Breeding Poultry For Free Range And Low Input Production System

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Introduction

Poultry production in free range and low input systems has often difficulties in purchasing improved breeding materials. This development has been more and more obvious in recent years as the overwhelming part of day-old-chickens offered on the market are derived from the few world wide breeding companies. These chickens are characterised as specialised and high yielding for large scale production under well controlled environments. They will often have problems with the adaptation to the harsh environment in terms of: insufficient disease resistance, improper balanced feed, lack of feed, and predation from wild birds or animals, and they will be too expensive as seen from the low input farmers point of view.

The free range poultry production is in principle all forms of production in which the birds has access to outdoors fields, and that includes: the organic managed poultry production which is popular in some parts of the industrialized world , La Bell Rouge production system known from France, and the smallholder poultry production known from the developing countries. These three groups of production system has in common the hazard of infection diseases as the hygienic level is considerably lower than in the production systems with caged birds or broiler production under complete controlled housing with a high level of bio security, and they are also exposed to the risk of predators from birds of prey, wildcats, foxes etc.

During the last half century keeping of poultry in the industrial part of the world has undergone a tremendous development away from small scale flocks of a few hundreds on almost all farms to few industrialised farms with up to hundreds of thousands of birds. Along with this development the many breeding farms that were in play 50 years ago to supply the farmers with day-old-chickens in moderate numbers per farm have increased in size to supply the farmers with hundreds of thousands of day-old-chickens per time. Along with this development the new and much more efficient breeding companies have improved their breeding materials in an ever increasing tempo with major emphasis on yield and efficiency.

Under the headings of sustainability and animal welfare a part of the consumers in the industrial world have called for systems that include free range production, and, beginning in the Western European countries, a growing number of customers asked for, and were willing to pay for products produced under the organic principle. In Denmark 18% of market eggs were organically produced (Anonymous, 2008). The highly competing breeding companies initially neglected the need for breeding material that was adapted to the more harsh environment under the free range condition, but in later years some of them have changed

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their attitude and declared that they have hybrids suited to or specifically developed to produce in free range systems.

The smallholder system differs from the two other free range systems by being a low input production system and also a system that is not based on the principle of all out all in management and furthermore the numbers of birds per farm are counted in numbers less than hundred, while the flock size in the two other groups are counted in numbers of several thousand. Yet another difference is that recruitment of chickens takes place by natural hatching and that part of the feed are searched for by the hen when she is in the field. The breeding materials used in many developing countries are local hens or indigenous hens that have adapted to the environment of the locality, and often also the wishes of the farmers through their choices of cocks and hens to reproduce.

In a recent study (FAO, 2010) the production patterns of these local breeds in their own environment is elucidated across the world. The general lack of success in improving the poultry production by either exchanging the local breeds with exotic breeds or hybrids or by introgression in the local breeds by cockerels from various exotics breeds are discussed thoroughly. The lack of success reported from several attempts to impose an improvement program are discussed. It is suggested that a way forward would be to improve the local breeds by using the conventional breeding methods that have been used with great success to farm animals in the industrialised world.

The aim of this presentation is to briefly discuss the Free Range systems in the developed world and then more thoroughly discuss various ways to improve genetically the local breeds in the developing world and by a simulation study to give an indication of how to get reliable information on breeding values in a low input management system. This presentation will discuss a system that characterise the major part of the smallholder poultry production systems in the developing world with emphasis on the Central African countries and some Asian countries.

Free Range systems.

