Genetic improvement in indigenous chicken of Ethiopia

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This research was conducted under the auspices of the Graduate School of Wageningen Institute of Animal Sciences (WIAS).

Genetic improvement in indigenous chicken of Ethiopia

Wondmeneh Esatu Woldegiorgiss

Thesis

Submitted in fulfillment of the requirements for the degree of doctor at
Wageningen University
by the authority of the Academic Board,
in the presence of the
Thesis Committee appointed by the Academic Board
to be defended in public
on Wednesday June 3, 2015
at 4 p.m. in the Aula.

Wondmeneh Esatu Woldegiorgiss
Genetic improvement in indigenous chicken of Ethiopia
130 pages.

PhD thesis, Wageningen University, NL (2015)
With references, with summaries in English and Dutch

ISBN 978-94-6257-316-1

Abstract

Wondmeneh Esatu Woldegiorgiss (2015). Genetic improvement in indigenous chicken of Ethiopia. PhD thesis, Wageningen University, the Netherlands

This thesis considered various approaches to study the potential for improvement of village poultry production system using improved indigenous chicken. The approaches were structured survey questionnaire, village poultry simulation model (VIPOSIM), Heckman two-step model (econometric model), and experiments involving laboratory and field. First factors that determine the probability and intensity of adoption of exotic chickens were assessed. The probability of adopting exotic chickens was found to be positively affected by access to an off-farm income and negatively by livestock income. The intensity of adoption was negatively affected by being male household head, having a larger farm size, and having livestock income. Then, perceptions of farmers towards village poultry and impacts of interventions on flock and economic performance were assessed. Farmers' perceptions affected their decisions about implementation of interventions, and interventions increased productivity but only in a few cases the increased revenues outweighed the additional costs. Subsequently, the evaluation of the breeds was conducted by comparing the natural antibody and productivity of improved indigenous chicken with crossbred, commercial and unimproved indigenous chickens. The results revealed that not only the NAb levels but also the effect of NAbs on survival differ between indigenous and improved breeds. NAb levels are associated with survival in commercial layer breed, but reduced survival in indigenous chickens placed in confinement. Improved indigenous chickens showed higher performance than unimproved one for all traits measured on-station, but remains lighter and developed more into a laying type than meat through the short-term selective breeding program. Overall, the present studies indicate that interventions need to be tailored towards the local situation to ensure that they lead not only to improved productivity but also to improved income.

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General introduction

1.1 The role of poultry breeding for food security

The FAO (2014) has predicted the global population will reach nine billion by 2050. Currently, 805 million people, which is equal to one in nine, live below the poverty line and are food insecure with food security defined as the state of having reliable access to a sufficient quantity of affordable, nutritious food (World Food Summit, 1996). As a significant number of the world's poor are food insecure, the demand for animal products in emerging economies continues to increase (Delgado et al., 1999; Foresight, 2011). Therefore, the big challenge is not only to provide food security to all people in the world, but to, in parallel, allow for these changing dietary preferences of improving economies.

But how to achieve this goal? Poultry is one of the contributors to the solution as it provides a source of animal protein and has an important role in food security. Poor households can have a few self-sufficient free ranging chickens as a source of cheap but valuable animal protein. These chickens need little to no external input, but in return, produce few eggs and grow slow. As an alternative, commercial poultry farms produce huge amounts of egg and meat from genetically superior and specialized animals. For example, commercial laying hens produce 300 or more eggs a year (WATT, 2011).

Selective breeding is largely responsible for such increases in livestock productivity over recent decades (Leakey et al., 2009), as has been clearly shown in broilers (Havenstein et al., 2003). The breeding goals of animals should include the productivity and efficiency traits (Neeteson-van Nieuwenhoven, et al., 2013). Traits of interest can be genetically improved but the environment to express them needs to be defined. Controlled and optimized environmental conditions are among the preconditions to achieve the genetic improvement. In developing countries, the suboptimal environment has the potential to negatively impact the performance of the breed. Despite these challenges, there are great opportunities to increase productivity in developing countries (Thornton, 2010).

Breeding for harsh environments

With a combination of within-breed selection, crossbreeding, and breed substitution, thus far, the demand for livestock products is being met (Thornton, 2010). The developing world has not practiced the within-breed selection all that widely, in part because of the lack of proper infrastructure (such as performance recording and genetic evaluation schemes), but the adoption of this practice needs to be promoted as the commercial lines often underperform in the substandard environments in developing countries. Alternatively, genetic improvement of indigenous chickens can be undertaken in the environments in which the breeds have developed and adapted as breeding goals should consider the variability of the production environment among regions, uncertainty and associated risk about the future circumstances (Smith, 1984).

Dual-purpose chickens?

In most rural areas, farmers favor a breed that combines both growth and egg production traits. Researchers described dual-purpose chickens as breeds that give reasonable numbers of meat and eggs (Iraqi et al., 2005; Mekki et al., 2005). Studies of these dual-purpose chickens have not clearly demonstrated reasonable egg numbers or changes in body weight, but a within breed selection of indigenous chickens has the potential to develop a well-adapted, dual-purpose chicken. However, developing a dual-purpose chicken through selective breeding can be difficult because of the negative genetic relationship between the egg and growth traits. A study on indigenous chickens in Tanzania showed that the heavier breed was a poor egg producer (Lwelamira et al., 2008). These difficulties with negatively correlated traits could be overcome by using crossbreeding. Crossbreeding between commercial cocks and indigenous hens may provide a way to produce productive dual-purpose chickens that can cope with harsh environments. The commercial poultry industry widely used crossbreeding to exploit the complementarity of different breeds or strains and make use of heterosis (Simm, 1998). Dual-purpose crossbreds from commercial cocks and indigenous hens can best perform in village poultry production systems because the crossbreds benefit from the adaptation trait from scavenging birds (Bekele et al., 2010). For instance, the Rhode Island Red (RIR) has been the most common commercial line used to obtain dual-purpose chickens by crossing with indigenous birds (Zaman et al., 2004; Khawaja et al., 2012; Bekele et al., 2010). In a study by Alemu (1995), crossbred chickens performed better than either of the indigenous or commercial parents under the village poultry production conditions. While crossbred chickens are usually heavier than indigenous chickens, there are some potential disadvantages of such crossbreds. For example, their feed requirements are higher compared with indigenous chickens, and therefore, dual-purpose crossbred chickens may suffer from poor nutrition and diseases in an environment where feed is limited and the search for feed requires scavenging for long distances. In addition, the commercial cocks are too heavy for the indigenous hens and attempts to produce crossbreds by natural mating is difficult. Therefore, production of crossbreds may require the technical skill of artificial insemination.

Developing separate lines of indigenous chickens for growth and egg production can be an alternative to the production of well-adapted, dual-purpose chickens. Potentially, these crossbred of dual-purpose indigenous chickens will not be productive, and two selection lines are required to produce such a crossbred. Given the market of limited size and the high costs associated with keeping two pure lines, this does not seem to be a viable option at the moment. A final alternative could be to totally replace the indigenous chickens with commercial breeds, but this will lead to the loss of breeds adapted to the environment (Arnold and Rochambeau, 1983).

Genotype by Environment interaction

Genotype by Environment interaction (GxE) is when genes express themselves in their action on a trait differently in one environment than in another (Weiner, 1994). It is essential that the potential of breeding stock is expressed in a wide range of production environments (Neeteson-van Nieuwenhoven et al., 2013). Large companies have not yet developed a chicken breed able to have high performance in a wide range of environmental variations in harsh environments (FAO, 2010). Effective selection programs require sufficiently large populations, pedigree recording, accurate measurement of individual performance and the capacity to lessen environmental variation (FAO, 2010). Therefore, Individual farmers cannot run a breeding program. An attempt to fulfill the needs of commercial breeds or crossbreds for higher productivity, by providing good quality feed and shelter, is risky and more prone to failure. The extra resources needed to maintain these birds may not be consistently available, and the maintenance and production costs may appear too high (Wiener, 1994). Commercial breeds perform better than indigenous breeds under better management, but only slightly better, or the same, under low input conditions (Tadelle et al., 2000; Singh et al., 2004). Feed shortages and environmental problems are prevalent. Large variation between the environment of genetic improvement and the villages causes the loss of productivity due to GxE interactions. Therefore, exploring the resources and constraints is important before introducing a breed into a certain environment, and the next step for optimizing production in harsh environments is to find or develop breeds for that environment (Wiener, 1994).

Rationale and the objective of this study

Disease, poor nutrition, poor management, and poor genetic capacity are the major problems of poultry production in Ethiopia (Halima et al., 2009). Past attempts to improve the poultry productivity in Ethiopia through the introduction of high performing commercial chickens was not successful. The contribution of commercial chickens in improving the productivity was less than 2% (Tadelle, 2000). Crossbreeding to combine both the high genetic potentials of commercial birds with the better adaptability and disease resistance of the indigenous birds has been attempted in Ethiopia (Tadelle, 2003).

An alternative approach to improving production levels is within breed selective breeding. In 2008 a breeding program of indigenous chickens was initiated at the national agricultural research station at DebreZeit, Ethiopia, using chickens from the Horro region. The goal was to improve the productivity of village chickens through selective breeding. The Horro chickens and the breeding objectives (egg number and live weight) for this program were identified using a participatory approach (Dana et al., 2010). The goal of the breeding program was to develop chickens with higher productivity and a more optimal adaptive capacity to withstand harsh conditions than the unselected population. The performance of the current generation of the improved breed does not yet meet the expectations of farmers, but considering the rate of improvement, it is anticipated that future generations will fulfill the needs of the farmers. Selection for increased production levels may negatively affect the adaptive capacity of the birds. This could be evaluated by studying the natural antibodies (NAb) of genetically improved versus unimproved birds, as NAb are expected to be indicators of adaptive capacity.

Objectives

This PhD study aims to integrate survey, model and experimental approaches to study the potential for improvement of indigenous chickens, focusing on farmers' perception and impacts of interventions, and evaluation the progress of an ongoing selective breeding program.

Specific objectives of the study are:

1. To understand the reasons behind the poor adoption of commercial chickens by the village poultry producers in Ethiopia
2. To understand the perceptions of rural poultry producers and impacts of interventions on the production and economic performance of village poultry production system
3. To compare the NAb level of Improved Horro, crossbred, commercial and unimproved Horro chickens

4. To compare the performance of productivity of Improved Horro, crossbred, commercial, and unimproved Horro chickens both on-station and on-farm

Thesis outline

Chapter 1 gives an overview on the role of poultry breeding for food security, challenges for breeding for harsh environments and rationale and objectives of the study.

Chapter 2 identifies the characteristics of adopter and non-adopters of exotic chicken breeds. Further, it identifies the causes for poor adoption of exotic chickens by rural poultry producers. A combination of structured questionnaire survey and econometric model was used. Responses of participants from two areas in Ethiopia were used in the study.

Chapter 3 identifies the perception of village poultry farmers towards the village poultry production system and quantifies the impacts of individual and packaged inputs (interventions) on the productivity and economic performance of the village poultry production system. Here also questionnaire survey and village poultry simulation model (VIPOSIM) was used. The survey identifies the existing poultry production system, the perceptions of farmers, and generated input values to the simulation model. The impact of improved indigenous chicken on the level on the productivity and economic performance was determined. Sensitivity analysis was also conducted.

Chapter 4 compares the natural immunity (NAb) of the four groups of chickens were evaluated and its relationship with survival. It applies the indirect ELISA technique to determine the IgG and IgM levels in the blood sera of the chickens. Hazard analysis was used to show the association of NAb levels in the blood serum with the survival of the chickens.

Chapter 5 compares the performance of the four groups of chickens under controlled environments. Two separate experiments were conducted, on station and on farm. The on station experiment was executed at the DebreZeit Agricultural Research Center, and farms in two separate regions for the on farm experiment. The on station experiment includes the comparison of improved indigenous (selected) with unimproved (unselected) chicken. The effect of breed, environment and environment x breed interactions were studied. The progress made through the selective breeding program was shown.

Chapter 6 reflects on the some important issues observed in the course of the study and issues that should be considered in the future of the breeding program. The selective breeding program is likely to continue. Aspects of the improvement that need to be considered are discussed. Potential adoption determinants that were not captured in the study were also discussed. Points that can maximize the profit or benefit from village poultry were also discussed.

References

Alemu Y., 1995. Poultry production in Ethiopia. World's Poultry Science Journal, 51:197-201.

Arnold J., & Rochambeau H. de., 1983. Inventaire des races menaces et des actions de conservation: les animaux de basse-cour. Ethnozootechnie, 33.

Bekele, F., Ådnøy, T., Gjøen, H. M., Kathle, J. & Abebe, G., 2010. Production performance of dual purpose crosses of two indigenous with two exotic chicken breeds in subtropical environment. International Journal of Poultry Science, 9(7): 702-710.

Besbes, B., 2008. Genotype evaluation and breeding of poultry for performance under sub-optimal village conditions. Proceedings of the 23rd World's Poultry Congress, Brisbane, Australia, July 2008. CD-ROM.

Delgado, C., Rosegrant, M., Steinfeld, H., Ehui, S. &Courbois, C., 1999. Livestock to 2020: The next food revolution. FAO discussion paper 28. IFPRI, FAO, and ILRI.

Foresight, 2011. The future of food and farming. Final project report. The Government Office for Science, London.

Halima, H., Neser, F.W.C. De-Kock, A. & Van Marle-Köster, E., 2009. Study on the genetic diversity of native chickens in northwest Ethiopia using microsatellite markers. African Journal of Biotechnology, 8: 1347-1353.

Havenstein, G.B., Ferket, P. R., Qureshi, M. A., 2003. Carcass composition and yield of 1957 versus 2001 broilers when fed representative 1957 and 2001 broiler diets. Poultry Science, 82:1509-1518.

Iraqi, M.M., Afifi, E.A., Abdel-Ghany, A.M. & Afram, M., 2005. Diallel crossing analysis for liveability data involving two standard and two native Egyptian chicken breeds. Livestock Research for Rural Development, 17(7).

Khawaja, A., Khan, S.H., Mukhtar, N. & Parveen, A., 2012. Comparative study of growth performance, meat quality and hematological parameters of Fayoumi, Rhode Island Red and their reciprocal crossbred chickens. Italian Journal of Animal Sciences, 2: e39.

Leakey, R. et al., 2009. Impacts of AKST (Agricultural Knowledge Science and Technology) on development and sustainability goals. In Agriculture at a crossroads (eds : B. D. McIntyre, H. R. Herren, J. Wakhungu & R. T. Watson), pp. 145–253. Washington, DC: Island Press.

Lwelamira, J., Kifaro, G.C. & Gwakisa, P.S., 2008. On station and on-farm evaluation of two Tanzania chicken ecotypes for body weight at different ages and for egg production. African Journal of Agricultural Research, 3(12): 843-851.

Mekki, D.M., Yousif, I.A. Abdel Rahman, M.K., Wang J. &. Musa, H.H., 2005. Growth performance of indigenous X exotic crosses of chicken and evaluation of general and specific combining ability under Sudan condition. International Journal of Poultry Science, 4: 468-471.

Neeteson-van Nieuwenhoven A-M., Knap, P.W. & Avendaño, S., 2013. The role of sustainable commercial pig and poultry breeding for food security. Animal Frontiers, 3: 52-57.

Nigussie Dana, Liesbeth H. van der Waaij, Tadelle Dessie, and Johan A. M. van Arendonk., 2010. Production objectives and trait preferences of village poultry producers of Ethiopia: implications for designing breeding schemes utilizing indigenous chicken genetic resources. Tropical Animal Health & Production, 42(7): 1519–1529.

FAO, 2010. Poultry genetics and breeding in developing countries: Genetic approaches to improved performance in sub-optimal conditions. By R. Pym. FAO Poultry Development Review.

Simm, G., 1998. Genetic Improvement of Cattle and Sheep. Farming Press: Tonbridge, UK.

Singh, D.P., Johri, T.S, Singh, U.B., Narayan, R. & Singh, D., 2004. Proceedings of the 22nd World's Poultry Congress, Istanbul Turkey.

Smith, C. 1984. Rates of genetic change in farm livestock. Research and Development in Agriculture. 1: 79–85.

FAO, 2010. Chicken genetic resources used in smallholder production systems and opportunities for their development, by P. Sørensen. FAO Smallholder Poultry Production Paper No. 5. Rome.

Tadelle D., 2003. Phenotypic and genetic characterization of local chicken ecotypes in Ethiopia. PhD Thesis. Humboldt University of Berlin, Germany.

Tadelle, D., Alemu, Y. & Peters, K.J., 2000. Indigenous chicken in Ethiopia: Genetic potential and attempts at improvement. World's Poultry Science Journal, 56: 45-54.

Thornton, P.K., 2010. Livestock production: recent trends, future prospects. Philosophical Transactions of the Royal Society B: Biological Sciences, 365(1554): 2853-2867.

Wiener, G., 1994. Animal Breeding. The Tropical Agriculturalist. CTA; Wageningen: The Netherlands.

FAO, IFAD & WFP, 2014. The State of Food Insecurity in the World 2014. Strengthening the enabling environment for food security and nutrition. Rome, FAO.

WATT, 2011.Poultry performance improves over past decades, by Best, P.WATT Executive Guide to World Poultry Trends. Accessed at http: // www. wattagnet.com / Poultry_performance_improves_over_past_decades.html.

World Food Summit, 1996. Rome Declaration on World Food Security.

Zaman, M. A., Sorensen, P. &Howlider, M. A. R., 2004. Egg production performances of a breed and three crossbreeds under semi-scavenging system of management. Livestock Research for Rural Development, 16(8).

2

Adoption of exotic chicken breeds by rural poultry keepers in Ethiopia

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Published at Acta Agriculturae Scand Section A, 2015

DOI:10.1080/09064702.2015.1005658

Abstract

This study examines factors that determine the probability and intensity of adoption of exotic chickens among rural poultry producers in Ethiopia. A total of 240 respondents were interviewed from households that were selected by systematic random sampling. The differences between adopters and non-adopters were identified using descriptive statistics. Factors that affect the probability and intensity of adoption were identified using the Heckman selection two-step model. Adopters of exotic chickens had more social contact and less livestock income than non-adopters. Additionally adopters had access to an off-farm income and credit and considered exotic chickens easier to manage than non-adopters ($p<0.001$). In the econometric analysis the probability of adopting exotic chickens was found to be positively affected by access to an off-farm income ($p<0.01$) and negatively by livestock income ($p<0.05$). The intensity of adoption was negatively affected by being male household head ($P<0.001$), having a larger farm size ($p<0.01$), and having livestock income ($p<0.05$).

