in Their Countries of Manufacture But Exported to Other Countries Should be Banned Worldwide

☞ BACKGROUND

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HUMAN SOCIETIES DEPEND ON VARIOUS TECHNOLOGIES, including pesticide use, to produce food and reduce incidence of epidemics of diseases. Unfortunately, problems associated with pesticides have clouded their positive contributions.

The world's grain harvest has almost tripled since the 1950s, mostly through intensified agriculture. The "green revolution" in developing countries was the result of the transfer and dissemination of high-yielding seed that proved vulnerable to arthropod pests, promoting increased pesticide use. Nevertheless, grain-yield increases managed to keep ahead of population growth during 1950–1980 (Brown 1997).

Epidemics of diseases have shaped human culture profoundly, even influencing the outcome of historical events. Insect-borne diseases have killed more people than has war, and frequently they have been decisive in determining military outcomes. Military and public health officials rapidly adopted use of effective and cheap insecticides developed to kill insect vectors. The decrease in the incidence of many diseases was dramatic, especially in tropical countries. From a perspective of disease prevention and food production, compounds such as DDT literally saved millions of lives and countless tons of food.

Indiscriminant spraying against crop pests and disease vectors soon led to selection of resistance among arthropod pests, prompting the use of increasing dosages and development of more effective but also more expensive pesticides. This race continues, and in some cases pesticide failure has caused localized crop abandonment. In addition, nontarget organisms have been affected adversely, frequently causing new pest problems by eliminating parasites and predators and thus encouraging increased dependence on pesticides. Some compounds accumulated and magnified in the food chain, even appearing in mothers' milk where they were passed to the next generation. Some of these pesticides can spread thousands of miles from their origin and are associated with chronic illnesses, neurological defects, reproductive anomalies, and cancer (PANUPS 1995, Vitousek 1997). Such associations eventually led many industrialized countries to ban the use of some compounds, despite opposition from the chemical industry. The increasing exposure of humans to synthetic chemicals parallels an increase in the overall incidence of different kinds of cancer and other illnesses. Although causes have not always been established, there is growing evidence that such connections exist.

Manufacture of many banned pesticides continues in countries that prohibit their domestic use but export them to countries without bans. Most of the importers are developing countries with pressing needs to feed a growing populace and with urgent public health problems because of vector-borne diseases. In many of these countries, resources for managing problems associated with these compounds are limited, and it is in these countries where most poisonings and deaths occur (Jacobo et al. 1993). An international, voluntary program designed to notify governments about hazardous pesticide imports exists, but should the import of hazardous pesticides be banned? Given that commercialization is the front line of globalization, is the sale of these compounds another expression of the free market? Is it unjust to require poor countries to buy safer but more expensive pesticides that may be less effective?

Relentless population growth, urbanization, increased consumerism, and degradation of cropland worldwide suggests that agriculture worldwide will become increasingly intensive. Within 25 years, farmers will be asked to feed 30% more people. Not only has grain production dropped and reserves have shrunk, but most major fisheries suffer serious depletion (Brown 1997), thus further compounding the food problem. Can continued use of banned, environmentally detrimental compounds be justified solely for the sake of production of more food? The public health outlook also is challenging, with many trends pointing to increased reliance on chemical control. Epidemics of diseases that were once under control are increasing as is the increased potential for new diseases. Global warming will cause shifts in the geographic range of vector-borne diseases, which will promote increased reproductive and biting rates and shorten the pathogen's incubation periods (Bright 1997). More introductions are occurring of potential vectors into new areas. The increasing concentration of people in slums and shantytowns favors epidemics. Does the short-term prospect of lives saved from disease outweigh the health and environmental problems associated with using these banned pesticides?

Acknowledgments

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PRO POSITION

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In 1985, the Pesticide Action Network (PAN), an international coalition supporting safe, sustainable pest control methods, initiated a campaign to impose strict controls and bans on highly hazardous pesticides. These pesticides were selected either because of their acute mammalian toxicity or their tendencies to bioaccumulate or contaminate ground water (Dinham 1995). By 1995, the PAN's list included aldicarb, aldrin, camphechlor, chlordane, chlordimeform, DBCP, DDT, dieldrin, EDB, endrin, HCH/BHC, heptachlor, lindane, methyl parathion, parathion, and PCP. Now widely restricted because of their known harmful effects, these pesticides nevertheless are still manufactured, exported, and used in many countries (Dinham 1995).

