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Animal genetic resource trade flows: Economic assessment ☆

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Abstract

Throughout human history, livestock producers have relied on a vibrant international exchange of genetic resources to achieve improvements in the quality and productivity of their animals. In recent years, however, some observers have argued that changes in the legal, technological, and economic environment now imply that international exchanges of animal genetic resources (AnGR) systematically benefit rich countries at the expense of poor countries. It is argued that international flows of AnGR are displacing the indigenous animal genetic resources of developing countries, and also that the genetic wealth of the developing world is being expropriated by rich countries.

In reaction, there have been growing calls for limitations and/or barriers to the exchange of animal genetic resources. These discussions, however, seem to be based on limited information about the magnitude and direction of current trade flows in AnGR. This paper offers an analysis of AnGR trade flows from 1990 to 2005. The paper draws on national-level data from 150 countries that reported information to the United Nations Statistics Division. Three major trade categories were evaluated: live cattle and pigs for breeding, and cattle semen.

Over the period studied, Europe and North America were the primary exporters of genetic resources for the species evaluated. OECD countries accounted for 98.7, 92.5, and 95% of cattle semen, live cattle, and swine exports in 2005, respectively. In evaluating the direction of trade between developed (North) and developing (South) countries, North–North trade had the largest magnitude, followed by North–South, South–South, and South–North. The data do not support the notion that Southern genetic resources are being used on a large scale in the North. We believe that importation from South to North is limited by the vast discrepancies in production efficiency and production systems between countries in the North and South.

Given the low volume of South–North exchange, it seems doubtful that sufficient revenues could be acquired through a "benefit-sharing mechanism" to have any substantial impact on *in situ* or *ex situ* conservation efforts, or to generate benefits for poor livestock keepers in developing countries. We question whether global agreements or restrictions on trade will achieve the desired goal of conserving rare breeds and threatened genetic resources. We also doubt whether these agreements will succeed in improving the well-being of the poor. We suggest that resources instead be urgently employed for conservation and that more direct measures should be taken to aid poor farmers, ranchers, and herders in their efforts to conserve genetic resources.
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Keywords: Animal genetic resources; Gene flow; Germplasm trade

1. Introduction

Since the 1990s, international dialogue has focused on legal and institutional frameworks governing property

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rights, access, and benefit sharing for various types of genetic resources. Driven by changes in technology and in the marketplace (e.g., the growth of private sector biotechnology research), the international community has sought to clarify national and transnational issues involving the ownership of genetic resources occurring in nature and those created or modified by humans.

Incomes have risen globally over the past several decades, and as the demand for animal protein has grown, intensive production systems have spread dramatically — in beef, dairy, pig, and poultry production. Globally, these high performance production systems have commanded increasing shares of meat and milk production. This trend seems likely to continue into the next several decades, as suggested by numerous forecasts (Delgado et al., 1999; Steinfeld et al., 2006).

Increasing commercialization of agricultural genetic resources was a motivating factor behind the completion of the Convention on Biological Diversity (CBD), an international treaty signed in 1992, which granted countries "sovereign rights over their own biological resources" (Convention on Biodiversity, 1992). The CBD articulated a general vision for conservation of biodiversity, to be funded and supported through "fair and equitable sharing" of the benefits that would presumably be generated from biodiversity. Subsequent concerns arose that the CBD did not provide a sufficiently clear or useful framework for dealing with plant genetic resources directly used in agriculture, and in consequence, the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGR) was adopted in November 2001.

The relevance of the CBD for animal agriculture has also been called into question in recent years. Specific to livestock, the CBD does not appear to recognize that livestock are privately owned by livestock producers and that markets already exist for the open exchange of animal genetic resources. Conferring national sovereignty over animal genetic resources may be problematic, given the difficulties of attributing resources to countries and given the robust international trade in these resources that has taken place over decades and centuries.