Key words: Adoption, Heckman sample selection model, improved poultry breed

2.1 Introduction

Among all livestock species, poultry appears to be the most suitable and practical intervention to improve the rural livelihoods in developing countries including Ethiopia (Simainga, 2011). Of the 38.1 million chickens of Ethiopia over 90% are local, low producing ecotypes (Central Statistics Agency, 2009). The rural poultry production system of Ethiopia is characterized by an average flock of 6 to 10 hens per family laying 30-80 eggs per hen per and year and receiving little or no additional inputs except shelter for the night (Alemu & Tadelle, 1997). The public agricultural extension program in Ethiopia dates back to 1953 (Gebremedhin et al., 2006). Since then poultry breeds (eg. Rhode Island Red and White Leghorn) were imported and disseminated to rural poultry producers through on-farm research and public extension programs to improve the egg and meat production in Ethiopia. There is no documented evidence how exotic breeds were chosen by the public extension body or whether the choice was supported by studies of the adaptability of the breeds under local conditions. Limited empirical evidence available on the adoption of exotic chickens in Ethiopia shows that after 40 years of dissemination exotic chicken breeds contribute less than 2% to the national eggs and meat production (Tadelle et al., 2000). The Rhode Island Red poultry were not adopted by farmers in most parts of the country (EEA: EEPRI, 2006), and adoption was limited by factors such as lack of extension follow-up, lack of complementary inputs, diseases, unavailability of credit services, and market problems (Teklewold et al., 2006). However, available studies are not adequate to draw conclusions about the adoption of exotic chickens distributed into villages through the public extension system in Ethiopia. The study examined the adoption level of exotic breeds at the time of the survey and is believed to contribute additional information. The objectives of this study were therefore to investigate the differences between adopters and non-adopters, and to identify factors that determine the probability and intensity of adoption of exotic chickens in the village poultry production system of Ethiopia.

Theoretical approach and empirical model

The adoption of new technology is not an instantaneous act but a complex, time consuming process (Shahin, 2004). The decision to adoption is made at household level, the decision-making unit, which determines the household's strategy for income generation (Sadoulet& de Janvry, 1995). The decision of whether or not to adopt a new technology is a result of a careful evaluation of a large number of technical, institutional and socio-economic factors (Alene et al., 2000). Although the decisions are complex, they are typically modelled as a binary. Households either accept or reject a given technology or policy according to their own perceptions of the expected benefits, costs and risks (Barry, 2005). Households are assumed to make such a decision with the objective to maximize utility as stated in the Von Neuman Morgenstern utility function (von Neumann & Morgenstern, 1947). Separate models can be developed for each decision as the underlying utility function depends on household specific attributes X (e.g. age of household head, gender of the household head, education, an off-farm income, access to credit, etc.) and an error term with a mean of zero. The observed choice of adopting a technology is hypothesized to be the result of socio-economic characteristics of households and a complex set of preference comparisons between technologies (Adesina & Forson, 1995). In general there are two types of models to determine the exogenous variables that affect probability and intensity of adoption: the Heckman sample selection model also referred to as Tobit II (Heckman, 1979) and Double Hurdle (Cragg, 1971). The relative magnitude and significance of results of both models were comparable (Shiferaw et al., 2008). The Heckman model, as opposed to the double-hurdle, assumes that there will be no zero observations in the second stage once the first-stage selection is passed. In contrast, the double-hurdle considers the possibility of zero realizations (outcomes) in the second-hurdle arising from the individuals' deliberate choices or random circumstances (Wodajo, 2007). The Heckman model was chosen for this study.

2.2 Material and Methods

Data

Sample structure

The study was conducted in the Horro and Ada districts in 2012. A two stage sampling procedure was followed to select eight villages) and 30 sample households from each villagein both districts. In the first stage, four villages from each district were selected purposively based on their prior experience in exotic chicken production and proximity to a road. Exotic chickens such as Rhode Island Red and White Leghorn were distributed in the past and commercial brown egg layers recently into the study areas, but were not studied well. These districts were among those considered in the poultry extension program of the country. Three focus discussion groups consist of (1) district agricultural office experts, (2) developments agents and (3) farmers were formed. Each group consisted of seven to eight people and discussed on the importance of village poultry production and the issues that need priority. In both districts focus discussion groups (Khan et al., 1991), and participatory rural appraisal (Mascarenhas et al., 1991), an effective approach to gather information in rural areas (Cavestro, 2003) were used to develop questionnaires. In the second stage, individual households (n=240) were selected using systematic random sampling. Systematic random sampling is often used to select large samples from a long list of households by using a sampling interval. (Bellhouse, 2005).Household in this study is defined as a unit consisting of the members of a family who live together. Household heads, referred to as farmers in this study, were interviewed and replied on behalf of their families. Interviewers were trained on the purpose and procedure of the survey. Interviewers followed the exact words of the questions, avoided suggestive paraphrasing, and coded the right answers. The whole process was monitored by supervisors during the interview and after the daily work has been completed to avoid interviewer-related errors. In our study more male household heads were interviewed than females. It was not possible to interview more females as it is custom that the household head responds and makes decisions on behalf of the family (Damisa & Yohanna, 2007). The women's decisions to keep even chickens would not have been binding unless the household head (males in most cases) agree. Therefore interesting insights from the women might have missed in this study.

Variable definition

Factors potentially affecting adoption and intensity were identified based on a combination of literature review and logical relationships (Shahin, 2004; Padel, 2001), and their expected relationship with the adoption of exotic poultry breeds in rural areas (Table 2.1). For each of these factors it was hypothesized whether they would positively or negatively affect the probability and intensity of adoption of exotic chickens as new technology. Variables that were not hypothesized to affect adoption were only used to characterize adopters and non-adopters (Table 2 and 3). Livestock income, in this study was hypothesized to affect adoption of exotic chicken breeds in rural areas. The increase in the proportion of livestock income tended to negatively affect adoption of exotic chickens as people getting more income from livestock species other than chickens tended to be richer and could be less interested in chickens. Roland-Holst et al. (2007) showed that the livestock income-dependent farmers include the relatively better-off rural households.

Table 2.1 Description of factors that may influence adoption of exotic chickens, with hypothesis of the direction of that influence.

acronym	Description	Type of measure	Hypothesized direction of the effect	Source
Dependent variables				
Adoption	Probability of adoption	discrete (1 if yes, 0 if no)		
Intensity of adoption	Number of exotic chickens	number		
Explanatory variables				
Easiness to manage	More care and protection for exotic chickens	1 if easy 0 otherwise	+	Davis(1989)
Input availability	Availability of the exotic breed	1 if available 0 otherwise	+	Foster and Rosenzweig (1995)
Education	Household heads educated beyond elementary school	1 if educated 0 otherwise	+	Waller et al. (1998)
Gender (male)	Gender of the house hold head	1 if male 0 if female	-	
Age	Age of the household head	years	+	Teklewold et al. (2006)
Credit access	Availability of credit to buy exotic chicken	1 available, 0 unavailable	+	Abebe et al. (2008)
Farm size	Farm size of the house hold	hectare	-	Teklewold et al. (2006)
Off-farm income	Access to off farm income	1 if available 0 otherwise	+	Teshale et al. (2006)
Social contacts	Participation in farmer’s association	1 if participate 0 no	+	Garcia et al. (2012a)
Extension visit	Frequency of visit by development agents	Number of visits per week	+	Adesina& Baidu-Forson(1995)
Livestock income *	Percentage of income from livestock	Percentage of income	-	-
Training	Frequency of attendance in trainings	Number of trainings/ 6 month	+	Belay(2003)

Source: various literatures and logical relationship. (+) effects means the explanatory variables have positive effect on the probability and intensity of adoption. (-) effects means the explanatory variables have negative effect on the probability and intensity of adoption.
* Livestock income refers income from equines, small and large ruminants.

Statistical Analysis

Data on the descriptive statistics were analyzed using SPSS version 17.0 (SPSS, 2008). A t-test was used to identify whether the differences among means of continuous variables were significant. A Chi-square test was used to identify differences among discrete variables. The analyses to identify the probability of adoption (selection regression equation) and intensity of adoption (outcome regression equation) were performed using STATA version 11.1 (STATA, 2009) by fitting the variables into the Heckman sample selection model. The justification of the use of this model was tested using a Wald chi-squared test. The rho value was significantly different from zero. The Wald chi-squared value was significantly higher than zero ($P < 0.001$). Before running the model all the hypothesized explanatory variables were checked for the existence of multicollinearity problem using the variance inflation factor (VIF) for association among the continuous explanatory variables (Theil, 1971) and contingency coefficients for discrete variables (Neter et al., 1996). Variables which showed high multicollinearity with each other were dropped from the model as their presence increase the variance of the coefficient estimates and make the estimates very sensitive to minor changes in the model.

Determination of probability and intensity of adoption

A discrete variable representing adoption or no adoption was used to determine the probability of adoption. An adopter in this study is a farmer who was keeping exotic chicken in 2012 and was given a value of 1. A non-adopter was a farmer who might have or might have not kept before but did not have exotic chickens at the time of survey and given a value of 0. A continuous variable representing the proportion of exotic chickens out of the total number of chickens owned by an adopter was used to measure the intensity of adoption (Teklewold et al., 2006). In our study the number of exotic chickens available in the hands of farmers was used to calculate intensity of adoption. It was not possible to find a better measure of intensity as famers only adopted the exotic chicken breeds rather than the complete package

Heckman sample selection model

The basic idea of a sample selection model is that the outcome variable (number of exotic chickens) y is only observed if some criterion, defined with respect to a variable *z*, is met (i.e. participants have exotic chickens). The common form of the model has two stages. In the first stage, a selection equation, a binomial variable *z* determines whether or not *y* (exotic chickens) is observed, *y* being observed only if $z = 1$

$z_i^* = w'_i\alpha + e_i$

Selection equation

$z_i = 0$ if $z_i^* \leq 0$;

$z_i = 1$ if $z_i^* > 0$

Where:

zi* = latent dependent variable (propensity to adopt exotic chickens for household i)

w'i = vector of covariates

α = vector of coefficients

ei = random error term for household i

zi = observed discrete variable (having or not having exotic chickens)

The second stage, the outcome equation, the expected value of y is modelled, conditional on it being observed. So, z is a discrete variable, which is a realization of an unobserved (or latent) continuous variable z*, having a normally distributed independent error "e" with a mean zero and a constant variance σ2e. z* is dependent variables for the selection equation that explains the propensity to adopt exotic chickens. Y is observed if and only if a second, unobserved latent variable (zi*) exceeds a particular threshold (zi* > 0). For values of z = 1, y is the observed realization of a second latent variable (a model with some independent variables x and a vector of coefficients β), y*, which has a normally distributed, independent error, u, with a mean zero and a constant variance σ2u. The two errors are assumed to have a correlation ρ. The joint distribution of u and e is bivariate normal. Latent variables are not directly observed or measured (z* and y*) but rather inferred (through the model) from variables that are observed or directly measured (z and y).

$y_i^* = x'_i\beta + u_i$ Outcome equation

$y_i = y_i^*$ if $z_i = 1$

y_i not observed if $z_i = 0$

Where:

y_i*= latent dependent variable (the number of exotic chickens of household i)

x'_i= vector of covariates

β= vector of coefficients

u_i= random error for household i

y_i = observed continuous variable (exotic chickens)

For both equations the error terms are independent, normally distributed, have a mean of 0 and a constant variance

$(\varepsilon,u) \sim N(0,0,\sigma^2_{\varepsilon}, \sigma^2_{u},\rho_{\varepsilon u})$

(ε,u) is independent of x and z

$\text{Var}(u) = \sigma^2_u = 1$

2.3. Results and Discussion

Characteristics of respondents

Descriptive summaries of the continuous and discrete variables used to characterize adopters and non-adopters of exotic chickens as well as demographic data are shown in Table 2.2 and Table 2.3 respectively. Out of the 10 continuous variables hypothesized to affect adoption, only two (social contact and livestock income) significantly vary between adopters and non-adopters. Farmers who adopted exotic chickens had more contact with each other per week and got relatively less livestock income than non-adopters. In agreement with our result early adopters have been reported to receive information from their peers (Garcia et al., 2012). In this study wealth indicating variables (livestock resource and farm size) did not vary significantly between adopters and non-adopter of exotic chickens. But the non-adopters of exotic chickens earned significantly higher livestock income than adopters. This might indicate that income from chickens remains less important and only complementary to the overall income of the household. In contrast to our hypothesis, studies indicated that it is the poor and landless households who derive a higher share of their livestock income than the relatively better off (Ellis et al., 2003). Information on livestock income was not available, and has been reported difficult to achieve as farmers do not keep records (Shahin, 2004). Abebe et al. (2008) reported similar results with respect to credit access. Credit gives an opportunity to allocate resources to invest in technological packages (Panin et al., 1996). Similarly an off-farm income was reported to positively affect adoption (Teshale et al., 2006). In our study, both adopters and non-adopters perceived that inputs (exotic chicken) are unavailable with no significant difference between them. Possible past experience on exotic chickens production might have helped non-adopters with a similar perception as adopters regarding the availability of exotic chickens. This was possible due to the purposive selection of villages based on prior experience on exotic chicken breeds production. Faster adoption was observed when technological innovations and complementary inputs were available more easily and cheaply (Foster & Rosenzweig, 1995).

Table 2.2 Descriptive summary of continuous variables used to characterize adopters and non-adopters in the study (N=240), with significance test for the differences between adopters and non-adopters.

Variables	Adopters		Non-adopters		
	n	mean	n	Mean	t-statistics
Age of household head(years)	97	40.5	143	45.2	1.222
Extension visit (per week)	70	3.2	116	3.1	-0.339
Family size (number)	97	7.0	143	7.3	1.166
Farming experience (years)	97	18.2	142	20.1	1.395
Farm size (ha)	95	2.5	138	2.4	-0.406
Labor availability (man days)	97	3.3	143	3.7	1.878
livestock herd (TLU)	97	10.2	143	11.1	1.062
Livestock income (%)	97	2.5	143	3.9	5.148***
Social contact (per week)	97	1.5	143	0.7	-6.297***
Training (per 6 months)	96	1.7	141	1.8	1.461

Statistical significance at *p<0.001; 1 TLU = cattle equivalent to 250 kg;
1 man day = amount of work that can be done by an adult per day

Table 2.3 Descriptive summary of discrete variables used to characterize adopters and non-adopters in the study (N=240), with significance test for the differences between percent of respondents out of adopters (n=97) and non-adopters (n=143).

Variables	Discrete	Adopters	Non-adopters	Pearson's chi-square
Credit access	No	16	88	122.689***
	Yes	84	12	
Easiness to manage	No	55	96	64.692***
	Yes	45	4	
Education	No	12	17	1.158
	Yes	88	83	
Gender	Male	77	83	0.992
	Female	23	17	
Input availability	No	94	90	0.983
	Yes	6	10	
Off-farm income	No	19	95	147.289***
	Yes	81	5	

Statistical significance at *p<0.001; discrete shows the reply of household heads corresponding to the variables and takes either of the two response

Econometric results: Heckman selection two step regression analysis

In this study we assumed that intensity of exotic chickens (outcome equation) to be more than zero. In addition we assumed that participants of the previous extension programs were not randomly selected and we applied purposive sampling in the current study. Heckman selection model was found to be more suitable. The results of the analysis of the probability of adoption (selection equation) are presented in Table 2.4. Only access to an off-farm income and livestock income affected the probability of adoption of exotic chickens ($p<0.01$). Farmers who have access to an off-farm income are more likely to adopt exotic poultry than those who do not. In contrast, Teklewold et al. (2006) found a non-significant effect of an off-farm income generating activity both on the probability and intensity of adoption of exotic poultry. The type of an off-farm activity and the magnitude of an off-farm income might be different between the sites of the two studies. The study sites in both studies were far from each other with potential variation in farming practices and off-farm income generating activities. Poultry is more important for women and less well-off farmers than for rich people, and often also complementary activity. In this study, the importance of poultry to women in relation to the adoption of exotic chickens was not fully captured because fewer women were interviewed. Poor farmers earn more from livestock and might not be encouraged to adopt exotic chickens which are regarded by farmers as difficult to manage (need more care and protection). The results of the analysis of intensity of adoption are presented in Table 2.5. Male farmers had a lower intensity of adoption (number of exotic chickens) than female farmers ($p<0.001$). A marginal increase in farm size resulted in a significant decrease in the number of exotic chickens. Some reported non-significant effect of farm size on adoption of technologies (Shiyani et al., 2002). Other studies (Foltz and Chang, 2002) showed that the farm size was positively related to adoption. Most likely the effect of farm size on adoption of new technology will vary depending on the type of technology.

Table 2.4 Probability of adoption of exotic chickens expressed as coefficient (SE) and percentage change in the probability of adoption of per unit change in the variables.

Variable	Coefficient (SE)	Probability level	Change in the probability of adoption (dy/dx)
Constant	2.510(2.90)	0.388	
Easiness to manage	-0.165(2.13)	0.938	-0.059@
Input availability	-0.496(0.710)	0.484	-0.165@
Education	-0.067(0.470)	0.887	-0.025@
Gender	-0.196(0.426)	0.645	-0.071@
Age	-0.007(0.014)	0.599	-0.003
Credit access	0.287(0.530)	0.588	0.107@
Farm size	-0.009(0.054)	0.862	0.496
Off-farm income	1.350(0.627)	0.031**	0.022@
Social contact	0.060(0.198)	0.761	-0.008
Extension visit	-0.022(0.094)	0.812	-0.383
Livestock income	-1.030(0.445)	0.021**	-0.045
Training	-0.121(0.355)	0.733	0.010

** : coefficients are significantly different from zero at p<0.05 confidence levels, (@) dy/dx shows the percent probability change as the binary independent variable changes from 0 to 1. Eg. Variable “easiness to manage” can be either easy (0); or not easy (1). That is called discrete change of independent variable from 0 to 1. The change in percent probability of adoption is then given as the change from easy (0) to not easy (1). For continuous variables the (dy/dx) indicates the amount of change in Y that will be produced by a unit change in X.

Table 2.5 Intensity of adoption of exotic chickens expressed as number of chickens adopted coefficient (SE) and change in the number of chickens per unit change in the variables.

Variables	Coefficient (SE)	Probability level	Change in number of exotic chickens (dy/dx)
Constant	2.486(0.681)	0.000	
Easiness to manage	0.010(0.42)	0.980	0.041@
Input availability	0.160(0.26)	0.531	0.257@
Education	-0.034(0.123)	0.780	-0.023@
Gender	-0.367(0.110)	0.001***	-0.330@
Age	-0.004(0.004)	0.316	-0.003
Credit access	0.406(0.283)	0.151	0.353@
Farm size	-0.025(0.011)	0.027**	-0.023
Off-farm income	0.364(0.390)	0.350	0.131@
Social contact	-0.085(0.06)	0.156	-0.096
Extension visit	-0.034(0.040)	0.347	-0.033
Livestock income	-0.512(0.120)	0.010**	-0.320
Training	0.073(0.093)	0.436	0.095

** and *** : coefficients are significantly different from zero at $p<0.05$ and $p<0.001$, (@) dy/dx is the amount of change in Y (number of exotic chickens) that will be produced as the binary independent variable changes from 0 to 1.Eg. Variable easiness to manage" can be either easy (0) or not easy (1). That is called discrete change of independent variable from 0 to 1. The change in percent number of exotic chickens (intensity of adoption) is then measured as the change from easy (0) to not easy (1). For continuous variables the (dy/dx) indicates the amount of change in Y that will be produced by a unit change in X.

