Excerpt from "Avian Genetic Resources at Risk: An Assessment and Proposal for Conservation of Genetic Stocks in the USA and Canada". 1999. J.M. Pisenti, M.E. Delany, R.L. Taylor, Jr., U.K. Abbott, H. Abplanalp, J.A. Arthur, M.R. Bakst, C. Baxter-Jones, J.J. Bitgood, F.A. Bradley, K.M. Cheng, R.R. Dietert, J.B. Dodgson, A.M. Donoghue, A.B. Emsley, R.J. Etches, R.R. Frahm, R.J. Gerrits, P.F. Goetinck, A.A. Grunder, D.E. Harry, S.J. Lamont, G.R. Martin, P.E. McGuire, G.P. Moberg, L.J. Pierro, C.O. Qualset, M.A. Qureshi, F.T. Shultz, and B.W. Wilson. Report No. 20. University of California Division of Agriculture and Natural Resources, Genetic Resources Conservation Program, Davis CA USA. 120 p.

1

Introduction

GENETIC DIVERSITY, IN BOTH WILD and domestic species, is a limited resource worth preserving for future generations (OLDFIELD 1984; ALDERSON 1990; FAO 1992; NRC 1993; BIXBY *et al.* 1994). While many strong advocates promote the conservation of wild species, fewer are aware of the increasing loss of biodiversity in our major food species, particularly among domestic birds. Fortunately, breed conservation organizations have already made some progress in encouraging hobbyists and small-scale farmers in their role as conservators of unique and historically important breeds (BIXBY *et al.* 1994), particularly the less common chicken and turkey breeds (CRAWFORD and CHRISTMAN 1992). These two species are considered more at-risk than most other livestock species (e.g., cow, pig, sheep, goat, or horse) due to recent and extraordinarily rapid expansion of the commercial poultry industry.

In just 50 years, poultry production went from small, individually owned and reproduced farm flocks that formed a small but significant part of the farm income, to the huge commercial meat- (turkey or broiler-chicken) or egg-production ranches that are generally owned or controlled by large corporations (CRAWFORD 1990). In 1997 this industry generated over $21 billion in poultry products in the US (Box 1 and USDA-NASS 1998).

The intense competition engendered by the rapid growth and often narrow profit margins has served to eliminate the less competitive poultry breeders and to consolidate the high production industrial bloodlines in the hands of a dozen or so poultry breeding organizations. This has created a relatively limited genetic base for the chicken, derived primarily from two breeds (Leghorn and Rhode Island Red) for egg production, and two breeds (Plymouth Rock and Cornish) for meat production (CRAWFORD 1990). A similar situation exists for the commercial turkey. These highly selected industrial stocks considerably out-perform the old production breeds, given the correct feed and management. But the relentless drive to improve the meat- (and egg-) producing abilities of the commercial chicken and turkey stocks has exacted a biological cost: disease susceptibility, leg weakness, muscle defects, and various other inherited conditions that interfere with the ability of the bird to hatch, grow, and reproduce normally (CRAWFORD 1990). Despite these limitations, such stocks have already displaced or diluted some of the hardy, disease-resistant indigenous farm stocks kept in developing countries (MASON and CRAWFORD 1993).

The threat to genetic diversity extends beyond the hobbyist, farm, and commercial poultry

Box 1. Commercial value of the poultry industry

THE CHICKEN AND TURKEY are the two most commercially important poultry species in the US, having steadily increased in popularity with consumers for several decades. In 1987 these two species were the source of over $12.5 billion in marketable products; in 1997, their total value was $21.6 billion, derived from almost 8 billion broiler chickens, 300 million turkeys, and 311 million laying hens that produced 77.4 billion eggs that year (USDA-NASS 1998). This placed the 1997 poultry industry below the beef industry in value, but well above the pork or sheep industries, and about on par with the dairy industry.

The Canadian poultry industry is also growing due to both increased consumer demand and a diverse export market. More closely regulated than the US market, poultry production in Canada has increased slowly but surely between 1988 and 1996 (the most recent production year available), from 370 to almost 480 million broilers; from 18.6 to 21.6 million turkeys; from 27.5 to 28.2 million eggs. In 1995, the Canadian poultry industry was valued at $3.7 billion Canadian dollars (approx. $2.4 billion US) (AA-FC 1996).

stocks. Many of the genetically diverse avian genetic poultry stocks developed, maintained, and studied by academic researchers have disappeared or become at risk in recent years (Boxes 2, 3, and 4, and Chapter 5). As these specialized stocks vanish, unique opportunities for genetic advancement of the different species are lost, and scientific advancement in the agricultural, biomedical, and basic sciences is hampered. Loss of these unusual genetic stocks is not a trivial matter, since the different forms (alleles) of each gene that underlie the observed differences in these stocks may be found only in a single population of birds; if that population is lost, the unique alleles are also lost.

Genetic stocks of chickens, turkeys, and Japanese (Coturnix) quail have played important roles in both basic and applied research, often serving as premier model organisms in the study of fundamental questions in vertebrate biology. In the biomedical field, all three of these species have numerous mutant forms that have provided animal models for the study of certain inherited human disorders (Appendix 2). These include defects such as (glaucoma, macular degeneration) various limb defects, cleft palate, muscular dystrophy, and autoimmune forms of thyroiditis, vitiligo, and scleroderma.

Agriculturally important genetic stocks include those selected for various production-related characteristics. These include egg production, body shape, feed-use efficiency, leg strength, and disease resistance. Ironically, it is these selected stocks that are particularly vulnerable when funds become limiting, because improvements in production-related traits require many years and a relatively large number of birds each year. Basic research can make use of all these types of stocks, but the various single-gene mutations and genetically uniform inbred and congenic lines have proven to be particularly useful.