The United States (like most other countries in the Americas) has — over the course of the past several centuries — been an importer of animal genetic resources for agriculture. In more recent decades, however, the U.S. has emerged as a major exporter of genetic resources for agriculture. In most OECD countries, animal agriculture has evolved towards high performance production systems, in which selection intensity and accuracy have improved, in conjunction with a reduction of environmental variability. Because these production systems can be replicated with minor modifications around the world, the animal genetic resources developed in the United States and Europe have proved widely adaptable to a number of production systems globally.

In recent years, some actors have called for an international treaty or other legal instrument to govern the cross-border exchange of animal genetic resources (Hiemstra et al., 2006), with a suggestion that such a treaty might simply parallel the ITPGR. To date, however, relatively little substantive analysis has been directed at the existing markets for genetic resources to assess the potential costs and benefits of binding international agreements. The goal of our work has been to quantify patterns of trade and utilization of animal genetic resources. To accomplish this goal, our study has explored the exchange of genetic resources at two levels. This paper evaluates trade flows between countries and regions, focusing on the economic significance of trade in animal genetic resources. The previous companion paper (this issue) reported on a biological evaluation that explores episodes of genetic resource importations to the US over the last 25 years. By tracing the subsequent utilization of imported resources within the U.S, the study obtains estimates of the long-run agricultural, biological, and economic significance of these importations. Our work leads us to a number of conclusions. In particular, we challenge many of the premises that underlie the calls for an international treaty or other framework governing international exchanges of animal genetic resources. Specifically, we will argue that the data do not support the idea that developing countries are now (or will be in the future) an important source of genetic resources for global animal agriculture. We will also suggest that a strong system of compensation for animal genetic resource flows is unlikely either to promote conservation or to improve the well-being of poor livestock keepers.

Effective conservation of animal genetic resources will require that significant efforts actually be devoted to collection and preservation — both *in situ* and *ex situ*. These efforts must begin immediately, and their funding must not be linked to current trade flows. It is unrealistic — and based on a misunderstanding of current genetic flows — to think that a treaty or similar mechanisms based on either the CBD or the ITPGR will achieve the needed conservation of threatened breeds or species. It is also unrealistic to imagine that this mechanism will result in significant net transfers to developing countries.

Improving the welfare of poor livestock keepers in developing countries can and should be a separate goal of policy, but this goal can be achieved more effectively through direct payments or transfers of technology (e.g., dedicated veterinary research or improvements in forage

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grasses). In some cases, *in situ* conservation can be consistent with support for traditional livestock keepers. But again, development of multinational agreements are likely to offer at best a crude means of improving the welfare of households or cultures involved in traditional animal agriculture.

2. Materials and methods

This paper reports on an analysis of international trade in animal genetic resources from the 1990's to 2005. It offers an assessment of the major directions, trends, and implications of trade flows, using data from the United Nations COMTRADE database (United Nations Statistics Division, 2007). This information was augmented by discussions with a number of breed societies on their views concerning breeders' access and utilization of non-U.S. genetic resources.

3. Results

3.1. Trade flows

Global cross-border flows of animal genetic resources occur through a number of channels. Informal movements, such as pastoralists herding animals across international borders, account for significant flows of germplasm in some countries. Scientific research accounts for limited flows of germplasm; scientists may send and receive genetic resources across international boundaries, after meeting appropriate phytosanitary requirements. However, the largest single channel (by far) for the flow of animal genetic resources for agriculture is the commercial trade in breeding animals, semen, and embryos for the major livestock species. These flows are quantitatively large and they dwarf other international movements of genetic resources in animal agriculture. Due to this scale and the quality of data, this study focuses solely on the commercial trade aspects of animal genetic resource exchange.

3.2. Regional trade patterns and trends

In recent years, the combined world exports of live animals for breeding (bovines and swine), plus the trade in bovine semen, has totaled US$ 500 million to US$ 1 billion annually, according to the United Nations COMTRADE database, which provides coverage from over 150 countries beginning in 1988 for live bovines and swine for breeding, and in 1996 for bovine semen. International statistics are not available or are very limited for genetic resources in other species (e.g., poultry, sheep and goats, fish), nor for boar semen. Limited data are available on the trade in bovine embryos. Including these materials, it seems likely that the annual value of international trade in animal genetic resources is likely to be well over US$ 1 billion. (Note that this represents the *private* value; i.e., the value placed on the genetic resources by private buyers and sellers, which may differ from the true economic value. In general, these private values reflect anticipated contributions to productivity, to the extent that those productivity gains will result in appropriable benefits.)

