

**INTERNATIONALIZATION OF LIVESTOCK BREEDING
SCIENCE****J. F. Taylor****Summary**

It appears that a series of paradigm shifts are occurring that will enhance the degree to which Livestock Breeding Science is internationalized. Technologies such as the WWW are revolutionizing the way we access information and communicate. Reductions in public investment in R&D force continual rationalization of how and where resources are allocated. Strategic alliances between universities, government research organizations, companies and industry funding agencies are developing, in some cases, without regard for international barriers. Scientists are becoming more intimately involved in the commercialization of sophisticated technologies to the public sector. Industry leaders are considering important philosophical issues that define just who or what is the competition for the products that they are producing. In the case of beef, are the Australian and U.S. industries in competition for the Pacific Rim markets? Or is poultry the true competitor to beef? If the latter is the case, the argument for international collaboration mediated by investment is most compelling. However, none of this should be construed to imply that new technologies developed within Livestock Breeding Science will all be publicly available. The trend is towards internationalization of ownership and commercialization, not publication and dissemination for the benefit of all.

Perhaps the first issue that should be addressed in this presentation is to ask the question "What is Livestock Breeding Science?" The term Livestock Breeding Science will likely mean different things to research scientists, extension specialists and producers. Therefore some definition of terminology seems appropriate before we tackle the specificities. Having spent the entirety of my career in an academic environment, I view the scientific process as having four logically connected phases which for convenience I shall define as: pure science, applied science, scientific demonstration or validation and commercialization.

Rad je priopćen na "The 6th World Congress on Genetics Applied to Livestock production", Armidale, January 11-16 1998.

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The fact that I jointly include pure science, applied science and validation (or extension) in this process reflects my experience within a College of Agriculture in the U.S. Land Grant University system. It is certainly true that this level of integration of the processes of research is not universal and this lack of integration may serve as an impediment to technology transfer in some countries.

The fact that I include commercialization in this process reflects the adoption of a relatively new paradigm within the U.S. University System and also in many other publicly funded international research organizations. This paradigm shift has been motivated by two realizations. The first is that the scientists responsible for the development of new technologies are probably the best people, both technically and due to their vested interest in the success of their technologies, to involve in the transfer of these technologies to the public sector. The second realization is that public funding to support university-based research (and instruction for that matter) has declined dramatically over the last 20 years and the prognosis is for a continuing erosion of the funding base. Capturing revenues generated by direct university involvement in the commercialization process is not as much motivated by avarice as it is by Charles Darwin's philosophy of the survival of the fittest.

I view the purpose of pure science as being to create new knowledge, methodologies and understanding of biological or physical systems. Pure science may not necessarily be performed with the express purpose of solving a practical problem. However, this is invariably the case within the domain of agricultural research. The caricature of university scientists performing irrelevant research within their ivory towers, simply cannot be substantiated in view of the limited resources available to support university research. The development of the theory of Best Linear Unbiased Prediction (BLUP) by C.R. Henderson provides an excellent case in point. This body of theory has had perhaps the most profound impact on livestock breeding in the history of the science. However, its application is not limited to livestock breeding and it has found application in numerous plant breeding, fish and tree breeding programs as well as in statistics and the physical sciences.

Applied research takes developed theory, methodologies and algorithms and focuses them to provide a solution to a practical problem. The development of computer software tools such as MTDFREML and BREEDOBJECT are excellent examples. Both tools required the development of substantive bodies of theory in diverse areas before they could be integrated to solve practical problems in livestock breeding. Scientific demonstration or validation requires the collaboration between scientists with research and extension appointments in the U.S. scenario. It serves at least three essential and rather practical purposes. The first is to determine whether the developed technology can be made to work in view of the physical and economic

constraints of the end-user. The second is to determine refinements that will increase biological and economic efficiency, while the third is to develop consumer confidence and thus generate demand for the technology. Finally, commercialization is the process by which technology finds adoption in the marketplace. It may be accomplished by licensing the technology to a commercial company, by the formation of a new company involving the university and perhaps also commercial ventures, or it may not happen at all if the technology is relegated to journal articles or is mishandled by its developers. In my experience, the commercialization of new technologies is the area in which most scientists have the least understanding of the process, and thus, it is the most difficult.

