THE ROLE OF TRADE IN GENETIC STOCK IN TRANSMITTING AVIAN INFLUENZA

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Paper presented at

Symposium on

The Market and Trade Dimensions of Avian Influenza

Rome, Italy,
14 November 2006

in conjunction with
the 21st Session of the Inter-Governmental Group on Meat and Dairy Products

Executive Summary

Continuing outbreaks of highly pathogenic Avian Influenza have highlighted the need to review the role that trade plays in transmitting the virus globally. In particular, it is useful to assess the differential risk posed by trade generated by the various players along the poultry chain. This paper provides an overview of the structure of the poultry breeding industry, assesses the risks of disease transmission through trade in genetic stock, and provides some recommendations on the health procedures which are necessary to minimize risks of virus transmission.

About 52 billion poultry (Chickens, Turkeys and Ducks) are produced annually around the world. Genetic input for commercial poultry operations[1] is usually sourced from one of four major poultry companies. Supply chains connecting the various layers of reproduction which lead to the production of commercial broilers, egg layers, turkeys or ducks originate with these organizations. The chain starts with primary breeding companies, each owning a gene pool of highly-prized birds selected year on year for breeding value and bred to produce their own replacements, and breeder progeny called Great Grandparents (GGP) which then produce Grandparents (GP) which, in turn, produce Parents (PS). Consistently high levels of biosecurity and health monitoring are essential to the survival of primary breeding organizations. As a result, the risk of contamination of primary breeding flocks and GGP flocks by highly pathogenic Avian Influenza or other microorganisms is extremely low.

> [Our biosecurity] "measures incorporate dynamic training of all company employees, physical isolation of farms, specially designed poultry housing, and entry guidelines"

Most GP and PS flocks are not owned by primary breeding companies. Direct control of GP bird health extends through the production of day-old chicks in their hatcheries, under high levels of biosecurity, and the transportation of the chicks to worldwide destinations at which point responsibility for protecting chick health is assumed by the customer. GPs are expensive and not easily replaced. Primary breeders work closely with GP farms to promote high quality health programs. Primary breeders claim that GP customers globally, in general, employ high levels of health management. The health situation for GPs imported into some developing countries is less clear. There, a minority of GPs may be at risk of disease exposure because some may be under less strict management conditions.

Among the roughly 400 million PS flocks needed for the global production of commercial poultry annually, management conditions are considered more variable and, generally, more at risk than for GPs. Characterizing the level of PS flock risk between and within developing countries, some with the highest numbers of PS flocks of any country, is difficult but industry health experts are concerned that too many are exposed to biosecurity conditions much less stringent than those practiced higher up the supply chain. There is little confidence that the current PS risk is likely to abate.

An AI outbreak can be expected to interrupt trade for a period of time but examples of extended bans beyond the time and geographic area bounds of the outbreak have been reported, exacerbating the economic disruptions on suppliers and customers. Trade interruptions clearly impact negatively those customers whose shipments are delayed or

[1] Commercial operations are those distinct from backyard poultry raising which usually consists of small flocks of indigenous poultry breeds. Quotes from primary breeding companies are found in boxes located throughout the text.

cancelled. Some of those may choose to produce breeders from within their breeder flock or purchase breeders from alternative sources. These short-term solutions may lead to a more serious disease situation and hurt the industry long-term.

There is growing consensus among key industry participants, including breeding companies, that OIE's compartmentalization guidelines offer an opportunity to keep trade flowing more smoothly and mitigate the economic impact of disease outbreaks, even with the continuing risk of Avian Influenza incidents. Until there is an agreement among industry participants on how compartments will function, individual companies will continue to conduct bilateral negotiations with regulatory authorities in export destinations.

No matter the success in keeping trade routes open and flowing smoothly, industry-government collaborations will continue to be important to the development of appropriate compensation plans and health certification of chicks and eggs moving from one region to another.

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Introduction

Trade in genetic stock refers primarily to a carefully-structured model of day-old chick transport from a small number of geographic locations to multiplication operations in more than 100 countries around the world on a regular schedule. Ultimately, this breeding stock supply chain's final hybrid products (egg layers, broilers, turkeys and ducks), after several rounds of carefully scripted reproduction, reaches the commercial producers of eggs and meat as day-old commercial chicks. By virtue of its geographic reach and significant contribution to the supply of commercial chicks globally, this distribution process has attracted attention from those seeking to identify points of potential risk of disease spread, particularly of highly pathogenic Avian Influenza (AI) which has animal and human health implications.

While the focus is understandably on the trade process, it is also important to recognize that policies aimed at regulating the process must be carefully prepared to avoid unintended consequences, including exacerbation of the disease situations that they are intended to control. Guided by the knowledge of how products move through these trade routes and how biosecurity, including health monitoring of flocks, is employed, policy makers may more effectively put in place regulations and practices which strengthen health security while minimizing the economic and social cost that a less-enlightened program can engender.

This study is aimed at examining the status and flows of trade in genetic stock in the context of international and domestic sectors of the breeding industry. Furthermore, it will identify what actions, technical support and development of policies and regulations may mitigate disease risk. To the fullest extent possible, the material presented here is the product of substantial communication with all major poultry breeding companies. However, errors or omissions are entirely my own.

Cherry Valley
Cobb-Vantress
- Cobb, Cobb-Avian

Erich Wesjohann Group
- Hyline, Lohmann Tierzucht, H&N International
- Aviagen (Ross, Nicholas Turkey, British United Turkeys, Arbor Acres, L.I.R., C.W.T)

Groupe Grimaud
- Hubbard, Grimaud Freres

Hendrix Genetics
- ISA, Babcock, Shaver, Hisex, Bovans, Dekalb, Hybro, Hybrid, Plumex

Maple Leaf Farms
Perdue Farms
- Perdue, Heritage

PureLine Genetics

Box 1. Major primary breeders and their brands

Structure of the industry

The primary poultry breeding companies, so called because of their role in designing matings of pure line individuals in order to advance performance levels in their hybrid commercial products, are listed in box 1 with their product brand names. The current structure and product mix of many of these companies have resulted from consolidation of the industry wherein one company acquired another and, with the acquisition, obtained the rights to use of the brands of the acquired breeder. In many cases, the current brand names were once breeding company names. Customers (franchisees or distributors) of the primary breeder mate together, in a carefully-prescribed fashion, birds they have receive from the primary breeders. Franchisees are distinguished from distributors in that the former are permitted to use company trade names and trade marks. In addition to those listed in box 1, there is an important primary breeding company (VRB) in India which has successfully charted a joint venture business strategy to have recognized programs derived from Babcock layer pure

lines and from Cobb broiler pure lines, their joint venture partners. These joint ventures emerged as a result of entrepreneurial initiatives by B. V. Rao in response to early '80's Indian government constraints on trade which severely restricted importations of breeding stock. In addition to breeding company agreements, the Indian business leaders developed joint ventures with global companies in the pharmaceutical and biologicals industries, creating a multifaceted breeding and health management structure which included modern poultry health practices adapted to the Indian context. Partners in the joint ventures provided advisors as part of their agreement terms. The Indian business leaders also invested in training and education of poultry farmers and young people entering poultry production. Today, their sales territory is limited geographically but they dominate the markets into which they sell, even in the face of a more open breeder importation policy in India today.

