Poultry genetics and breeding in developing countries

Genetic diversity and conservation of genetic resources

Robert Pym, *School of Veterinary Science, The University of Queensland, Gatton, 4343, Queensland, Australia*

BREED DEVELOPMENT AND GENETIC DIVERSITY

Globally, there is enormous genetic diversity within most poultry species resulting from:

- the activities of poultry fanciers and breeders around the world over many years;
- the prodigious numbers of small semi-scavenging flocks kept by subsistence farmers in developing countries;
- commercial breeders' efforts to produce high-performing meat and egg production lines of birds.

Many of the breeds developed over hundreds of years were selected for morphological and appearance characteristics as much as for production purposes. This is demonstrated by the huge numbers of chicken breeds and ecotypes found globally.

The principal features of poultry that permit rapid increases in the numbers of breeds and ecotypes in all countries are their very high reproductive rates and short generation intervals. Paradoxically, it is this capacity that now threatens the survival of many earlier-developed breeds. The need for high production efficiency, combined with the complexity and cost of running effective breeding programmes has resulted in commercially selected lines of broilers and layers replacing several of the breeds previously kept for productive purposes; over the past 20 years, there have also been dramatic reductions in the numbers of commercial breeding companies and genetic lines.

In any discussion of genetic diversity, "breeds" are essentially cultural concepts rather than physical entities. This is because breed standards have long been defined by phenotype, which may or may not involve significant differences in genotype. It is only recently that molecular tools capable of defining the degree of genetic diversity between different breeds have been developed. It is therefore necessary to adopt a broad definition of breed, until the term has been defined by a more objective measure.

Poultry breeds can be categorized into several different groupings according to present and past usage. Russell (1998) differentiates poultry breeds as: industrial or commercial lines; breeds used in traditional agriculture, historical breeds including old landraces; game breeds used primarily for cockfighting; ornamental breeds or those used mainly for exhibition; and experimental lines. Within these breeds there are many feather colour and comb variations (Simianer and Weigend, 2007), suggesting that a huge degree of genetic diversity is available, and posing questions regarding how best to allocate the limited resources for conserving this wide diversity as effectively as possible.

BREED CATEGORIES AND RISK STATUS

There is currently considerable concern regarding the number of poultry breeds that are either extinct or at risk of extinction. This information has been obtained from the *State of the World's Animal Genetic Resources* (FAO, 2007b), the first ever assessment of domestic animal diversity. The assessment process included updating the Domestic Animal Diversity Information System (DAD-IS) global databank, which now contains breed-related information on 16 avian species, with 3 505 country breed populations and about 2 000 breeds. Chicken breeds make up the vast majority (63 percent) of total avian breeds, followed by ducks (11 percent), geese (9 percent) and turkeys (5 percent); indigenous or local breeds make up most of the world's poultry genetic diversity. Breeds have been categorized according to whether they occur in one country (local), several countries in the same region (regional transboundary), or several regions (international transboundary). The proportions of each of these categories vary considerably from region to region (see Hoffmann, 2008 for details).

As noted by Hoffmann (2008), population data are frequently missing, which makes risk assessment extremely difficult. The absence of data is a result of the difficulties with monitoring small livestock and the general low importance that most governments attribute to poultry, despite their important roles for food security, rural livelihoods and gender equity. For 36 percent of reported avian breeds, the risk status is unknown; 35 percent are reported as not at risk, and 30 percent as at risk. Of 2 000 reported avian breeds, 9 percent – mainly chickens (83 percent) – were reported as extinct (FAO, 2007b). Most of these extinct breeds were from Europe (Figure 1).

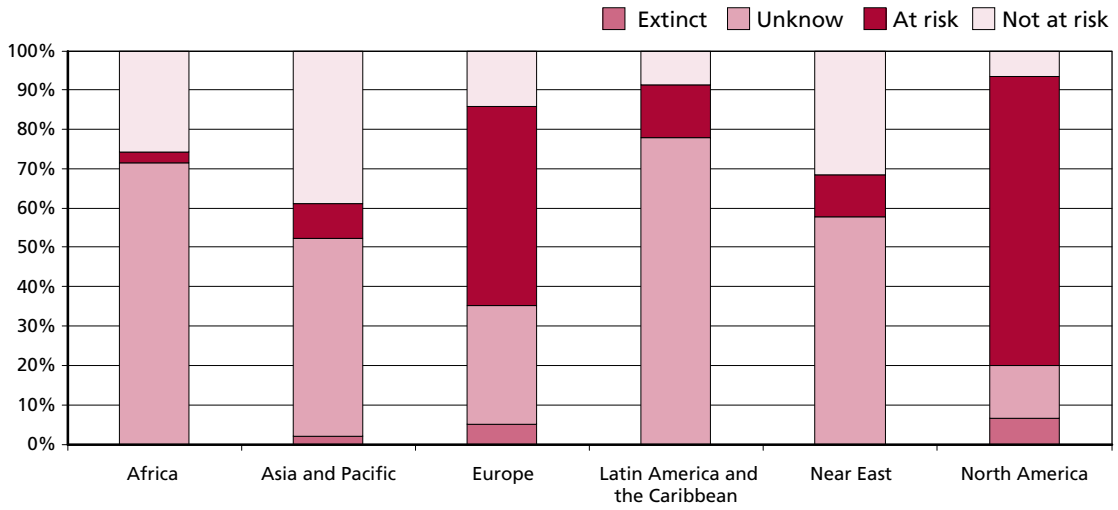
The regions with the highest proportions of avian breeds classified as *at risk* are North America, with 73 percent of total avian breeds, and Europe and the Caucasus, with 51 percent. Among the different avian species, the proportions of breeds at risk are 36 percent for chickens and turkeys, 31 percent for geese, and 25 percent for ducks.