The second question that occurred to me was "Is the Internationalization of Livestock Breeding Science desirable?" In an attempt to answer this question it occurred to me that it might be better to try and answer the question "Is the Internationalization of Livestock Breeding Science occurring?" From the perspective of pure and applied science, it is clear that there is a high degree of international involvement in the generation and sharing of new knowledge. After all, the measure of a researcher is usually his or her productivity in publishing peer reviewed journal articles. Even if these articles divulge information that is subject to patent restrictions! Never the less, the amount of new information published in hard journals, electronic journals or available through databases on the World Wide Web (WWW) is almost incomprehensible and certainly is beyond the capability of most of us to keep up with, even within the narrow domains of our research interests.

A second important area in which internationalization occurs is through the need to limit redundancy. The scarce availability of resources dictates that scientific research should be duplicated only to the extent that is necessary for validation of the technology. Thus research group foci have evolved in centers in different countries according to the resources and expertise that has been developed in each group with the expectation that research findings will be shared with the international community.

Third, mechanisms of communication and exchange such as conferences, training of foreign students, sabbatical leaves for scientists, hiring of foreign scientists, and E-mail listservers such as the Animal Genetics Discussion Group (AGDG) and Animal Gene Mapping Discussion Group (ANGENMAP) are rather obvious venues that facilitate the Internationalization of Livestock Breeding Science. There is also considerable evidence for the internationalization of validation research and for the commercialization of developed technologies. In the case of validation research, there are numerous examples which include the evaluation of exotic breeds, feed additives, growth implants, bST in dairy cattle and of gene markers for various characteristics in swine and cattle. Many of these studies have been conducted as precursors to

the marketing of new products, and of course this is a necessary and important step in my view of the scientific process.

From the perspective of commercialization, it is obvious that any company should attempt to commercialize its products in the international arena so as to maximize profitability. Thus commercialization is often international but may not necessarily be viewed as being internationalized. There are many companies that have very successfully commercialized their germplasm in the international marketplace and there is no doubt that there have been economic benefits to most markets into which their products have been introduced. However the profits that these companies achieve probably should not be viewed as being internationalized. Under the free market model, this realization should provide motivation for the development and commercialization of new technologies within the countries in which they were developed.

Viewed from this perspective, the Internationalization of Livestock Breeding Science would, in general, appear to be a good thing, because it seems to happen rather extensively. However, there are also areas in which the Internationalization of Livestock Breeding Science is not occurring. Although we have come to live in a "world economy" idealistically based on free trade, this free trade is based on competition. Under this model, whoever can produce the best quality product at the most competitive price should be guaranteed access to international markets and thus achieve the economic benefits of foreign exchange!

One example of this is the view that the competition for certain beef products in the Pacific Rim and European markets is from the Australian and Argentinean industries. Thus there is rather strong motivation to maintain a degree of secrecy in areas of research that may lead to the development of new technologies that may provide a competitive advantage to the domestic industry, or have considerable opportunity for international commercialization. Such technologies may remain secret until international patent protection has been achieved, or may be held secret and commercialized as a trade secret. The incorporation of commercialization into the previously sacrosanct triage of pure, applied and demonstration research has been directly responsible for a constriction in the freedom of availability of internationally developed science. Companies that fund directed research projects at universities do not want to endanger their likelihood of bringing a product to market by losing control over their investment through unexpeditiously making it public. Universities themselves are increasingly aware of the opportunities to commercialize technologies developed within their institutions and thus must ensure that these technologies are protected to the degree necessary to ensure their attractiveness to commercializing agencies. When based on a realistic expectation of near-term commercialization, I view this aspect of the de-Internationalization of Livestock Breeding Science in a positive light. Placing the expectation of

commercialization on the scientists involved in the development of new technologies will increase the rate at which technology is transferred to the public and will also increase the rate of successful technology transfer.

Any constraint to the free flow of scientific information must have the greatest impact on the small investors. Large economies that invest a relatively high proportion of their GDP into research and development (R&D) will become the leaders in the development and commercialization of new technology. Countries that invest relatively smaller amounts in R&D will become rapidly constrained in their ability to develop and commercialize new technologies and thus will be relegated to become the purchasers, or end-users of new technologies.

Clearly, this argument reflects my belief that investment in R&D is an economic stimulus, but I do not mean to imply that such investment should be the sole responsibility of the public sector. Further, the validity of this argument is based to an extent on the rather naive assumption that investment strategies in R&D are scale independent. As R&D budgets have declined in many countries, responsible resource managers have developed a number of models to maximize expected returns and minimize the risk in investment. Common components of these models include: 1) focusing resources in areas of excellence and with the greatest opportunity for return, 2) leveraging public funds against industry and private funds, 3) portfolio diversification, and 4) investment in controlling technologies. The CRC model in Australia provides an excellent example. If we consider the Beef CRC in Armidale with which I am most familiar, this center is focused on an industry with a considerable opportunity for expansion of foreign trade through the production of specification products, it reflects the development of an R&D base without parallel in the country, and is funded through a consortium of federal, state, industry and private sources.