Conclusion

Adopters and non-adopters showed differences in few of the demographic or descriptive variables which were expected to affect adoption of exotic chickens. Similarly, the econometric analysis showed that the adoption and intensity of adoption of exotic chickens were affected by few income related variables. The perception of both adopters and non-adopters regarding input (breed) availability seemed to have negatively affected the adoption. The findings of the study suggest reconsidering the feasibility of the dissemination of exotic chickens to rural farmers who have no or little means to improve the management of exotic chickens. The gender of household head remains to be important as far as the intensity of adoption of exotic chicken is concerned. More women should also be considered to increase complete understanding about the adoption exotic chickens in rural areas.

Acknowledgments

The authors thank all the farmers, development agents for their interest and cooperation. We also thank Alemayehu Amare, Adey Melsese and Dawud Ibrahim of the Debre Zeit Agricultural Research Centre. This study was financially sponsored by Koepon Stichting.

References

Abebe, W., Puskur, R., and Karippai., R.S., 2008. Adopting improved box hive in Atsbi-Wembereta district of Eastern Zone, Tigray region: determinants and financial benefits. Improving productivity and market success of Ethiopian farmer's project working paper No. 10, (Nairobi: International Livestock Research Institute).

Adesina, A.A. & Baidu-Forson, J., 1995. Farmers' Perceptions and Adoption of New Agricultural Technology: Evidence from Analysis in Burkina Faso and Guinea, West Africa. Agricultural Economics, 13: 1-9.

Alemu, Y. & Tadelle, D., 1997. The state of poultry research and development in Ethiopia. Poultry Research Bulletin No.4. (Debre Zeit: Alemaya University of Agriculture).

Alene, A.D., Poonyth, D., & Hassan, R.M., 2000. Determinants of the adoption and intensity of use of improved maize varieties in the central highlands of Ethiopia: A Tobit analysis. Agrekon, 39: 633-643.

Belay, K., 2003. Agricultural Extension in Ethiopia: the case of participatory demonstration and training extension system. Journal of social development in Africa, 18(1):49-84.

Barry, M.B., 2005. Determinants of Urban Livestock Adoption in the 'Zone Dense' of Khorogo, Côte D'Ivoire: A Tobit Approach. In L.J.A. Mougeot (ed.), The Social, Political and Environmental Dimension of Urban Agriculture (Ottawa: IDRC), pp 89-105.

Bellhouse, D. R., 2005. Systematic Sampling Methods. In P. Armitage & T. Colton (eds.), Encyclopedia of Biostatistics (2nd edn; Hoboken, NJ : Wiley-Blackwell), pp 6100.

Cavestro, L., 2003. P.R.A. - Participatory rural appraisal Concepts Methodologies and Techniques.Master in Cooperazione Allo Sviluppo Nelle Aree Rurali. Universita' Degli studi Di Padova Facolta' Di Agraria.

Central Statistics Agency, 2009. Agricultural sample survey, 2 Vol., No. 446. (Addis Ababa: Central Statistics Agency).

Cragg, J. G., 1971. Some statistical models for limited dependent variables with application to the demand for durable goods. Econometrica: 39, 829–844.

Damisa, M.A. and Yohanna, M., 2007. Role of Rural Women in Farm Management Decision Making Process: Ordered Probit Analysis. World Journal of Agricultural Sciences, 3: 543-546.

Davis, F. D., 1989. Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS Quarterly, 13 : 319-340.

EEA: EEPRI., 2006. Evaluation of the Ethiopian agricultural extension with particular emphasis on the participatory demonstration & training extension system (PADETES). (Addis Ababa: Ethiopian Economic Association/Ethiopian Economic Policy Research Institute).

Ellis, F., Kutengule, M. and Nyasalu, A., 2003. Livelihoods and Rural Poverty Reduction in Malawi. World Development, 31: 1495-1510.

Foltz, J. & Chang, H.H. 2002. The adoption and profitability of rbST on Connecticut dairy farms. American Journal of Agricultural Economics, 84: 1021-1032.

Foster A and M. Rosenzweig., 1995. Learning by Doing and Learning from Others: Human Capital and Farm household Change in Agriculture. Journal of Political Economy, 103(6), 1176-1209.

Garcia, C.G.M., Dorward, P., Rehman, T., 2012a. Farm and socio-economic characteristics of smallholder milk producers and their influence on technology adoption in central Mexico. Tropical Animal Health and Production, 44: 1199 – 1211.

Gebremedhin, B., Hoekstra, D., and Tegegne, T., 2006. Commercialization of Ethiopian agriculture: Extension service from input supplier to knowledge broker and facilitator. IPMS (Improving Productivity and Market Success) of Ethiopian Farmers Project Working Paper 1. (Nairobi: International Livestock Research Institute).

Heckman, J., 1979. Sample selection bias as a specification error. Econometrica, 47: 153-161.

Khan, M.E., Anker, M., Patel, B.C., Barge, S., Sadhwani, H.& Kohle, R., 1991. The use of focus groups in social and behavioral research: some methodological issues. World Health Statistics Q, 44(3):145-9.

Mascarenhas, J., Parmesh, S., Sam J., Ravi J., John, D., Vidya, R., Aloysius, F., Robert, C. & Jules, P., 1991. Participatory Rural Appraisal. Proceedings of the February 1991 Bangalore PRA Trainers Workshop. RRA Notes Number 13, IIED, / MYRADA.

Neter, J., Kutner, M., Wasserman, W. & Nachtsheim, C., 1996. Applied Linear Statistical Models. (4th ed. (Multi); New York: McGraw - Hill/Irwin).

Padel, S., 2001. Conversion to organic farming: A typical example of the diffusion of an innovation? Sociologia Ruralis, 41: 40-61.

Panin, A., Nahabile, M., & Nfila, B., 1996. Sources and effects of rural credit systems on small holder farming systems in Botswana. Tropenlandwirt, 97: 29-34.

Roland-Holst, D., Kazybayeva, S. & Otte, J., 2007. PPLPI's Livestock Development Goals: Application to LDG1 to Peru, Senegal and Vietnam. Research Report. Rome: Pro-poor Livestock Policy Initiative, FAO.

Sadoulet, E., & de Janvry, A., 1995. Quantitative Development Policy Analysis. (Baltimore, MD: Johns Hopkins University Press).

Shahin, A.S.A.H., 2004. Adoption of innovations in smallholder buffalo dairy farms in the Menoufia Province in Egypt. PhD, Humboldt University of Berlin.

Shiferaw, B., Obare, G., & Muricho, G., 2008. Rural market imperfections and the role of institutions in collective action to improve markets for the poor. Natural Resource Forum, 32: 25-39.

Shiyani, R. L., Joshi, P.K., Asokam, M., & Bantilan, M.C.S., 2002. Adoption of improved Chickpea Varieties: KRIBHCO experience in tribal region of Gujrat. India. Agricultural Economics, 27: 33-39.

Simainga, S., Moreki, J.C., Band, F. & Sakuya, N., 2011. Socio-economic study of family poultry in Mongu and Kalabo districts of Zambia. Livestock Research for Rural Development, available at: Vol. 23/2/sima23031.htm.

SPSS, 2008. Statistical package for Social sciences, (Chicago, IL: SPSS Inc., 17.0).

STATA, 2009. STATA - (Texas, TX: Stata. 11.1).

Tadelle, D., Alemu, Y. & Peters, K.J., 2000. Indigenous chicken in Ethiopia: genetic potential and attempts at improvement. World Poultry Science Journal, 56: 45-54.

Teklewold, H., Dadi, L., Yami, A. & Dana, N., 2006. Determinants of adoption of poultry technology: a double-hurdle approach. Livestock Research for Rural Development, available at: Vol. 18 /3 /tekl18040.htm.

Teshale, A., Mulat, D. & Bezabhe, E., 2006. Determinants of fertilizer adoption in Ethiopia. (Addis Ababa: Agricultural economics society of Ethiopia).

Theil, H., 1971. Principles of Econometrics. (New York: NY: John Wiley & Sons, Inc. (VIF)).

Von Neumann, J.& Morgenstern, O., 1947. Theory of games and economic behavior (2nd edn: Princeton, NJ: University Press).

Waller, B.E., Hoy, C.W., Henderson, J.L., Stinner, B. & Welty C., 1998. Matching innovations with potential users: A case study of potato IPM practices. Agriculture, Ecosystems and Environment, 70: 203-215.

Wodjao, T.B., 2007. A Double-Hurdle Model of Computer and Internet Use in American Households. (Department of Economics Western Michigan University), available at http: // www.atususers.umd.edu/wip2/papers_i2007/Wodajo.pdf).

3

Village poultry production system: perception of farmers and simulation of impacts of interventions

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Submitted to Livestock Science

Abstract

This study not only identifies perception of poultry farmers' on impact of interventions in village poultry production but also quantifies the impacts of individual and packaged interventions on flock and economic performance using modelling. A structured questionnaire was used to collect data on perceptions of poultry keeping and poultry performances from 240 randomly selected households in two districts of Ethiopia (Horro and Ada). Crop production was the major source of income, and poultry generated supplementary income. Farmers perceived that demand and price of poultry products increased in the last 3 years. Majority (85 %) of the farmers believed that additional inputs would not lead to higher income. Subsequently a dynamic simulation showed that the baseline situation made a positive financial contribution to household income. Vaccinations had the largest positive impact on flock performances and using improved indigenous chicken had the smallest. Combined application of interventions had the largest effect on flock size, bird off-take, egg production and egg-offtake in the base situation but did not lead to profitability. The sensitivity analysis showed that feed cost had the largest impact on the profitability followed by housing, vaccination and breed. In conclusion, farmers' perceptions affected their decisions regarding implementation of interventions. Simulated interventions increased productivity but only in a few cases the increased incomes outweighed the additional costs. Interventions need to be tailored towards the local situation to ensure they lead not only to improved productivity but also to improved income.

Key words: poultry, smallholders, interventions, flock performance, profitability, simulation

3.1 Introduction

It is widely acknowledged that village poultry in developing countries plays an important role as source of animal protein and income for smallholder farmers (Creevey, 1991; Alders & Pym 2009). In village poultry production systems, farmers raise small number of domestic fowl mainly for home consumption with small, mostly seasonal surpluses being sold in villages (Farrelly, 1996). Investments in village poultry farming can improve productivity and generate additional income which contributes to poverty reduction and increased food security (Mack & Otte 2005; Pica-Ciamarra & Otte, 2010). Village poultry are often associated with good quality/size eggs and meat flavor, hard egg shells, high dressing percentages and low production costs (Gueye, 1998). Despite the contribution of village poultry to the national economies of developing countries, the main function of village chickens according to the farmers is the provision of meat and eggs for home consumption (Andrews, 1990; Cairns & Lea 1990).Over the last decade, the consumption of poultry products in developing countries grew by 5.8 percent per annum, faster than that of human population growth (Sonaiya et al., 2004). Commercialization of indigenous poultry production might be timely in terms of meeting the needs of the increasing population (Ondwasy et al., 2006). The profitability however, depends very much on feed costs, market prices, stock sizes, and number of birds sold and consumed (Masku, 2013). Commercialization of village poultry might increase the dependency on modern technologies and inputs (Farrelly, 1996). Before making an investment to increase poultry production, farmers need to be convinced that the investment is economically feasible. Reddy (1998) stated that village poultry production can be more sustainable when farmers use indigenous chicken with appropriate and affordable technologies with 'low external inputs'. A breeding program aiming at improving the productivity (egg production, survival and body weight) of an indigenous chicken population is underway in Ethiopia (Dana, 2011). The breeding program is run on a research station but the productivity of the improved chickens (Horro) is being tested in the field. To ensure successful adoption of an improved breed, farmers' perceptions towards interventions, the extent to which the improved breed requires additional inputs (feed, housing, vaccination), and the impact on profitability need to be known. Modelling is increasingly accepted tool to increase understanding of the complex interactions of the various parts of farming systems, and to guide resource use decisions about specific technical innovations and to assess the risks and returns from such innovations (Pandey & Hardaker, 1995). The objectives of this study were (1) to determine the perceptions of rural farmers towards feasibility of interventions in their village poultry system, (2) characterize the existing village poultry production system (base situation) (3) evaluate the impacts of individual and packaged interventions into the existing production system.

3.2. Material and Methods

Research Design

The study employed a structured questionnaire survey and the dynamic simulation model VIPOSIM (Asgedom, 2007). The survey was conducted in the Horro and Ada districts of Ethiopia in 2011. These districts were used for an on-farm evaluation of the improved indigenous chicken. They represent village poultry production system areas, but they differed in distance to the major market. Participatory rural appraisal was used to formulate the structured questionnaire for the survey which aimed to capture farmers understanding of the village poultry production system and to gather baseline input for our modelling. A two stage sampling procedure was followed to select eight villages and 30 sample households from each village in both districts. In the first stage, four rural villages from each district were selected purposively based on their prior experience in applying innovations. In the second stage, individual households were selected using systematic random sampling. Systematic random sampling is often used to select large samples from a long list of households by using a sampling interval (Bellhouse, 2005). A total of 240 household heads (120 from each district) were randomly selected and interviewed by 12 enumerators. Each interview took on average one and half hours. The results of both districts were analyzed and differences in responses were examined using a t-test (SPSS, 2008).

Simulation model: VIPOSIM

The VIllage POultry SImulation Model (VIPOSIM) was developed at Wageningen University, the Netherlands, and was validated on data from Ethiopia (Asgedom 2007). VIPOSIM considers the dynamics of village poultry production systems by incorporating flock off-take, egg production, egg loss, egg off-take and reproduction. The model determines the flock dynamics and performances and performs a cost-benefit analysis. It performs calculations in time steps of 3 months which represents the reproduction cycle: the period a hen needs to produce and hatch eggs and rear chicks up to an age of 8 weeks. The maximum number of steps in the model is 12, which corresponds to a period of three years (Asgedom, 2007). It was programmed in Microsoft Excel®. The input variables include chicken production and management parameters such as initial size and composition of the flock, mortality rates for different categories, bird sales and consumption rates, egg production, reproduction parameters (incubation and hatching), egg sales, egg loss, egg consumption rates, and bird off-take limits. The economic parameters such as prices of birds and eggs and costs are also input variables. Costs are categorized into overall costs per bird per season for each intervention. As output, the model gives the values of bird off-take and egg off-take, and the final composition of the flock for each season during the three-year period of simulation. The model can be used to perform a sensitivity analysis by varying a financial value of an individual intervention while the others are kept at their base situation (default), so showing the consequences of the change(s) of varying the value of an uncertain parameter. The outcome variable can be any performance measure or indicator. Results of a sensitivity analysis were presented in a tornado diagram (Eschenbach, 1992). This ranks a large number of variables in their order of importance without becoming over crowded. It shows the lower and upper values of the outcome variable (profit in our case) obtained from the variation of each variable (inputs), with the variable with the widest limits displayed on the top, and the parameter with smallest on the bottom, indicating the widest the limits the more attention the parameter deserves. It is important to note that the width obviously depends on the actual difference between the high and value input value which is the total cost of the base situation in this study.

Formulation of interventions

Based on the result of the survey the following interventions were hypothesized to affect the productivity of the flock positively. (1) Formulated feed that contains standard level of protein and energy. (2) Improved indigenous breed (Horro). (3) Improved housing (4) Full vaccination against major diseases along with disinfectants and vitamins. Improved indigenous chicken demands the use of supplementary feed. The improved breed intervention was chosen to represent performance of chickens that resulted from the selective breeding program on Horro chicken at Debre Zeit station Dana et al. (2010a). The use of vaccination demands confining the chickens in a house (to avoid the potential re-infection) and provision of feed. Feed was used alone as it can be given at a fixed time of the day and chickens can be left to roam around. The impacts of previously studied interventions were indicated in Table 3.1.

Table 3.1 Interventions used in previous studies.

Intervention	Description	Impact	References
Feed	Supplementary feed	50 % more eggs, 15 % earlier age at first egg	Tadelle (1996) Siamba et al. (1999)
Housing	Night shelter & fencing	Mortality from predation lowered to 0 %	Okitoi et al. (2006) Pratseyo et al. (1985)
Vaccination	Newcastle disease	50 % - 80 % lower mortality	Sonaiya (1990) Gueye (1998)
Breed	Improved indigenous chicken	45.8 % increase in egg, mortality lowered to 3 %	Dana (2011)

3.3 Results

Perceptions of farmers

Perceptions of farmers towards poultry production are presented in Table3.2. The majority of respondents (89%) perceived crops as the most important income-generating activity, but over half of them (54%) keep poultry to support family income. The majority (60%) of respondents perceived an increasing demand of poultry products and 68%responded that the prices for poultry products had increased in the last three years. The majority (77%) of respondents perceived that their poultry are low producing, and 85% believed that using extra inputs in their poultry production is not profitable. There were no significant differences between the two districts for the outcomes of the questions on farmers' opinions about village poultry keeping.

Table 3.2 Opinions of household heads towards village poultry production system.

Characteristics	Percent (n=240)
Which is more profitable income generating activity	
crops	89
livestock	11
Keeping poultry support family income	
yes	54
no	46
Did you notice improvement in livelihood (past three years)	
yes	83
no	17
How do you see the demand (past three years)	
increasing	60
decreasing	40
How do you see the current price of chicken and egg	
Increasing	68
no change	21
decreasing	11
Why did not you use more inputs	
not profitable	85
profitable	8
break-even	7
Does indigenous chicken produce less than exotic	
yes	77
no	27

Characterization of the base situation

The production characteristics of poultry farms in the two studied regions are presented in Table3.3. No significant differences were found between the two districts. Farmers on average keep mixed flocks of 15 chicks, 4 pullets, 3 cockerels, 4 hens and 1 cock. Farmers lose 57% of their flock through mortality in one year. A smaller proportion of birds (29%) were either consumed or sold in the village. On average 15 eggs per clutch (approximately 3 months) were produced, of which 50% was used for hatching. Hatchability percentage was high (79%). The averages of production parameter in the two districts were used in modelling the base situation. Fig. 3.1 presents changes in flock size and flock composition in the base situation.