Of the three categories of animal genetic resources for which data are available, live cattle for breeding represent the largest fraction of total trade, with world exports between US$ 300 million and US$ 500 million in recent years. (Year-to-year variations in trade have in part reflected phytosanitary restrictions related to outbreaks of foot and mouth disease and BSE, in major exporting countries such as England, Canada, and the US.) International trade in bovine semen rose from US$ 130 million in 1996 to about US$ 180 million in 2005, while trade in swine for breeding increased from about US$ 30 million in 1990 to about US$ 80 million in 2005.

Fig. 1 shows trends in these three trade categories over time and by region. Several features of the data emerge at a glance. First, the countries of North America and Europe together dominate the commercial exports of animal genetic resources, and they have done so consistently for the past decade. The exceptions to European and North American dominance are relatively minor. Australasia holds a moderate share in the export market for breeding cattle, and the countries of Latin America and the Caribbean plus Asia together account for a modest share of the swine genetics market — although this may reflect the fact that in North America, shipments of semen have largely replaced movements of live animals as a means of exchanging genetic resources. With these exceptions, the world trade in animal genetic resources for agriculture is overwhelmingly based on flows out of the rich countries of Europe and North America.

3.3. Flows of animal genetic resources: rich and poor countries

Another fact suggested strongly by these data is the importance of modern high productivity breeds in world trade. Although no separate data are reported at the global level on exports by breed, the patterns of trade suggest strongly that most of the world exports of genetic resources for animal agriculture involve breeds and individuals that are suited to high productivity systems.

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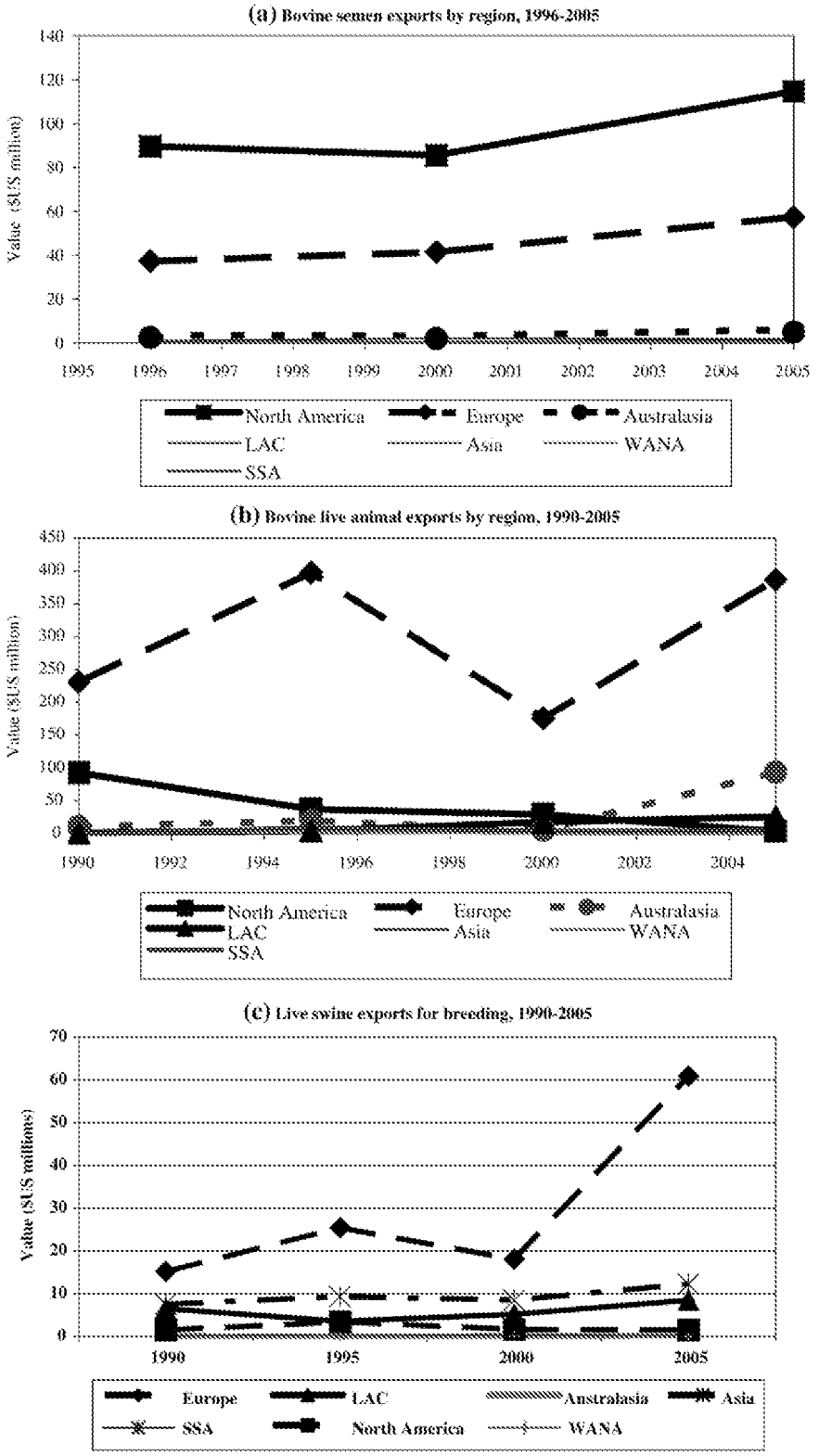