Organic egg production in European countries takes place under rules that requires: access to outdoor facilities, diet composed of organic grown ingredients without synthetic produced elements, and no prophylactic treatments and no mutilations is allowed. Flock sizes are restricted to 3-4.000, but it is allowed to have more than one flock. When beginning the organic egg production in the middle of 1990's there were discussions of which breeding materials should be used (Sørensen, 2001). The hybrids available in sufficient numbers were those genetically developed for hens producing eggs in cages. Used in the organic production environment they suffered from lack of immunity to withstand the harsh environment, lack of ability to cope with the unbalanced diet, lack of ability to have social contact with many hens and a weak nest searching. The results were an average mortality of 18-20% during a production period compared with less than 5% for hens in cages. After a while some breeding companies started to develop breeding materials that had the genetic ability to produce under this harsher environment. Looking on the Danish statistics the average mortality has the last three year been close to the mortality for caged hens, which is a clear indication that the organic farmers have got breeding material that is better genetically adapted to their production system.

Free range production of chicken meat takes place under the French programme termed Label Rouge and has been transferred to USA under the name: Pasture-based poultry production. A similar concept is the organic produced chickens that are produced still in small amounts in Europe. The two types of product has a number of restriction and requirements. From a genetic point of view the two production systems have some common requirements, these are: average daily gain that not exceeds 30-35 g, access to outdoor facilities after 6 weeks of age, limited use of ingredients for feed, lower limit of age at slaughter that was 81 days for the La Bell Rouge and 56-63 days for organic produced chickens. This means that the hybrids used should be bred for: moderate growth and genetic adaptation to the outdoor challenge and the diets permitted to be used.

Why local breeds?

In the FAO-publication (FAO, 2010) the various ways to improve the smallholder poultry production by various means of introducing exotic breeds/lines seemed to have a lack of success. High yielding hybrids have difficulties to survive in the harsh environment and the farmers are not prepared to pay for the regular recruitment. Introgression with cocks from an improved breed has been widely used, but without a permanent improvement – often resulting in a short-term improvement in terms of growth and egg yield. Due to absence of ability to withstand the harsh environment the higher yielding offspring from these improved cocks are not chosen as the breeding birds because the hens are not good enough to do the incubations and brooding, and therefore the genes from these high yielding cocks disappears after a while. This is documented by the fact that the local breeds have hardly improved the egg yield over the last 20 year (from comparison of Horst, 1988 with FAO, 2010).

Yet another method were used in the so called Bangladesh model (FAO, 2010) in which chickens from a two way cross of a RIR line males mated to Fayoumi hens, have to be transferred to the smallholder farmer to produce eggs. This specific cross has been proven to perform better than a large number of other pure lines and crosses (Rahman, 1997). This system worked well during the period it was supervised from a developing project, but afterwards the smallholder farmers refused to recruit the F1 crosses and that was a disaster since the F1 females were poor in brooding and incubation and the F2 females had a lower production capacity (FAO 2010). More recently, Indian researchers have proposed models based on cross-breeding programme with the CARI Nirbheek chicken (Singh et al, 2004), and a local breed (Aseel). There is as yet no published evidence regarding success.

Assuming the low input/output smallholder system will continue to exist, in a considerable proportion, in many parts of the developing world, and on the background of the poor results from the previous 20 years, it is believed that a sustainable progress in poultry production based on a genetic improvement of the local breeds is possible in using the appropriate breeding programme that includes traits of importance for reproduction and survival under the smallholder environment, that also account for the needs of hens that can incubate and brood, and for the cultural needs of the farmers.