One way to measure the relative contribution of different species to the global poultry population is through the number of 'commercial' animals per year in each sector. Commercials are birds raised strictly for meat consumption (broilers, turkeys, meat ducks etc) or for table egg production (layers, layer ducks), not for reproduction. The numerical dominance of the global broiler industry (45 billion commercials annually) compared to that of the egg-layer industry (6.5 billion commercials), the duck industry (2.4 billion commercials) and the turkey industry (600 million commercials) means that much of the discussion in this report focuses on the routes by which broilers are produced.

Hierarchy along the supply chain

At the proximal end of each supply chain to the market place each year stands the primary breeding operation whose role is to add performance improvement, year on year, to the pure line crop which will subsequently parent the next pure line (PL) generation and from which several flocks of great grandparents (GGPs) and grandparents (GPs) will be derived during the course of about one year. So, in figure 1 for example, the transition (horizontal arrow) from red to green between 2001 and 2002 represents an increment of performance improvement when comparing the genetic potential of progeny derived from those two PL flocks. Consequently, the difference in performance potential between commercial progeny hatched from PS in 2005 and those hatched in 2004 is a reflection of genetic selection decisions, among other factors, made several years before in the PL breeding programs. The significance of this with respect to the economic value of these PLs is that the performance level of pure lines in any given year reflects an *accumulation* of genetic improvement over *all* previous years. Pedigreed breeders in these pure lines do not, themselves, leave the primary breeding farm except to be slaughtered. They are retained on these farms only as long as they are required to provide performance information and produce eggs for hatching pure line and multiplication stock progeny.

Generational linkages between breeding stock

Figure 1 illustrates simplistically the relationship between successive generations of pure lines (the horizontal arrows). The top line of the diagram is the unique domain of "Primary Breeders" Also shown is the relationship between any given crop of pure lines and their GGP and GP offspring which, in turn, feed the global supply lines (the diagonal arrows). Only one colored line per year is shown between pure line flocks and GGP

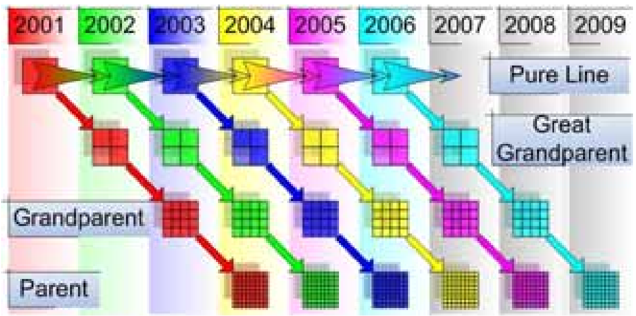

Figure 1. Schematic of pathways linking successive generations in a breeding program and the offspring delivered to the marketplace

operations, but, in reality, there could be many GGP flocks produced each year, depending on the poultry species. GGP flocks are, of necessity, more common in the broiler industry than in other poultry or waterfowl sectors of the industry because of the requirement to produce many GP flocks in order to multiply up the numbers and meet the market need for the requisite volume of commercial broilers.

In contrast, for egg layers, GGP flocks are much less common and GP flocks are generally derived directly from lines in the breeding program. It may also be true that some parent stock (PS) may be produced directly from lines in the breeding program. Whatever the number of GGP flocks, they are, like the PLs, under the direct management control of the primary breeders, if for no other reason than to assure that they retain complete oversight of these assets which represent irreplaceable accumulation of decades of scientific and capital investment in performance. Beyond the PL and GGP levels, breeders (GP, PS) are generally owned by the customer.

At the distal end of the diagonal pathways are the PS flocks from which are hatched the commercial birds that supply table eggs or are slaughtered for meat for the food marketplace. The pathways which link PL to GGP to GP to PS are subject to disease threats from several quarters. The level of vigilance by the shippers and owners of these birds determines, to a great extent, the degree to which these birds remain disease free. Wild and domestic birds must be kept out of contact with the breeders through appropriate building and transport design and property fencing. Staff must be held to high standards of personal hygiene and prohibited from owning pets which could be a source of disease. Delivery vehicles are expected to use transfer stations to avoid roadway contamination. Feed and bedding supplies must be treated to kill microorganism.

Relationships between chain components

Primary breeders generally own any GGPs produced from their PLs and would administer health and biosecurity programs in a manner similar to the programs applied to PLs.

Some GP flocks are owned or closely controlled by primary breeders but most are under sales agreements that include considerable provision of technical service to the GP flock owner, including management training, assistance with interpreting test results and advice about biosecurity and health. A close working relationship is considered an essential component of good business relationships between the supplier and its direct customer.

Reducing disease transmission

It is clear that management and biosecurity can influence the risk of AI transmission and it is important to identify where efforts to mitigate the threat of AI transmission already are in place and where additional efforts may be most productively applied In order to assess the risk of disease spread, it is important to characterize some pertinent operational features of breeder production and flock management. Clearly, isolation, to keep the disease organism from making contact with the breeders, is the first and most important line of defense. The University of Minnesota[2] website links to several biosecurity program descriptions, all of which, in one form or another, make this point. Highlighted in my discussions with primary breeders are their requirements for absence of any "contact with wild birds" and "contact between staff and other non-commercial poultry". At the other end of the range of

> "For more than 30 years, [primary breeding company] has been sending day-old chicks of type GP and PS to many different countries in the world. So far, there is no record of any disease that has been spread by such trade."

[2] http://www.ansci.umn.edu/poultry/resources/biosecurity.htm

measures used in managing a biosecurity program is "surveillance" used to monitor the health status and detect problems early enough to contain and/or eliminate them.