Despite recommendations for conservation (CAST 1984; NRC 1990), no formal conservation plan exists in the US or Canada for such research stocks, and many have been lost or now face extinction as curating researchers either retire or lose funding for stock maintenance.

The real and threatened loss of genetic diversity in chicken, turkey, and Japanese quail

Box 2. Dispersal of a genetically significant poultry collection

ONE OF THE LARGEST commercially derived collections of chicken genetic stocks in North America was located at the Center for Farm Animal Research (CFAR) in Ottawa, Ontario. Many informative studies were conducted with historical and modern commercial stocks that dated back to at least 1950. Some of the accomplishments include production of unique control strains from these stocks, improvement of production traits by selection with no evidence of plateaus, study of resistance to diseases including Marek's disease and lymphoid leukosis, comparison of methods of measuring eggshell quality, and the development of semi-congenic lines for meat-bird-derived endogenous viral genes (GRUNDER *et al.* 1995). The stocks used in these studies included versions of both meat- and egg-selected stocks that had been sequestered from commercial stocks several times since the 1950s, including control strains, multitrait selected strains, and specialty strains selected for one trait such as endogenous viral genes. Unfortunately, the facility in Ottawa lost its government support and was shut down April 1, 1997. Embryonic blastodermal cells from some 30 CFAR stocks not transferred to other institutions were frozen at the University of Guelph (Ontario, Canada).

Box 3. Collections at risk: University of California–Davis

AN EXAMPLE OF THE PROBLEMS confronting poultry genetic stocks is found at the University of California–Davis (UCD). As with other organizations across the country, UCD has reduced resource allocations for maintenance of genetic stocks. This has become an acute problem for poultry genetic stocks once maintained by the Department of Avian Sciences. The department itself has been subsumed by the Deptartment of Animal Science. The retirements of Ursula Abbott and Hans Abplanalp of the former Avian Sciences Deptartment have put at risk over 50 inbred, mutant, and specialty lines of chickens collected or developed by these two researchers since 1955 (see Appendix 2 for descriptions of these stocks) and formerly maintained by their research grants and departmental funds. These stocks have been distributed widely to researchers for use in such diverse areas as studies of the immune system (the effects of the major histocompatibility complex haplotypes on disease resistance and the characterization of the physiological parameters of a chicken genetic immune-deficiency syndrome), the architecture of the chicken genome (two of Abplanalp's inbred lines were used to create reference backcross populations and provide baseline DNA for the Chicken Genome Mapping Project), and the effects of inbreeding on different reproductive traits. Some of the mutations are useful as animal models for the study of certain human genetic diseases (ichthyosis, muscular dystrophy, scoliosis, and scleroderma). In addition, Abbott has maintained and studied 14 mutations with defined effects on craniofacial and/or limb development and two that affect the integument. Studies with these mutations have provided significant insights into mechanisms controlling vertebrate morphogenesis and pattern formation. These stocks have the potential to contribute significantly to our understanding of a variety of current and future problems within the basic, biomedical, and commercial/agricultural science realms of study, particularly with the use of the rapidly evolving technology that allows researchers to address the molecular genetic basis of such problems.

prompted the formation of the Avian Genetic Resources Task Force (AGRTF). Early in the discussions, Task Force members realized that there were several major, but different, conservation issues. One is the protection of the ancestral wild populations, another is the conservation of unique breeds and landraces of domesticated poultry species, and finally, a more specialized conservation effort is the preservation of unique genetic types developed for use in agricultural, biomedical, and basic biological research, including the various single-gene traits, highly inbred lines, and the populations or lines under improvement for various economic or other defined traits. While the preservation of wild progenitors of domestic species is of critical importance, as is the conservation of nondomesticated avian species world-wide, the Task Force decided that the scope of this report should be restricted to specialized genetic stocks. The Task Force also recognized that rare breeds conservation, as practiced by hobbyists and others, was already in place in North America. The North American poultry stocks currently most at-risk are the unique genetic variants and specialty stocks held by research institutions in the US and Canada. A comprehensive genetic resources management strategy is herein proposed that can, in the future, provide support and services for all economically important avian species.

This report discusses the history and uses of the different species, presents results of a survey of the genetic resources in the targeted species, gives overviews of major research areas dependent on such genetic stocks, discusses the different conservation methods currently available, and, finally, proposes a plan for a comprehensive Avian Genetic Resource System that would insure long-term maintenance and accessibility of these (and potentially other) endangered avian genetic stocks.

Box 4. Successful conservation of at-risk genetic stocks

THE EXAMPLES OF THREE LINES (Trisomic, mPNU, and Triploid) serve as models of the traditional mode of curator transfer from originating-investigator/institution to a new curating-researcher/institution. The Trisomic and mPNU lines originated in the Poultry and Avian Sciences Department at Cornell University (S.E. Bloom) and were recentl1y transferred to the University of California–Davis (M.E. Delany). The Trisomic line is also maintained at the University of New Hampshire (R.L. Taylor, Jr.). The CSIRO Triploid line was transferred from one CSIRO facility (B. Sheldon) to another (R. Pym). Thus, these specialized-cytogenetic lines represent success stories not only because of their significant contributions to basic and applied research, but also in that new homes for the lines were established so that their use and availability for future research are secure, at least for the foreseeable future. Unfortunately, this model of successful transfer of curatorship of genetic lines is the exception today rather than the rule.