ILRI MANUAL

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A guide to setting up a selective indigenous chicken improvement program: The Tilili breed in Ethiopia

A guide to setting up a selective indigenous chicken improvement program: The Tilili breed in Ethiopia

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Foreword

'See it big and keep it simple.'

Wilfred Peterson

This manual shows the critical steps that need to be followed to start up and run an indigenous chicken breed improvement program in Sub-Saharan African (SSA) settings. Although the steps in most programs remain the same, indigenous chicken breeding programs have peculiar characteristics. The indigenous chicken breeding program in SSA ideally focuses on developing a dual-purpose chicken based on the interests and aspirations of village chicken producers. Indigenous chicken must meet in simple terms the farmers' desires to have chicks with high survival rate, chicken that grow fast and big, lay more eggs, chicken strains with mixed colour and with high scavenging ability. Indigenous chickens may not compete with commercial chickens but are preferred by farmers. Our previous engagement was successful, and confident that such a program can be successful with less sophisticated facilities. This manual will be instrumental in achieving the overall goal of developing an improved indigenous chicken strain.

Tadelle Dessie

Principal scientist, ILRI - Tropical Poultry Genetic Solutions program leader

1 Introduction

The indigenous chicken (IC) genetic improvement involves generating new, improved poultry strains. They are expected to have higher performance, improved adaptation, and disease resistance. The new strain will ideally possess a new set of qualities that offer significantly better than the existing or its parents. Past attempts to improve the production and productivity of the poultry industry through introducing exotic breeds present potential challenges such as erosion of indigenous chicken genetic resources and increased production costs for poor poultry producers. The indigenous chicken is a massive reservoir of the chicken genome and is essential for breeding and conserving the vast gene pool they represent (Ajayi 2010). Their ability to survive and produce under harsh environmental and limited resources conditions, ability to escape from predators, brooding behaviours, high preference of their egg and meat, and socio-cultural value are among high importance attached to these strains.

Their diverse and unique genes will enable the indigenous chickens to have their niche, particularly under a semi-scavenging production system. Despite all these comparative advantages of indigenous chicken, they still have low egg and meat production potential that makes them low fit to cater to the ever-increasing meat and egg demands of the Amhara region of Ethiopia. Genetic improvement of indigenous chicken is among the region's strategic interventions to cater to the poor poultry producers' needs in an area where resources are limited. Sustainable use of the indigenous chicken can be through selective breeding. The Ethiopian livestock master plan highlighted the need to improve indigenous chicken genotypes through selective breeding to improve their genetic potential and ensure sustainable use (Shapiro et al. 2015). The wide range of variability in morphological, production and genetic characteristics in indigenous chicken such as Tilili chicken (Hassen et al. 2007) indicates the potential for improving through selective breeding (Faruque et al. 2016). Establishing a solid breeding program to combat constraints related to poultry production is highly essential, for which a broader genetic base of germplasm is a prerequisite. Native chicken types named Tilili, Gellilia, Debre-Ellias, Mello-Hamusit, Gassy, Guanghua and Mecha were studied in the Amhara region, northwest of Ethiopia.

Tilili was promoted to the breeding program among the ecotypes due to its distinct body feature and a reasonably considerable within-breed variation. Most Tilili males have predominantly light red plumage with rich brown on the backside. In some cases, the feather around the male's breast is black. The female has a partridge or black, red colour, and the tails in both sexes are black (Hassen et al. 2007). This indigenous ecotype is found in Awi and west Gojam zones of Amhara region.

Table 1. Least squares means (LSM + SE) for body weight of six ecotypes of chicks in Ethiopia (day old to 6 weeks of age)

Group	Live weight			
	Day old body weight (g)	Two weeks body weight (g)	Four weeks body weight (g)	Six weeks body weight (g)
Ecotype				
Tilili (rep)	30.7 ± 0.25^{c}(7)	57.2 ± 1.9^{b}(7)	111.2 ± 2.1^{c}(7)	159.5 ± 3.1^{c}(7)
Horro (rep)	28.7 ± 0.37^{d} (3)	54.5 ± 2.9^{b}(3)	83.7 ± 3.2^{d} (3)	131.6 ± 4.8^{d}(3)
Chefe (rep)	32.4 ± 0.29^{b}(5)	68.1 ± 2.1^{b}(5)	118.2 ± 2.4^{b} (5)	179.7 ± 3.7^{b}(5)
Jarso (rep)	25.8 ± 0.26^{e}(6)	36.7 ± 2.0^{c}(6)	64.7 ±2.2^{e}(6)	108.2 ± 3.4^{e}(6)
Tepi (rep)	26.0 ± 0.37^{e}(3)	41.2 ± 2.9^{c}(3)	73.8 ± 3.2^{e}(3)	113..2 ± 4.8^{e}(3)
Mean local	28.7 ± 0.15	49.9 ± 1.5	90.3 ± 1.24	138.4 ± 1.7
Fayoumi (rep)	41.04 ± 0.37^{a} (3)	71.2 ± 2.8^{a}(3)	131.9 ± 3.2^{a}(3)	206.7 ± 4.8^{a}(3)
Sig. level	**	**	**	**
Overall mean	30.8 + 0.13	53.4 + 1.0	97.3 + 1.1	149.8 + 1.7

Figures in bracket represent number of replications from which the means were derived.

^{abcde} Means within a column followed by different superscripts show the presence of significant differences.

Source: Dessie et al. (2002).

Table 2. Least squares means (LSM) for body weight of six groups of chicken by ecotype and sex in Ethiopia (8 to 12 weeks of age)

Group	Live weight		
	8 weeks (g)	10 weeks (g)	12 weeks (g)
Ecotype			
Tilili (no.)	284.5 ± 4.5^{b}(327)	395.0 ± 6.6^{b}(271)	519.8 ± 8.9^{b}(227)
Horro (no.)	266.9 ± 11.4^{c}(75)	366.7 ±16.5^{c}(64)	421.4 ± 22.6^{c}(47)
Chefe (no.)	281.4 ± 4.7^{b}(217)	391.1 ± 6.9^{b}(203)	509.3 ± 9.3^{b}(200)
Jarso (no.)	215.9 ± 5.9^{d}(257)	299.3 ± 8.6^{d}(191)	385.4 ± 11.7^{c}(148)
Tepi (no.)	226.0 ± 9.4^{d}(107)	283.1 ± 13.6^{cd}(96)	372.3 ± 18.6^{c}(54)
Mean local	241 ± 2.3	332.7 ± 3.14	443 ± 5.7
Fayoumi (no.)	365.0 ± 8^{a}(303)	531.8 ± 11.6^{a}(281)	666.3 ± 15.9^{a}(264)
Overall mean (no.)	273.4 ± 3.2 (1,286)	377.8 ± 4.6 (1,103)	479.1 ± 6.3 (943)
Sig. level	**	**	**
Sex:			
Male (no.)	314.7 ± 5.2^{a}(409)	433.9 ± 7.6^{a}(361)	558.2 ± 10.4^{a}(346)
Female (no.)	232.2 ± 3.5^{b}(877)	321.8 ± 3.8^{b}(742)	399.9 ± 7.0^{b}(597)
Sig. level	***	***	***

Figures in bracket represent number of observations from which means were derived.