The inadequacies of international regulations and the environmental impacts of these pesticides are obvious and leave global banning as the most responsible policy.

Pesticides banned in the countries of manufacture should be prohibited at the global level for the following four reasons: (1) these pesticides are extremely hazardous and are already banned by many nations, (2) many developing countries lack adequate law enforcement, financial resources, knowledge, and training for safe pesticide use, (3) pesticides may have environmental impact beyond their country of use, and (4) the current international efforts to restrict pesticide trade are not sufficient to protect humans and the environment from potential harm.

The World Health Organization (WHO) classified aldicarb, aldrin, and methyl parathion as extremely hazardous based on acute mammalian toxicity (Dinham 1995). Aldicarb is one of the most common pesticides found in groundwater in the United States, and the situation must be similar in many other countries (Pimentel 1996). Organochlorines, such as chlordane, DDT, and BHC, are environmentally hazardous because of their bioaccumulation. In India, DDT and BHC account for approximately 70% of the total pesticide used, and their use is doubling every 6 years (Pimentel 1996). These pesticides need to be banned because of their harmful effects to humans and other nontarget organisms, as well as the environment.

Pesticides are often applied in unsafe ways in developing countries. Farmers often cannot read complex labeling and seldom can afford protective clothing and equipment (Dinham 1995). Poisoning by pesticides is widespread. In 1995, in China, 48,000 people were poisoned by pesticides and 3,204 farmers died as a result (FAO 1997a). Many developing countries have difficulty regulating pesticide use and enforcing restrictions on trade (Dinham 1995).

Chemical residues may cross international borders through air, water, or export of contaminated food; thus, international regulation is appropriate. Wind currents carry DDT into the northern latitudes from the tropics where it still is used widely (Wania and Mackay 1996). Organochlorine residues have been detected even in the Arctic Ocean and are accumulating in marine mammals (Mossner and Ballschmiter 1997). In the United States, 25% of all fresh and frozen products come from developing countries (Miller 1990). Thus, regulating the use of hazardous pesticides only within a country does not ensure food safety.

Current world regulatory programs, such as the International Code of Conduct (ICC) on the Distribution and Use of Pesticides, and the Prior Informed Consent (PIC) procedure, although a step in the right direction, are inadequate. The ICC was designed in 1985 to establish responsibilities and voluntary standards of conduct for all public and private entities engaged in or affecting the distribution and use of pesticides. Unfortunately, 30% of the signatory nations are not observing the ICC (FAO 1997b). The PIC (amended to the ICC in 1989) allows national governments to decide whether they wish to permit importation of chemicals that are banned or severely restricted in other countries (Dinham 1995). Under the PIC, exporting countries are required to inform receiving countries when shipping PIC-listed pesticides. However, the PIC is voluntary and does not include insecticides such as aldicarb, campheclor, and endrin (FAO/UNEP 1997).

The inadequacies of international regulations and the environmental impacts of these pesticides are obvious and leave global banning as the most responsible policy. A ban will simplify regulation because all supplies, movement, and use will be illegal everywhere. A ban will help stifle black markets that thrive because legal manufacture and stockpiles provide supplies for illegal trade. A ban will protect the environment by eliminating materials that can move globally by wind and ocean currents. A ban will encourage the use of less hazardous materials and stimulate research and extension efforts on integrated pest management practices for agricultural and medical pests. At least until global infrastructure, education, regulation, and enforcement capabilities are better developed, a ban will protect humans and the environment from these pesticides.

Acknowledgments

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CON POSITION

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IT IS NOT SURPRISING THAT A WORLDWIDE BAN on certain pesticides is considered medically and environmentally sound within nations that already have banned domestic use of most of the compounds in question. Although these nations recognize the detrimental health and environmental effects associated with the use of certain pesticides, they must appreciate the socioeconomic, environmental, and health conditions necessitating their continued use in other countries. Even though a long-term effort to replace these compounds is imperative, decisions to ban their use must remain the domain of sovereign nations.