Fig. 1. Exports of animal genetic resources by region: (a) bovine semen exports (1995–2005); (b) live bovine exports (1990–2005); (c) live swine exports (1990–2005).

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Additional evidence for this can be found in Fig. 2, which shows, for specified years, the leading countries involved in the export of animal genetic resources for agriculture. For the purposes of these figures, countries are divided into the members of the Organization for Economic Cooperation and Development (OECD) and

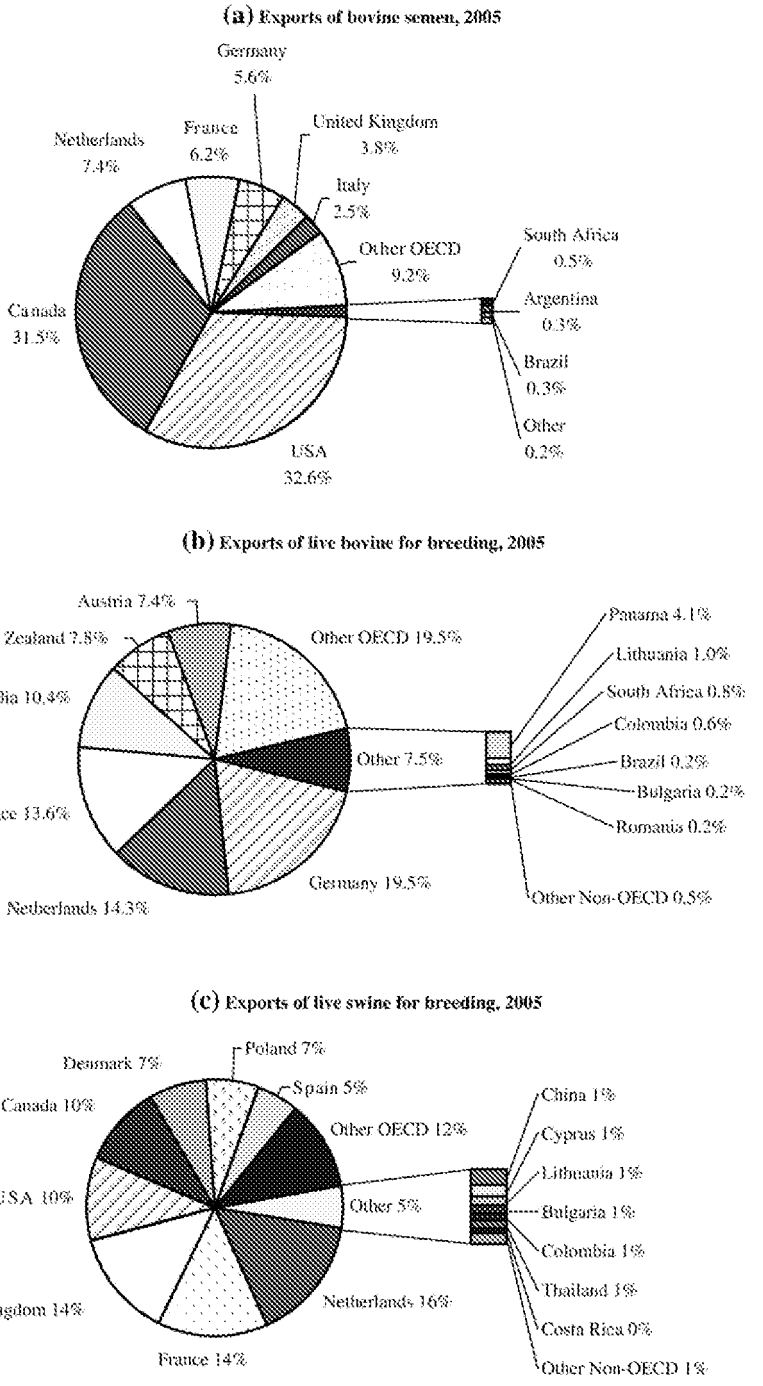

Fig. 2. Percentage of world total exports of animal genetic resources by leading countries during 2005: (a) Exports of bovine semen; (b) Exports of live bovines for breeding; (c) Exports of live swine for breeding. (Source: United Nations COMTRADE data, online at http://unstats.un.org/unsd/comtrade/dqBasicQuery.aspx).

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others, based on membership in the OECD in 2006. The OECD is effectively a group of thirty advanced market economies. Thus, OECD countries tend to be quite rich, relative to the rest of the world.

Fig. 2(a) shows the leading exporters of bovine semen in 2005. The US was the largest single exporter in this period, accounting for about one-third of world exports, followed closely by Canada. Other OECD countries were the source of almost all remaining exports; non-OECD countries provided slightly over 1% of the total world exports of bovine semen.