Biosecurity in the primary breeding sector

Primary breeding facilities are the most tightly controlled of all breeder facilities in the supply chain between them and the final customers. Within the primary breeding operation[3], there are several separate locations, each a site of potential risk, through which birds and/or eggs must pass: the hatchery, the transport vehicles and the farms (growing and production). Hatchery facilities and procedures are designed to start all baby chicks in good health. The hatchery structure and equipment are meticulously sanitized between and during incubation lots. Hatchery ventilation is designed to ensure that air flow is in keeping with best practices, isolating the incubating eggs from newly hatched chicks. Hatchery surfaces and equipment are swabbed for testing and hatching debris (down, dead chicks and unhatched eggs) is sent to labs for examination. Freshly hatched pedigree chicks are vaccinated (where appropriate), individually identified and allowed to rest before being transported in clean vehicles to sanitized, completely-enclosed growing facilities or to airports for trans-shipment.

> [We] "set the highest standard in biosecurity in our primary breeding operations and encourage our GPS customers to achieve the same standards"

On the farms, light, heat, feed supply and ventilation are carefully managed and alarms are in place to alert staff of malfunctions. The farms on which these buildings are located are surrounded by walls or fencing and serviced on internal roadways by vehicles that rarely leave the farm. Entry to the farms is by way of a facility in which staff or visitors are required to shower and make complete clothing changes, including the first of several boot and coverall changes between buildings within the farm. A dated written record of visits is maintained by the company. Staff are required to challenge all visitors and report sightings of animals or unauthorized people in the immediate vicinity of the farms. These farms are equipped with lunch facilities to minimize the need for staff to leave the farm during working hours and with laundry equipment to avoid possible contamination of on-farm clothing.

> [We are] "morally and ethically committed to fully prevent, diagnose and report all notifiable poultry diseases"

This level of biosecurity vigilance is easily justified by recognizing that the pedigreed pure lines are the very lifeblood of these organizations. There is no way to reconstitute these flocks if they fall victim to disease or other disaster. Primary breeders have learned over decades how vital to their survival a sound biosecurity program is. Hard-won confidence in a company's products can be lost almost overnight by delivering unwanted micro-organisms with a shipment of chicks. Furthermore, resources are committed to ensuring that improvements in biosecurity technology are sought and harnessed when warranted.

Isolation practices in pedigreed pure line facilities include the following:

1. Isolation of breeders from wild birds, animals and commercial poultry through the use of sturdy fences, windowless buildings, screened ventilation systems (often under "forced air positive pressure" [FAPP]), a space around each building clear of

[3] Primary breeders own pure line males and females whose individual identities, parentage and breeding values are used to design matings to maximize genetic progress in their hybrid progeny.

perches, a carefully-managed rodent control program, access roads with entry restricted by locked gates and property perimeters equipped with boundary screens.
2. Isolation of feed supply from other poultry and animals by use of designated vehicles subject to rigorous cleaning, inspection and delivery schedules which minimize exposure to other animals or facilities.
3. Isolation of depleted stock from other poultry and animals by having them incinerated on-site. Manure and litter, tested routinely for pathogens, are handled through use of isolated storage, incineration and/or composting as warranted by test results.
4. Prohibition of staff from owning birds, including pet birds, game birds and domestic production stock. Additionally, staff are required to avoid exposure to avian species (including animal fairs, etc.).
5. Visits to facility are strictly limited to authorized and vetted individuals subject to time requirements since any previous contact with avian species. Furthermore, visits to facilities within a farm follow an age-governed sequence with older flocks visited after younger.

Additionally, traffic control and sanitation practices ensure that

1. Delivery and egg pickup vehicles are kept outside of fenced facilities, using transfer stations along the fence to avoid vehicle and personnel contact with poultry buildings inside the fenced area.
2. Facilities are thoroughly cleaned between flocks, using dry and wet cleaning methods, often involving appropriate applications of heat and disinfectant which would kill bacteria and viruses, including avian influenza virus.
3. Facilities, occupied and unoccupied, are regularly inspected by veterinary health authorities

The effectiveness of these biosecurity programs are monitored closely

1. Test standards are in excess of national standards
2. Monitoring tests are analyzed by at least two labs
3. The health status is carefully classified by antigen and antibody status

Resources are committed to improvement of biosecurity

1. Program technologies are under regular review for improvement and revisions implemented as warranted
2. Biosecurity expense is counted in millions of dollars annually.

National standards of health practices strengthen trust along the chain

Underpinning the uniformity of compliance with best practices in several countries (e.g. USA, Canada, Chile, Brazil, many parts of Western Europe) are national standards of health practices. In the US, for example, provisions, developed jointly by industry members and State and Federal officials, establish standards for the evaluation of poultry breeding stock and hatchery products with respect to freedom from certain diseases and thereby provide certification of poultry and poultry products for interstate and international shipment   This program is called the National Poultry Improvement Plan (http://www.aphis.usda.gov/vs/npip/).

After flocks have arrived at their destinations, their health programs are managed by the flock owners. Technical service staff from the primary breeder (see figure 2) may visit and inspect GP flocks on short notice but their influence is through technical persuasion and advice, not through binding enforcement. Continuing business relationships between the primary breeder and the GP customer often depend on fulfillment of health and biosecurity standards incorporated into the sales agreement. Within a given country or sales region, there is sufficient competition for the limited number of franchises or distributorships to motivate high levels of compliance with health and management standards prescribed by the primary breeder.

Technical support links the chain participants

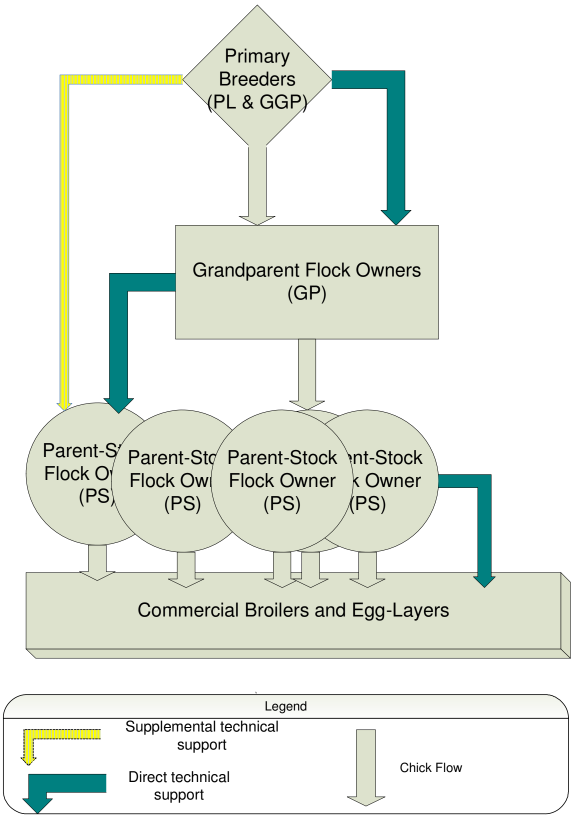

Figure 2. Schematic of technical service relationships along the poultry dissemination chain.