Table 3.3. Average flock characteristics found in the survey of farms in two districts, p-value of the difference between the districts and the average value used to model the base situation

Parameters	Ada	Horro	P-value	Average
Flock size (No.)	26	27.7	0.25	27
Mortality (%) (predation, diseases, others)	59	55.5	0.40	57
Bird off-take (%) (consumption and sale)	29.3	28.7	0.84	29
Egg production (eggs/clutch)	15.2	15	0.93	15
Egg off-take and losses (%) consumption, sales)	51.5	50	0.57	50
Egg set for hatching (%)	52	48.3	0.09	50
Hatchability (%)	78	80	0.65	79

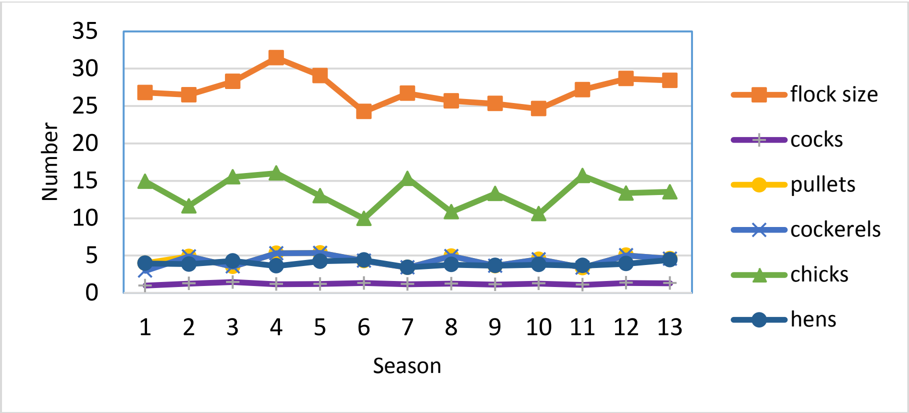

Fig.3.1 Changes of flock size and flock composition of cocks (male adult chickens), pullets (female chickens older than three months but not started producing eggs), cockerels (male chickens older than three months but not sexually mature), chicks (age up to three months) and hens (female adult chickens)) over 12 seasons for the base situation.

Evaluation of interventions

Percent flock size, bird off-take, egg production and egg off-take changes as a result of simulated interventions compared to the base situation at the end of the simulated period of three years is presented in Table 3.4. All interventions, individually and combined had positive impact on the flock performance on flock size, bird off-take, egg production and egg-off-take. The highest effect resulted from combined use of all interventions, followed by vaccination, housing and feed. Breed resulted in the least impact.

Table 3.4. Changes in bird off-take, egg production, egg off-take and flock size as a result of simulated interventions to the base situation at the end of the simulated period of 3 years.

Intervention	Flock size (%)	bird off-take (%)	egg production (%)	egg off-take (%)
Feed	223	268	217	220
Housing	244	292	259	353
Vaccination	324	333	362	364
Breed	154	165	210	111
All interventions	389	317	514	434

Cost benefit analysis

Total costs, benefits and net returns for the interventions over the simulated period of 12 seasons are shown in Fig.3.2. All individual and combined interventions applied to the base situation did not lead to a higher net return: The costs associated with the interventions were higher than the additional benefits. A break-even was found for introduction of the improved breed. The results of sensitivity analyses are shown in Fig.3.3. Changes in the price of feed and vaccinations resulted in negative net profit. The increase in price also resulted in negative returns in the other interventions. However, feed cost is the most sensitive as it showed the widest range of negative impact on profitability.

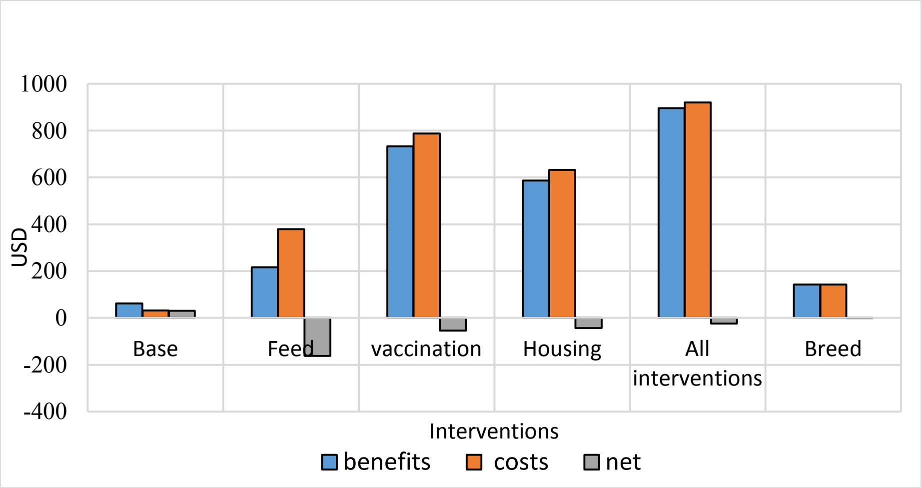

Fig. 3.2 Total costs, benefits and net returns for base situation, feed, vaccinations, all interventions vaccination and breed

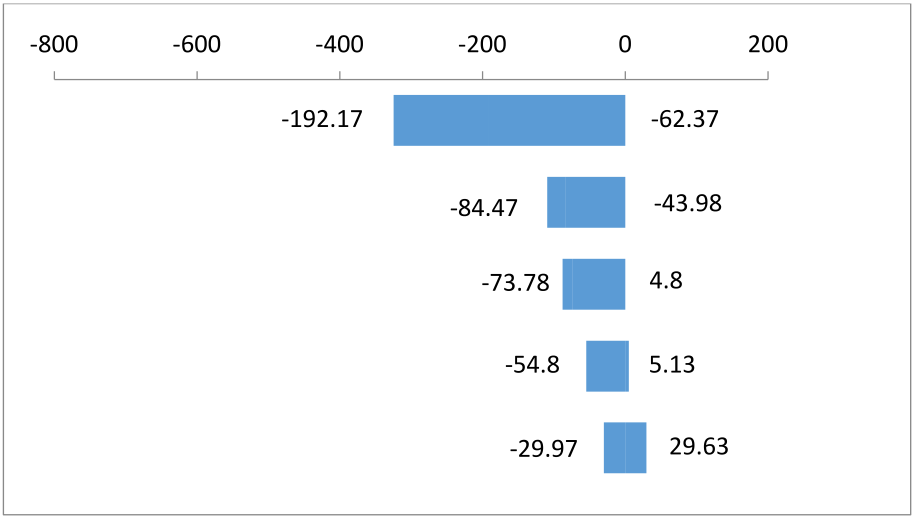

Fig. 3.3 A tornado diagram showing the range of variables representing the net profit ($) for high and low values of feed, housing, vaccinations, breed and all interventions ranked from top to down in order of magnitude of influence.

3.4 Discussion

This study showed that the perception of rural farmers were in line with the feasibility of simulated interventions into the existing poultry production system. Crop production was the main income generating activity of the farmers and the majority of respondents keep poultry as an additional source of income. The focus of governments in developing counties is also more oriented to crop production. Mack & Fernandes-Beca (1990) stated that improving livestock production in rural areas is restricted to providing improved forages and vaccinations rather than promoting interventions aimed at improving overall livestock's contribution to livelihoods. Farmers indicated that their livelihood was improved in the past three years. This might be associated with an increase in the prices of agricultural products in recent years in Ethiopia (Haji & Gelaw, 2012). Farmers perceived an increase in the demand for poultry products and in prices of poultry products in the last 3 years. The increase in demands will continue (Islam, 2003). The prices of poultry products also increased which might be partly attributed to the low supply relative to the demand (Ghafoor et al., 2010). Not only the price of poultry products increased but also the price of inputs increased, leading to unsteady net returns for poultry farmers (Achoja, 2013). This could explain why farmers said they were reluctant to use interventions: spending on inputs might not pay back. Okitoi et al. (2006) stated that improvements in such systems should require limited additional resources leading to only small additional costs. Characterization of the existing village poultry production system provides the basis for designing and evaluating interventions. Farmers keep small flocks of chicks, pullets, cockerels, hens and cocks together. More than half of the chickens died during a year. The most important reasons reported for mortality were predation, diseases and unknown reasons in line with literature, where mortalities ranging from 50 to 80% were reported (Gueye, 1998; Gueye, 2000). The observed bird off-take was close to a previous study in northern Ethiopia (Udo et al., 2006). On average 15 eggs were produced per clutch which results in 45 eggs per hen per year and lies within the range of annual egg production per hen in village poultry systems (20 to 100 eggs) reported earlier (Sonaiya et al., 1999). This low productivity reflects not only the low genetic potential of the chickens but also the poor feeding and management conditions. About 50% of the eggs produced were used for hatching and the rest were sold or consumed. The hatchability (79%) was close earlier findings of Kitalyi (1998).

The simulation result showed that all interventions applied to the base situation increased flock performances. Package application resulted in the maximum flock performance followed by vaccination and housing. Vaccination is one of the most important technical possibilities to improve village chicken production (Tomo, 2009). Vaccination against Newcastle alone can save 50-100% of mortality caused by this disease among chickens in rural areas (Jordan & Alderson, 2009; Alders & Pym, 2009). Housed chickens produce more as predation and harsh weather can be avoided (Pratseyo et al., 1985). In the scavenging system, supplementation is rarely practiced. The base situation was economically feasible and the use of improved indigenous breed resulted in a break-even. The explanation could be that whatever small village chickens produce, it is produced with a very little spending from the farmers (Smith, 1990). Application of interventions resulted in a positive flock performance but negative profit. The poor profitability seen in this study might be associated with a flock size of non-economic scale. Feed cost had the largest impact and needs more attention. Similar result was reported by Sazzad et al. 1988. This might mean that with the current price of feed, it is not possible to make any profit. Masuku (2013) recommended that farmers should organize themselves to take advantage of discounts when purchasing feed. As hypothesized, the perception of farmers influenced their decision towards the village poultry production system. Farmers' perceptions were logical, and derived from their experiences that the productivity from this system is low but still important. At regional level, poultry production is important seeing the increasing demands. The village poultry production system in different areas seems to be very similar even though they are located farm from each other. Increased productivity was realized when more inputs were applied. However, the study clearly demonstrates that higher productivity does not necessarily lead to higher income. The simulation of the use of improved breed resulted in only a break-even.

Acknowledgement

We sincerely thank Koepon foundation for funding this study and providing a scholarship for the first author, and the farmers for their participation in the study.

References

Achoja, F.O., 2013. Allocative efficiency of feeds among poultry farmers in Delta state, Nigeria. Russian Journal of Agricultural and Socio-Economic Sciences, 2(14).

Alders, R.G. &Pym, R.A.E., 2009. Village poultry: Still important to millions, eight thousand years after domestication. World's Poultry Science Journal, 65:181-190.

Andrews, P., 1990. Rural poultry development in the Gambia. In: proceedings CTA Seminar on smallholder rural poultry production, Thessaloniki, pp.81–85.

Asgedom, H.A., 2007. Village Poultry in Ethiopia: Socio-technical Analysis and Learning with Farmers, (unpublished PhD Thesis, Wageningen University).

Bellhouse, D. R., 2005. Systematic Sampling Methods. In P. Armitage & T. Colton (eds.), Encyclopedia of Biostatistics (2nd edn; Hoboken, NJ: Wiley-Blackwell), pp 6100.

Cairns, R.I. & Lea, J.D., 1990. An agricultural Survey of the subsistence farmers in the Nkandla district of KwaZulu. Development Southern African Journal, 7: 77–104

Creevey, L.E., 1991. Supporting small-scale enterprise for women farmers in the Sahel. Journal of international Development, 3: 355–386.

Dana, N., 2011. Breeding programs for indigenous chicken in Ethiopia: Analysis of diversity in production systems and chicken populations, (unpublished PhD Thesis, Wageningen University).

Dana, N., van der Waaij, E. H. & Dessie, T., 2010a. Genetic and phenotypic parameter estimates for body weights and egg production in Horro chicken of Ethiopia. Tropical Animal Health and Production, 42: 1519-1529.

Eschenbach, T.G., 1992. Spider plots versus tornado diagrams for sensitivity analysis. Interfaces, 22: 40–46.

Farrelly, L.L., 1996. Transforming poultry production and marketing in developing countries: lessons learned, (Michigan State University, East Lansing, Michigan)

Ghafoor, A., Badar, H., Hussain, M. & Tariq, N., 2010. An empirical estimation of the factors affecting demand and supply of poultry meat. Pakistan Veterinary Journal, 30: 172-174.

Gueye, E.H.F., 1998. Village egg and fowl meat production in Africa. World’s Poultry Science Journal, 54: 73-86.

Gueye, E.H.F., 2000. The role of family poultry in poverty alleviation food security and the promotion of gender equality in rural Africa. Outlook on Agriculture, 29: 129-136.

Haji, J. & Gelaw, F., 2012. Determinants of the recent soaring food inflation in Ethiopia. Universal Journal of Education and General Studies, 1(8): 225-233.

Islam, A.M., 2003. Poultry Products Processing and Marketing System in Bangladesh. Pakistan Journal of Biological Sciences, 6: 883–886.

Jordan, J.W. & Alderson, M., 2009. Scale, Skills and Sustainable livelihoods. Participatory approaches to improving poultry production in Peri-Urban communities. Evidence from South Africa, Outlook on Agriculture, 38: 83-88.

Kitalyi, A. J., 1998. Village chicken production systems in rural Africa Household food security and gender issues, (Food and Agriculture Organization of the United Nations, Rome).

Mack, S.D. & Fernandez-Baca, S., 1990. Strategies for effective extension services to guide the advancement of animal agriculture in developing countries. In: Simon Mack (eds), Strategies for sustainable animal agriculture in developing countries, (Proceedings of the FAO Expert Consultation. Rome)

Mack, S.D.H. & Otte, J., 2005. The Contribution of Poultry to Rural Development. World's Poultry Science Journal, 61: 7–14

Masuku, M.B., 2013. Determinants of Profitability of Indigenous chickens in Swaziland. Business and Economic Research, 3(2).

Okitoi, L.O., Udo, H.M.J., Mukisira, E.A., De Jong, R. & Kwakkel, R.P., 2006. Evaluation of low input inventions for improved productivity of indigenous chickens in Western Kenya. Agricultura et Subtropica*,* 39:179-182.

Ondwasy, H., Wesong, H., & Okitoi, L.O., 2006. Indigenous chicken production manual, (Technical note series no. 18, Kenya Agricultural Research Institute).

Pandey, S. & Hardaker, J.B., 1995. The role of modelling in the quest for sustainable farming systems. Agricultural Systems, 47: 439–450.

Pica-Ciamarra, U. & Otte, J., 2010. Poultry, Food Security and Poverty in India: Looking beyond the Farm-gate, World's Poultry Science Journal, 66, 309–320.

Prasetyo, T., Subiharta, W.D. & Sabrani, M., 1985. The effect of chick and egg separation on village chicken egg production. (Research report, Research Institute for Animal Production, Indonesia).

Reddy, C.V., 1998. Towards sustainable poultry production. Indian poultry review, 29: 35-47.

Sazzad, M.H., Mamtazul, S.M.H. & Asaduzzaman, A.U., 1988. Growth pattern of Deshi and Khaki Campbell ducks under rural condition. Indian Journal of Poultry Science, 23: 165-166.

Siamba, Ndegwa, J.M., Kimani, W., Nampaso, J., ole Sinkeet, S.N., Mukisira, E.A. & de Jong, R., 1999. Rural poultry production: efforts to improve production and contribution to household economy. In: de Jong, R., Mukisira, E.A. (eds), Testing of livestock technologies on smallholder mixed farms in Kenya, (Kenya Agricultural Research Institute, Nairobi), 141–156.

Smith, A.J., 1990. Poultry -Tropical Agriculture Series, (CTA, McMillan Publishers London), 184 -185.

Sonaiya, E.B., 1999. The context and prospects for development of smallholder rural poultry production in Africa. In: CTA seminar proceedings, (Smallholder Rural Poultry Production, Thessaloniki), 35-52.

Sonaiya, E.B. & Swan, S.E.J., 2004. Small-scale poultry production: technical guide, (FAO Animal production and health Manual No1. Roma, Italy).

SPSS, 2008. Statistical package for Social sciences, (SPSS Inc., 17.0. Chicago, IL, USA).

Tadelle, D., 1996. Studies on village poultry production systems in the central Highlands of Ethiopia, (unpublished MSc Thesis, Swedish University of Agricultural Sciences).

Tomo, A., Crawford, E., Donovan, C., Lloyd, J., Udo, H.M.J. & Viet, T., 2012. Does Village Chickens Vaccination Raise Farmers' Income? Evidence from Rural Mozambique. Paper presented at Triennial Conference, (International Association of Agricultural Economists (IAAE), Foz do Iguaçu, Brazil).

Tomo, A.A., 2009. Economic impact of Newcastle disease control in village chickens: A case study in Mozambique, (unpublished PhD Thesis, Michigan State University, USA).

Udo, H.M.J., Asgedom, A.H. & Viets, T.C., 2006. Modelling the impact of interventions on the dynamics in village poultry systems. Agricultural Systems, 88:255-269.

4

High natural antibody titers of indigenous chickens are related with increased hazard in confinement

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Published at Poultry Science 00:1-6, 2015
DOI:10.3382/ps/pev 107

Abstract

Natural antibody (NAb) levels and survival rates were evaluated in 4 breeds of laying hens in Ethiopia: indigenous, improved indigenous, exotic layer, and crossbred. Titers of NAb isotypes IgG and IgM binding keyhole limpet hemocyanin (KLH) in serum were measured at 20, 26, 35 and 45 weeks of age. Repeated measure analysis of variance showed that IgG and IgM levels vary with time within each breed ($p<0.05$). Indigenous chickens had significantly ($p<0.05$) higher NAb levels at all ages. The cox-proportional hazard analysis showed increased hazard with increased levels of NAbs in the exotic layers ($p<0.05$). However, the reduced hazards with increased levels of NAbs were not significant in the improved indigenous and crossbred chickens. Indigenous chickens showed increased hazard with increasing levels of NAb ($p>0.05$). We concluded that not only the NAb levels but also the effect of NAbs on survival vary between indigenous and improved breeds. The results indicate that NAb levels are associated with survival in elite (improved) breeds, but are associated with increased hazard in indigenous chickens.

Key words: confinement, indigenous chickens, natural antibody, survival

4.1 Introduction

Indigenous chickens are abundant in village poultry production systems. They have managed to survive and produce under harsh environments where they scavenge for feed. Indigenous chickens are less suitable for confined management systems primarily due to their poor genetic potential for growth and egg production. Raising indigenous chickens in confinement in Ethiopia resulted in high morbidities and mortalities (Duguma, et al., 2005; Demeke, 2003). Improving the health management may decrease the mortality and further improve the survival of indigenous chickens in confinement as shown by improved survival of indigenous chickens after applying vaccination for Marek's disease (Duguma et al., 2006).