It could be argued that the pre-eminence of OECD countries in this export market reflects the relatively high degree of technological capacity required for trading bovine semen, but in fact the data on live animal exports for breeding offer much the same pattern, as shown in Fig. 2(b). Although phytosanitary restrictions have limited the U.S. and Canada from participating significantly in this market since 2003, the OECD countries still generate well over 90% of world exports. Apart from a pocket of live bovine exports for breeding from Panama (directed to other countries in Central America), the other non-OECD countries combined were responsible for less than 4% of world exports.

Fig. 2(c) shows the countries involved in exports of live swine for breeding. Once again, it is clear that the non-OECD countries account for a small fraction of total exports — around 5%. OECD exports are spread around widely, with a number of countries having roughly equal shares of the total.

In all three commodities, then, it is clear that the non-OECD countries are minor exporters, at best. The countries of the OECD are overwhelmingly the sources of genetic resources entering into commercial trade. Contrary to some speculation, the developing countries are not, for the most part, exporting animal genetic resources to the rest of the world — at least through formalized trade channels.

3.4. The "North" and "South" in global flows

To what extent are there significant flows of animal genetic resources from the global "South" to the "North"? To address that question, we can document the extent of flows between OECD and non-OECD countries over time. Fig. 3 shows the relative importance over time of these different flows. There are four possible flows: North–North, North–South, South–North, and South–South, and Fig. 3 plots these over time for each of the three commodities with available data.