^{abcd} Means within a column followed by different superscripts are significantly different.

Source: Dessie et al. (2002).

The preconditions for a breeding program can be summarized as below:

> *Selective breeding exploits the substantial genetic variation present for most traits with desirable qualities. The main benefit of selective breeding is that genetic improvement remains permanent and the genetic progress per generation will be transferred to generations*

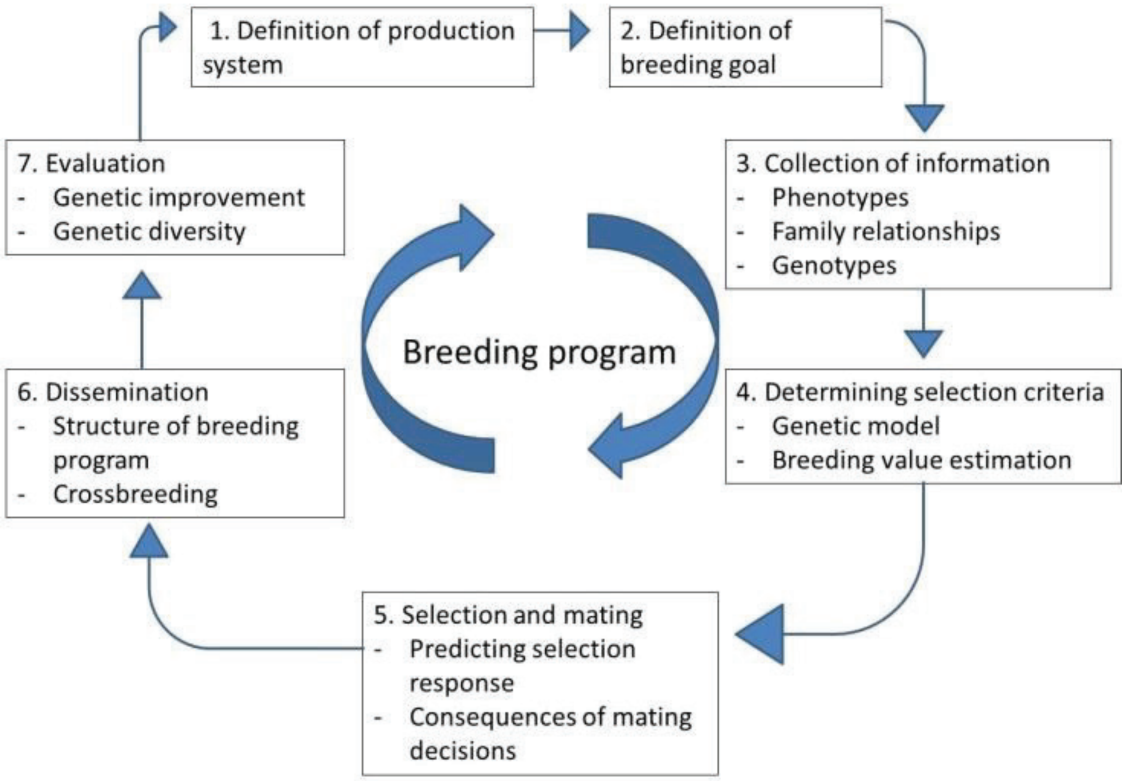
- There must be variation between animals for the traits under consideration. Since if all animals share identical phenotypes, there are no individuals with higher-than-average trait value to select.
- A portion of this variation must be due to genetic differences since it is only the genetic variation that is transferred to the next generation through eggs and sperm.
- The life cycle of the species must be known and could be able to be controlled since it must be possible to evaluate progeny for trait characters, subsequently select parents for the next generation and cross them in a controlled manner.
- Individual animals must be identifiable (through various tagging methods) to keep track of their pedigree.

2 Steps

The overall process and steps in a typical breeding program can be summarized in the scheme below. The steps need to be followed to arrive at the overall aim are shown in Figure 1.

> Selecting future parents of chickens by monitoring the laying capacity of the hens relating to their parents and relatives is essential. A method of trap nesting is therefore required. A trap nest is a box with a door that automatically closes when the hen enters it to lay an egg. A 'trap nesting' will help determine who's laying how many eggs each day and help to choose the breeding chicken.

Figure 1. Steps in a typical breeding program.



2.1 Defining the selection and production environment

The locations where the improved chickens are kept and where the birds end up are the two most important aspects of the breeding program. The selection environment is where the candidates are kept, mated and the best individuals are selected. They are provided with ideal/appropriate management to help them reveal their genetic potential. The breeder should consider the expression of the traits of the birds in their destination environment. When there is a big difference between the selection environment and the actual production environment, there will be a difference in expressing the traits of interest. When animals are destined to a substandard environment, exposing the selected candidates to less ideal conditions might help the selected birds to best fit to the actual environment.

In most cases many environmental factors influence a quantitative trait measured in an animal. These environmental factors may be divided into systematic and random environmental effects. In a breeding program, a significant goal is to obtain the best possible estimate of the genotype of each animal. This estimate defined the animal's breeding value and is typically predicted based on phenotypic records of the animal itself and its close relatives. The influence of the environmental factors tends to mask the underlying genotype and should therefore be minimized to obtain the most accurate estimates of the animal's breeding value. There are several ways to do this. The different genetic groups to be compared (families or flocks) should be reared under conditions as similar as possible concerning feed, water, temperature, and light regime. In practice, this can be achieved by communal rearing of families in the same housing or cages. The effect of systematic environmental factors like age, sex, cage, farm and feed can be reduced by estimating correction factors and adjusting the data.

2.2 The selection environment

The Tilili indigenous chicken improvement program is located at Andassa Livestock Research Center. The centre is about 22 km south of Bahir Dar city on the road to Tis Abay, located at $11^{0}29'$N latitude and $37^{0}29'$E longitude with an elevation of 1,730 metres above sea level. The area has various topography, ranging from a river valley plain to gentle slope grassland characterized by dark clay soil, seasonally waterlogged in the rainy season and cracked when dry. The site receives about 1,434 mm of rainfall annually. The mean annual temperature varies from a maximum of 29.5^{0}C in March to a minimum of 8.8^{0}C in January.