Continued use of certain pesticides in other countries is necessary where the use of recommended alternatives is not feasible for reasons including expense, cultural barriers, lack of efficacy, and pesticide-related health hazards. The necessity for continued use of some hazardous pesticides can be exemplified by control of disease vectors. In Africa alone, more than 1 million people die from malaria each year, including 1 in 20 children under the age of 5 years. Further, 2.2 billion people, or 40% of the world's population, are at risk of contracting malaria (WHO 1993). Malaria is controlled primarily with DDT and malathion. According to the World Health Organization, chemical alternatives to DDT often are more hazardous and prohibitively expensive. One nonchemical alternative being investigated is the use of *Bacillus thuringiensis* Berliner to control mosquito larvae. However, because this alternative is expensive, lacks persistence, and can be applied only during the dry season, it cannot fully replace current chemical controls (WHO 1995). Measures, such as biological control, cultural or mechanical controls, and integrated pest management (IPM), that reduce or eliminate chemical control of agricultural pests and disease vectors often are situation-specific, require detailed knowledge of the pest complex, and are not amenable to immediate widespread adoption. Thus, although a worldwide ban ideally would alleviate some of the hazards associated with pesticide misuse, essential uses also would be eliminated.

Continued use of certain pesticides in other countries is necessary where the use of recommended alternatives is not feasible for reasons including expense, cultural barriers, lack of efficacy, and pesticide-related health hazards.

Where the reasons for a ban concern human health and the conditions of use, all factors that result in misuse of pesticides must be dealt with to ensure safe and judicious application. The factors involved are numerous and include improper labeling and handling, improper storage and disposal, poor access to information in local languages, and lack of registration and monitoring of pesticide use. In the absence of effective product stewardship, new and "safer" pesticides also may pose problems. For example, cotton workers in China have experienced dizziness, muscle contractions, and convulsions following use of several pyrethroids (Charbonneau 1989). Further, should a ban occur, would it be effective? The United States, for example, has no record of the exact identity of 74% of the pesticides they export, and an estimated 100 million pounds of the pesticides shipped around the world cannot be traced (Smith 1993). A ban that cannot be enforced may give a false impression of security without actually solving any problems. Finally, banning certain pesticides may result in increased trade in other hazardous pesticides, including those for which registration has been rejected in their countries of manufacture.

The United Nations has been developing international agreements on the safe distribution, use, and disposal of hazardous chemicals; these agreements include the protocol on Persistent Organic Pollutants (IFCS 1996) and the Prior Informed Consent procedure (FAO/UNEP 1997). The approaches taken by the international community must be continued and strengthened for effective and sustainable change. Perhaps the money, time, and expertise required to implement a worldwide ban would be spent better by working in partnership with pesticide users to find safe and sustainable alternatives and to facilitate the establishment of education and extension programs for proper use of potentially hazardous chemicals. A worldwide ban is neither an effective nor a desirable solution to the problems associated with use of hazardous pesticides.

Acknowledgments

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Topic:

Should Type Specimens of Insects Indigenous to One Country but Housed in Another be Returned to Their Country of Origin?

BACKGROUND

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The International Code of Zoological Nomenclature (ICZN 1985) contains little information on type specimen deposition, stating only that type specimens must be available to the scientific community. Only neotypes must be deposited in a public repository. All other types (e.g., holotypes, paratypes, lectotypes) may be deposited in an institution of the author's choice. It is the biological community, including taxonomists, that would be affected most by changes in the location of type specimens. However, one also must consider political/governmental implications and practical issues of implementation, especially if repatriation is to be retroactive. The following debate will address not only academic concerns but also important political and economic elements related to the location of type specimens.