The proposed breeding programme

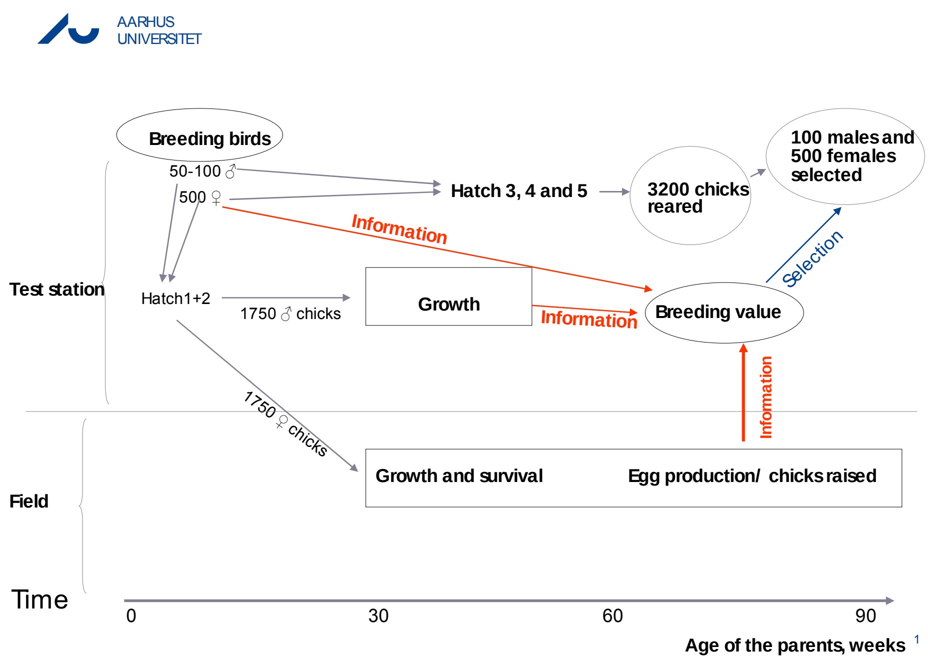

Figure.1 Flow diagram showing the test of chicks in ▭ and the birds in ⬭

Imagine a region in which the majority of Smallholder farmers have the same opinion of how the local hen appears and also agree on the major purpose to keep hens. Then a sample of hens and cocks have to be collected that looks like the ideal of the local hens. Also imagine that somewhere in the centre of the region there is a station or another big farm that is able to keep a breeding flock of 500 local hens and up to 100 local cocks in which pedigree mating and hatching can be performed, preferentially in small pens or in cages, and further facilities to rear a flock of 3200 chickens is available.

This flock should be considered as the elite flock in which the selection takes place based on a progeny test in which the female progeny is placed at the smallholder farmers. There will be one breed/line only and no cross breeding taking place. The flow of reproduction and information is shown in figure 1

The breeding nucleus is reproduced in 5 hatches each from collection of eggs laid during 14 days. Hatch no 1 and 2 are expected to hatch at the parent age of 35 weeks in a number of 1750 pedigreed females that will be transferred to 150 smallholder farmers at and age of 12 weeks, that means an average of 11.6 per farm They will be recorded for daily gain up to start of lay. The laying intensity and the number of chickens raised to 8 weeks will be recorded. Mortality will be recorded as well.. Information from this test will be the major component in calculating the breeding value for the father. The 1750 male chicks also produced from Hatch 1 and 2 will be reared up to 20 week and weighed at the station after which the best part will be given to the farmers. The information will be used in calculating the breeding value for the father combined with the field test of their sisters. In addition a breeding value calculated on the base of the mothers regarding egg yield at the station is calculated. Hatch 3, 4 and 5 are produced when the daughter in the field test has started the lay of egg. The elite birds are, at an age of 64 weeks, expected to produce 1000 chicks per hatch or in total 3200 from which 100 males and 500 females has to be selected based on the breeding value of the farther and they will be the elite birds of the next generation.

Methods

A selection procedure was simulated using the stochastic program ADAM (Pedersen et al.,2009) in the breeding nucleus illustrated in figure 1. 10 generations of non-overlapping generations was simulated, by selecting 10 males among the 100 with the highest aggregate breeding values. The breeding goal consisted of 4 traits at the field level: survival, daily gain (DG), numbers of chicks raised to 35 weeks (NCR), and egg yield in terms of rate of lay during production (EY). The mean, standard deviation (SD), heritability (h^2) and economic value per unit (Ec.v.) for each of these traits and the correlations among them is presented in table 1.