A popular conception is that South–North flows of germplasm are especially important, reflecting some

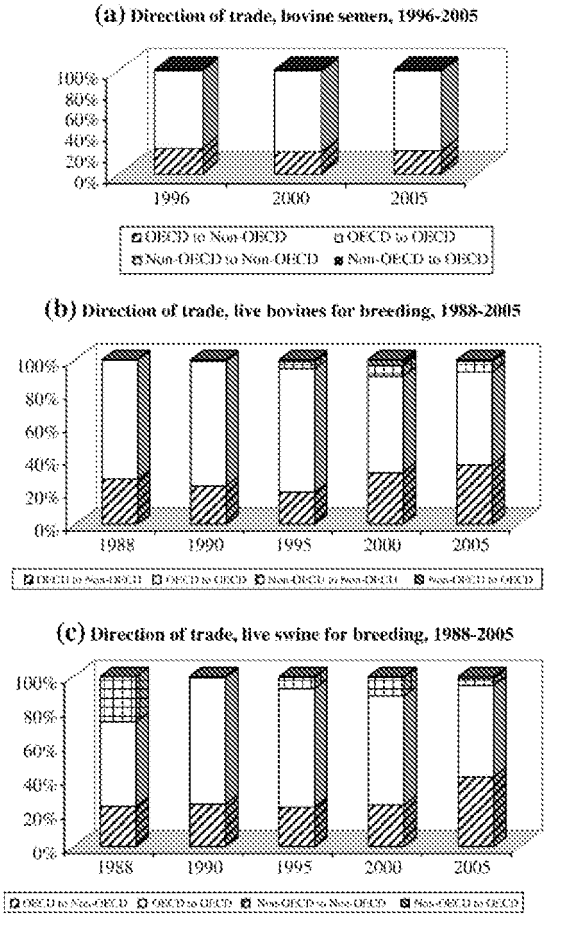

Fig. 3. Animal genetic resource direction of trade flows between OECD and Non-OECD countries over time.

kind of expropriation of germplasm by the North. If this is, in fact, the case, it is not showing up in the trade data, where we find little evidence to support the notion that South–North flows of animal genetic resources are important quantitatively.

For all three commodities, the value of South–North trade is very small, in comparison with total trade flows. With the exception of live bovine breeding animals in 2000 (when, as noted previously, there is a surge in exports from Panama to OECD member Mexico), South–North flows otherwise make up less than 2% of total global flows. Nor is there any trend for South–North flows to increase over this period. In 2005, the most recent year for which data were available, South–North flows were just under one percent of total world trade for the three commodities evaluated in this study.

Of the South–North flows that do occur, most are taking place among neighboring countries in Europe and Latin America. This is especially true for movements of live animals for breeding. Thus, Hungary

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exports to Greece; Romania to Turkey; and Panama to Mexico. These flows appear in the data as South–North flows, but they do not necessarily reflect movements of "traditional" germplasm from poor countries to rich. Instead, they may reflect sales among relatively high productivity commercial entities in nearby countries. (They may also reflect tariffs or regulations that make it attractive for farmers in neighboring countries to misreport as breeding animals some trade in livestock intended for meat and milk production.)

Although South–North flows are not large, there are significant flows of animal genetic resources from North to South. About one-third of the value of international trade in genetic resources for animal agriculture consisted of exports from OECD member countries to non-members in 2005. This represents a significant increase on the levels of 1995, when North–South trade was only about 20% of the total. The magnitude of North–South trade would suggest that such exchanges are commercially oriented and relatively successful. This view is counter to some earlier perceptions that the North–South exchange was principally dominated by governmental and/or NGO activities (Hiemstra et al., 2006). An important shift in trade is the reduction in percentage of North–North trade and an increase in North–South trade during the 1990s. North–North trade accounted for about 75% of global trade in animal genetic resources in the mid-1990s but has decreased to 60% in 2005, with the decline reflecting, in large measure, the collapse of cross-border movements in live animals within North America, due to disease issues.

3.5. Trade and income levels of participates in world markets for animal genetic resources

The last point appears to hold quite generally. World trade in animal genetic resources for agriculture is effectively segmented into trade within high productivity systems and trade within low productivity systems. There is very little trade across these two types of production systems. Within low productivity systems, there are modest South–South movements of live animals for breeding. For example, Burkina Faso exports bovines to the coastal countries of West Africa (e.g., Côte d'Ivoire, Ghana, Togo, and Benin), and some of these flows involve breeding animals. Animal movement between South–South high productivity systems seem to occur on a selected basis. For example, Thailand exports some swine to China for breeding and we presume for intensive commercial production, given China's wealth of pig genetic resources.