Generally speaking, franchisees and distributors owning GPs provide technical service to their PS customers using technical staff in the employ of the franchisee or distributor. Technical service staff from the primary breeder may be called in by the franchisee or distributor from time to time to augment training of PS owners and to attempt to update and standardize good health and biosecurity practices. These arrangements are not binding on the PS flock but economics often drives the motivation toward best practices.

Commercial growing operations in the broiler industry often have a close working relationship with the PS operation that supplies them, in many cases integrated or vertically aligned within a business relationship. This business alignment can lead to geographical and operational considerations which place commercial broilers within short transport distances from their supplying hatchery (up to 10 hours transit time) and from processing plants or markets. This can result in high regional concentrations of commercial broilers around a parent stock hatchery and relatively close to market outlets. On the one hand, close proximity to a market served by many different sources increases the risk of cross contamination, and possible contamination of the PS flock. On the other hand, this concentration limits the geographical reach of disease break and offers containment opportunities if prompt detection is possible.

This is particularly true if "wet" markets are involved, where birds are sold live, or if free range/organic operations, practicing extensive management, are in close physical proximity to intensively-managed flocks. The issue is the degree to which cross-contamination might occur between people, feed or market-bird delivery vehicles servicing commercial production operations and the vehicles, staff and access roads which service breeder flocks. Good biosecurity would call for geographic and traffic (human and transport) separation of broiler production farms from PS farms supplying broiler hatching eggs. Likewise, under ideal conditions, there would be geographic separation of breeder flocks from any extensively-

managed flocks of birds (FAO's sectors 3 and 4). Regional differences in achieving such separation increase the mean level of and variation in the risk of disease transmission into PS flocks.

Formal institutional linkages

Finally, there may be business ties between a PS operation and their commercial customers through direct ownership of the commercial progeny or by contract. In broilers, there's a rule of thumb that when a commercial broiler production unit exceeds 500,000 birds per 8-week cycle, there are economies of scale that justify their ownership of PS flocks to produce those commercial broilers. Under such circumstances, these larger production units are likely to employ technical and health professionals who would, in that role, design a health program which would benefit both PS breeders *and* their commercial broiler progeny. Even though these staff may be employed by the same company, good health practices dictate that they be dedicated to *either* PS *or* broiler production and not go from one farm type to another, thereby avoiding possible cross-contamination.

The network of technical service personnel employed by primary breeders extends across the globe. They influence health practices in breeder flock operations in a variety of ways but the direct impact of their sales agreements is greatest through the GP level. The uniformity of adherence to primary breeders' recommendations is in the hands of the customer throughout the supply pipeline but is influenced by the force of sales agreements and by regulatory programs (such as NPIP in the US) in the country where customers are located. For PS, there is large variation in standards between and within countries and there are even PS flocks managed no more securely than commercial flocks.

Risk of disease transmission by downstream market participants involved in breeding activities

FAO has characterized the poultry industry in terms of target market, degree of management control and level of biosecurity (Appendix 1). In relating the AI transmission risk associated with breeding stock to the four sector classes, one of the most important factors is the degree to which poultry are kept exclusively indoors. In the industry, operations which prevent birds from direct contact with the outside environment are referred to as "intensive" since they require detailed and reliable management of all nutrient, air quality, lighting and social factors in the life of a flock. Operations which permit some outdoor activity are referred to as "extensive". Both may successfully achieve good performance. Both can require careful management and be subject to stringent, certifiable standards of care. But one, that involving outdoor activity, carries a much higher risk of contact with other birds and animals and, therefore, of contracting disease and transmitting that disease to other birds and animals.

> "There has been extensive movement of stock from areas in which there have been [AI] outbreaks. Flocks are depleted and sold for food or as breeding stock (sometimes crossing national borders). Valuable stock (especially fighting stock in areas with high activity in breeding fighting cocks) is moved to 'safe' regions. The developed markets will not be so affected because stock is normally purchased from reputable sources. This problem has a disproportionate effect on the less developed markets"

Under that characterization, sectors 1 and 2 would be considered "intensive" while sectors 3 and 4 would be considered "extensive". While commercial progeny (those destined to be food for humans or those producing eggs for human food consumption) of PS breeders could be managed either intensively or extensively, primary breeder companies would always *recommend* intensive, enclosed management for

PS breeders. The extent to which primary breeders' recommendations are followed varies with country. For example, while it is fair to say that primary breeders would require that all broiler breeder Grandparent Stock (GPs) in all developing countries operate as sector 2 operations, it has been reported that, in China where only GPs are imported because PS importation is forbidden by law, a small proportion of GP operations may be subject to a high risk of contamination. Quantifying the risk and proportion of flocks has proven difficult because of suspected under-reporting.

Within China, due to current trade regulations, all PS would originate from GP hatcheries within the country. Some proportion of those PS operations would likely qualify as belonging to sector 3 with all of its attendant risks. There is a feeling that the risk at GP farms in China will be reduced by consolidation (eliminating some smaller operations), but that the risk of contamination at the PS level will still be of concern. In most other Asian countries, the situation is better but not yet risk-free. GP operations and most PS operations operate at a low-risk level. In Indonesia, GP flocks shipped from western breeding companies are, reportedly, under closer influences by the primary breeders who want strict adherence to biosecurity guidelines. In most other developing countries, PS are supplied by western breeding companies. Compared to China, the size of these markets is relatively small and the management of PS flocks is by only a few, relatively professional companies.

Trade flows

Details of the flow of trade in GGPs, GPs and, to a lesser extent, PS is not widely known outside of the primary breeding companies. Competition between the remaining four major breeders renders a detailed public disclosure of this information very difficult without a bottom-up assembly of information, country by country. What can be inferred from public domain information on chicken slaughterings is the geographic distribution of parent stock (PS), because of their tendency to be proximal to their customers raising commercial broilers or egg layers.