2.3 Production environment

The production environment is where the improved birds are expected to perform. This is part of the dissemination plan once the goals of the breeding program are met. Birds that are meant for substandard management conditions should fit to the smallholder poultry production system.

3 The breeding goal traits

The breeding program aims to address the needs of the smallholder farmers and need to be set the breeding goals during the planning stage. The breeding goal dictates which traits to consider and the direction of the improvement. The breeding goal indicates the traits of interest ideally identified through communicating directly with the end users (Dessie 2003; Dana 2011; Woldegiorgiss 2015). Previous studies conducted in Amhara region through the African Chicken Genetic Gains identified that farmers are interested in meat related traits such as growth rate, weight for age and feed efficiency and egg production traits such as age at first egg, egg size and number.

3.1 Formation of breeding flock

Enough birds should be established to set up the breeding program by collecting either birds or fertile eggs from the field. Both options have their challenges. Collecting birds from the village might appear an easy option but presents a higher mortality challenge due to confining of free-ranging chicken. The mortality is due to the stress of confinement and diseases that these birds might have carried. The second option is the collection of fertile eggs from the field. The eggs can be fertile or infertile, fresh or old, and can cause poor hatchability. Therefore, collecting a greater number of eggs that can cater to potential hatchability problems is required. It is necessary to pay higher prices for fertile eggs to motivate farmers to bring high-quality and fresh eggs. Eggs were collected based on the criteria shown below.

Quality parameters of fertile eggs:

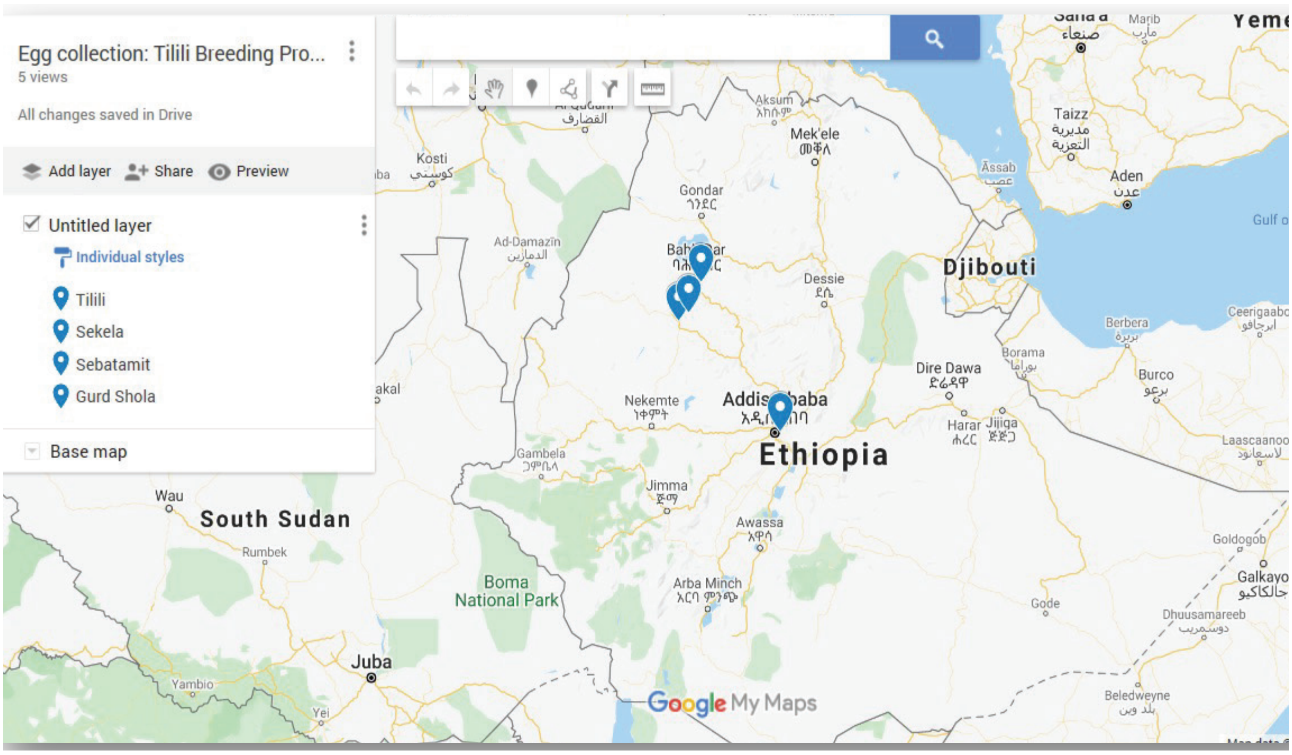
- Medium sized not too large or too small
- Fertile
- Free from any cracks
- Without rough shells, not misshaped and no spots

Eggs must be packed in trays and well wrapped with boxes, securely positioned to avoid unnecessary bumps to ensure the safety of hatching eggs during transporting. The eggs should be left to settle and cleaned following the proper procedure upon arrival. The eggs should be properly disinfected to avoid the introduction of disease-causing agents into the hatchery. It is essential to apply the proper hatchery procedures (providing proper sanitation, temperature, relative humidity, turning, ventilation, and position of eggs) to produce best quality chicks. There is a direct relationship between the size of the egg and the size of the chick. Clean and fertile eggs would have quality chicks. Candling should be used to remove infertile or dead eggs from the setter.

Figure 2. Cleaning eggs with wet cloth

(Map by Wondmeneh E.)

Figure 3. Collection sites: Tilili and Sekela.



(Photo by Wondmeneh E.).

3.2 Hatching of eggs

Once the eggs are cleaned and stored in the cold room overnight, the eggs should be set into the incubator. During setting, eggs should be labelled to relate the eggs weight with the chicken weight after hatching.

3.3 Preparing before chick arrival

Cleaning and disinfecting are critical components of routine biosecurity in poultry farming and help to kill any disease-causing organisms like viruses, bacteria, parasites, and molds that might be present on a farm at the end of a production cycle or after a disease outbreak. It involves the physical removal of foreign material like dust and organic material such as droppings, blood, secretions to protect disease causing agents. Cleaning generally involves dry and wet cleaning followed by disinfection. Dry cleaning involves cleaning equipment and facilities using a broom, a brush, a shovel, and a high-pressure washer to remove all debris and dust left by the previous flock. Wet cleaning involves cleaning using detergent/soap and water to soak the area and scrub to remove remaining organic material and dirt and grease. A commonly available detergent powder can be used. Wet cleaning reduces the risk of aerosolization (dispersal of a viral particles in the form of an aerosol) of the virus. Disinfection kills the remaining disease agents left after cleaning and helps to slow the disease agent's activity, multiplication, and growth or kill the disease agents. After cleaning and disinfecting, the poultry farm will be left vacant for two weeks before placing a new flock. Then the brooding house should be bedded with well dried and disinfected litter with enough depth two or three days before the entrance of the newly hatched chicken.