As biodiversity increasingly becomes a commodity, the issue of its ownership must be addressed. Who owns the biodiversity of a given region or country? What does this ownership mean? In reference to ownership, type specimens can be viewed (1) as representative of a species, (2) as a physical specimen, and (3) as the bearer of a proposed name. Which of these facets is emphasized has strong bearings on ownership. When governments possess species within their borders, they could lay claim to types representing endemic species. Widespread or migratory species are problematic. As physical specimens, type material collected from a country also could be claimed. However, a type specimen's primary value is as the bearer of a particular name, an attribute given to the particular specimen by the describing author. As such, claims of ownership could be made by the author or the author's country.

Economically, the issue of where type specimens are deposited involves the potential benefits of ownership balanced by the costs of maintenance and accessibility. Type specimens are more valuable to museums than nontype material. This is illustrated by the U.S. government's policy of granting tax write-offs for the donation of specimens to public museums. A tax write-off of $290.00 is given for the donation of a holotype, whereas nontype material of the same species receives only $3.00. Institutions do not profit directly from their type specimens. Rather, the types increase the scientific importance of a museum's holdings thereby affecting the museum's ability to acquire governmental funding, private endowments, and additional donations of specimens.

Museums with many type specimens (e.g., British Museum) receive hundreds of visitors annually who stay in local hotels, eat in local restaurants, and use local transportation. This economic influx, negligible in large cities, could be substantial in developing countries with weaker economies. However, economic benefits must be weighed against the high costs of maintaining a sound and environmentally stable building to protect type specimens, other materials, cabinets, drawers, and insect pins. Further, curators must be hired to monitor specimens for dampness, mold, and insect damage. Protection against theft and vandalism also must be considered. Museums that ship specimens to researchers also will have to pay for packaging material, person-hours to prepare and register loan material, and postage. Questions as to the ability of particular countries to meet these demands are real. The stability of local governments as well as economic support for institutions housing collections cannot be taken for granted.

Superimposed over national and institutional interests are the interests of individual taxonomists. Repatriation of type material would not affect all taxonomists equally because it would affect monographic, phylogenetic, and faunistic studies unequally. Monographic revisions and phylogenetic research are defined taxonomically and involve determining nomenclature and species limits for superspecific taxa. Revisors must examine type material for all names proposed within their group. If an institution cannot afford to ship the required types, individual researchers incur these costs or visit the museum. Thus, a researcher doing this kind of research prefers to have types housed in fewer, well-funded institutions. Repatriation would increase the number of museums housing types for a given taxon because most superspecific taxa (e.g., genera) contain species from more than one country.

In comparison, faunistic studies are defined regionally and are often conducted by researchers who live near or within the region they are studying. For these researchers, travel/shipping costs of viewing type material would be reduced if types were located locally (although some widespread taxa still might be housed in foreign collections). In regions with poorly known biotas, maintaining types near the type locality would facilitate identification of new species. However, para-types and accurately identified reference collections also could serve this purpose.

Returning type specimens to institutions near the type locality raises important issues of implementation. How would the type locality be determined for type specimens with vague locality information (e.g., "Africa") or specimens collected from political regions that no longer exist or have had variable boundaries (e.g., Surinam or Ecuador)? Also, older types often are not distinguished from other material, making their recognition difficult and time consuming. Last, who will bear the economic burden of implementing a repatriation program requiring thousands of work hours to locate, recognize, package, and ship types? However, if type specimens remain where they are, taxonomists from countries with few types will continue to be frustrated unless they acquire the necessary resources to visit foreign institutions. The following debate should help to clarify these two positions and allow both perspectives to be compared and evaluated for their relative merits.

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PRO POSITION

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TYPE SPECIMENS DEPOSITED IN THEIR COUNTRIES OF ORIGIN can become a catalyst for greater exchange of scientific information and increased accessibility to type specimens by native scientists. Important cultural aspects of this issue, including national patrimony and natural heritage of native peoples, also must be considered.