Table 1 (based on Watt Publishing's 2006 executive guide, summarizing poultry meat production during 2005) illustrates how 2005 chicken slaughter numbers may be used to infer the probable number of parent stock breeders in the same geographic region. Some countries in the region have sufficient market demand for quantities of parent stock or prohibit importation of PS so as to justify the presence of GPs in those countries. GP numbers are estimated in table 1 but the true GP numbers could be lesser or greater depending on the degree to which PS are either shipped directly from the primary breeding company facilities (which would lower the need for "local" GPs) or produced by that country to meet the demand for cross-border supplies of PS to neighboring countries (which would raise the need for GPs).

Table 1 Chicken population estimates (millions) and required parent stock and grandparent stock in selected regions in 2005

Region	Selected country	Layers and broilers slaughtered in 2005	Parent stock females required to produce the commercials (estimated)	Grandparent stock female line females required to produce the parents (estimated)
World	All	48,147	385	9.63
Africa	All	2,810	22	0.55
	Egypt	373	3	0.08
	South Africa	599	5	0.13
North & Central America	All	11,803	94	2.35
	Canada	645	5	
	Mexico	1277	10	
	USA	9150	73	
South America	All	7,427	59	1.48
	Brazil	5260	42	1.05
Asia	All	17,992	144	3.6
	China	7326	59	1.48
	India	2000	16	0.4
	Indonesia	1556	12	0.3
	Japan	633	5	0.13
	Malaysia	537	4	
	Thailand	720	6	
	Turkey	550	4	
Europe	All	7,582	61	1.53
	France	824	7	
	Netherlands	400	3	
	Poland	524	4	
	Russian Federation	830	7	
	Spain	880	7	
	UK	848	7	
Oceania	All	533	4	0.1
	Australia	434	3	0.08

The calculation of parent stock numbers was based on assuming a world market of 370 million broiler PS and a 24:1 ratio of broiler parents to layer parents. GP numbers were estimated assuming 40 PS per GP.

Supporting safe trade flows in breeding stock: biosecurity precautions

When the products of primary breeders leave the hatcheries, they do so with strong assurance of freedom from microorganisms which would threaten the health of downstream recipients of those chicks, within the limits of testing capabilities to reasonably detect and

diagnose disease. Breeders impose high standards of quality on the health status of these baby chicks with veterinary requirements falling into three categories of immune status:

1. Absence of antigens and antibodies. In this disease category, antibodies due to vaccination or to disease are *not* permitted.
2. Absence of antigen. In this disease category, antigens of viral, bacterial or parasitic origin are *not* permitted.
3. Presence of antibodies. In this disease category, antibodies, generally of maternal origin, *are* permitted.

Source flocks which meet these standards will be allowed to supply chicks and GP or PS hatching eggs between certain countries. The vehicles in which the chicks are transported for trans-shipment are clean, held in a secure environment immediately prior to loading chicks and equipped with heating/cooling, ventilation and humidity controls. The chicks themselves may be supplied with a nutrient gel to ensure hydration and health protection during transit.

> "For more than 30 years, [primary breeding company] has been sending day-old chicks of type GP and PS to many different countries in the world. So far, there is no record of any disease that has been spread by such trade."

Most international shipments involve delivery of the chicks to a sheltered location at an airport. The boxes in which the baby chicks are shipped are palletized in groups for ease of handling and to provide a measure of temperature stability. Breeding companies endeavor to have airport storage facilities isolated from other animals and birds being shipped on the same day and to avoid having shipments of other avian species on the same flight. A violation of those agreements by the airlines will generally result in cancellation of the shipment and require a later replacement to the customer. During the flight, the chicks are under environmentally controlled conditions prescribed by the airline's code of animal transport and IATA.

Chicks arriving at their destination airport are met by customer representatives equipped with transport vehicles which have been sanitized and are equipped with environmental controls suited to the destination environment. The responsibility for equipping the transport vehicles appropriately lies with the customer. Prompt delivery of the chicks to a supply of food and water in growing facilities ensures that transport stresses are kept to a minimum. Mortality occurring during the journey is noted soon after arrival and is reported to the primary breeder; the cause(s) of mortality is (are) investigated immediately by company representatives working with labs and country health authorities, if necessary. If the chicks being delivered are GGPs, they are almost certainly under strict control of the primary breeder and would be under a biosecurity program resembling that of primary breeder operations.

> Reovirus
> Mycoplasma gallisepticum
> Mycoplasma synoviae
> Salmonella pullorum
> Salmonella spp.
> Newcastle disease virus
> Infectious bursal disease virus
> Avian encephalitis
> Chicken anemia virus
> Avian influenza
> Infectious bronchitis virus
> Avian pneumovirus
>
> **Box 2: Examples of microbial agents tested for in broiler GPs**

The customers have paid a high price in monetary and other resource investments for each of these baby chicks and this, in itself, is an important motivator for protecting those chicks from disease. Despite this, smaller GP

> "Pedigree, great-grandparent, and grandparent operations worldwide participate in active surveillance programs for transmissible poultry diseases including all types of Avian Influenza. These ongoing testing programs have been in place for many years"

flocks in some developing countries are reported to be *at risk*. By virtue of numbers and unit cost, economic motivators in place are similar for PS flocks in the egg layer, turkey and duck sectors of the poultry industry as for GP flocks in the broiler sector. That is, the investment in birds and resources, and the need for high levels of productive efficiency from the hatchery (often greater than 90% utilization) coupled with the risk of possible delays in flock replacement motivate a mostly *proactive* biosecurity strategy.

As with PL operations, GP operations place great emphasis on disease *monitoring* (box 2) and *early detection* of problems to play a role in avoiding disease exposure and spread. Several countries (e.g. Mexico, Brazil, others in Central America) have in place government regulations for monitoring PS flocks. In Mexico, the law requires that PS flocks are monitored for *S. gallinarum, S. pullorum,* A.I. and Newcastle disease. Many flocks are voluntarily monitored for Mycoplasma species without the requirement of law. Furthermore, Brazil requires monitoring PS for those diseases and for *S. enteritidis* and *S. typhimurium.* Unfortunately, the presence of laws and regulations does not ensure uniform enforcement. In any region without uniform standards or enforcement, there is bound to be greater risk. Wherever corruption makes for uneven distribution of penalties, violations are possible.