3.4 Identifying and weighing of chicks

Necessary preparation such as availing vaccines and vaccinators, vitamins, tags, weighing balance must be prepared before the chicks are taken out of the hatchery. Brooding of chicks can be done either in the pens or in the dedicated brooding houses. Chicks should be unloaded from boxes quickly, weighed and identified by attaching an aluminium wing tag. Individual body weight should be taken using balance.

3.5 Brooding chicks

Brooding rings, lighting systems, bedding materials, feed, and water should be placed in the brooding house. Chickens are best provided with vitamin-mineral premix or a sugar solution to help them adapt to the environment soon. Providing very cold water is not advisable for the newly hatched chicken; rather gently warm water is recommended. The brooding ring should allow the feeder and drinker to be easily accessible, and the adjustable light source for monitoring. Temperature control is the most critical factor during brooding. The ability of chicks to regulate their temperature effectively will directly affect their ability to grow proficiently.

On day one of age, the chicks should be housed at a temperature between 30–33^{0}C, relative humidity between 40–60%. Appropriate care should be taken to prevent the chicks from being exposed to drafts, resulting in wind chill. When the chicks are one week of age, the temperature should be reduced by 2^{0}C and continue reducing until the housing temperature of 21^{0}C is reached. During the brooding period, observing the bird assists in providing the most desirable temperatures. Birds that are cold huddle together in a very tight group. When this condition exists, the temperature needs to be increased. Chicks that are too hot will pant and appear drowsy. Chicks that are comfortable will be evenly dispersed within the brooder ring and be active except during the rest periods. The source of heat in the brooder ring can be an infrared bulb hanging from the house's roof. These act as a source of heat and light. Lighting during the first few days should be maintained for 20–22 hours per day for the first two days at an intensity of 30–40 lux to encourage water and feed intake. Lux is a measure of the intensity of light that hits or passes through a surface. Bright light (30–50 lux) during 0–7 days helps the chicks to find feed and water and adapt to a new environment. After the first week, we begin a slow step-down lighting program to provide rest periods for chicks (establishes more natural behaviour of rest and activity) and feeding. From the day old to two weeks of age, feeding chicks can be done by placing a small amount of feed on a newspaper or flat tray and shifting to a round pan and finally to a bell/round feeder. This will encourage comfortable feeding and avoid wastage of feeds. Feeding must be done early in the morning around 0700 hours with ad-lib feeding, where feed is always available with the required quantity and frequency of consumption being the free choice of the animal. Brooding can alternatively be done using the whole poultry house if the temperature can be controlled. Almost similar performance can be realized in this way.

3.6 Feeding and watering

The feed for the indigenous chicken can best be formulated using the locally available raw materials in the country. Formulating feed should consider the requirements of the birds. As opposed to commercial chicken, finding the proper nutrient requirement for indigenous chicken might pose a challenge. However, one can create a hybrid formula between layers and broilers to feed dual-purpose heavy chicken. Lighter birds can adopt a layer diet until the right formula can be identified through nutrition optimization studies. There are several feed formulation applications. There are also freely available excel programs that do the right job. In the Tilili breeding program, feed was formulated using locally available feed ingredients in Bahir Dar and its surroundings. The feeding regime for Tilili chicken was set by considering several standard feed regimes from the literature. However, the amount indicated is higher than the values indicated in the standards.

Fresh and clean water should be made available always in the chicken brooding house. The drinking material should be cleaned three times a day to prevent the development of germs and thereafter filled with fresh and clean water.

Figure 4. Tilili three weeks old chicken in a brooding house at Andassa, Bahir Dar.

(Photo by Wondmeneh E.)

Table 3. Suggested feeding regime for Tilili chicken

Week (Age)	Type of feed	Approximate daily feed consumed	Daily feed consumed + 40% allowance
1	Chick	15	21
2		25	35
3		30	42
4		35	49
5		40	56
6		45	63
7		50	70
8		55	77
9	Grower's	60	84
10		65	91
11		70	98
12		75	105
13		80	112
14		85	119
15		90	126
16		95	133

3.7 Vaccination

Vaccination is an important way of preventing diseases. Different regional epidemic situations require suitably adapted vaccination program.

Vaccination methods used at poultry unit:

i. Individual vaccinations such as sub-cutaneous injections and eye drop which are very effective and generally well tolerated are used in the hatchery for vaccination of chicks against Marek's disease.

ii. Drinking water vaccinations are used to vaccinate chickens against Newcastle, infectious bronchitis, infectious bursal diseases.

iii. Wing web vaccinations are used to vaccinate chicken against fowl pox.

Table 4. Suggested vaccination schedule

Age	Disease	Application
Day 0 at hatchery	Marek's infectious bronchitis	Subcutaneous injection Course spray
7 days	Gumboro (infectious bursal disease)	Drinking water
10 days	Newcastle disease Infectious bronchitis	Drinking water
16 days	Gumboro (infectious bursal disease)	Drinking water
3 weeks	Newcastle disease Infectious bronchitis	Drinking water
6 weeks	Fowl pox	Wing web
8 weeks	Newcastle disease Infectious bronchitis	Drinking water
10 weeks	Fowl pox Avian encephalomyelitis	Wing web Drinking water
12 weeks	Newcastle disease Infectious bronchitis	Drinking water
24 weeks	Newcastle disease Infectious bronchitis	Drinking water
36 weeks	Newcastle disease Infectious bronchitis	Drinking water
48 weeks	Newcastle disease Infectious bronchitis	Drinking water
60 weeks	Newcastle disease Infectious bronchitis	Drinking water
72 weeks	Newcastle disease Infectious bronchitis	Drinking water

3.8 Biosecurity and disease management

Biosecurity is a plan of practices designed to prevent the entry and spread of infectious diseases into and from a poultry farm. Biosecurity requires adopting a set of attitudes. The brooder house should be located at an isolated place away from adult birds. It is better, if the brooder and grower houses are built on separate premises at least 1 km away from the layer farm.