Type specimens housed in their country of origin will lead to reciprocal benefits for local researchers and scientists abroad. Systematic research often requires the study of type specimens and is encouraged when the type specimen is readily available for study. Scientists from other countries who wish to study a particular species need to contact the local repository housing the type specimen(s). Not only will the visiting scientist gain valuable information, but local scientists will learn from the experiences of the visiting scientist. Use of collections by the local research community will facilitate the education of local people, making them more aware of their rich natural heritage. The National Institute for Biodiversity in Costa Rica already has implemented this approach. Local people are trained as parataxonomists and play an integral role in tropical biodiversity surveys. The project is producing valuable taxonomic knowledge and data and serves to promote conservation of biodiversity as local people learn to value their rich natural heritage by participating in its discovery (Gutierrez 1992). Clearly, depositing type specimens in their country of origin will not hinder research but will enhance it.

Type specimens deposited in their countries of origin can become a catalyst for greater exchange of scientific information and increased accessibility to type specimens by native scientists.

The cultural aspects of returning type specimens to their countries of origin can be summed up by the concept of patrimony. Patrimony is defined as the cultural and natural heritage of a country and includes the importance given to an object when it becomes a symbol for that country. It is our belief that nature is an integral aspect of culture. In all human cultures, symbols of nature have come to stand for national pride. Some examples in the United States are the bald eagle, the bison, and the giant redwood. These symbols represent our pride of having these species in our country, and hence they are protected and conserved. Type specimens are considered patrimony because they reflect the biodiversity and natural heritage of a nation. When type specimens are not housed in their country of origin, there is no official representation of that species and, hence, no official representation of the true biodiversity of that country.

In conclusion, there are two fundamental reasons why type specimens should be returned to their countries of origin. First, the placement of the type specimen in the care of its native country will enhance the advancement of local taxonomy and comparative systematics. As stated in *The Ichneumonidae of Costa Rica* by Ian Gauld, "We commend this form of collaboration between institutes in tropical and temperate countries not only as the most effective way of developing the basic taxonomic understanding of tropical biodiversity, but also of transferring this essential expertise to tropical countries so that local scientists can develop their own biological expertise and indigenous popular literature to underpin conservation efforts" (Gauld 1991). Second, the concept of patrimony applies to type specimens in that they are cultural objects of a nation. Type specimens are official representations of a species and without type specimens these symbols of a nation's natural history and biodiversity are missing. Thus it is essential that type specimens be returned and kept in their country of origin.

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CON POSITION

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THE PRIMARY CONCERN IN PLACEMENT OF TYPE SPECIMENS is their long-term preservation. Loss of type specimens is loss of biological history. The repatriation of type specimens to their country of origin should not occur for several reasons. First, cost could prevent repatriation to many countries. Maintaining and housing type specimens is expensive. The Natural History Museum in London is a large, established museum, with operating costs for its insect collection totaling 1.5 million pounds annually (Quicke 1993). Many nations would be unprepared to assume the cost of managing these valuable collections. Unknown costs associated with type specimens also make this goal untenable. David Furth of the National Museum of Natural History in Washington, DC, states that "although difficult to estimate, there is a real cost associated with the preservation of each specimen, and this cost increases with its age" (D. Furth, personal communication). Institutions that have maintained type specimens for decades or even centuries cannot give them to new museums without compensation. There is no way to ensure that every country can afford the costs associated with type specimens. These economic hurdles probably will help keep type specimens in their present locations. Second, political unrest and governmental instability are complications that would hinder repatriation of type specimens. Mail systems often are part of the government; consequently, any government instability can affect the mail system. Greg Courtney at Iowa State University conducted research in several Asian countries. As is true of many systematists, he is a world authority on certain insect taxa. Because of the shortage of systematists, specimen identification and higher-level systematic investigations often utilize specimens worldwide. The need for a dependable mail system is evident. Even in countries such as Thailand, a relatively safe and stable country, postal deliveries are inconsistent, and it can take from 1 week to 2 months to receive a letter (G. Courtney, personal communication).

> Placement of type specimens should be based on where they best can be curated and made accessible to researchers.