Ongoing protection of the chicks against disease is strengthened by vaccination against diseases such as those listed in box 3. Vaccination programs are likely the same for broiler GGPs and GPs within a country or region.

Marek's disease
Coccidiosis
Infectious bronchitis
Newcastle disease
Infectious bursal disease
Reovirus infection
Avian pneumovirus infection
Avian encephalitis
Chicken anemia

Box 3. Diseases against which GGPs and GPs may be vaccinated

Trade threats from market access constraints placed on primary breeders

Pure line operations are subdivided into small units that are managed as independent biosecure entities with all the appropriate restrictions on personnel and vehicles moving between units. In keeping with the high value placed on their genetic lines, PL egg-production units are operated as all-in-all-out facilities and are completely depopulated and disinfected between bird placements. One generation of PLs is replaced by the next generation and the replaced generation is slaughtered. Eggs and birds cannot be "archived" in order to provide backup in case of disaster (such as disease outbreak). Some protection against disaster is afforded breeding programs and market supply lines by placing replicate flocks in separate geographic locations. Despite the high reproductive rate of poultry, however, such a program of replication has biological, economic and logistical limits. Operational efficiency requires maximum use of these replicate flocks for production of multiplication stock to be sold into the global marketplace.

[We employ measures that] "offer protection from Avian Influenza (AI) and the possible spread of infected breeding stock around the world. These measures and programs include strict biosecurity policies, disease surveillance, distinct geographic locations of breeding stock, and AI emergency preparedness plans"

In today's climate of AI concern, some regions may be suddenly rendered off-limits by importation restrictions imposed out of proportion to the risks posed by the flu incidence and without recognizing that the health status of breeding flocks *within* those regions remains at

high health levels. An important example of disproportionate trade bans occurred when 45 countries banned imports from the UK based on the death of a small number of birds in a *quarantine* facility. Most of these bans were lifted when OIE confirmed that there had been no further isolations of H5N1. Some of the bans persisted after OIE clearance.

A similar incident occurred when a dead swan was discovered in the ocean off Scotland. No isolates were ever made from a live bird but the same countries again imposed immediate restrictions. Because of one AI case in France in February, 2006, China imposed an import ban on French shipments which lasted through November, 2006. Bans by other African countries lasted from two to six months. In 2003, an AI outbreak in the Netherlands led to a blockage of poultry exports for more than three months. However, almost all countries outside the EU closed their border for import from the Netherlands for up to 12 months. Some countries are still not open after three years (e.g. Mexico, Peru).

In 2006, HPAI cases in Germany, Denmark and LPAI case in the Netherlands led to border closings in more than twenty countries for three to twelve months from South Korea, Philippines, Japan, Russia, Thailand, Bangladesh, Sri-Lanka, India, Nigeria, Tanzania, Israel, Palestine, Syria, Central America. So, even with careful forward planning, trade flows may be interrupted with negative economic consequences on the supplier and its customer for whom orders were placed months in advance.

International coordination

Breeding companies are continually trying to establish agreements between exporting and importing country authorities to promote procedures and methods that reduce risks to trade. These companies understand that well-executed disease prevention and containment procedures play a key role in keeping supply lines open and avoiding great amplitude swings in supply numbers. These activities can be audited and monitored in approved laboratories in many regions. OIE has established criteria for defining so-called "compartments"[4]. Compartmentalization is viewed by breeders as an important opportunity to reduce the number and length of trade restrictions. In late 2006, The US program (NPIP) endorsed compartmentalization and details should be available after their meeting in Atlanta in January, 2007. Unfortunately, in some regions of the world, particularly in developing countries, the laboratory network may not be sufficient to support rapid turnaround times for tests. This could be an impediment to the speed required for effective monitoring.

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[4] **Principles for defining a zone or compartment** In conjunction with the above considerations, defining a zone or compartment should be based on the application of the following principles:

1. The extent of a *zone* and its limits should be established by the Veterinary Administration on the basis of natural, artificial and/or legal boundaries, and made public through official channels.
2. The requirements regarding a compartment should be established by the Veterinary Administration on the basis of relevant criteria such as biosecurity management and husbandry practices, and made public through official channels.
3. Animals and herds belonging to subpopulations need to be clearly recognizable as such. The Veterinary Administration must document in detail the measures taken to ensure the identification of the subpopulation and the recognition and maintenance of its health status.
4. The procedures used to establish and maintain the distinct health status of a zone or compartment should be appropriate to the particular circumstances, and will depend on the epidemiology of the disease, environmental factors, applicable biosecurity measures (including movement controls, use of natural and artificial boundaries, commercial management and husbandry practices), and surveillance.

Terrestrial Animal Health Code. 2006. OIE. Zoning and Compartmentalization: Article 1.3.5.4

Some countries make demands on primary breeders that are *beyond* the OIE requirements. For instance, Mexico's demands have included a requirement to have their authorities visit and inspect breeding operation sites. Brazil only allows the importation of hatching eggs from some sources after direct negotiation with the breeding companies involved. China, Thailand and Korea extend bans beyond the OIE guidelines (see examples cited previously in this report). On the other hand, some importing authorities cooperate fully in a risk assessment and acknowledge the importance to their domestic industry in ensuring early lifting of restrictions or a change in supply source. Rationalizing these differences, in the context of disease outbreaks, would reduce the economic shock to the breeding industry and to their customers.

Veterinary specialists of primary breeding companies are also active with the veterinary authorities of the countries into which their company products are sold. These company professionals participate in AI prevention workshops, and in international negotiations to help find health certificate wordings that provide an acceptable level of assurance to the importing countries.

Disease outbreaks, costs, and control

Cost of preparedness

The maintenance of surplus capacity by breeding companies is a significant cost. Overall the estimate of annual biosecurity cost to primary breeders is in excess of $20 million. This is the cost of preparedness. It is reported that the laboratory costs alone of these programs have increased by about 50% in order to meet requirements called for in response to HPAI-driven health stipulations from importing countries. It is estimated that up to one third of the labor hours required to run a primary breeding operation are spent on biosecurity.