Innate immunity plays an important role in survival of organisms, though additionally acquired immunity is often required in vertebrates (Beutler, 2004). Natural antibodies (NAb) are found in healthy unimmunized individuals and are an important part of the first line of defense in animals by providing early resistance against infection (Ochsenbein & Zinkernagel, 2000). Low levels of innate immunity may be related with enhanced disease susceptibility and high levels with disease resistance. NAbs are thought to participate in the maintenance of immune homeostasis by exposure to environmental stimulations (Coutinho et al., 1995). In modern housing systems the (opposing) relationships between NAb at early age and survival has been reported for commercial (elite) layer breeds (Star et al., 2007; Sun et al., 2011). The aim of the present study is to compare the NAb levels and survival rates in indigenous, improved indigenous, exotic and crossbred laying hens under confinement in Ethiopia. In addition, the phenotypic relation between NAb and survival was studied.

4.2. Material and Methods

Chickens, housing and feed

A total of 480 laying hens from 4 breeds were included in this study: indigenous, improved indigenous, exotic and crossbred. The indigenous chickens were hatched from eggs collected from Horro region in Ethiopia. The improved indigenous chickens were produced by parents selected from the 7 generations of a selection experiment with Horro chickens on egg production and growth (for details of the experiment see Dana et al., 2011). The exotic chickens were commercial brown egg layers which were obtained as fertile eggs from ISA a Hendrix genetics company (The Netherlands). The crossbred chicks were produced at Debre Zeit Agricultural Research Centre (DZARC) poultry research farm by crossing cocks from exotic RIR strain, which were imported as 1 day old chickens from ISA a Hendrix genetics company (The Netherlands) with hens from 7th generation improved indigenous breed. Both exotic RIR males and hatching egg of exotic layers were imported from the same company few months apart and their genetic relationship was not known. Eggs of the four breeds were hatched at Debre Zeit agricultural research centre the same day at the same hatchery. Chickens were provided with a chick feed (20% CP and 2,950 kcal/kg) until 8 weeks of age, and grower ration (18% CP and 2,850 kcal/kg) from 8 to 18 weeks. From 18 weeks onwards the birds were provided with ad libitum layer (16% CP and 2,750 kcal/kg) feed. The chickens were kept in open house filled with *teff* straw concrete floor and deep litter up to 45 weeks of age. Standard density of 8 and 6 birds/meter square were used during the rearing and laying period respectively. A 22-23 hours of light was provided during the first 3 days and 10 hours of light afterwards until week 8. Natural lighting was used after week 8 as the day length was more or less the same in Ethiopia during the study period. Infrared lamp of 250 watts was used to provide heat. The temperature during the first 3 days was 28-30 ^{o}C and was reduced to 23^{o}C in 4 weeks. Afterwards 23-25 ^{o}C of temperature was provided throughout the study period Temperature was monitored using thermometer and ventilation was adjusted by opening the curtains. After 18 weeks of age approximately 150 pullets from each breed were picked and transferred to the layer house and reared in pens partitioned with mesh wire. The four breeds were randomly assigned into twelve pens with a size of 7 meter square in a replication of three. At 20 weeks of age 120 pullets of each breed were randomly selected for blood sampling. Blood sampling was conducted at 20, 26, 35 and 45 weeks of age on these birds. All chickens were housed in the same house and managed by one person to minimize environmental variation. All chickens were vaccinated against Newcastle (HB1 strain at day 1 and Lasota at day 21), Marek's disease (day 1), Gumboro (day 7), and fowl pox (week 14). The description of the experimental chickens is shown in Table 4.1.

Table 4.1 Number of chickens used for blood collection at the start of the experiment (wk 20); average survival of chickens in days (SD); proportion of survival till end of week 45 (%) and mean survival time (d) of surviving birds

breed	No at wk. 20(n)	Mean survival (days ± SD)	Proportion of survival till the end of week 45 (%)
UN	120	290(9)	38
IH	120	307(5)	87
FH	120	311(4)	95
CR	120	309(4)	90

Indigenous Horro -UN, improved Horro-IM, crossbred-CR and exotic layer-FH

Experimental design

The chickens were followed from 20 to 45 weeks of age. Blood samples from 120 layers of each breed were taken from the wing vein at 20, 26, 35 and 45 weeks of age. Collected blood was clotted and serum was separated by gravity. Collected sera were stored at -20 ^{o}C for ELISA. NAb binding KLH were determined at 20, 26, 35 and 45 weeks of age. Keyhole limpet hemocyanin (KLH) is a large cooper-containing protein found in the hemolymph of the sea mollusk *Megathura crenulata*. Antibodies in chickens to this protein are regarded as 'natural' as birds are unlikely to encounter KLH.

NAb isotypes: IgG and IgM

Titers of NAb isotypes IgM and IgG binding KLH were determined in individual serum samples by an indirect enzyme-linked immunosorbent assay (ELISA) as follows (Sun et al., 2011). Flat-bottomed 96-well medium binding ELISA plates were coated with 100 µL coating buffer (pH 9.6) containing KLH (2 µg/mL, MP Biomedicals Inc., Aurora, OH), and incubated at 4°C overnight. Duplicate standard positive serum samples were stepwise diluted in columns 11 and 12 per plate, respectively. After subsequent washing the plates were filled with 100 µL of PBS containing Tween 20 (0.05%) and horse serum (0.5%) per well. Serum samples were stepwise three fold diluted starting at 1:30, and the plates were incubated during 1 hour at room temperature (25 °C). After washing, plates were incubated with 1:20,000 diluted rabbit-anti-chicken IgM labeled with peroxidase (RACh/IgM/PO), or 1: 40,000 diluted rabbit-anti-chicken IgG-Fc (RACh/IgG/Fc/PO), respectively (Bethyl Laboratories, Texas, U.S.A.), and incubated 1.5 hour at room temperature (25 °C). After washing, binding of isotype specific antibodiesin the serum sample to KLH was visualized by adding 100 µL substrate (70 µg/mL tetramethylbenzidine and 0.05% H2O2). After 10 minutes, the reaction was stopped with 50 µL 2.5 N $H2SO4$ solution. Extinctions were measured with a Multiskan (Labsystems, Helsinki, Finland) at wavelength of 450 nm. Titers were calculated based on log2 values of the dilutions that gave extinction closest to 50% of EMAX, where EMAX represents the mean of the highest extinction of the standard positive serum present on each plate.

Survival: Hazard analysis

Survival analysis was conducted to establish the relation between natural antibody levels binding KLH and survival. The time to die or survival time (time until death) were used during the follow up period of week 20 to 45. Chickens that were alive at the end of the each period were treated as censored because information about their survival time was incomplete as mortality was not observed in the chickens until the end of the period. Post mortem study was done on gross abnormalities in major organs including spleen, liver, gizzard, intestines, caeca (abnormal size, shape, and colour). The findings did not indicate that mortalities were due to apparent disease and further investigation was not conducted. Survival time and probability of being dead or alive were used to plot survival trend using the Kaplan-Meier function. The levels of NAb (IgG and IgM) in individual chickens and the survival days were used to conduct survival analysis using a Cox proportional hazard model. The IgG and IgM level of week 20 was used as explanatory variables. Survival is commonly characterized by a hazard function that represents the instantaneous death rate for an individual surviving to a particular time point (Allison, 1997). The hazard function for individual $_i$ at time t, h_i (t), can be described using a proportional hazards model with k explanatory variables (x_{i1}, x_{ik}):

$$h_i (t) = h_0(t) x \exp [\beta_1 xi_1 + \beta_2 x_2 + ... + b_n x_{in}]$$

Where h_0 (t) denotes an unspecified baseline hazard function and $\beta 1, . . . , \beta k$ are the regression coefficients associated with the n explanatory variables. The baseline hazard function is an arbitrary function common to all observations. The hazard ratio, $h(t)/h_0(t)$, provides an estimate of the risk per unit change in the explanatory variables (NAb levels) relative to the baseline hazard function Collet (1994) and Allison (1997) and associated standard errors are approximated as described by Collet (1994). The Cox proportional hazard is one of the most commonly used approaches to model hazard functions (Collet, 1994; Allison, 1997). In the Cox proportional hazards model, the baseline hazard function is unspecified and no assumptions regarding the particular form of this function are required.

Statistical analysis

A one-way ANOVA was performed to compare the NAb isotype levels binding KLH between breeds at each time point using SAS 9.1.2 (SAS, 2004). Mean differences among breeds was tested with a multiple comparison test (Bonferroni Test). Further repeated measure analysis of variance with breed as factor and weeks (time) as repeated variable was conducted to show the between and within subject interactions with time. The Kaplan-Meier survivor function and cox proportional hazard regression analysis were conducted using STATA 11.1 (Stata, 2009). The data were first declared into a survival-time data using survival days as time variable and the probability to die or alive as failure. $P<0.05$ was regarded as significant.

4.3. Results

Natural antibody isotypes in the various breeds

Results of analysis of variance of IgG and IgM levels binding keyhole limpet hemocyanin (KLH) in serum in different breeds are presented in Table4.2. The average NAb levels of IgG and IgM binding KLH in all breeds was lowest at week 20, peaked in week 35 with the exception of IgM level in indigenous chickens. The NAb levels were higher in indigenous chicken than in the other breeds at the different times (Table 2). At most times the difference was significant ($P<0.05$) except for difference with the crossbreds in IgG at week 45 and IgM at week 35. The repeated measure analysis of variance showed significant ($p<0.001$) interactions between breed and time (Table4.3).

Table 4.2 One way ANOVA of the LS mean (SE) levels of IgG and IgM antibodies binding KLH in sera from the 4 breeds studied at wk. 20, 26, 35 and 45.

Item		Week			
		20	26	35	45
IgG titer					
	UN	5.3(0.16)^{a}	7.8(0.19)^{a}	8.0(0.26)^{a}	7.2(0.24)^{a}
	FH	3.1(0.10)^{b}	5.8(0.13)^{b}	6.6(0.16)^{b}	6.4(0.15)^{a}
	CR	3.1(0.10)^{b}	5.4(0.1)^{b}	5.9(0.17)^{bc}	5.7(0.18)^{b}
	IH	2.8(0.10)^{b}	4.7(0.12)^{c}	5.4(0.18)^{c}	4.9(0.19)^{c}
IgM titer					
	UN	6.6(0.11)^{a}	8.9(0.19)^{a}	8.4(0.28)^{a}	8.5(0.27)^{a}
	FH	5.0(0.10)^{b}	7.6(0.10)^{b}	7.9(0.19)^{ab}	7.7(0.18)^{b}
	CR	4.9(0.10)^{b}	6.8(0.11)^{c}	7.4(0.18)^{bc}	6.8(0.19)^{c}
	IH	4.8(0.10)^{d}	6.7(0.11)^{c}	7.0(0.20)^{c}	6.2(0.21)^{c}

Means with different superscripts indicate significant difference between breeds ($p<0.05$)

Table 4.3 Statistical result of a repeated measure ANOVA with Breed and Time as factors

Effect	SS	df	MS	F	P
Between group					
Breed	1762.4	3	587.5	119.3	<.0001
Error	2344.8	476	4.9		
Within group					
Time	2488.7	3	829.6	295.4	<.0001
Time*Breed	114.1	9	12.7	4.5	<.0001
Error (Time)	4010.7	1428	2.8		

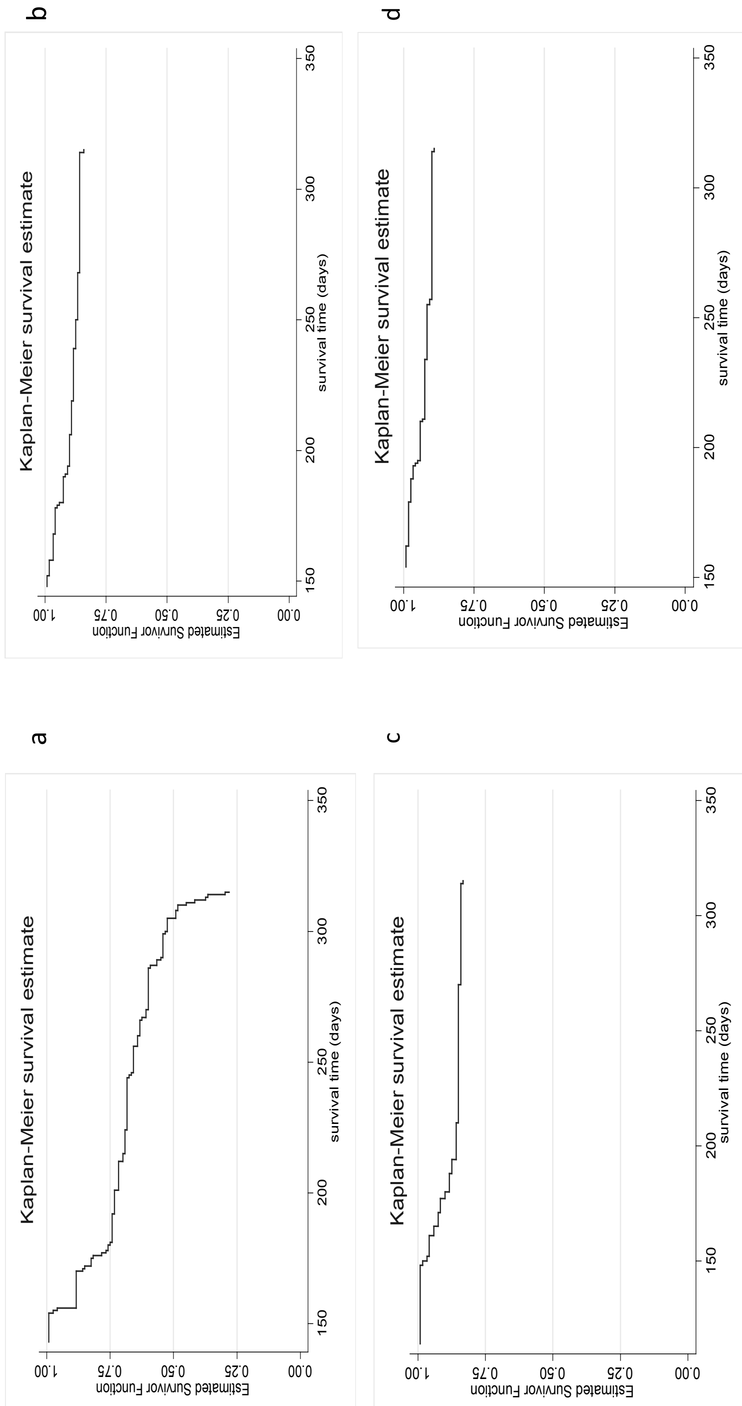

Fig.4.1 Kaplan-Meier estimated survivor functions for (a) unimproved Horro-UN, (b) improved Horro-IM, (c) crossbred-CR and (d) exotic layer-FH.

Survival analysis

The mean survival patterns resulting from survival analysis (Cox proportional hazards model) in the four breeds over the follow up period (week 20 to 45) are presented in Fig. 4.1. Each time point of the estimated survival function represents the probability that a layer of 20 weeks will survive to that given point in time. Marked decrease in survival probabilities were observed for indigenous chickens (Fig. 4.1a). The estimated hazard ratios for NAb levels measured at 20 weeks of age are presented in Table4.4. Generally, the hazard (risk of death) was slightly higher than 1 for both NAb levels in indigenous chickens but not significantly different from 1 (p>0.05). The hazard decreased with increasing level of IgG and IgM binding KLH in other the breeds (Improved indigenous, exotic layer and crossbred). Only in exotic layer the hazard ratio was significantly lower than 1 (p<0.05).

Table 4.4 Hazard ratios and (SE) showing the risk of mortality during the follow-up period of 25 weeks estimated using increasing titers of IgG and IgM binding KLH at week 20.

effect	**Wk. 20-45 (140-315 days)**	**P value**
IgG-UN	1.05(0.06)	0.505
IgG-IH	0.70(0.15)	0.106
IgG-FH	0.59(0.15)*	0.040
IgG-CR	0.74(0.10)	0.142
IgM-UN	1.05(0.09)	0.495
IgM-IH	0.76(0.15)	0.170
IgM-FH	0.52(0.12)*	0.006
IgM-CR	0.79(0.16)	0.264

Indigenous Horro-UN, improved Horro-IM, crossbred-CR and exotic layer-FH

4.4. Discussion

Natural antibodies of the IgM and IgG isotypes

Natural antibody isotypes binding KLH were found in chickens that were not immunized previously with KLH (Parmentier et al., 2004a; Star et al., 2007; Sun et al., 2011). Higher NAb levels were associated with high immune responsiveness (Parmentier et al., 2004). In the present study indigenous chickens showed higher NAb levels of both isotypes (Table 4. 2). The lowest NAb level was found in improved indigenous birds, i.e. birds from an indigenous line that was selected for enhanced egg production and growth for seven generations. This improved indigenous chicken line was started from Horro chickens collected on local farms and is genetically closest to the indigenous chicken. The breeding program resulted in a substantial increase in egg production and growth rate (results not shown). However, there needs to be a study to verify the genetic correlation between NAb and production traits in indigenous chickens and the consequences of selection on productivity and adaptation to confinement. Indigenous chickens managed to survive stress for generations without proper nutrition and vaccination (Udo, 1997). The higher NAb levels might explain the ability of indigenous chickens to survive disease pressure in the village poultry production systems. In all breeds, NAb levels were lowest at young age, peaked at 35 weeks and decreased thereafter with age (Table 4. 2). Earlier studies reported mixed effects of ageing. Increasing NAb titers were found with aging of birds by Parmentier et al., (2004) and Star et al. (2007) and decreasing level of NAb with age (Sun et al., 2011). Many studies on the effect of aging on immunity were done in rodent models. These studies reported deficiencies of cellular and humoral immunity with age (Gahring & Weigle et al., 1990; Frasca, et al., 2005; Haynes & Eaton, 2005). However, these studies did not consider NAbs.

Survival analysis

To study mortality associated with NAb level, both logistic regression and Cox proportional hazard analysis can be used (Southey, 2001). However, treating mortality as binary trait portrays deaths as having occurred during a defined period of time, and ignores the continuity of the mortality process and the time of death (Allison, 1997). Similar estimates of the explanatory variables could be obtained from both the survival analysis and logistic analysis, but the survival analysis has lower standard errors than the logistic analysis (Southey, 2001). Kaplan-Meier estimated survivor functions revealed reduced probability of survival over time in all breeds. A markedly lower probability of survival was found for indigenous chickens.