One must practice the 'all-in all-out' while pursuing the poultry houses. The brooding can be done on deep litter for the first three weeks before shifting to cages. Alternatively, the chicks can be brooded in specially designed brooder cages from day one. The chicks should be free from infections when they arrive. The indicator of poor health is mortality in the first week. The first week mortality should not exceed 5%. There should be no loose droppings, and the paper of bedding material should be dry. There should be no discharges in the eyes or nostrils. The chicks should not hobble under normal circumstances and should be active and agile.

The three elements of biosecurity procedures Segal (no date).

1 Segregation and traffic control: This is the most effective form of biosecurity to prevent contamination.

- Preventing disease agents from entering the farm by keeping potentially infected animals and contaminated objects such as clothing, footwear, vehicles, equipment, etc., away from healthy chicks by constructing physical barriers.
- Preventing unauthorized people from entering the chicken house.
- Preventing poultry contact inside the chicken house from wild and domestic animals and birds from the outside and preventing contact of differently housed chickens.
- All workers or visitors must wash their hands with soap before entering the chicken house.
- All workers or visitors must change or cover clothes and footwear before entering the chicken house (wear farm's clothes).
- All workers or visitors must clean and disinfect footwear between sheds using a footbath or changing footwear.
- Only essential visitors are allowed on the farm, such as veterinarians and service providers.
- Never allow chicken and eggs dealers to enter.
- All-in all-out management system (don't add new birds to a flock).

2 Cleaning is the next most effective step to remove 80% of the contaminants. Cleaning makes the surfaces of the object visibly clean with no dirt left. The list below indicates all the things that should be regularly cleaned.

- Vehicles and equipment (syringes, de-beakers, egg trays)
- Clothes and footwear
- Workers and visitors' hands and feet
- Equipment used on the farm (drinkers, feed pans, egg trays)
- Workers clothes and footwear
- Workers hands in between jobs
- Poultry houses (inside and outside).

3. **Disinfection**

- removal of all dirt during the cleaning process
- usage of only approved disinfectant
- preparation of disinfectant solution in correct concentration
- application of disinfectant in the correct volume to ensure effective contact time and to cover the entire surface
- preparation and application of disinfectant in a safe manner

Table 5. Suggested biosecurity measures and procedures

Biosecurity measures	Procedures
Disinfect foot dips	Foot dips/bath on entering the site, main gate, and each pen. Replenish every 4–5 days or when visibly contaminated
Hand washing	All staff wash their hands before starting work, after breaks and when changing activities
Wheel wash, vehicle, sprays, and mobile equipment	Any vehicle entering the site must pass through a disinfectant wheel wash or vehicle spray. The wheel wash should be done regularly to avoid dilution or contamination. Mobile equipment brought into the site from other units must be washed and disinfected before entering
Water lines and drinkers	To maintain water quality during the production cycle continuous disinfection is important. Header tanks and pipelines need to be regularly cleaned and disinfected with a non-tainting disinfectant
Disinfecting the area	Spraying a fine disinfectant mist or fog over birds reduces infection and re-infection during outbreaks time. It is particularly of value in preventing secondary bacterial infection (e.g., E. coli) following a virus attack
Rodent and insect control	Implement an effective insect and rodent control program
Work cloth and other wearing (boot, glove, mouth protection etc.)	Clean work cloth should be available in every house. Other wearing should be in the hand of individual workers and supervision for the wearing is properly used by the workers
Disposal	Dispose of dead birds promptly either by burning or burying
Cleaning building	Thorough washing of all surfaces and equipment is essential to achieve the best results from subsequent disinfection
Ventilation	To facilitate the entrance of large amount of fresh air and dilute microbes and reduce disease build-up, good ventilation is very important
Remove all litter	All old litter should be hauled to a remote part of the farm and composted
Vaccination	To prevent diseases occurrence, follow strict vaccination schedule
Information access	Getting timely information related to disease occurrence in other farms or newly emerging disease threat and improved biosecurity measures are useful for preventing the disease

One of the most critical issues in managing breeding flock is the challenge posed by parasites (coccidiosis and helminths). Coccidiosis is the most difficult health problem that the eggs can survive sun. An option is a vaccine currently developed which limits the severity of the infection and shading of the eggs to the ground. For helminths, regular deworming is necessary.

4 Collecting information

All required data and related information are critical for successfully implementing the breeding program. Such information is data on the phenotypes, family relationships and genotypes. The program should start by establishing and collecting indigenous birds from the field. The protocol includes locating the source of the genotype, number, and quality of the material, handling, storage and transporting fertile eggs. Tilili eggs were collected from geographic areas where the chickens exist (Hassen et al. 2007).

Based on the breeding goals set beforehand, a proper data collecting system must be available. Body weight is registered starting from day-old then weekly or biweekly until the selection decision for body weight is met. Feed intake must be measured the same way as body weight till the birds are culled. Age at first egg, mortality, serum, etc. can be collected based on the breeding goal. Necessary records regarding each bird must be kept facilitating pedigree information. If one decides to collect genotypic data, phenotypic data on essential traits, pedigree information and genotypes are crucial.

Figure 5. Floor pens arranged to keep birds.

(Photo by Wondmeneh E.)

4.1 Data recording

Data recording is essential for a sustainable breeding program to generate the information required for genetic selection and other critical decisions. Estimating breeding value needs phenotypic data on selection candidates; therefore, in Tilili breeding program, the following data are collected from individual chickens:

Body weight in both sexes: The hatch weight and subsequent records of body weight of each chicken are collected every week using a digital weighing scale. After collection, the data are entered into the computer for analysis. The body weight record on individual chicken will be taken up to 16 weeks.

Age at first egg in female: The age (days) at which the female chicken will first produce eggs will be recorded. The ability of chickens to start egg laying sooner in life increases the farmer's profitability.

Group feed intake daily: These records are taken daily where chicken is fed with a certain number of feeds and then the next day in the morning before giving them another feed, then the amount of feed refused are collected, weighed, and recorded.

Egg number and weight until 45 weeks in females: Egg production will be measured until the age of 45 weeks. Best egg producers will be identified based on egg production ranking and selected to produce eggs to be hatched as next generation. Ideally, pens with trap nests will be used.

4.2 Correlation between traits

Many quantitative traits are associated with each other and therefore show a varying level of covariation. The underlying reason for covariation between characteristics includes the possibility that the same genes control them. In Tilili chicken breed improvement program, it is necessary to keep an eye on attributes like body weight and egg number, whose relationship is negative. Several selection experiments for increasing part-year egg production have yielded positive egg number responses and invariably produced a concomitant reduction in egg weight (Sharma et al. 1998).

4.3 Determining selection criteria

Selecting a standard or set of standards by which selection candidates can be judged to be the parents of the future generation. These sets of criteria indicate the level that birds should meet or exceed to be considered. In the Horro breeding program birds should weigh at least 1,500 grams or more at week 16.