Costs to exporters from order losses

Loss of orders due to trade disruption is an extra cost to the breeding companies and can be substantial where bans are in place for extended periods of time. There is a concern that primary breeders may be impeded from exporting their breeding stock not because of health status but rather because of political barriers imposed by governments attempting to protect their own poultry industry. This is more likely to be an attempt to shelter their own meat production industry (and prices) from imported meat than a direct blockage of breeding stock. But it appears that the term "poultry" covers the range of imported products from poultry meat to day-old-chicks and breeding industry shipments get caught in the ban. When this happens, and the primary breeder company is not able to export its product from one region, the penalties include that of the lost revenue from the rejected shipment and the increased shipping cost of sending product from an alternative location. For example, losing the ability to ship a 15,000 day-old PS chicks valued at US$35,000 from the UK to The Philippines and replacing the order with a similar shipment from the US would cost the company the $35,000 in income from the rejected shipment and, for freight and handling costs alone, an additional US$3,300, the difference between shipping from The Philippines (US$7,700) and shipping from the US (US$11,000). When one considers the fact that the value per GP may be higher than that per PS by a factor of 10 or more, it's easy to understand how quickly the economic costs on suppliers of day-old breeder chicks escalates and can be seriously compounded by extended bans on shipments.

Unless breeding companies have excess capacity, a flock of baby chicks lost to disease or other disaster may not immediately be replaced since subsequent lots of baby chicks from the source flocks would, to the greatest extent possible, be allocated to other customers.

Delays in replacement could place the customer's economic status at risk since forward planning would have committed him to deliver progeny to *his* customers on a schedule, months in advance, which would be jeopardized by interruptions in his supply of breeders. Primary breeders have accepted the cost of excess capacity but it clearly has limits which can be strained if trade interventions become onerous.

Costs to importing countries

Given the biological nature of the day-old-chicks 'goods' and their supply flocks, trade interruptions of any kind can be economically disruptive and potentially costly to both shipper and customer. Extended interruptions in supplies of genetic material can impose a more insidious penalty on the importing country. Rather than *protecting* the domestic industry, poorly designed import regulations could, in fact, impose unintended economic penalties on the producer and consumer of commercial products (broilers or eggs) in that country. Requirements placed on exporting countries by a given importing country may differ in important features, making it difficult or impractical for a supplier to shift rapidly between source countries. Recently, after the UK HPAI outbreak in turkeys, there were instances where orders could not be filled, leaving the customer in a quandary about facing economic downturn in his business or seeking alternative, and possibly less safe, chick sources. Another example of negative economic consequence which may seldom be considered when fresh supply of genetic material is interrupted is the (temporary) impact of unrealized genetic gain. It is estimated that annual genetic improvement of broiler breeding stock provides an improvement in production of about 2% in broiler performance, part of which is the improvement of about 1% per year in converting feed to bird growth. Globally, this means that, with an annual chicken meat production in the world of about 70 million tonnes, approximately 1.4 million tonnes of feed is spared every year in order to produce a given amount of weight gain. No matter how this feed is valued 'on average', the greatest economic impact is likely to be in regions where keeping feed costs down are of greatest importance, namely in developing countries.

The importance of compensation as a control measure

Compensation is a necessary part of any program designed to speed recovery and mitigate socio-economic penalties of outbreaks. It must be administered, together with the threat of penalties for violation, in a way that motivates breeders to report *promptly* any outbreaks. The sooner any outbreak is detected and contained, the better. The closer the compensation scheme is to fully covering the costs of the disease outbreak, the more that flocks owners are likely to participate. Compensation rules should motivate a strong surveillance program (flock health monitoring) since prevention is generally less costly than cleanup. Finding an appropriate compensation figure for the bird population under threat (GP, PS, commercials) is important and should recognize that breeder stock value increases substantially the further up the chain the chicks are toward the primary breeder source. On a cautionary note, compensation which is overly generous can motivate false or opportunistic claims to the detriment of the financial resources committed to the industry. Recently[5], in an Op-Ed piece by Ruth Faden of Johns Hopkins University Berman Institute of Bioethics, Dr. Faden stated that "The Indonesian government pledged to pay about $1.50 for each bird infected with the H5N1 virus, a sum that may approximate the bird's fair market value. But most birds that have been killed under this policy are healthy, so their owners, most reports suggest, will receive nothing." The danger in such a situation is that those whose survival depends on the poultry destined to be destroyed and for whom compensation seems unlikely may seek to

[5] RUTH R. FADEN, PATRICK S. DUGGAN and RUTH KARRON. 2007. "Who Pays to Stop a Pandemic?" New York Times. February 9,

move these birds or otherwise dispose of them for monetary reward of some kind. In November, 2006, Dr. Bob Burden presented his views on a "Shared Risk Management" approach at the FAO symposium entitled "Market and Trade Dimensions of Avian Influenza Prevention and Control". Lessons learned from experiences in Canada makes it important to consider SRMA as part of a long-term strategy which could unite producers and suppliers around shared security across a region with interlinked poultry dependencies.

Models of success

Keeping the industry disease-free is not itself free of cost. This cost, however, is considered less than the cost of disease outbreaks, particularly in the case of AI, with its direct consequences on poultry operations, large and small, as well as the toll it takes in public confidence and economic shock on markets. Success is possible when there is cooperation between industry participants and state regulatory authorities. Successful national programs of industry-government collaboration, such as the NPIP program in the US, model this participatory and evolving process with enough flexibility built in to be able to respond to emerging disease risks and threats in a consolidated fashion. In addition to the US NPIP program, there are other programs to consider:

1. Council Directive 90/539/EEC of October 15,1990 on animal health conditions governing intra-Community trade in and imports from third countries of poultry and hatching eggs [Official Journal L 303 of 31.10.1990][6]
2. National health programs in Canada, Chile and Brazil

