

Poultry genetics and breeding in developing countries

Genetic approaches to improved performance in sub-optimal conditions

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SELECTION IN COMMERCIAL LINES OF POULTRY

When producing poultry stock for developing countries, large global breeding companies tend to promote the strains that are used in developed countries, most of which have temperate climates, claiming that these strains are suitable for all environments. However, most of these strains have been selected for increased productivity and general robustness under relatively good management and nutrition conditions, generally without significant temperature stress. If they prove to be tolerant to sub-optimal conditions it is usually owing more to chance than to directed selection. To maximize performance, the companies often promote improved management standards and practices in the target countries.

Given the very wide range of nutritional factors that affect performance, large companies have not attempted to breed birds with tolerance to specific nutritional deficiencies, but a case could be made for selecting birds for increased tolerance to heat stress (Cahaner, 2008). Heat stress has a marked impact on performance, particularly the growth of broilers, owing to their high metabolic heat output. High temperatures are a feature of most developing countries, and maintaining reasonable house tem-

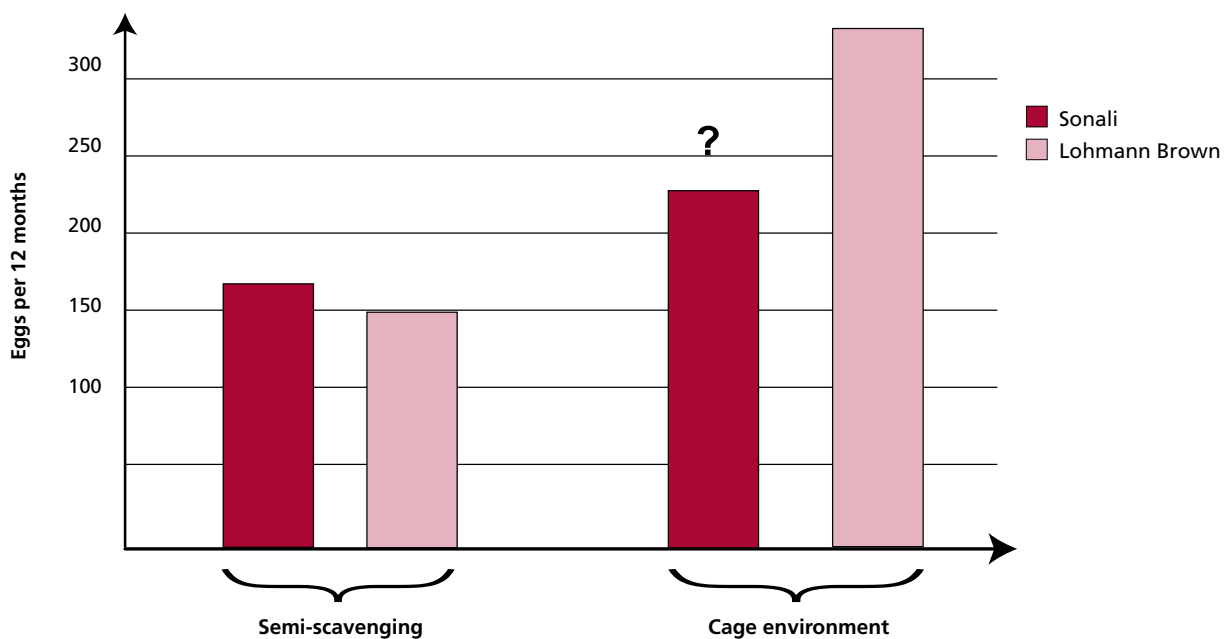
peratures is either too costly or simply not possible, owing to a limited or lacking power supply and other factors. As a result of this susceptibility to heat stress in broiler strains, it is standard practice in many tropical developing countries to market the birds at an early age and low weight, before heat stress becomes a major problem.