4.3.1 Estimating breeding value

Data are recorded, cleaned, and arranged, so that the breeding value of each bird can be estimated. Breeding value is part of the genotypic value transmitted to the offspring. The choice is to use the animal model, a tool in quantitative genetics used extensively to estimate essential parameters, such as additive genetic variance or heritability (Hill 2010). Ideally, estimated breeding values should be unbiased and of high accuracy. The animal can be ranked and selected as a parent for the next generation based on the estimated breeding value. Best Linear Unbiased Prediction (BLUP) methods will be used in the breeding program (Jeyaruban et al. 1995).

The advantage of using BLUP is that:

i. it considers the systematic environmental effect

ii. BLUP is more flexible and therefore more suitable as operational tool

iii. it takes account of selection

Selection based on the ranking of estimated breeding value can be possible if population parameters are available. However, when all this information is not ready, the selection of birds based on their own performance, also known as the mass selection, will be considered; hence breeding value will be estimated by using the heritability (h^2) of the traits under consideration. Heritability is the proportion of the difference in phenotype (phenotypic variation), which can be explained by differences in breeding values (A).

An animal model that uses information from relatives and adjusts data for fixed effect will be used in estimating breeding value. Models of genetic effects are maps relating phenotypes to parameters with genetic meaning and biological insight. Genetic models assume a genotype-phenotype linkage. An implicit assumption of animal models is that all founder individuals derive from a single population.

Estimated breeding values (EBVs) provide a measure of the breeding potential of an animal for a specific trait. They consider performance data collected on known relatives, the relationships between performance traits (correlations) and the degree to which traits are inherited from one generation to the next (heritability). EBVs are expressed in the same units as the recorded trait and compared to the average breeding value of a population (zero). A hen with an EBV of +20 for cumulative egg number is estimated to have the genetic potential to lay 20 more eggs per year if compared to the one with an EBV of 0.

5 Selecting and mating

Selection is selecting individuals to be the parent of the next generation. The individual is identified based on merits on traits of importance. In the Tilili breeding program, mass selection will be applied where chicken with superior characteristics (highly heritable breeds) will be selected from a flock and then allowed to mate among each other at random (Saxena and Kolluri 2018).

5.1 Selection intensity

This term defines the proportion of male and female selection candidates that will be selected as the parent of the next generation. In indigenous breeding programs like Tilili, the proportion is set considering the available chicken surviving mortality and physical deformities. When more animals that are required per generation survive till selection age, more intense selection can be applied. In this approach, selecting birds of both sexes that qualify the criteria will be selected for body weight in both sexes. Afterwards, eggs will be collected for 21 weeks after egg production is commenced and selected for egg number. In the Tilili breeding program, selecting was made when the chicken were 16 weeks old. We practice truncation selection (i.e., chicken, which will reach 1,500 kgs at 16 weeks) to select male and female candidates. Fifty cocks and 400 hens are chosen based on the index to produce the next generation in each generation. For every generation, 7–10% of the best cockerels and 50–60% of the best hens will be selected as parents of the next generation.

5.2 Predicting rate of genetic gain

Selection response per year is the function of intensity, accuracy, genetic standard deviation, and generation interval

$$\Delta G = \frac{i * r_{IH} * \sigma_A}{L}$$

where ΔG = is the selection response per year expressed in trait unit

I = intensity of selection

rIH = is accuracy of selection

σA = is the additive genetic standard deviation of the trait under selection

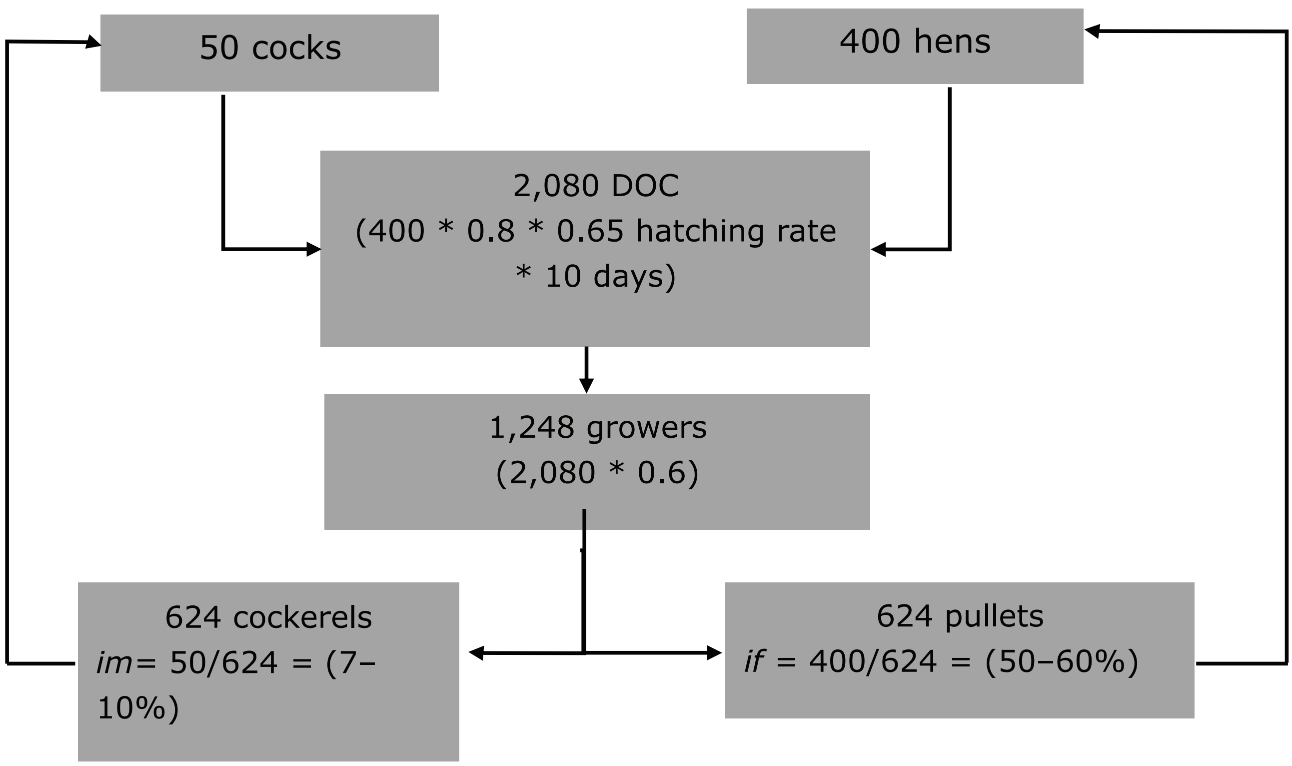
L = is the generation interval expressed in years

The above equation is based on single trait only but, under Tilili breeding program it aims to improve multiple traits (body weight and eggs) simultaneously. Therefore 'selection index theory' will be used to predict the rate of genetic improvement (Hazel et al. 1994). With multiple trait selection we want to predict ΔG for each trait separately and in addition we want to predict the rate of improvement in the breeding goal H.