An even more serious situation exists where political instability prohibits outside scientists from entering a country and, in extreme cases, endangers the life of the scientist. For instance, Courtney and his colleagues have been conducting a 4-yr survey of the mosquitoes of Nepal. The first 2 yr proceeded without incident. Since then, escalating unrest in remote areas has prevented completion of the project. In this instance, entering the country and traveling in "tourist" areas is safe, but conducting research in remote areas endangers foreign scientists as well as Nepalese colleagues. Systematists need access to type specimens in good condition to properly reference and classify new organisms. Conclusions about life history traits and evolutionary relationships are dependent on accurate classification of specimens. Species names do not belong to any one country; therefore, type specimens should be in locations where systematists have the best access to them.

Type specimens also provide information important to the advancement of scientific ideas. Few scientists regret that Charles Darwin took finches from their country of origin for his studies. His work benefited the entire scientific community. It is impossible to estimate the potential scientific losses if specimens are repatriated to countries where access to them is difficult.

Lastly, living insects to do not adhere to political boundaries, so why should dead ones? Where should the holotype of the monarch butterfly be deposited? Canada? The United States? Mexico? Identifying the country of origin may not be possible. Placement of type specimens should be based on where they best can be curated and made accessible to researchers.

One systematist, Robert Lewis, summed up our thoughts with a quote, "Returning all type specimens to the country of origin may be a good idea (idealistically), but it will never happen" (personal communication).

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Topic:

The Use of Crops Genetically Engineered to be Resistant to Pests, Pathogens, and Herbicides is Unlikely to Benefit Resource-Poor Farmers in Latin America.

BACKGROUND

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THE WORLD POPULATION IS EXPECTED TO GROW to a total of 8 billion people between now and the year 2020. About 94% of the population increase will occur in developing countries. The world food demand is high and always will be. Ensuring an adequate food supply in developing countries will be a forbiddingly difficult challenge in years ahead!

With the advent of biotechnology, many believe we are at the beginning of a second Green Revolution. Success from the first Green Revolution resulted, in part, from the quick and widespread adoption of new varieties among resource-poor farmers. Biotechnology is the science and art of genetically modifying an organism's DNA, such that the transformed individuals can express new traits that enhance survival such as insect, disease, or herbicide resistance. Often, this involves making a plant transgenic. Transgenic refers to an organism genetically engineered by the addition of foreign genetic material (DNA) from another organism into its DNA. Biotechnology, as a science, has been advanced considerably by private and public-sector institutions during the past two decades. It has resulted in development of many transgenic crops that have become available commercially during the past 2 years in the United States.

Transfer of biotechnology to Latin America already is occurring. More than 150 transgenic plant varieties have been released for research in developing countries (de Kathen 1996). Evaluation is just starting in Central America. Allan Hruska (1996), from Zamarano, the Panamerican Agricultural College in Honduras, presents the following potential advantages of transgenic crops: (1) they reduce need for chemical insecticides; for example, *Bt* cotton may allow reintroduction of the crop into parts of a region that have stopped producing cotton because of the high cost of insecticides; (2) they are easy to implement; in most countries in Latin America, agricultural extension services have faced budget cuts or complete elimination, making the extension of new technologies difficult, especially among resource-poor farmers; (3) no new practices need to be learned for basic use of the technology, and (4) the entire technology is "in the seeds."

Now let us consider the disadvantages. First, food safety is a concern. Do Latin Americans want to eat maize that contains *Bt* toxins? Second, the costs of transgenic crops may be too high. Costs will have to be competitive with existing control tactics. Third, gene flow and genetic erosion is a concern. Hybridization and backcrossing between transgenic BASTA-tolerant oilseed rape, *Brassica napus* (L.) and *B. campestris* (L.), a weedy relative, already has occurred under field conditions (Mikkelsen et al. 1996). Next, development of resistance also is a serious issue. To date, no appropriate insect-resistant management system exists in Central America. Monsanto is using the same recommendations from the United States and applying them to BollGard cotton in Central America (Fred Gould, personal communication). Have all ecological and socioeconomic differences between the United States and Latin America been considered in implementing the same kind of strategies? A final disadvantage is the issue of intellectual property rights. Many genes that confer beneficial properties originate in developing countries, but the initial benefits are realized in developed countries.