GENOTYPE-ENVIRONMENT INTERACTION

Studies have demonstrated genotype-environment interactions by measuring the growth or egg laying performance of different strains when subjected either to good management, high-input conditions or to harsh, low-input conditions (Besbes, 2008). Nutrient intake is typically one of the major differences between the two conditions. In almost all the cases studied, commercial stock performed considerably better than indigenous stock under good conditions, but only marginally better, or the same, under low-input, harsh conditions (Tadelle, Alemu and Peters, 2000; Singh *et al.*, 2004).

An example of this is the comparison of egg laying performance between Lohmann Brown and Sonali hens under optimal (German Random Sample Test) and semi-scavenging conditions

FIGURE 1
Effects of breed and environment interactions on egg production



Source: Sørensen, 1999.

(Sørensen, 1999). The Sonali hens are F1 crosses between Rhode Island Red males and Fayoumi hens. Figure 1 shows the relative performances of the two strains in the two environments. The Lohmann Brown produced 303 eggs in 12 months under the optimal conditions of the German Random Sample Test, but only 140 eggs under semi-scavenging conditions, where the Sonali produced 156. The Sonali was not tested under the German Random Sample Test, but its production was estimated at slightly more than 200 eggs (Sørensen, personal communication).

There is therefore a persuasive argument for applying genetics to produce stock that perform well under the less than optimal conditions prevailing in many developing countries. First, however, any improved management conditions that have been demonstrated to result in improved performance and that are cost-effective and sustainable should be applied, particularly those that improve the survival rate of young birds (confinement early rearing with the hen, with supplemental feeding and vaccinations), the supplemental feeding of growing and older stock with locally available feedstuffs, and ongoing disease prevention measures.

BREEDING FOR PERFORMANCE UNDER SUB-OPTIMAL CONDITIONS

Given the complex processes and inputs involved in genetic improvement, there is little point in attempting to improve the performance of a breed with inherently low production potential. Selection of the breed(s) to use is therefore critical, and involves a good understanding of each breed's specific attributes and a clear definition of the breeding goals.

Small-scale, semi-scavenging operations require dual-purpose birds that produce both eggs and meat. The opportunities for selecting for improved egg production are limited by the hen's hatching each clutch of eggs and rearing the chicks to about six or seven weeks of age before recommencing lay. The production system is complex, and emphasis on one component could have negative repercussions on another. Two obvious requirements are for broodiness and mothering ability. Some breeds/ecotypes are renowned as good layers and mothers, and are thus suitable candidate breeds, at least as the hens in any proposed cross-breeding programme. It is rather more difficult to apply effective selection at the individual bird level because of possible marked differences in the impacts of nutritional and disease factors on individual birds' performances. Nonetheless, there is a good case for culling poor-performing hens, although there is often limited opportunity to exert any selection pressure in smallholder situations, where all surviving hens are needed to maintain flock size.

The greater interest in meat than egg consumption in many developing countries justifies an emphasis on growth rate and body conformation, in all stock in single-breed operations, and in males in cross-breeding programmes. This should be balanced against the available feed resources. If the latter are limited, heavy body weight may be a disadvantage, as the bird may obtain sufficient nutrients to meet only maintenance requirements, with nothing left for growth.

In small-scale commercial operations involving confinement rearing and supplementary feeding, there is a persuasive argument for using commercial improved breeds/strains of broilers or layers. However, their suitability depends on the level and quality

of feeding and the birds' likely exposure to extreme climatic conditions. Where feeding is sub-optimal and commercial diets are either not available or considered too expensive, there is a case for using local or other genotypes. One important factor is the relative prices paid for the meat and eggs produced by the different genotypes. Where a significant premium is paid for meat and eggs from indigenous breeds, the confinement rearing and feeding of these birds can be justified, in spite of their considerably lower productivity.

For all small-scale production systems in tropical developing countries, tolerance to high temperature is a key requisite in the birds. One of the most effective ways of improving heat tolerance is through the incorporation of single genes that reduce or modify feathering, such as those for naked neck (*Na*), frizzle (*F*) and scaleless (*Sc*), as well as the autosomal and sex-linked dwarfism genes, which reduce body size (Cahaner *et al.*, 2008). These genes are segregating in some indigenous populations, as there is natural selection for heat tolerance as an important component of reproductive fitness. There is also a good case for incorporating these genes into existing commercial lines, as the inputs and time required for this are minimal compared with those required to develop a high-producing, heat-tolerant line from a base population (Cahaner, 2008).