The largest flows of genetic materials take place within high productivity systems. Countries participating in these flows are typically both exporters and importers of genetics. Subject to phytosanitary restrictions, the countries involved in these flows tend to trade genetic resources quite freely, to the presumed benefit of both importing and exporting countries.

Table 1 shows the income level of countries involved in different types of trade activities for the three commodities with available data. Table 1 is comprised of countries with available data on income per capita from the widely used Penn World Tables (Heston et al., 2006). This summary indicates that countries not engaging in either importing or exporting animal genetic resources are the poorest countries. This does not reflect a causal relationship; it simply points out that the poorest countries of the world are often those where subsistence agriculture dominates and therefore international markets may play little role in agriculture. This category also includes a number of countries and territories with insignificant livestock industries (e.g., Macao), which are thereby non-participants in the world market for animal genetics.

Interestingly, the next poorest group of countries is typically the set of those countries that only import animal genetics. These are countries that turn to others

Table 1
Classification of country trade status (import, export, or both) based upon real per capita GDP by commodity during 2000

Commodity income and trade category	Real per capita GDP ($)	Number of countries
Trade in bovine semen trade, 2000		
Income of countries that both export and import	18,578	37
Net exporters	26,179	10
Net importers	15,763	27
Income of countries that only export		0
Income of countries that only import	8576	89
Income of countries that do not trade	7400	51
Trade in live bovines for breeding		
Income of countries that both export and import	14,385	48
Net exporters	19,215	24
Net importers	9556	24
Income of countries that only export	6719	15
Income of countries that only import	8128	56
Income of countries that do not trade	6819	69
Trade in live swine for breeding		
Income of countries that both export and import	15,835	36
Net exporters	21,933	15
Net importers	11,479	21
Income of countries that only export	17,125	9
Income of countries that only import	7911	39
Income of countries that do not trade	6580	104

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for improved genetic technologies. In general, it appears that they follow, in income, those countries that are net importers of genetics.

Finally, the richest countries are typically engaged in both export and import of animal genetics. These countries are involved in an international flow of animal genetic resources that is closely related to high productivity systems. Within these systems, individual producers are seeking the best genetics, regardless of country of origin. Trade is multi-directional and appears competitive. Many countries participate; it is not the case that the world market is dominated by a single country.

In short, the high productivity animal agriculture systems of the world engage in busy and competitive trade in genetic resources. These countries are sources of genetics for the rest of the world, and they make little use of genetic resources originating in the low productivity systems of the developing world.

4. Conclusions

Our analysis of the data leads us to doubt the usefulness of a treaty on animal genetic resources, access and benefit-sharing agreements or other broad policy initiatives as a vehicle for promoting conservation of threatened breeds or species, and also as a vehicle for improving the welfare of poor livestock farmers in developing countries.

Most flows of animal genetic resources occur between countries that are relatively rich and involve animals suited to high productivity systems. As these data show the South–North exchange of animal genetic resources is small, therefore suggesting that any sort of a system of compensation based on these flows could not generate sufficient revenue to support needed conservation efforts. It is also a mistake to imagine that a treaty-based compensation system would create sufficient value for indigenous genetic resources to ensure their conservation. Finally, for flows of genetic resources occurring between commercial breeders around the world, it is difficult to imagine why a treaty-based compensation system is needed when markets have already been established and are functioning.

We believe that conservation measures should be pursued urgently, without any explicit link to a treaty or erection of trade barriers as pointed out by Blackburn (2007). We further believe that efforts to improve the well-being of traditional livestock keepers and their farming systems are worthwhile and should be pursued without linkage to broad policy instruments that are ill-suited to meet the needs of the targeted populations. Furthermore, we fear that the financial burdens of negotiating an international agreement and supporting a secretariat and administrative superstructure might reduce the funds available for needed conservation efforts.

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