Biodiversity probably is one of the most important considerations when discussing the benefits of resource-poor farmers using transgenic crops. Many ask what role these farmers should play in demanding things such as agricultural diversity. It has been suggested that traditional, resource-poor farmers generally have a profound knowledge of biodiversity and that their knowledge and environmental perceptions must be integrated into schemes of agricultural innovation that attempt to link resource conservation and rural development (de Kathen 1996). Polycultures promote diversity of diet and income, stability of production, minimization of risk, reduced insect and disease incidence, efficient use of labor, intensification of production with limited resources, and maximization of returns under low levels of technology (Altieri 1991).

The greatest contribution of transgenic crops to a safer and more environmentally friendly crop protection system may be in developing countries (Hruska 1996). Technical innovations are essential for increased production and productivity in tropical agriculture, but these innovations must be developed and adapted to specific situations. Adoption probably will depend on the potential gain in income, complexity of transgenic crop use, compatibility with the farming system, and avoidance of risk.

In developing countries, small, resource-poor farmers account for the bulk of agricultural production (Hruska 1996). Typically, family farmers in these countries are thought to be highly risk-averse. Crop failure can result in burdensome debt, loss of land, or starvation. Resource-poor farmers have a fixed quantity of land, labor, and capital with which to meet their substinence goals.

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PRO POSITION

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PROPONENTS HAIL TRANSGENIC CROPS AS THE PANACEA to the pest management problems of resource-poor Latin American farmers because the pesticide technology is "in the seed." However, this technology, developed for the large-scale agribusinesses characteristic of the United States, may not be appropriate for subsistence farmers practicing traditional agriculture in a biologically diverse agroecosystem. Most Latin American countries lack the regulations and extension services necessary to enforce the recommended use of trans-genic plants (Hruska 1997). The economic and ecological problems that consequently will develop make it unlikely that these Latin American farmers will benefit from the introduction of the technology. What follows is an outline of some of the problems that poor farmers in Latin America may encounter from the introduction of genetically engineered plants.

> Most Latin American countries lack the regulations and extension services necessary to enforce the recommended use of transgenic plants.

The introduction of transgenic plants to Latin America may worsen the economic situation of resource-poor farmers because these farmers are unlikely to be the first to adopt the technology (Hruska 1997). Inadequate extension and outreach programs in some regions of Latin America mean that rural, subsistence-level farmers are unlikely to learn about the technology before it has become established on larger, richer farms. Furthermore, poor farmers, who traditionally save seeds from their crops for planting the following season, may be unable or unwilling to purchase more expensive engineered seeds every year, as required by most manufacturers of transgenic crops. The poor farmers then would have to compete with the increased yields and decreased prices charged by farmers of larger farms where the technology was adopted.

Ecologically, the entry of transgenic plants into Latin America could magnify pest problems. Constant exposure to the *Bt* toxins expressed by many genetically modified plants represents an extremely strong selective pressure for the evolution of resistance in insect populations. Resistance to *Bt* already has developed in populations of diamondback moth, *Plutella xylostella* (L.), in Central America (Perez and Shelton 1997). Proponents of transgenic crops argue that resistance could be avoided with effective management; however, resistance management programs do not exist in Latin America (A. J. Hruska, personal communication). Lack of funds and trained personnel make it unlikely such programs could be enforced successfully should they ever become established. Likewise, in the absence of adequate grower education, the use of herbicide-resistant plants could result in increased application of herbicides by farmers and hence the rapid development of herbicide-resistant weeds (Schultz et al. 1990). Latin American farmers, thus, could face a potential pest management nightmare if resistance developed. The higher costs of crop production and exacerbation of environmental problems associated with increased herbicide applications could further complicate matters for poor farmers.

Also of concern is the potential for transgene flow between genetically engineered crops and native species, which has already been demonstrated for transgenic oilseed rape, *Brassica napus* (L.), and its weedy relative *B. campestris* (L.) (Mikkelsen et al. 1996). The incorporation of transgenic traits may lead to increased fitness of resulting hybrids and, hence, development of new weeds and increased aggressiveness of existing weeds. The introduction of new, dominant genotypes from transgenic plants to populations of rare wild species also could erode the genetic diversity of native plants. These dangers are considered minimal in the United States because most of the transgenic crops used thus far do not grow in close proximity to their wild relatives. However, unless regulations are put into place to prevent it, transgene flow to wild relatives is a real possibility in Latin America, the center of diversity of many crop species (Rissler and Mellon 1996).