5.3 Selection scheme

The suggested selection scheme to be used is shown below. This is a scheme used in the Horro chicken improvement program and can be adopted. As need basis, the number of the ratio of males to females can be 1:10 or 1:8 based on the fertility of the flock.

Figure 6. Selection scheme followed in the Tilili chicken improvement program.



5.4 Mating

Mating is the process that determines how maternally, and paternally derived alleles are combined within individuals. The total flock size in each generation will comprise 450 chickens (50 cocks and 400 hens), and the mating ratio will be 1 cock to 8 females; hence, 50 cocks will be mated with each generation of 400 hens. Indigenous cocks are active in mating the hens assigned to them in a pen. Regular monitoring of fertility will be done. If cocks have a special attraction towards certain hens and avoid others, artificial insemination can be introduced.

Currently, the base generation (G0) of Tilili flock has been selected for body weight at week 16 and will be selected for egg production in few weeks. The mean body weight of the day old Tilili chicken was 30.4 gram with high variation between the smallest and highest birds. Similarly, as age increased the variation in body weight among the ecotype significantly increases. The body weight of selection candidates at the time of selection decision is shown in Table 6 below.

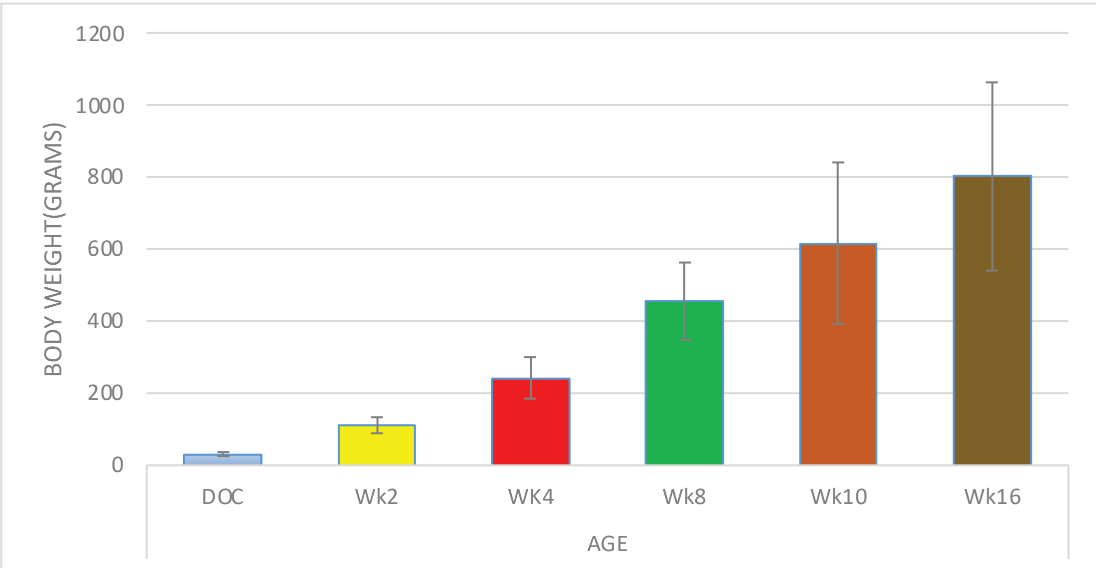
Table 6. Selection of chicken (G0) based on week 16 body weight

Selection candidates by sex	> 1500 g	> 1300 g	> 1200 g	> 1100 g	< 1000 g	Total selection candidates
Male	8	12	9	41	180	250
Female	3	7	12	17	365	404

When the selection candidates failed to meet the minimum set criteria, it would be good to lower the criteria. Although the objective is to develop a dual-purpose chicken, we may end up with lighter birds.

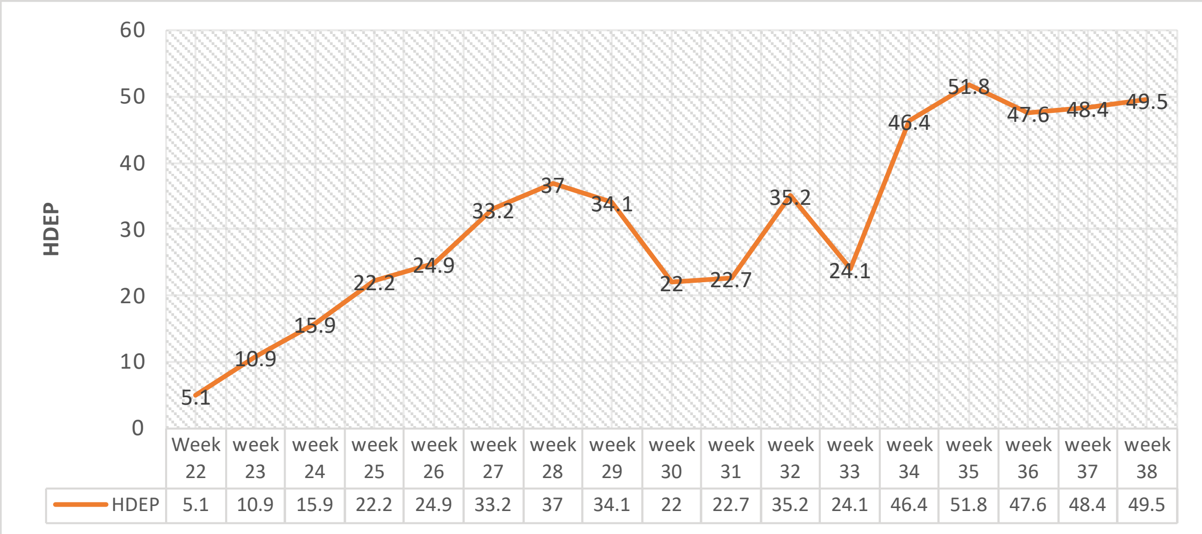
The number of male and female chickens required per generation is at least 40 and 400, respectively. The selection exercise revealed that not enough birds qualify the 1,500 grams of cutoff point set for selection. As a result, the 1,500 grams cutoff point was lowered to 1,000 grams to select both males and females.