Table 1 Mean, SD, h^2 , Ec.v. of field traits and correlation among them[a)]

					Field				Station	
	Mean	SD	h^2	Ec. v	Surv.	DG	NCR	EY	DG	EY
Survival	0.50	0.05	**0.01**	35.0	-[b)]	0.2	0.3	0.0	0.1	0.0
DG, g	6.5	1.3	0.35	7.0	0.2	-	-0.2	-0.2	**0.3**	-0.2
NCR, nos.	35	7	0.10	6.0	0.3	-0.2	-	**-0.2**	-0.2	**-0,2**
EY, %	27.2	8	0.15	5.0	0.2	0.0	0.2	-	-0.2	**0.1**
DG, g	11.6.	1.8	0.50	-	-	-	-	-	-	-0.2
EY	41.7	8	0.25	-	-	-	-	-	-	-

a) Genetic correlations above and phenotypic correlation below the diagonal
b) Not relevant

The means of field data is mainly from FAO (2010) that gives an average of published results from scavenging/semi scavenging studies of poultry production in rural areas of tropical zones in developing countries. Heritabilities and genetic correlations are taken from the literature in general, and where uncertainty is large scenarios with alternative values has been performed. The economic values are mainly from the Bangladeshi work by Rahman et al. (1997) and given as Taka (1 Taka ≈ 0.01 US$). The value of survival is chosen to have the value of an 18 week old hen per survived bird.

The parameter values in Table 1 have been used as the basic values. A number of 1750 daughters from 100 sires has been generated and distributed to 150 farmers which mean that in average a smallholder farmer receives 11.7 hens per generation and they will be derived from 8 to 10 sires. Genetic evaluation was based on an animal model accounting for herd effects.

Each scenario was repeated 100 times to obtain a reliable estimate for genetic gain and rate of inbreeding,

The figures in Table 1 marked with bold face indicate that a scenario has been run in which other genetic parameter values has been used. The following alternatives scenarios have been run.

- Scenario 2. Higher h^2 for survival (0.05) while the rest of the genetic parameters were unchanged: This could happen in case hens died from a specific disease for which genetic resistance exists.
- Scenario 3.The genetic correlation between egg yield and numbers of chickens raised to 8 week has been set to be slightly negative (-0.2). It is clear that egg yield reduces if the hen has a strong incentive to get broody and therefore we chose to run a scenario with a genetic correlation of -0.5.
- Scenario 4.Genetic correlation between the same traits in field and at station is set to 0.1 for egg yield and 0.3 for daily gain which expresses a considerable G × E interaction or a poor transfer of genetic improvements between environments. Depending of the situation that could be higher. We ran a situation in which these were increased to 0.4 and 0.7 respectively.

Another group of scenarios were run for which variation could exist for other reasons. These are:

- Scenario 5.The Breeding nucleus could be composed of 50 ♂♂and 500♀♀, this is a very common proportion of males to female when kept in breeding pens. This scenario gives larger progeny groups and therefore higher accuracy of the breeding values, but also higher risk for inbreeding. We run this as a scenario without considering the higher risk of inbreeding.
- Scenario 6. Individual counting of the egg laying at smallholder farm is possible in farms with few hens and farmers that are particular interested, but often it will not be possible to get individual information on egg laying. In this scenario we assumed that egg yield waqs only observed on the test station.
- Scenario 7. Making use of 75 smallholder farms in stead of 150. This gives larger groups of birds per farm.

Results

The economic values of a hen based on the 4 field based traits under the conditions in Bangladesh, given in Taka. The overall economic output has increased with 1.7 % per generation for the basis scenario. That could be increased to 1.9% by reducing the number of males allowing a higher number of progeny per male; also a higher h^2 for survival could increase the output. Omitting to record the egg laying in the field on the other hand reduces output to an improvement of only 1.0% per generation, while a higher negative genetic correlation between egg yield and numbers of chickens raised per hen reduces the output to 1.3%.