Transgenic crops were developed in countries with big-business agriculture and a relatively low diversity of native plant species. In contrast, in Latin America many farmers may be unable to afford the technology, and enforceable regulations are not in place to slow the development of resistance. The introduction of transgenic crops to this region could lead to creation of new weeds, decreased genetic diversity of traditional crop varieties, and development of transgene-resistant pest populations with little or no financial gain to poor farmers. Unless an effective infrastructure is established for education, monitoring, and management, resource-poor farmers in Latin America are unlikely to benefit from introduction of transgenic plants.

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CON POSITION

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BIOTECHNOLOGY HAS GREAT POTENTIAL in agriculturally based Latin American economies because it provides the tools that will increase crop productivity on available land, increase farm revenues, and stabilize food supply. Resource-poor farmers in Latin America are as diverse as the socioeconomic conditions prevailing in each of their countries. It is our view that, in most cases, resource poor farmers in Latin America will benefit greatly from the use of transgenic crops. We base our argument on the following: (1) transgenic crops will become more available, (2) their use will be adopted by farmers, and (3) production systems favor the sustainability of transgenic crops. These crops are becoming available through two avenues, international cooperation and commercial seed companies.

Recently, biotechnology transfer to developing countries has gained private and public interest worldwide as a way to solve socio-economic problems through international cooperation. Several organizations and programs have been created for this purpose and include the International Service for the Acquisition of Agri-Biotech Applications (ISAAA), the Directorate General International Cooperation (DGIC), and the USAID-Agricultural Biotechnology for Sustainable Productivity (ABSP). Several projects have been facilitated by these organizations and include the donation of technology by the Monsanto Company to produce virus-resistant potatoes in Mexico, the donation by Asgrow Seed Company of technology to introduce virus resistance into locally grown melon varieties in Costa Rica, and the facilitation of a Brazil-Cornell University project to introduce virus resistance genes into papaya. In the area of commercial products, international seed companies such as the Monsanto Company and Dekalb Corporation, with great economic interests in the region, are pursuing regulatory approvals for transgenic crops in Brazil and Mexico. With new free-trade agreements being reached among Latin American countries, these products undoubtedly will reach many other markets in the region. Many transgenic crops already have been released already in Latin America. The list of confirmed crop releases includes 118 items distributed within 10 countries (De Kathen 1996). The potential for an increase in availability of trangenic products in the near future cannot be negated.

Small farmers exposed to biotechnological tools are likely to adopt them at the same rate they adopt conventional technologies. If transgenic crops are effective in reducing production losses due to pests, they will be attractive to at least some of the small farmers. This will translate into small trials by innovative farmers and, if successful, will lead to widespread adoption. Small farmers in some areas of Central America have a history of technology adoption that often has resulted in significant increases in crop yields and concurrent reductions of overall production costs (Mausoff and Farber 1997). Adoption of transgenic crop technology only requires a change in seed type use and should not differ from the adoption of conventional varieties with improved pest tolerance.

Transgenic crops provide an unprecedented opportunity to solve pest problems that limit crop production and economic growth in Latin America.

The main challenges to widespread use of transgenic crops is their successful integration into traditional farming systems and the preservation of their performance by preventing or delaying the development of resistant arthropod populations (Peferoen 1997). Production systems in selected areas of Latin America are ideal for the sustainable use of pest resistant-transgenic crops as integrated pest management tools. These production systems are characterized by small, widely dispersed farms that grow multiple crops. In most cases, farms are surrounded by large areas of native vegetation and are located across topographically diverse landscapes. This diversity in crops, native vegetation, and topography will reduce the chances for resistance development by (1) creating spatial and temporal refuges for maintaining susceptible individuals and (2) providing habitat for alternate prey/host for natural enemies. Transgenic crops provide an unprecedented opportunity to solve pest problems that limit crop production and economic growth in Latin America.

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