[6] http://europa.eu/scadplus/leg/en/lvb/l12007.htm

Conclusions

1. The global trade network in day-old poultry breeders delivers millions of chicks at the GGP and GP level to more than 100 countries with extremely low risk of transmitting disease of many kinds, including Avian Influenza, because of health practices and risk awareness throughout the network.
2. Some small GP flocks in China are considered to be at higher disease risk than most GP flocks globally because of the absence or incompleteness of effective biosecurity measures. PS flocks in that country, and in other developing countries are at higher disease risk than most PS flocks globally. As a consequence, the commercial broilers and layers sold from these hatchery facilities may spread diseases throughout the lines of trade through which they move.
3. Breeding stock are under continuing threat of contamination from birds under extensive management, including commercial broilers and layers which are exposed to bird and human traffic without the protection that intensive management can provide.
4. Breeding stock are under continuing threat of contamination from animals in contact with disease-carrying birds.
5. With the aid of programs such as NPIP and the internal biosecurity procedures of primary breeders, the threat of disease contamination is kept to a minimum.
6. The risk of AI transmission by genetic stock exists to the extent that well-understood and thoroughly tested health procedures are not followed. That risk is considered to be low at the higher levels of flock multiplication and dissemination (PL through most GP flocks) in most global locations. Factors which can increase this risk include:
    a. Lack of uniform standards for health practices within and between countries. Developing countries are likely to have variable application of high health practices, variable enforcement of health regulations and limited capabilities to monitor flocks effectively because of fewer laboratory resources and slower turnaround on tests.
    b. Failure by breeding stock owners to implement procedures which combat the dangers that exist in their immediate vicinity (e.g. neighboring flocks, traffic patterns of transport vehicles, staff requirements). Low profit margins can exacerbate these dangers if breeder operations are unable to support the investment needed for effective biosecurity.
    c. Inadequate insurance against catastrophe can delay reporting or motivate illegal sale and movement of condemned flocks.
    d. Prospects of delays in restocking can lead to less safe restocking methods and sources. For example, a parent stock flock owner might use the commercial progeny of breeder parents as breeders themselves. Or the owner might obtain breeders from sources within the country that are not subject to the same rigorous biosecurity that characterize the primary breeders. There are disease risks posed by these practices. Delays in restocking may be the result of well-intended, but unsuitable efforts by regulatory authorities to block shipments without health-justified cause.

Recommendations

1. Create more uniformity and transparency in poultry health standards.
    a. Convene a meeting of officials who administer national poultry health programs (e.g. NPIP) and those from developing countries charged with creating national standards.
    b. Convene a meeting of willing participants from breeding companies, OIE and policymakers from certain key countries importing breeding stock in order to gain consensus on acceptable criteria for compartmentalization.
    c. Promote, at the state level, wider acceptance and strict implementation of OIE guidelines and acceptance of OIE independent arbitration in case of conflict.
    d. Enforce existing regulations more uniformly
    e. Strengthen testing resources to enable effective proactive monitoring
2. Improve awareness of the number and location of breeder operations
    a. Build and maintain a database of global breeder/hatchery operations using current import/export information, including number and type (GP, PS) of breeder operation.
    b. Develop an understanding of the chick traffic patterns at the lowest end of the supply chain and how well and how rapidly that flow may be managed in a disease outbreak.
    c. Reward flock registration and health certification. The right to trade is the key reward.
3. Educate
    a. Through political networks, educate policy makers about the real economic consequences of trade interruption and about serious efforts already in place in major parts of the breeding sector. Build relationships with those in a position to develop international consensus.
    b. Through agricultural extension, ensure that extensively-managed poultry are aware of the risks posed to their own poultry and to breeder operations from direct contact between confined breeding stock and unconfined birds (see Appendix 2 and multiple references on biosecurity on the web). Recognize that adding more than 1% of production costs to improve health will be met by resistance from producers who already budget 6-8% of their production costs for medication and vaccination.
    c. Promote 'good neighbor' policies between intensively managed operations and surrounding communities.
    d. Promote and motivate use of procedures which isolate subsets of poultry from one another and separate caretaking personnel with whom these subsets have contact. Appeal to the alignment of sound health policies and self-interest.

> [We] "educate our neighbors keeping poultry of the dangers of mixing poultry species and especially interaction with wild waterfowl. We encourage free range bird producers to utilize diagnostic monitoring laboratories to assure the health and well being of their poultry"

Appendices

Appendix 1
FAO's poultry sector classification scheme

Sectors[7] (FAO/definition)	Systems			
	Industrial and integrated	Commercial poultry production — Bio-security		Village or backyard
		High	Low	
	Sector 1	Sector 2	Sector 3	Sector 4
Biosecurity	High	Mod-High	Low	Low
Market outputs	Export and urban	Urban/rural	Live urban/rural	Rural/urban
Dependence on market for inputs	High	High	High	Low
Dependence on good roads	High	High	High	Low
Location	Near capital and major cities	Near capital and major cities	Smaller towns and rural areas	Everywhere. Dominates in remote areas
Birds kept	Indoors	Indoors	Indoors/Part-time outdoors	Out most of the day
Shed	Closed	Closed	Closed/Open	Open
Contact with other chicken	None	None	Yes	Yes
Contact with ducks	None	None	Yes	Yes
Contact with other domestic birds	None	None	Yes	Yes
Contact with wildlife	None	None	Yes	Yes
Veterinary service	Own Veterinarian	Pays for veterinary	Pays for veterinary	Irregular, depends on

[7] ***Sector 1***: Industrial integrated system with high level biosecurity and birds/products marketed commercially (e.g. farms that are part of an integrated broiler production enterprise with clearly defined and implemented standard operating procedures for biosecurity).
Sector 2: Commercial poultry production system with moderate to high biosecurity and birds/products usually marketed commercially (e.g. farms with birds kept indoors continuously; strictly preventing contact with other poultry or wildlife).
Sector 3: Commercial poultry production system with low to minimal biosecurity and birds/products entering live bird markets (e.g. a caged layer farm with birds in open sheds; a farm with poultry spending time outside the shed; a farm producing chickens and waterfowl).
Sector 4: Village or backyard production with minimal biosecurity and birds/products consumed locally.

		service	service	govt vet service
Source of medicine and vaccine	Market	Market	Market	Government and market
Source of technical information	Company and associates	Sellers of inputs	Sellers of inputs	Government extension service
Source of finance				
Breed of poultry	Commercial	Commercial	Commercial	Native
Food security of owner	High	Ok	Ok	From ok to bad

Appendix 2
Requirements to minimize risk of disease transmission

1. **Isolation**: Ensure isolation of breeders from other avian species and animals that could have had contact with avian species.
2. **Traffic Control**: Ensure and reward safe practices by staff that tend the breeder flocks and hatcheries. Build good relationships with neighbors, service providers and community leaders. Educate them on the dangers. They may be the best sentinels for a disease outbreak.
3. **Sanitation**: Disinfect material, people and equipment entering the farm. Attend to the cleanliness of farm facilities and personnel on the farm. Develop close relationships with veterinary, law and emergency personnel. Keep them well informed about the operation and the possible dangers. Their prompt response may save the operation from disaster.
4. **Surveillance**: Monitor aggressively. Follow guidelines by local authorities and implement new developments as soon as possible. From time to time, verify the reliability of labs by submitting duplicate samples to other labs.