CONSERVATION OF POULTRY GENETIC RESOURCES

Indigenous poultry breeds' importance for subsistence farmers in many developing countries, combined with many consumers' preference for their eggs and meat, suggests that these genetic resources are not under immediate threat. However, gradual erosion of the genetic integrity of the stock, through cross-breeding and upgrading programmes, is cause for concern. In addition, the actual genetic variation between so-called different breeds of indigenous birds in neighbouring regions has sometimes been shown to be minimal, owing to long-term exchanges of breeding

FIGURE 1

Risk status of local and regional chicken breeds, by region



Source: DAD-IS.

stock among villages. Substantial genetic diversity among village chicken populations is observed only in populations separated by wide geographical distances (Tixier-Boichard, Bordas and Rognon, 2008).

Poultry fanciers in developed countries play a vital role in the retention of genetically diverse populations of poultry species. The high reproductive rate and short generation interval of most species mean that viable breeding populations can be maintained at reasonable cost. Most "pure breeders" are motivated by the pleasure that the stock and the breeding enterprise bring them, but they are without doubt a largely untapped and vital source of avian genetic resources and diversity. These breeders and the smallholder poultry farmers in developing countries provide important means for the *in vivo* conservation of poultry genetic resources.

Recently, poultry genetic resources have suffered significant losses due to the termination of commercial lines associated with breeding company take-overs and the global consolidation of commercial poultry breeding operations. There have also been significant losses of experimental lines, most of which are generated at research institutions; it is becoming increasingly difficult to find the funds necessary for retention of these lines.

As well as *in vivo* conservation, genetic material is also conserved *in vitro*, mainly through cryo-preservation of semen. Under this approach, repeated back-crossing is required to re-establish a breed, which may take up to seven generations. In addition, the original genome of the lost breed can never be fully restored through this approach, owing to the loss of mitochondrial DNA. Although cryo-conserved embryos allow the complete re-establishment of a breed, this is not possible for avian species at present. Cryo-conservation of isolated embryonic cells, primordial germ cells or blastoderm cells may be an option in the future, but is currently too costly for genetic conservation programmes (Hoffmann, 2008).

CONSERVATION PROGRAMMES

From the FAO database, it is estimated that about 25 percent of chicken breeds are included in conservation programmes, but there is no information about the nature or efficiency of these programmes. According to country reports to FAO, only 15 percent of countries (half of them developing countries) have poultry conservation programmes (*in vivo and in vitro*), covering 63 percent of local breeds and 11 percent of national populations of transboundary breeds. The Global Databank shows that 195 poultry breeds (of which 77 percent are chickens, 9 percent ducks, 9 percent geese and 3 percent turkeys) have conservation programmes, but some of these data are out of date. Hoffmann (2008) provides details of country-specific programmes that may not be recorded in the Global Databank.

MEASURING GENETIC DIVERSITY

Recently, there has been a major shift from the differentiation of poultry breeds according to morphological and feather colouring characteristics, to differentiation based on measurements at the molecular level. The use of molecular markers can provide quantified criteria for assessing genetic diversity, either within or between populations. However, although they can be used to study relatedness between populations, provide information on past history of populations, detect introgressions and contribute to the genetic definition of a breed's entity, molecular markers do *not* provide information on phenotypes and special adaptive traits.

Appropriate sampling is critical to the molecular characterization of a breed for comparative purposes; a minimum of between 30 and 50 individuals is required. Determination of the chicken genome in 2004 (Hillier *et al.*, 2004) has facilitated the use of molecular markers for breed/ecotype characterization. Although genome knowledge is less complete for other poultry species, linkage maps are available for ducks, quails and turkeys, and reference to the chicken genome is generally an efficient approach for studying gene order and gene structure. The availability of molecular markers is therefore not a limiting factor in most poultry

species. Highly polymorphic microsatellite markers are preferred because they provide much information for a limited number of loci; most studies use between 20 and 30 markers. Molecular tools for studying genetic diversity using single nucleotide polymorphisms are likely to be developed further.

GENETIC DIVERSITY WITHIN BREEDS AND POPULATIONS

As reported by Tixier-Boichard, Bordas and Rognon (2008), studies using microsatellite markers have shown large variations in heterozygosity, ranging from 28 percent for a fancy breed to 67 percent for a village population, but the average value (of about 50 percent) is rather lower than that observed in domestic mammals. The highest levels of within-population diversity were found in wild ancestor species, unselected local populations, a few standardized breeds kept in large populations, and some commercial broiler lines. A range of values were obtained for European fancy breeds, reflecting the variability of population history within this type of population. Expected values for heterozygosity range from 50 to 63 percent for broilers and 45 to 50 percent for brown-egg layers, to about 40 percent for white-egg layers, which exhibit the lowest levels of all commercial lines. These studies suggest that there is a significant reservoir of genetic diversity within local breeds of chickens.

MONITORING OF GENETIC POPULATIONS

The *Global Plan of Action for Animal Genetic Resources* (FAO, 2007a) identifies the need for country-based strategies to ensure that inventory and monitoring activities can be linked to and coordinated with action plans such as agricultural censuses or livestock population surveys. Monitoring requires the regular checking of population status and the evaluation of trends in the size and structure of breeds/populations, their geographical distribution, risk status and genetic diversity. Because of their important contribution to poultry meat consumption in rural regions of developing countries, it is highly desirable that local breed chicken populations are monitored. Such monitoring will contribute to the planning of national development policies in these countries.

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