The hazard analysis in the present study showed that a unit increase in the levels of both IgG and IgM titers to KLH were associated with increased hazard (risk of mortality) in indigenous chickens (UN) albeit not statistically significant. The probability that were exposed to a certain disease is small due to the fact that all of them were kept under the roof and managed by a single person. Confinement was reported to be stressful by Horning et al. (2003). In addition, a number of studies (Koelkebeck & Cain, 1984; Roush et al., 1984; Adams & Craig, 1985) showed that mortality increased with an increase in housing density. The primary glucocorticoid secreted by the avian adrenal gland was reported to increase in stressful conditions (Curtis et al., 1980; Siegel, 1980). Stress may result in immunosuppression but the actual mechanisms remain elusive (Karel & Skinner, 2008). The higher mortality of indigenous chickens even in the absence of apparent disease was observed and the relation between higher NAb and increased hazard in confinement may need further study. Antibody titers to human serum albumin were not affected when chickens were treated with immunosuppressive agents like glucocorticoids (El-Lethey et al., 2003). Since the level of stress hormones was not measured, we cannot confirm the link between increased levels of stress hormones and higher mortality.

Wijga et al (2009) estimated heritabilities in brown and white layer breeds, where in lower heritabilities were found for IgG than IgM, and lower heritabilities were found in white than in brown layers (Sun et al., 2011). In improved indigenous, exotic layer and crossbred chickens, increasing levels of NAbs were associated with decreased hazard, but the effects on hazards was only statistically significant in exotic layer. Higher NAb levels in the exotic layer were associated with better survival. Our findings suggests that NAbs have a positive effect on survival in chickens that have adapted to confinement whereas that effect is not found or even reversed in indigenous birds that are not adapted to confinement. In this respect, we speculate that the effect of confinement, and as a consequence stress, i.e. no homeostasis, may also result in different levels of NAb directed to other antigens than KLH. Previously it was shown that levels of Nab are affected not only by aging, but also by antigenic challenges in different fashion (Berghof et al., 2010).

Acknowledgement

We sincerely thank Koepon foundation for funding this study and providing a scholarship for the first author.

References

Adams, A.W. & Craig, J.V., 1985. Effects of crowding and cage shape on productivity and profitability of caged layers: a survey. Poultry Science, 64:238-242.

Allison, P. D., 1997. Survival analysis using the SAS system. A practical guide. SAS Institute Inc., Cary, NC, USA.

Berghof, T.V.L., De Vries Reilingh,G.,Nieuwland,M.G.B.&Parmentier,H.K., 2010. Effect of aging and repeated intratracheal challenge on levels of cryptic and overt natural antibodies in poultry. Poultry Science, 89:227-235.

Beutler, B., 2004. Innate Immunity: An overview. Molecular Immunology, 40:845-859.

Collet, D., 1994. Modelling Survival Data in Medical Research. Chapman and Hall, London, UK.

Coutinho, A., Kazatchkine, M. D. & Avrameas, S., 1995. Natural autoantibodies. Current Opinion Immunology, 7:812-818.

Curtis, M.J., Flack, I.H. & Harvey, S., 1980. The effect of Escherichia coli endotoxins on the concentrations of corticosterone and growth hormone in the plasma of the domestic fowl. Research in Veterinary Sciences, 28:123-127.

Dana, N., van der Waaij, E.H. & van Arendonk, J.A.M., 2011. Genetic and phenotypic estimates for body weights and egg production in Horro chicken of Ethiopia. Tropical Animal Health &Production, 43:21-28.

Demeke, S., 2003. Growth performance of indigenous and White leghorn chickens under scavenging and intensive system of management in Ethiopia. Livestock Research & rural Development. 15:11. Available at: http://www.cipav.org.co/Irrd/Irrd15/11/deme1511. htm.

Duguma, R., Dana, N. & Yami, A., 2006. A Marek's disease vaccination opened the door to rear indigenous chickens of Ethiopia under confined management. International Journal of Applied Research in Veterinary Medicine, 4: 2.

Duguma, R., Yami, A., Dana, N., Hassen, F. & Esatu, W., 2005. Marek's disease in local chicken strains of Ethiopia reared under confined management regime in central Ethiopia. Revue Medecine Veterinaire**,** 156: 541-546.

El-Lethey, H., Huber-Eicher, B. & Jungi, T.W., 2003. Exploration of stress-induced immunosuppression in chickens reveals both stress-resistant and stress-susceptible antigen responses. Veterinary Immunology and Immunopathology, 95: 91-101.

Frasca, D., Riley,R. L. & Blomberg, B. B., 2005. Humoral immune response for specific antibody response. Poultry Science, 88:1805-1810.

Gahring, L. C. & Weigle, W. O., 1990. The effect of aging on the induction of humoral and cellular immunity and tolerance in two long-lived mouse strains. Cellular Immunology, 128:142-151.

Haynes, L. & Eaton, S. M., 2005. The effect of age on the cognate function of CD4+ T cells. Immunological Reviews, 205:220-228.

Schat, K. A., & Skinner, M.A., 2008. Avian immunosuppressive diseases and immune evasion. Pages 299-322 in Avian Immunology. F. Davison, B. Kaspers, K. A. Schat, ed. Academic publishers. Great Britain

Koelkebeck, K.W. & Cain, J.R., 1984. Performance, behavior, plasma corticosterone, and economic returns of laying hens in several management alternatives. Poultry Science, 63: 2123-2131.

Ochsenbein, A. F. & Zinkernagel, R. M., 2000. Natural antibodies and complement link innate and acquired immunity. Immunology Today, 21:624-630.

Parmentier, H. K., Lammers, A. Hoekman, J. J. Reilingh, G. D. Zaanen, I. T. A. & Savelkoul, H. F. J., 2004. Different levels of natural antibodies in chickens divergently selected for specific antibody responses. Developmental & Comparative Immunology, 28:39-49.

Roush, W.B., Mashaly, M.M. &. Graves, H.B., 1984. Effect of increased bird population in a fixed cage area on production and economic responses of single comb White Leghorn laying hens. Poultry Science, 63:45-48.

SAS, 2004. SAS User’s Guide. SAS Inst. Inc., Cary, NC.

Siegel, H. S., 1980. Physiological stress in birds. Bioscience. 30:529-534.

Southey, B.R., Rodriguez-Zas, S.L. & Leymaster, K.A., 2001. Survival analysis of lamb mortality in a terminal sire composite population. Journal of Animal Science, 79:2298-306.

Star, L., Frankena, K., Kemp, B., Nieuwland, M. G. B. & Parmentier, H. K., 2007. Natural humoral immune competence and survival in layers. Poultry Science, 86:1090-1099.

Stata, 2009. Stata Statistical Software: Release 11. College Station, TX: StataCorp.

Sun, Y., Parmentier, H. K.,Frankena,K. & van der Poel,J. J., 2011. Natural antibody isotypes titers as predictors of survival in purebred laying hens. Poultry Science, 90: 2263-2274.

Udo, H.M.J., 1997. Relevance of farmyard animals to rural development. Outlook onAgriculture, 26:25-28.

Wijga, S., Parmentier, H. K., Nieuwland, M. G. B. &Bovenhuis, H., 2009. Genetic parameters for levels of natural antibodies in chicken lines divergently selected for specific antibody response. Poultry Science, 88:1805-1810.

5

Comparison of different poultry breeds under station and on-farm conditions in Ethiopia

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Submitted to Livestock Science

Abstract

A selective breeding program was implemented to improve the performance of indigenous chickens. Improved indigenous chicken from the 7th generation were compared with commercial layer, crossbred and unselected indigenous chickens both on-station and on-farm. A total of 870 chickens were used. More than 600 chickens (n=150 and n=120 from each breed during growing and laying period respectively) arranged in completely randomized design were followed on-station, and 270 (90 from commercial, crossbred and improved during laying period) were evaluated on-farm in Ada (n= 6 farms) and Horro (n=9 farms) districts in a split-plot design. Body weight, cumulative feed intake, and survival were recorded while feed conversion ratio was calculated at week 8, 12, 16 and 20 during the growing period on-station. Age at first egg and total egg number during lifetime were recorded once. Survival and hen housed egg production were recorded at month 3, 6, 9 and 12 of age both on-station and on-farm. Egg weight, and feed per egg were recorded and used to calculate feed conversion ratio during the laying period on-station. Significant effect of breed ($p<0.001$) and interaction with time ($p<0.001$) was observed for traits measured on-station during the growing and laying period. Similarly significant effect of breed, village and breed-village interactions were observed on-farm ($P<0.001$). Improved indigenous chickens had higher performance than indigenous chickens for all traits measured on station ($p<0.05$). 10 farmers out of 16 in the Ada district and 7 out of 16 in the Horro district dropped out after M3 at different times either due to high chicken mortality or reduced motivation of the farmer. Improved chickens have been genetically improved as compared to unimproved, but their performance is still low compared to commercial

Key words: selective breeding program, improved indigenous chickens

5.1 Introduction

Earlier studies indicated that the average annual egg production of indigenous chickens under village conditions was between 30-60 eggs per year with an average egg weight of 38 grams (Kidane, 1980). The productivity of indigenous chickens can be improved by providing improved housing, disease control, improved genetics and nutrition. Upgrading the genetic level of local chickens by using cockerels of exotic breeds has been considered to be the most important strategy for improvement (Tadelle et al., 2000). Although improved livestock have been introduced in favorable areas of the tropics, many of the attempts have failed (Philipsson et al., 2011). Some on-farm studies involving cross breeding of indigenous chickens with exotic cocks (WLH and RIR) have been performed (Dana & Ogle, 2000; Tadelle & Ogle, 2001). However, such programs were unsustainable partly due to unreliable supply and high costs of acquiring and maintaining exotic breeding cocks (Tadelle et al., 2000; Udo et al., 2001). Implementing a selective breeding program to improve indigenous chickens is an alternative for crossbreeding to increase productivity.

A selective breeding program to improve the productivity of indigenous Horro chicken in Ethiopia was started in 2008 (Dana et al., 2011). The program used mass selection and aimed to improve survival and productivity of the chickens. The breeding goal identified after consultation of local farmers included age at first egg, egg production, body weight and survival (Dana et al., 2010). The body weight of the base generation chickens was 701 (528) grams in males (females) and egg production in the base population was 34 eggs in 6 months after onset of egg laying. (Dana et al., 2011). After 6 generations of selection, the egg production was increased to 76 eggs in 6 months after the onset of egg laying and the analysis revealed positive genetic changes over generations (Wondmeneh et al., 2014). The selective breeding program was conducted at Debre Zeit Agricultural research center under controlled group housed conditions. The aim of the program was to breed chickens for village production systems. Due to possible genotype by environment interaction, the selection response observed on station does not necessarily translate into similar response under village conditions. It is, therefore, important to evaluate the performance of the improved chickens under on-farm management condition in the villages. Comparing breeds or strains under different environments may reveal genotype by environment interaction.

The aim of this study is to evaluate the performance of improved indigenous (Horro) chickens in comparison with commercial, crossbred and unimproved indigenous chickens under controlled conditions on station and on-farm condition in villages.

5.2. Materials and methods

Description of on-station and on-farm systems

This study was carried out on-station and on-farms. The on-station experiments were carried out at the Debre Zeit Agricultural Research Centre, Debre Zeit (Ethiopia). The selective breeding program was carried out on the same station. Two districts (Ada and Horro) were used for an on-farm evaluation of the different chicken breeds. The Horro district was the origin of the ancestors of the improved Horro chickens, and Ada was used as a reference.

On-station management

More than 600 chickens from 4 breeds were followed at Debre Zeit Agricultural Research Centre during the growing period (n=600 from week 0 - 20) and laying period (n=480 for 52 weeks after the onset of egg laying). Starters were provided with a chick feed (20% CP and 2,950 kcal/kg) until 8 weeks of age, and grower feed (18% CP and 2,850 kcal/kg) from 8 to 20 weeks. From 20 weeks onwards all female birds were provided with ad libitum layer feed (16% CP and 2,750 kcal/kg). The chickens were kept in an open house in deep litter system with concrete floor filled with *teff* straw until 20 weeks of age under a standard housing space, with natural lighting after 8 weeks of age. After 20 weeks of age approximately 120 chickens from each breed were randomly picked and transferred to a layer house and reared by breed in pens partitioned with mesh wire. All chickens were housed in the same house and managed by one person to minimize environmental variation. All chickens were vaccinated against Newcastle (HB1 strain at day 1 and Lasota at day 21), Marek’s disease (day 1), Gumboro (day 7), and fowl pox (week 14).

On-farm management

A total of 32 farmers from four villages in each of the two districts were identified. For the on-farm study, the unselected Horro chicken was not used as farmers were not willing to invest in housing to keep these birds. Farmers were given a five days training on how to manage the chickens and keep records. Formulated ration, feeders, drinkers, medicaments, and monthly monitoring visits were provided by Debre Zeit Agricultural Research Centre. Farmers constructed a poultry house with a run made from wood and mud. Each farmer received 18 three-month-old chickens and 5 cockerels of one of the three breeds (commercial, crossbred and improved indigenous chicken). Farmers requested to also get cockerels as they believed chickens can only produce eggs in the presence of cocks. Most farmers sold out 3 of the 5 cocks and kept 2 with their flock. Each farmer received only one type of breed, therefore a farm and a breed are confounded in the on-farm study. The same rearing and vaccination program as on-station was followed for chickens in the on-farm study.

Breeds

Four breeds were used for the on-station study. The breeds were improved indigenous chicken (Horro), crossbred between improved indigenous chickens and RIR cock, Bovan brown commercial egg layers, and unimproved indigenous chicken. The RIR-type cocks for the production of crossbreds were commercial parent stock, provided by ISA, selected for egg production and growth. All breeds except indigenous were also used for the on-farm study. The breeds were produced as follows. (1) Hatching eggs of improved Horro chicken from generation 7 parents were collected to produce improved indigenous chicken. (2) RIR-type cocks (150) were imported as one-day old chicks from the ISA (Boxmeer, The Netherland) and were used to produce hatching eggs of crossbreds by artificially inseminating improved indigenous chickens of generation 7. (3) 2160 hatching eggs of Bovans brown layers (commercial) were imported from ISA. (4) A total of 2500 eggs of indigenous chickens were collected from the Horro district. All eggs were hatched at Debre Zeit Agricultural Research centre.

Traits recorded

On all growing birds, data on body weight (individual, weekly), cumulative feed intake (pen, weekly), and survival (individual, week 20) were recorded, and feed conversion ratio (pen, weekly) was calculated. Data were summarized at week 8, 12, 16 and 20 on all chickens in a pen during the growing period (0-20 weeks) on-station.

During the laying period, age at first egg was recorded for the chickens at pen level (approximately 40 hens per pen) as number of days between hatching date and date of the first eggs (when 5% of the chickens in a pen start egg laying) both on-station and on-farm. Similarly, total egg number per year was recorded both on-station and on-farm by counting the number eggs produced up to one year after first egg. Survival was recorded and hen housed egg production was calculated at month 3, 6, 9 and 12 both on-station and on-farm. Hen housed egg production was calculated as a ratio of total eggs produced during the laying period to total number of chickens housed at the beginning of the laying period multiplied by 100 (North, 1984). Additionally, on station also egg weight was recorded, and feed per egg and feed conversion ratio were calculated at pen level. During the period of the on-farm study, 10 farmers out of 16 in the Ada district and 7 out of 16 in the Horro district withdrew from the study or stopped data collection. The major reasons behind drop out farmers were separately analyzed. Finally, data over the full period of one year from 15 farms (6 from Ada and 9 from Horro) were analyzed. In the on-farm study feed intake, egg weight were not recorded. As a result, feed conversion ratio and feed per egg could not be calculated for the on-farm conditions.

Statistical Analysis

A completely randomized design (CRD) was used for the on-station evaluation of the breeds. A three-way ANOVA with week as repeated factor (a with-in subject factor), and the two factors (breed and pens) as between-subject factors was used for the analysis of the on station study. A split plot design was used for the on-farm study, in which districts were treated as whole plots and villages as split plots. Farms were distributed with-in split plots as experimental units. A generalized linear model procedure of SAS 9.1.2 (SAS, 2004), with the model including the effects of breed, pens, weeks and their interactions (on station); breed, village and breed-village interactions (on-farm) was used. Pens (on-station), and a farm (on-farm) were treated as experimental units. Bonferroni test, multiple mean comparisons, was done to determine the differences among the breeds.

5.3. Results

On-station performance: growing period

The performances of the breeds during the growing period at the research station are presented in Table 5.1. There were significant effects ($p<0.001$) of breed, week and breed-week interactions for body weight, cumulative feed intake and feed conversion ratio during week 8, 12, 16 and 20. Similarly, the overall survival of chickens at week 20 varied among breeds ($P<0.001$). Body weight, cumulative feed intake and feed conversion ratio of all breeds increased with age. Commercial chickens weighed the highest and indigenous chickens the lowest. Highest cumulative feed intake ($P<0.05$) was observed in commercial chickens at most ages except week 12. The improved chickens had the lowest cumulative feed intake in week 8 and 12, and indigenous chickens in week 16 and 20. The overall survival of Improved chickens was comparable to that of commercial, which was higher than ($P<0.05$) both crossbred and indigenous. Comparable feed conversion ratio was observed for commercial, crossbred and indigenous chickens at week 8 and 12, but later on week 16 and 20, improved chickens had lower ($P<0.05$) feed conversion ratio than indigenous chickens but higher than commercial and crossbred chickens ($P<0.05$).

On-station evaluation: laying period

The results of the laying period of all breeds are presented in Table 5.2. During the laying period, significant effects (P<0.001) of breed, week and breed–week interaction were observed. Improved chickens started egg production earlier (153 ± 0.24) than unimproved (208 ± 2.16), but later than commercial (125± 0.14) and crossbred (141.3 ± 0.35) days. Similarly improved chickens produced more eggs per year (171) than unimproved that only produced 66.5 eggs, but less than commercial (289 ± 0.26) and crossbred (254.6 ± 0.19) birds. Comparable survival to commercial was observed for improved chickens at M3, 6 and 9, but at M12. Commercial chickens had higher hen housed egg production, higher feed per egg and higher egg weight at 3, 6, 9 and 12 months than the other breeds. Commercial chickens started egg production earlier (P<0.05) and produced more eggs per year than the other breeds (P<0.05).

Table 5.1 Least square means (SE) of body weight (grams), cumulative feed intake (grams), feed conversion ratio (kg feed / kg gain) and survival (%) of commercial, crossbred, improved and indigenous chickens at week 8, 12, 16 and 20 during the growing period kept on-station.