However, other interesting examples have also begun to emerge. Recently, I was visited in the U.S. by representatives of the Australian Meat Research Corporation (MRC) who were evaluating U.S. research addressing issues of beef quality. I was very surprised to learn that the MRC was no longer constrained to invest in R&D solely within Australia. The philosophy with which I was presented was that the MRC was examining opportunities to invest in near-market technologies regardless of where they had been developed; that part ownership of many useful technologies was of greater value to the Australian beef cattle industry than sole ownership of relatively few technologies. Not only does this philosophy reflect a major paradigm shift from the domestic agenda to the internationalization of publicly funded R&D, but it makes inherent sense from a business perspective! By internationally diversifying the R&D portfolio, investment becomes possible in the highest-value and most near market technologies.

Similar examples exist in industry. The U.K. based PIC invests in R&D at universities internationally and the consortium of the New Zealand LIC and Holland Genetics have made a major investment in the laboratory of Michel Georges in Belgium to identify genes associated with variation in milk production in dairy cattle. Perhaps the one opportunity area that has yet to be fully exploited is the internationalization of investment in controlling technologies. By a controlling technology, I mean the development of a resource that essentially must be used by all researchers working in the area. These resources must also be so technologically advanced and expensive to produce that they should only be produced one time, thus directing most, if not all researchers to the owners of the technology in order to pursue their research. Access to the technology would be granted based upon co-ownership of any subsequent technology that is commercialized as a result of access to the controlling technology. In the early days of genome mapping in the livestock species, there was some indication that the developed genetic maps would be maintained privately so as to become controlling technologies. However, the construction of these maps was not that technologically advanced and the importance of having these maps in the public domain was so great that public funds were allocated to ensure that this was accomplished. Never the less, it is my view that there are a number of controlling technologies that could be identified within many areas of Livestock Breeding Science that are worthy of investment.

In conclusion, it appears that a series of paradigm shifts are occurring that will enhance the degree to which Livestock Breeding Science is internationalized. Technologies such as the WWW are revolutionizing the way we access information and communicate. Reductions in public investment in R&D force continual rationalization of how and where resources are allocated. Strategic alliances between universities, government research organizations, companies and industry funding agencies are developing, in some cases, without regard for international barriers. Scientists are becoming more intimately involved in the commercialization of sophisticated technologies to the public sector. Industry leaders are considering important philosophical issues that define just who or what is the competition for the products that they are producing. In the case of beef, are the Australian and U.S. industries in competition for the Pacific Rim markets? Or is poultry the true competitor to beef? If the latter is the case, the argument for international collaboration mediated by investment is most compelling. However, none of this should be construed to imply that new technologies developed within Livestock Breeding Science will all be publicly available. The trend is towards internationalization of ownership and commercialization, not publication and dissemination for the benefit of all.

INTERNACIONALIZACIJA ZNANOSTI O UZGOJU STOKE

Sažetak

Čini se da je u tijeku niz promjena paradigmi što će povećati stupanj internacionalizacije znanosti o uzgoju stoke. Tehnologije kao što su WWW uvode potpun preokret u način na koji dobivamo i prenosimo podatke. Smanjenje javnog investiranja u R&D tjera na neprekidnu racionalizaciju kako i gdje dati sredstva. Razvijaju se strateški savezi između sveučilišta, državnih istraživačkih organizacija, poduzeća i agencija za financiranje industrije, u nekim slučajevima bez obzira na međunarodne barijere. Istraživači su sve više upleteni u komercijalizaciju sofisticiranih tehnologija u javnom sektoru. Voditelji industrije razmatraju važna filozofska pitanja koja definiraju kome ili čemu služi natjecanje za njihove proizvode. U slučaju govedine takmiči li se australska i američka industrija za tržište Pacifičkog kruga? Ili, je li perad stvarna konkurencija govedini? Ako je to točno onda je argument za međunarodnu suradnju potpomognut investiranjem vrlo zanimljiv. Međutim, ništa od toga ne bi trebalo shvaćati kao da će sve tehnologije razvijene u okviru znanosti o uzgoju stoke biti dostupne javnosti. Tendencija je internacionalizacija vlasništva i komercijalizacija, a ne objavljivanje i širenje za dobrobit svih.

Primljeno: 20. 6. 1998.