The improvement of the individual traits recorded in the field as results of the selection during 10 generation is shown in Table 2

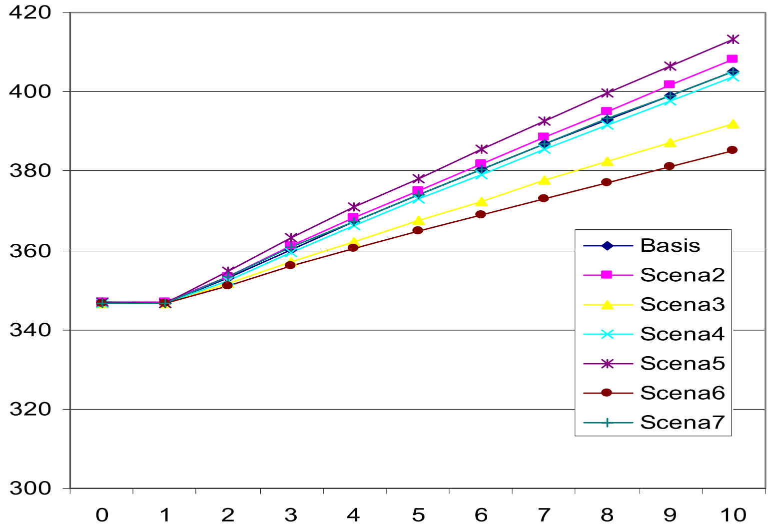

Figure 2 Economic values of a hen under various scenarios of selection based on Bangladeshi economy in 1997.

Table 2. Improvement of the 4 field trait in percentage after 10 generations of selection for the various scenarios.

Scenario		Trait selected with mean in generation 0			
		Survival	Daily gain, g	Nos. of chicks per year	Egg Yield
		0.50	6.5 g	35	27.2
Basis		9.5 %	4.3 %	12.2 %	31.0 %
2	Higher h^2 surv.	37.9 %	5.1 %	12.1 %	28.6 %
3	R_g more unfav.	10.1 %	5.4 %	8.5 %	19.6 %
4	Reduced G x E	11.1 %	4.5 %	11.1 %	27.2 %
5	50 males tested	10.2 %	4.2 %	13.9 %	35.3 %
6	No egg record.	13.4 %	8.0 %	23.5 %	-8.1 %
7	75 farms	9.4 %	4.6 %	11.7 %	20.2 %

For the individual traits there is considerable variation due to the scenarios used. For the survival there are obviously a much higher progress if the heritability could be expected 5 times higher (scenario 2). Opposite when egg yield is not recorded in the field even a

decrease is seen (scenario 6), but then there are space for at larger improvement for the other traits.
Unfavourable correlations cause limited improvements for the involved traits as demonstrated in scenario 3 without a corresponding increase for the two other traits.

The economic values used from Bangladesh reflects a situation in which egg yield is the major goal while the meats are less important for the farmers, and that reflects the relative small progress seen for growth of the body. A similar analysis having used economic data from African countries would probably have reflected the larger interest for higher growth rate that surely is met in most African countries.

In spite of using the egg laying of the mothers in the nucleus herd to predict the breeding values for egg laying under field condition this was not enough to avoid a decrease in egg yield when direct recording of egg yield was not possible. This underlines the shortcomings of relying on records from other environments if G x E is considerable.

An improved nucleus flock of the local breed in a region means that in order to utilize the improved local birds it is necessary to have a programme that organize replacement of the old cocks on the smallholder farms with young cocks from the improvement programme. Having a programme that regularly makes the exchange of cocks will contribute to a steady increase of the production potential, and as no crossing effects are included the improvement will be permanent, even in cases of disasters from floods and other catastrophic situations, that may occur.

The simulation study indicates that it is possible to improve the local breeds with 1.5 to 1.8 % per generation. As a generation interval is about 66 weeks it means 1.2 to 1.4 % per year, when considering the traits survival, growth, egg yield and brooding capacity. Refinements of such a breeding programme should be done and adapted to the particular region.

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