		Week 8	Week 12	Week 16	Week 20
Body weight	commercial	655 (1.4)^{a}	902(10.6)^{a}	1230.1(6.1)^{a}	1629.6(58)^{a}
	crossbred	463.1 (1.9)^{b}	757.0 (3.1)^{b}	992.(1.1)^{b}	1070.7(3.8)^{b}
	improved	428.9(0.9)^{c}	742.1(7.7)^{b}	873.4(1.9)^{c}	964.2 (1.4)^{c}
	indigenous	224.1 (2.9)^{d}	481.3(7.7)c	608.5(4.2)^{d}	684.8(4.7)^{d}
Cummulative feed intake	commercial	1915.7 (1.1)^{a}	3531.9 (7.0)^{b}	5752.1(4.6)^{a}	7368.0(15.5)^{a}
	crossbred	1476.6 (2.8)^{c}	2705.3 (0.6)^{c}	5100.6(0.3)^{b}	6912.0(1.86)^{b}
	improved	1182.0(1.1)^{d}	2520.6(2.2)^{d}	5030.6 (2.1)^{c}	6837.6(1.53)^{c}
	indigenous	1732.3 (3.4)^{b}	3763.0(7.3)^{a}	4816.0(1.1)^{d}	6635.6(11.6)^{d}
Feed conversion ratio	commercial	3.2 (0.0)^{bc}	4.3(0.06)^{b}	4.9(0.0)^{c}	7.6 (0.1)^{d}
	crossbred	3.5 (0.0)^{b}	3.8 (0.01)^{c}	5.4(0.0)^{c}	11.4(0.1)^{c}
	improved	3.0(0.0)^{c}	3.6 (0.03)^{c}	6.0(0.0)^{b}	12.4(0.1)^{b}
	indigenous	9.3(0.2)^{a}	8.6(0.13)^{a}	8.4(0.6)^{a}	15.3(0.2)^{a}
Survival	commercial	-	-	-	98.9(0.1)^{a}
	crossbred				97.1(0.0)^{b}
	improved				98.8 (0.0)^{a}
	indigenous				88.8(0.0)^{c}
Source of variation					
Breed		***	***	***	***
week		***	***	***	***
Breed x week		***	***	***	***

^{a,b,c,d} Means within a column and breed with no common superscript different significantly ($P<0.05$). ***$P<0.001$

Table 5.2 Least square means (SE) of hen housed egg production (%), Feed conversion ratio (kg/kg), Feed per egg (grams), egg weight (grams), and survival (%) of commercial, crossbred, improved and indigenous chickens at month 3, 6, 9 and 12 during the laying period on-station

		M3	M6	M9	M12
Hen housed egg production	commercial	93.3(0.1)^{a}	92.2(0.1)^{a}	79.0(0.1)^{a}	79.5(0.1)^{a}
	crossbred	84.4(0.1)^{b}	83.0(0.1)^{b}	71.0(0)^{b}	71.1(0)^{b}
	Improved	57.8(0.3)^{c}	57.1(0.3)^{c}	49.1(0)^{c}	48.7(0.3)^{c}
	Indigenous	0.0(0.0)^{d}	27.1(0.1)^{d}	23.1(0.1)^{d}	23.3(0.1)^{d}
Feed conversion ratio	commercial	2.3(0.0)^{c}	2.4(0)^{d}	2.5(0)^{d}	2.5(0)^{d}
	crossbred	3.2(0.1)^{b}	3.3(0)^{c}	3.4(0)^{c}	3.4(0)^{c}
	Improved	3.2(0.4)^{b}	3.4(0)^{b}	3.7(0)^{b}	3.8(0)^{b}
	Indigenous	4.3(0.3)^{a}	7.1(0)^{a}	7.4(0)^{a}	7.3(0)^{a}
Feed per egg	commercial	132.9(0.2)^{d}	144.6(0.2)^{d}	153.5(0.3)^{d}	152.8(0.2)^{d}
	Crossbred	177.2(0.8)^{c}	191.5(0.8)^{c}	201.8(0.8)^{c}	201.0(0.8)^{c}
	Improved	195.4(0.4)^{b}	212.7(0.6)^{b}	225.1(0.7)^{b}	224.1(0.7)^{b}
	Indigenous	232.0(0.7)^{a}	269.7(0.9)^{a}	283.5(1.5)^{a}	282.4(1.7)^{a}
Egg weight	commercial	58.3(0)^{a}	61.2(0)^{a}	61.5(0)^{a}	61.5(0)^{a}
	crossbred	55.6(0)^{a}	58.4(0)^{b}	58.9(0)^{b}	58.9(0)^{b}
	Improved	50.2(0.5)^{b}	55.2(0.1)^{c}	54.6(0.1)^{c}	52.3(0.3)^{c}
	Indigenous	23.6(1.6)^{c}	38.1(0.1)^{d}	38.4(0.9)^{d}	38.4(0.2)^{d}
Survival	commercial	98.3(0.1)^{a}	97.3(0.1)^{a}	96.8(0)^{a}	96.0(0)^{a}
	crossbred	94.4(0.1)^{c}	93.4(0.1)^{c}	92.4(0.1)^{b}	92.4(0.1)^{b}
	Improved	98.8(0)^{a}	97.7(0)^{a}	96.7(0)^{a}	87.6(0.6)^{c}
	Indigenous	73.2(0.2)^{d}	55.7(0.1)^{d}	22.8(0.1)^{c}	16.5(0.1)^{d}
Source of variation					
Breed		***	***	***	***
Month (time)		***	***	***	***
Breed x Month (time)		***	***	***	***

^{a,b,c,d} Means within a column and breed with no common superscript different significantly (P<0.05). ***P<0.001

On-farm evaluation: laying period

The results of the on-farm studies of Horro and Ada districts are presented in Table 5.3 and 5.4 respectively. There was a significant effect of breed, village and breed-village interactions in all of the traits measured over time (P<0.001) both in Horro and Ada districts. In Horro, commercial chickens started egg laying earlier (143 ± 0.88), produced more eggs per year (202.5 ± 1.73) and had highest hen housed egg production on M3, M6, M9 and M12 than the rest of the breeds. Whereas, 151.6 ± 0.69 and 156.6 ± 1 days of AFE, and 174.2 ± 0.59 and, 149.6 ± 0.88 of eggs per year were recorded for crossbred and improved chickens respectively. Improved chickens showed highest survival at M3 and M6, but lower at M9 and comparable with that of commercial at M12.

In Ada, commercial layers started egg laying earlier (146.5±0.83), had more eggs (183.6±0.35) per year and highest hen housed egg production than the rest of the breeds. However, 155.5±0.35 and 159.5±0.59 days of age at first egg, and 161.9±1.38 and 148.1±0.45 of eggs per year were recorded for crossbred and improved chickens respectively. Both crossbred and improved chickens had similarly lower survival than commercial at M3 and M6, and M9.but they all showed similar survival at M12 under on-farm condition of Ada district.

Table 5.3 Least square means (SE) of hen housed egg production (%) and survival (%) of commercial, crossbred and improved chickens at different Month 3, 6, 9 and 12 during the laying period on-farm condition in Horro district.

Traits	Breed	M3	M6	M9	M12
Hen housed egg production	commercial	54.83(1.2)^{a}	53.47(0.5)^{a}	56.58(1.0)^{a}	52.21(0.3)^{a}
	crossbred	51.6(0.4)^{b}	47.37(0.5)^{b}	50.59(0.2)^{b}	47.31(0.4)^{b}
	improved	37.64(1.0)^{c}	46.83(0.9)^{c}	46.19(0.1)^{c}	43.46(2.9)^{b}
Survival	commercial	85.1(1.3)^{b}	85.10(1.3)^{b}	85.10(1.3)^{a}	77.7(2.2)^{a}
	crossbred	75.9(1.2)^{c}	74.03(0.6)^{c}	72.20(0)^{c}	66.63(1.1)^{b}
	improved	87.0(2.3)^{a}	87.00(2.3)^{a}	78.73(1.1)^{b}	77.46(0.6)^{a}
Source of variation					
Breed		***	***	***	***
Village		***	***	***	***
Breed* village		***	***	***	***

^{a,b,c,d} Means within a column and breed with no common superscript different significantly (P<0.05). ***P<0.001

Table 5.4 Least square means (SE) of hen housed egg production (%) and survival (%) of commercial, crossbred and improved chickens at Month 3, 6, 9 and 12 during the laying period under on-farm condition in Ada district.

Traits	Breed	M3	M6	M9	M12
Hen housed egg production					
	commercial	49.9(0.1)^{a}	48.3(0.4)^{a}	52.0(0.3)^{a}	50.1(0.1)^{a}
	crossbred	37.7(1.8)^{b}	47.6(0.4)^{a}	51.3(0.1)^{a}	48.9(0.3)^{a}
	improved	35.5(0.1)^{c}	40.1(2.3)^{b}	47.3(0.3)^{b}	47.7(0.5)^{b}
Survival	commercial	97.2(0.7)^{a}	83.3(2.7)^{b}	74.5(0.7)^{b}	74.5(0.7)^{a}
	crossbred	94.4(0.1)^{b}	88.8(1.3)^{a}	80.5(2.0)^{a}	74.9(1.9)^{a}
	improved	94.4(0.1)^{b}	88.8(1.3)^{a}	80.5(0.7)^{a}	74.9(1.9)^{a}
Source of variation					
Breed		***	***	***	***
Village		***	***	***	***
Breed* village		***	***	***	***

^{a,b,c,d} Means within a column and breed with no common superscript different significantly (P<0.05). ***P<0.001

Drop-out farmers

10 farms out of 16 in Ada were not included in the analysis (3 were Improved, 3 were crossbred and 4 were commercial). In Horro 7 farms out of 16 were not included in the analysis, (2 improved, 2 crossbred and 3 commercial). The main reasons were mortalities due to management problems (irregular feeding, poor hygiene and poor housing management) and incomplete data recording due to decreased motivation. In Ada, reduced motivation was equally observed in all breeds (one drop out from each breed). However, mortality of chickens due to poor management was more severe on commercial chickens than the other breeds. More farms of commercial chickens (3 farms) dropped out as compared to the crossbred (2 farms) and improved chickens (2 farms). Again in Horro, reduced motivation was equally observed in all the breeds (one drop out from each breed). However, loss of chickens due to poor management was more severe on commercial chickens (2 farms) than crossbred (1 farm) and improved chickens (1 farm).

5.4. Discussion

This study aimed at comparing the performances of chickens from different poultry breeds both on-station (controlled environment) and on-farm (Ada and Horro). The on-farm management represent an improved village poultry system in which farmers are encouraged to use better housing, feeding and management. The motivation of the study was to evaluate the performance of the improved indigenous chicken that has been selected for growth at 16 weeks of age on both sexes and egg number at 45 weeks of age in females. The on-station study included the comparison of improved chickens with indigenous both during the growing and laying period. All the traits measured indicated that the improved chickens were superior to their indigenous type. This indicates that the 7 generations of mass selection for body weight at week 16 and egg number at 45 weeks has been successful and confirms a genetic trend analysis that showed a positive change from generation 4 to 6 (Wondmeneh et al., 2014). Average body weight at 16 weeks grew by about 74 % and egg number of 24 weeks after on-set of egg laying increased by 21% from generation 4 to 6. Earlier, Lwelamira, (2008), reported that within ecotype selection can successfully bring about genetic improvement within some generations. The improved chickens are still lower in performance compared to crossbred and the commercial layers. However, given the large increase in performance after only 7 generations of selection, this difference is expected to decrease further with more generations of selection.

Significant effects village-breed interactions showed the presence of genetic by environment interactions between farms. With G × E, the phenotypic expression of a trait in different environments is genetically not the same trait and the breeding goal should define not only the traits but also the environment in which those traits are to be improved (Kolmodin & Bijma, 2004). In the current study, variation in the performance of the breeds was observed when measurements on the same trait were taken in different villages. Evaluation of the improved Horro under harsh environments would reveal if their adaptation to local conditions still present after generations of selection for production. It was suggested that information on the genetic correlation between the traits measured in the two environments is required to determine whether the rate of genetic improvement in environment 1 would be higher with direct selection in environment 1 or with indirect selection in environment 2 (Cameron, 1997).

In this study several traits were measured to compare the breeds. This study showed that the earlier the layers started egg laying, the more eggs they lay per year. Additionally, traits that were measured in this study such as feed conversion ratio (a kg feed required to produce a kg of egg) conveys more or less similar information with feed per egg (a gram of feed required to produce a gram of egg). Feed conversion ratio was identified as the major trait in egg production (Farooq et al., 2002). We did not measure adaptation traits other than survival. Survival was very similar for all breeds except unimproved Horro which showed clearly lower survival rates. The environments, however, were relatively favorable. It is important to assess the ability of the different breeds to perform under harsher environment to determine to what extend the improved indigenous breed has lost the adaptive capacity of its ancestors.

Not all participants in the on-farm study remained motivated to produce complete information about the chickens. All of the farms had complete records till 3 months of age. Drop out farms already had lower hen housed egg production and lower survival rates at 3 months of age as compared to those that continued till the end. More than half of the farmers at the start of the study were missing during the analysis as they either dropped out due to mortalities or stopped data collection due to reduced motivation. The causes for losing motivation was not studied but mortalities were caused mainly by poor management. The analysis of drop out farmers suggested that commercial chickens were more affected by the poor management. These results are in agreement with previous studies where commercial stock performed considerably better than indigenous chickens under good conditions, but only marginally better, or the same, under low input, harsh conditions (Tadelle et al., 2000; Singh et al., 2004). It is important to study the reasons for this apparent genotype by environment interaction so that they can be taken into account in the selection program of the Improved Horro so that they keep their potential to do relatively well under sub-optimal circumstances.

Conclusion

Better performance of improved chickens over indigenous both on-station and on-farm indicates that the selective breeding program has been successful. It has brought about an increase in growth of 95 % and egg number of 123 % over the six generations of mass selection on body weight at 16 weeks and egg number at 45 weeks of age. The level of performance of improved chickens was lower than that of commercial chickens or crossbreds. This difference in performance is expected to decrease with further generations of selection in the Improved Horro. Further study on the genotype by management level interaction is required to further optimize the selective breeding program of the Improved Horro. Additionally, it would be important to evaluate performance under harsher conditions and perform an economic analysis.

Acknowledgement

We sincerely thank Koepon foundation for funding this study and providing a scholarship for the first author. We also thank the technical staff at DZARC (Dawud Ibrahim, Alemayehu Amare, and Amsale Kebede) and farmers for their participation in the study.

References

Cameron, N.D., 1997. Selection Indices and Prediction of Genetic merit in Animal Breeding. CAB international. Pp 203. Wallingford. UK.

Dana, N. & Ogle, B., 2000. On-farm evaluation of the performance of RIR and local breeds of chicken. Proceeding of the 8th National Conf. of the Ethiopian Society of Animal Production, 21-23 August 2000, Addis Ababa, Ethiopia.

Dana, N., vander Waaij, E. H. & van Arendonk, J. A. M., 2011. Genetic and phenotypic parameter estimates for body weights and egg production in Horro chicken of Ethiopia. Tropical Animal Health &Production, 43:21–28

Dana, N., vander Waaij, E. H., Dessie, T.& van Arendonk, J. A. M., 2010. Production objectives and trait preferences of village poultry producers of Ethiopia: implications for designing breeding schemes utilizing indigenous chicken genetic resources. Tropical Animal Health &Production, 42:1519-29.

Farooq, M, Mian, M.A., Durrani, F.R. & Syed, M., 2002. Feed consumption and efficiency of feed utilization by egg type layers for egg production. Livestock Research for Rural Development, 14 (1).

Kidane, H., 1980. Performance of F1 crossbred birds. Wolaita Agricultural Development Unit. Animal Husbandry and Breeding. Wolaita Sodo, Ethiopia, Bulletin No. 4.

Kolmonid R. & Bijima, P., 2004. Response to mass selection when the genotype by environment interaction is modelled as a linear reaction norm. Genetics Selection Evolution, 36: 435–454.

Lwelamira, J., Kifaro, G. C. & Gwakisa, P. S., 2008. On station and on-farm evaluation of two Tanzania chicken ecotypes for body weights at different ages and for egg production. African Journal of Agricultural Research, 3(12): 843-851.

Philipsson, J., Rege, J.E.O., Zonabend E. & Okeyo, A.M., 2011. Sustainable breeding programmes for tropical farming systems In: Animal Genetics Training Resource, version 3, 2011. Ojango, J.M., Malmfors, B. and Okeyo, A.M. (eds). International Livestock Research Institute, Nairobi, Kenya, and Swedish University of Agricultural Sciences, Uppsala, Sweden.

SAS, 2004. SAS User's Guide. SAS Inst. Inc., Cary, NC.

Singh, D.P., Johri, T.S, Singh, U.B., Narayan, R. & Singh, D., 2004. Proceedings of the 22nd World's Poultry Congress, Istanbul, Turkey.

Tadelle, D., & Ogle, B., 2001 Village poultry production systems in the central highlands of Ethiopia. Tropical Animal Health & Production, 33(6): 521-537.

Tadelle, D., Alemu, Y. & Peters, K.J., 2000. Indigenous chickens in Ethiopia: genetic potential and attempts at improvement. World Poultry Science Journal, 56: 45-54.

Udo, H.M.J., Asgedom, A.H. & Viets, T.C., 2001. Modelling the impact of interventions in village poultry systems. In: Livestock Community and Environment. Proceedings of the 10th Conference of the Association of Institutions for Tropical Veterinary Medicine.21-22 August 2001, Copenhagen, Denmark accessed at http://www.aitvm.kvl.dk/C_poultry /C13Udo.htm.

Wondmeneh, E., Van der Waaij, E.H, Tadelle, D., Okeyo, M. & Van Arendonk, J.A.M., 2014. A running breeding program for indigenous chickens in Ethiopia: evaluation of success. Proceedings, 10th World Congress of Genetics Applied to Livestock Production. 17 – 22 August 2014, Vancouver, Canada.

6

General discussion

6. General discussion

The productivity of chickens in villages is low, but with stable flock dynamics, the systems are self-sustaining (Chapter 3). Considering the ever-increasing population and demand for affordable animal products, there is a need to improve the productivity of chickens in the rural areas. Smallholder poultry production systems are dominated by low producing, indigenous chickens that have adapted well to the harsh environmental conditions (Halima et al., 2007). There is potential for the existing productivity gap to be reduced through the implementation of different interventions in existing village poultry production systems as investigated in chapter 3. While the integration of external inputs into the system have the potential to increase productivity, this option is often less attractive to farmers because such a high expenditure is considered too high risk considering the low productivity of the indigenous chickens. An alternative intervention could be genetic improvement of the indigenous chicken population, with a target of combining improved productivity with better adaptability. While genetic improvement remains a viable and farmer-preferred intervention, breed selection is not an easy task and takes years to bring a significant change. Additionally, for genetic improvement to be a successful intervention for smallholders, the productivity increase needs to be expressed in the smallholder poultry production systems. It is possible to improve indigenous chickens with a breeding goal consisting of few traits and the application of mass selection, but it is critical to consider that when more than one trait with negative genetic correlations are considered, less progress will be achieved in any one of the traits. This chapter will discuss five points that were studied in the chapters of this thesis. The points are: (1) Genetic improvement of indigenous chickens, (2) Improving the breeding program, (3) Comparison of different poultry breeds, (4) Increasing profit from village poultry, and (5) Adoption of chicken breeds by village poultry producers.