BREEDING APPROACHES

Cross-breeding

Genetic improvement can be achieved through cross-breeding, with or without genetic selection in the parent lines; through upgrading by repeated back-crossing to a superior parent breed; or through within-line selection. The cross-breeding approach normally involves a two-way cross between an improved exotic and a local breed, with the aim of combining the better production capacity of the former with the latter's adaptability to harsh environments. This system also maximizes the expression of heterosis, or hybrid vigour, in the cross, normally reflected in improved fitness characteristics.

Examples of this approach are the Bangladesh and Indian cross-breeding programmes, which are described in some detail by Sørensen (FAO, 2010). Briefly, the Bangladesh programme is based on crosses between Rhode Island Red (RIR) males and Fayoumi females to produce the F1 Sonali cross-bred. RIR is a United States breed that has been used by many commercial breeding companies globally as the base population for their brown-egg lines; Fayoumi is an Egyptian breed with reasonable egg production under difficult environments, and is particularly known for its genetic resistance to disease. The cross-bred Sonali fowl has proved to be the highest-yielding and most profitable breed combination in several comparisons under semi-scavenging conditions in Bangladesh (Rahman *et al.*, 1997).

The Indian programme is based on crossing Aseel breed males with CARI Red hens to produce cross-bred CARI Nirbheek hens. The native breed Aseel is well adapted to tropical conditions and is known for its high majestic gate and dogged fighting qualities, which make it capable of protecting itself against predators; the female CARI Red has been selected for improved egg production capacity under tropical conditions. In the field, CARI Nirbheek hens receiving about 30 g of supplementary feed per day were

able to produce 163 eggs a year, with a survival rate of 90 to 95 percent (Singh *et al.*, 2004).

Upgrading through back-crossing

Poultry genetic improvement programmes through repeated back-crossing of female offspring with the superior-performing male parent breed, or through cockerel exchange programmes in which males of improved breeds are distributed to smallholders, have not been particularly successful. In both cases it is necessary to retain separate populations of parent birds, and the progeny often lose the capacity for broodiness, so cannot hatch or rear their young. This is a major shortcoming given the purpose for which the birds are being produced. In addition, the survival of improved breed males is often threatened by their lack of adaptation to the environment and its dangers. Not the least of these dangers is the attractiveness of these birds to other farmers, resulting in frequent thefts for breeding or eating. These limitations also apply to cross-breeding programmes.

Within-line selection

Within-line selection for increased growth or egg production involves complex procedures that have to be undertaken at a central breeding station (Besbes, 2008). The need for a sufficiently large population, pedigree recording, accurate measurement of individual performance and the capacity to minimize environmental variation makes it impossible for individual farmers to run an effective selection programme. Even when the necessary resources are available at a central breeding station, response is generally slow, and the logistics for distributing selected stock to farmers pose considerable difficulties. Economies of scale are very relevant, as evidenced by the dramatic reduction in the number of poultry breeding companies globally over the past 20 years.

There is certainly need for stock with the capacity to perform well under the less than optimal environments typically encountered in developing countries. The link between performance and nutritional and other management inputs means that any genetic improvement in performance capability must be matched by increased inputs. Genetic improvement through cross-breeding or back-crossing undoubtedly results in improved egg and/or meat production (provided it is accompanied by increased nutritional and other management inputs), but account should be taken of:

- the increased complexity of running several different lines;
- the birds' probable loss of broodiness and capacity to rear their young;
- the impact that it may have on farmers' interest in the chickens and on consumers' interest in their meat and their eggs.

Although within-line selection avoids most of these problems, to be effective, it needs to be conducted at a central breeding station, and to be well organized and funded. The choice of breed(s) for the base population is critical to the success of the enterprise.

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