Figure 7. Mean body weight (mean ± SD) of Tilili chicken measured during growing period at Andassa, Bahir Dar.



Egg production performances of base population till week 38 is plotted. The hens of the base population of Tilili chicken produce 39 eggs per 17 weeks under intensive management. Maximum hen house egg production was recorded in week 35. Hen day egg production increases up to week 28, however, after that lower value is recorded up to week 33. This is since local chickens become broody after a certain laying period.

Figure 8. Hen day egg production (%) of the G0 population measured during egg laying period at Andassa, Bahir Dar.



	Week 22	week 23	week 24	week 25	week 26	week 27	week 28	week 29	week 30	week 31	week 32	week 33	week 34	week 35	week 36	week 37	week 38
HDEP	5.1	10.9	15.9	22.2	24.9	33.2	37	34.1	22	22.7	35.2	24.1	46.4	51.8	47.6	48.4	49.5

6 Inbreeding

Inbreeding is the practice of mating two genetically related animals. Inbreeding is inevitable in long-term selection program involving a closed population. Sometimes, it might be necessary to mate inbred chicken to introduce certain characteristics in the flock that increases the frequency of favourable genes or more rarely to expose recessive genes. The practice of breeding inbred lines causes inbreeding depression by increasing the number of recessive or deleterious genes being expressed. Reduction in fitness and productivity is called inbreeding depression. Breeders need to find a balance to optimize rates of genetic gain, while controlling increases the levels of inbreeding.

Breeding programs are prone to increase inbreeding due to the frequent use of artificial insemination, fast generation turnover, selective use of specific family lines and the tendency for a relatively small number of different sire families to dominate within certain breeds. It is important to monitor and evaluate the level of inbreeding created in a population in every generation. This is calculated as inbreeding coefficient. Inbreeding coefficient is defined as the probability of two alleles being identical by descent. Complete avoidance of inbreeding is impossible, and a balance should be created between the genetic superiority obtained from a specific chicken and the level of inbreeding that it creates in the future flock. The best solution to the inbreeding challenge is to measure the level of inbreeding between individuals and make recommendations based on this information.

Typical inbreeding percentages, assuming no previous inbreeding between any parents:

- Father/daughter, mother/son, or brother/sister ⇢ 25%
- Grandfather/granddaughter or grandmother/grandson ⇢ 12.5%
- Half-brother/half-sister ⇢ 12.5%
- Uncle/niece or aunt/nephew ⇢ 12.5%
- Great-grandfather/great-granddaughter or great-grandmother/great-grandson ⇢ 6.25%

7 Data analysis

Several methods and computer software will be used to analyse the data collected under Tilili breeding program:

- **BLUP (Best Linear Unbiased Prediction)** is a standard method for estimating random effects of a mixed model. This method will be used for estimating breeding values.
- **ASREML** is a powerful statistical software specially designed for mixed models using Residual Maximum Likelihood (REML) to estimate the parameters.
- **SelAction** is a computer software which will be used to analyse the response to selecting the resulting mass selection (use of own phenotype only).
- **R-Statistical package** is a language and environment for statistical computing and graphics that provide a wide variety of statistical (linear and nonlinear modelling, classical statistical tests, time-series analysis, classification, clustering) and graphical techniques.
- **RelaX2** is a program for studying relationships of animals in large pedigrees, it involved pedigree checking, pedigree pruning (e.g., for estimating variance components or inbreeding studies) and selecting individuals and their ancestors.
- **Proximate method:** This method analyses the composition of feeds in terms of its fundamental components (proximate composition) moisture, crude protein, ash, fat, and the residue (nitrogen free extract).

7.1 Disseminating genetically superior chickens

The overall objective of the breeding program is to take a genetically superior chicken to the households. Improving the flock can continue in a nucleus flock where they are continuously improved and multiplied and disseminated to the end-users. Ideally, multiplying chickens is best done at a different farm than at the nucleus breeding flock. Keeping multiple flocks in a few places is also essential to protect against potential loss through disease outbreaks. The government best handles breeding programs involving indigenous chickens to attract private sector companies. Public, private partnerships might be an ideal arrangement. The public sector should transfer the improved nucleus flock and focus on other programs aiming to generate breeds.

8 Assessing genetic gain and genetic trend of the breeding program

Realized genetic gain is the change in the average breeding value over at least one cycle selection for a particular trait or index of traits. The change in the breeding or genetic values of the population over many cycles or years is referred to as a genetic trend. Genetic trends are used to assess the effectiveness of breeding programs (Rutkoski 2019). In the indigenous chicken improvement program, the genetic gain and genetic trend should be evaluated after the program was run for a few generations, ideally six generations. In the Horro chicken breeding program, an apparent gain and trend were observed after six generations of selection (Woldegiorgiss et al. 2014). Evaluating impacts of the selective breeding program can be seen as improvements realized in the breeding flock, at the field, or economic benefits.

8.1 Genetic gain realized in the breeding flock

This can be done by carrying out the genetic trend plot. Estimating breeding values can be plotted against the generations of improvement and evaluated whether the trend is increasing or decreasing. The other is carrying out the signature of selection by using whole-genome analysis. The signature of selection analysis would indicate the traits that were affected by the selective breeding program.

8.2 The change at the field

The improved chicken can be compared both on-station/controlled environment or at the field/on-farm condition against the wild or unimproved chicken (Woldegiorgiss et al. 2016). The magnitude of the difference in the performance under similar management conditions would reveal the actual improvement achieved in the program.

8.3 Economic benefits

The economic benefit of a breeding program can be evaluated by the per cent of genetic gain achieved and the corresponding profit gained by the program. Genetic gain is the response to selection for additive genetic variance (Lush 1945). Routine estimation of the rate of genetic gain should be performed. Changes in genetic gains realized by a breeding program are used to monitor its effectiveness. Genetic gains (ΔG) depend on additive genetic ($\sigma^2 A$) and phenotypic variances ($\sigma^2 P$), which are used to estimate a ratio known as narrow-sense heritability ($h^2 = \sigma^2 A/\sigma^2 P$), selection intensity (or the percentage of individuals selected and advanced to the next generation), parental control of males and females and time.

9 Conclusion

This manual provides the essential information and procedure required to set up and conduct indigenous chicken improvement programs. It is necessary to carry out a breeding program that needs to be run for generations. Besides, to ensure the chickens retain their adaptive capacity for on-farm circumstances, the future generations should be performance tested in less expensive management conditions that resemble their on-farm production environment. The exact formulation of the breeding goal should be re-evaluated and may need to include additional traits the farmers prefer. Such characteristics may consist of feather colour. Farmers in villages are interested in brown feather colour, suggesting it should be included in the breeding goal.

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