Genetic improvement of indigenous chickens

Indigenous chickens can be genetically improved using within-breed selection (Wolliams et al., 1998). In the smallholder production environment, chickens frequently experience feed scarcity, disease challenges and stress. Considering these production circumstances, a tailor-made breeding program is needed to ensure that genetic improvement is expressed. Therefore, the need to define a breeding goal that considers both production and adaptive traits has been emphasized (Solkner et al., 1998; Olesen et al., 2000). Genetic improvement in poultry is commonly generated on a single nucleus farm (Wolliams et al., 1998).

The nucleus is defined as a flock or farm in a breeding scheme that contains the best animals in which genetic improvement is practiced and from which breed improvement is disseminated to other farms (Weiner, 1994). Nucleus breeding schemes enable implementation of efficient genetic evaluation methods such as BLUP (Kosgey, 2004).

The importance of indigenous chickens in developing countries has already been demonstrated several times. These countries are dominated by complex, diverse and risk-prone rural livelihoods, and considering this context, smallholders in developing economies need breeds that are flexible and resistant to the prevailing environment (Andeson, 2003). Developing countries, therefore, can opt to develop their own breeds suitable for prevailing production circumstances. However, stakeholders need to specify who should take the responsibility of the genetic improvement. In this part of the general discussion the advantages and disadvantages of breeding programs managed by either (I) public universities or research institutes (government), or (II) private breeding company will be detailed.

Government

Governments have responsibilities to improve the livelihoods of their people. In most developing countries, the role of the government is more significant than that of the private sector in stimulating development. In Ethiopia, for example, the public extension system took up the role of multiplying and disseminating improved genotypes to farmers. However, genetic improvement of indigenous chickens in Ethiopia through breed selection was only started recently. The Horro breeding program was initiated at a public research facility, Debre Zeit Agricultural Research Centre, and this example is the only successful breeding program involving indigenous chickens in Ethiopia. The program has been running for seven generations, resulting in significant changes in egg production and body weight (Chapter 5). However, the continuation of the breeding program requires continuous investment. While the breeding program has resulted in a significant improvement, the field experiment revealed that the performance of the improved Horro remains lower than of commercial layers. Therefore, continuation of the program is required to further improve the local breed. Due to the primary role in improving the livelihood of the people, governments should bear the responsibility of genetic improvements of indigenous chickens. As compared to private companies, it is more viable for governments to make the long-term investment required for realizing the genetic potential of indigenous chicken. Government should compare the advantages and disadvantages of improving an indigenous breed with those of importing a commercial strain. In that evaluation, governments should consider the impacts for the livelihoods of smallholders, the conservation of local genetic resources and the need for capital for importation.

Private companies

The alternative to governments is private breeding companies taking the responsibility for the genetic improvement programs of indigenous chickens. A critical difference between governments and the private sector is the private sector's motive of positive returns from the investments. The decision to invest in a breeding program aimed at the improvement of indigenous chickens could be too risky for private companies because of the time required to develop a genetically improved breed that is competitive with exotic birds. The history of genetic improvement in Ethiopia has shown that after seven generations of mass selection, the performance of improved chickens remains lower than that of exotic chickens (Chapter 5). If the breeding program continues for some generations, the difference in performance between improved and exotic chickens will decrease, but it remains unclear whether these improved indigenous chickens can compete with commercial breeds for egg and meat production. For instance, while the indigenous chickens may have lower productivity than exotic breeds their production in smallholder systems may be comparable due to higher adaptability, but farmers may not be willing to adopt strains that have lower productivity when compared to exotic birds. When given the choice farmers might favor exotic birds over local birds based on physical appearance and productivity. Due to this potential for low adoption, genetic improvement of indigenous chickens might not be attractive to private companies. Private companies might view the importation of an exotic breed as a more attractive alternative based upon the fact that a long-term investment in product development is not required. While stakeholders in the private sector might be hesitant to make long-term investments in untested strains, there is a higher likelihood of private sector engagement in the maintenance and management of a genetic improvement program of an indigenous breed once that breed has been shown to be demanded by farmers.

Improving the breeding program

The breeding program to improve the egg and growth traits of indigenous Horro chickens in Ethiopia was started in 2008. The breeding goal of the Horro program was established around the interest of farmers (Dana et al., 2010). The program improved the traits under selection (egg number and growth rate) significantly as shown in Chapter 5. The improvements were found not only on-station but also on-farm. The positive trends in body weight, egg production and survival over generation demonstrated the success of the program. The breed comparison trial revealed that there remains a considerable difference between the performance of the improved Horro and that of exotic chickens (Chapter 5). This difference in productivity indicates the need to continue the genetic improvement program. There is also a need to determine the difference in adaptability. For instance, it is unknown whether the improved Horro has maintained high survivability under harsher environments. In the remainder of this section, a few items are discussed that deserve attention in following generations, namely disease resistance, uniformity and selection method.

Disease resistance

NAb are known to play an important role in the maintenance of physiological and immunological homeostasis (Anania et al., 2010), and serve also as stimulus for the adaptive immunity (Iwasaki and Medzhitov, 2004). In the absence of NAb, there is delayed adaptive immune response and increased mortality in mice caused by influenza (Baumgarth et al., 2005). Star et al., (2007) showed that titers of total NAb binding keyhole limpet hemocyanin (KLH) were indicative for a higher probability that chickens survive a laying period. The selection for growth at week 16 and egg number at week 45 resulted in a correlated response in the natural antibody titers. The NAb titers (IgG and IgM) in indigenous chickens were higher than in the improved chickens of generation 7 (Chapter 4). The improved breed had a higher survival rate under confinement (Chapter 4). This is also in line with the improved survival rates during the first generations of selection. The correlated response in NAb titers, revealed in chapter 4, is in contradiction with results from other studies. Rauw et al. (1998) indicated that selection for production has increased immunological disorders. Within line, a positive effect of higher NAb on survival was found (Star et al., 2007). In future generations, continued selection for productivity is expected to have a negative impact on disease resistance, resulting in lower survival. It is important to determine the exact NAb level that renders or indicates better survival. In order to know the association of NAb levels to adaptation to sub-optimal conditions, it is suggested to monitor the NAb level and survival under less favorable conditions.

Uniformity

After seven generations of selective breeding, the population still showed large variation in color and plumage type as selection decisions did not consider color and plumage type. In village poultry production in Ethiopia, however, farmers express a strong preference for brown feathered chickens (Dana et al., 2010). This preference has been linked to cultural grounds and the fact that commercial layers, which are often brown, have the reputation of being more productive. In the future, selection for plumage color should be considered in the breeding scheme.

New methods

Our breeding program dealt with two traits (body weight and egg number), and with the application of the most simple selection method, mass selection, these traits were successfully improved (Chapter 5). Individual birds were selected based on their growth and egg production performance irrespective of the performance of relatives. Considering the utilized methods and the outcomes, the breeding program could be improved by applying BLUP. Using BLUP, breeding values of individual chickens can be predicted more accurately by including information from relatives. Selection based on BLUP breeding values can result in increased rate of inbreeding. The increase in inbreeding can be avoided by using methods that balance genetic diversity and genetic progress (Meuwwissen, 1997). Simulation studies showed that, at the same level of inbreeding, differences between BLUP and mass selection are much smaller than if inbreeding is unrestricted (Quinton, et al., 2014).

Comparison of different poultry breeds to monitor progress from selection

The genetic change achieved through selection can be monitored by comparing the unselected animals with the selected ones. It is also possible to compare the performance of the selected animals with commercial animals to find out whether a selection program is making progress. In Chapter 5, we have compared improved Horro chickens (selected) with both unselected and commercial chickens by subjecting them to the same environmental effects to measure the success or failure of our selection effort.

In general, several traits can be used to compare the breeds. But, it is important to identify which trait or traits are best suited as comparison points. For example, body weight and egg weight are two relevant productive traits in poultry (Sorensen et al., 1980). As outlined in chapter 5, the improved Horro was smaller and lighter than crossbred and commercial birds. This is an important indicator as heavy birds consume more feed and lay larger eggs with larger egg yolks when compared to light hens (Lacin, et al 2008). Egg weight is more relevant in layers but it might not be a good trait when eggs are not sold on weight basis. Additionally, the hen-housed egg production is more useful than hen-day egg production, and similarly, the egg to feed ratio (weight of feed/weight of eggs) is a better measure of performance than the traditional “feed conversion” (pounds of feed per dozen eggs) (University of California, 2003). Also, with the forecasts that feed costs will remain high, the bird’s ability to convert nutrients is an important aspect of overall performance efficiency (WATT, 2011). Therefore, feed efficiency should serve as a parameter to evaluate performance of laying hens.

Increasing profit from village poultry

Better management of village poultry could result in hundred folds increased productivity (Chapter 3). Management interventions included feeding, housing, vaccination and hygiene, and use of an improved indigenous breed (Horro). However, the simulation study also indicated that the higher productivity gained from improved management may not be high enough to cover the extra costs. Reddy (1998) suggested that success of village poultry production depends on the use of appropriate and affordable technologies. The on farm and on station evaluation of the four groups of chickens (chapter 5) were obtained using full packages for management improvement. Under those circumstances the genetically improved indigenous chickens performed better than their unimproved counterparts. Are these results in chapter 5 indicative of the extra income that the higher productive chickens could generate? Based on the simulation results in chapter 3, the answer would be no. However, unlike in chapter 3, the flock was composed mainly of hens. About 18 hens were kept to produce eggs. Therefore, farmers would have more eggs that can be sold. So, the profitability from 18 laying hens in chapter 5 could be better than 4 laying hens in chapter 3. However, the cost-benefit analysis was not conducted both on station and on farm, and the profitability could not be evaluated. In general, profitability from indigenous chicken can be realized when the productivity of the breed is high enough to exceed the cost of production, and interventions are applied along to maintain the productivity. In poor countries locally available feed resources should be used to develop diets (Sonaiya and Swan, 2004; Branckaert et al., 2000). Additionally, proper shelter should be constructed using locally available materials (Branckaert et. al., 2000). In Chapter 3, feed from locally available ingredients and houses from locally available materials were considered. But farmers keep few laying hens for egg production part of which would also be used for replacing the flock. The poor profitability, therefore, could be because farmers keep few laying hens. Previously, egg production and survival were identified as the main determinants of profitability of family flocks (Hossen, 2010). For more production and better financial performance reasonable number of productive laying hens should be used with appropriate inputs.

Adoption of the breeds by village poultry producers

Adoption of agricultural technologies is affected by several factors related to household, farm, technology, wealth, contact with extension agents, farmers' knowledge about specific technologies, price, access to credit etc. (Legesse, 1992; Wolday, 1999). Adoption studies have so far focused mostly on non-livestock or non-chicken technologies. In chapter 2 of this thesis, factors such as off-farm income, livestock income, and gender were found to affect the adoption of exotic chickens. Exotic chickens in villages of Ethiopia are poorly adopted to smallholder farming systems (chapter 2). Other factors that specifically affected the adoption of exotic chickens include farm size, and availability of inputs (breed). Discussions with farmers prior to the start of the breed comparison study pointed out that they preferred the brown feathered, exotic layer over the other available indigenous or crossbred type of animals (personal communication). Again during the dissemination of chickens, farmers expressed particular interest towards the brown exotic layers and tried to avoid receiving improved indigenous chickens that were not as brown and uniform as the exotic layers. However, the type of chickens received was not necessarily related to the quality of the management the farmers performed, and some farmers poorly managed the brown exotic chickens. Poor management of chickens has been associated with poor productivity, and eventually affected their adoption negatively (chapter 2). Farmers may indicated a preference for a breed, but they may ultimately choose to not adopt the chickens they identified as "preferred" upon receiving access to such chickens. Two possible reasons that may lead to poor adoption of exotic chickens will now be discussed in more detail: (1) Genetic (biological) characteristics of the breed, and (2) External factors, such as resources, dissemination, and awareness related

Genetic (biological) characteristics of breeds

The decision of a farmer to adopt a technology will depend on the characteristics of an innovation (Kinnucan et al., 1990). Factors that are associated with the biology of the breeds such as adaptation to the production environment and disease resistance are critical to adoption (chapter 2). Distribution of exotic chickens that lack both traits will lead to lower survival rates and consequently lower productivity of exotic chickens. Feder et al. (1985) explained that adoption of a technology will be possible when a farmer has full information about the new technology and it's potential. Our participant farmers were aware of the management requirements of the breeds they received prior to the commencement of breed comparison (Chapter 5). However, farmers managed the exotic chickens in the same manner as their indigenous chickens. Failure to adapt management practices contributed to disappointing production levels and survival rates. For some farmers, a breed requiring fewer changes might be a better option.

External factors

Oladele (2005) showed that a range of economic, social, physical, and technical aspects of farming influence the adoption of agricultural technologies. In Ethiopia, mainly institutional factors (i.e. public extension system) are responsible for failures in disseminating technologies. The extension system is mainly handled by the government, and recommendations are implemented following a top-down approach (EEA: EEPRI, 2006). According to the survey described in chapter 2, in the previous extension program of Ethiopia, few chickens were handed out to farmers without associated packages. Additionally, the distribution period varies year to year that farmers were unable to plan better. This is a problem as farmers may not have prepared the shelter or feed yet, and in that case they are not ready to receive the chickens, with negative consequences for the expected success of chicken distribution. The capacity of the production environment in supplying the feed and its constraints has never been considered either. As a result, high performing commercial chicken were introduced into the system where feed is scarce and the availability is seasonal. There is a need to consider the distribution of technologies to various agro-ecological zones (Abate, 2007; Lemma & Hoffman, 2006), as technologies can be environment specific (agro ecosystem variance, or local demands). Additionally, in extension programs, little attention was paid to gender, culture, and youth (Ashworth, 2005; EEA: EEPRI, 2006). Farmers continue to express interest in exotic chickens, but adoption also remains low as seen in chapter 2. Chapter 5 revealed that farmers need to be informed about the requirements of the breeds (better feeding, medication and housing management), and of the consequences of failing to fulfill the requirements. Adoption could be increased through the development of a breed that is suited to the production system and the interest of farmers. But, external factors that affect successful adoption of technologies such as availability of resources, timely communication of dissemination schedules, and awareness of farmers about the technology are very important.

Conclusion and recommendations

The study showed that mass selection was successful in improving egg production and body weight of indigenous chickens. Prior to organizing future dissemination it is important to consider factors that would affect the successful adoption of this improved chickens by rural farmers. Based on experiences in the breed comparison study, it is possible that the genetically improved chickens, as they are at present, will not meet the expectation of farmers. The reason behind this calls for further investigation.

What should be improved?

The breeding goal of the ongoing breeding program to genetically improve the indigenous Horro chickens is to improve the egg production and growth traits of chickens without losing their ability to adapt harsh environments. The breeding program is conducted at the Debre Zeit Agricultural Research Center, under a more intensive management, including a good poultry house, formulated feed and vaccination, than would be common on farm level. This management system would be too costly for farmers to follow. To make sure that the chickens retain their adaptive capacity for on farm circumstances, then we suggest that the future generations of chickens should be performance tested in less expensive management conditions that resembles their aimed on-farm production environment. Second, the exact formulation of the breeding goal should be re-evaluated and may need to include additional traits that are preferred by the farmers. Such traits may include plumage color. However, it needs to be investigated whether this would really be a trait of additional value. In our study, farmers were interested in brown plumage color, suggesting it should be included in the breeding goal. However, reason for this preference may be that the public extension system in Ethiopia had been distributing brown commercial layers to farmers for many years. Preference for brown feather thus may be related to association with commercial, higher productive hens. It is debatable whether this would be reason enough to introduce selection for brown plumage color in the Horro breeding program. Finally, results in chapter 5 did not show a clear benefit of the current generation of improved Horro chickens over commercial layers. There may be two important reasons for this: first of all the improved Horro have only been selected for improved productivity for 7 generations, whereas the commercial hens have been selected for very many generations. More generations of selection in the Horro are expected to reduce the difference in productivity with the commercial hens. Second, the circumstances during the breed comparison were not very harsh. It is expected that under more harsh conditions, for example because of reduced quality and/or amount of feed, the improved Horro will do relatively much better than the commercial hens. Future comparative testing will reveal whether this indeed is the case.

References

Abate, H., 2007. Review of extension systems applied in Ethiopia with special emphasis to the participatory demonstration and training extension system. Rome: Food and Agriculture Organization of the United Nations.

Anania, C., Gustafsson, T., Hua, X., Su, J., Vikstrom, M., de Faire, U., Heimburger, M., Jogestrand, T. & Frostegard, J., 2010. Increased prevalence of vulnerable atherosclerotic plaques and low levels of natural IgM antibodies against phosphorylcholine in patients with systemic lupus erythematosus. Arthritis Research and Therapy, 12:R214.

Anderson, S., Negussie, E., Duguma, G.& Rege, J.E.O., 2012. Genetic parameter estimates for growth traits in Horro sheep. Journal of Animal Breeding & Genetics, 119, 35-45

Ashworth, V., 2005. The challenges of change for agricultural extension in Ethiopia: A discussion paper. Addis Ababa, Ethiopia: Government of Ethiopia.

Baumgarth, N., Tung, J. W. & Herzenberg, L. A., 2005. Inherent specificities in natural antibodies: a key to immune defense against pathogen invasion. Springer Seminars in Immunopathology, 26:347-362.

Branckaert, R.D.S., Gaviria, L., Jallade, J. & Seiders, R.W. 2000. Transfer of technology in poultry production for developing countries. In FAO Sustainable Development Dimensions, October 2000 and Proceedings WPC2000 Montreal, Canada (under same title also available at www.fao.org/ag/aga/AGAP/LPA/fampo1/links.htm).

EEA: EEPRI, 2006. Evaluation of the Ethiopian agricultural extension with particular emphasis on the participatory demonstration & training extension system (PADETES). Ethiopian Economic Association/Ethiopian Economic Policy Research Institute, Addis Ababa: Ethiopia.

Feder, L., R.E. Just. & Zilberman, O., 1985. Adoption of Agricultural Innovation in Developing Countries: “A Survey” Economic Development and Cultural Change, 32(2): 255-298.

Halima, H., Neser, F.W.C., vanMarle-Koster,E.&deKock, A., 2007. Phenotypic variation of indigenous chicken populations in northwest Ethiopia. Tropical Animal Health & Production, 39: 507-513.

Hossen, M.J., 2010. Effect of management interventions on the productivity and profitability of indigenous chickens under rural condition in Bangladesh. Livestock Research for rural development, 22(10).

Iwasaki, A., Medzhitov, R., 2004. Toll-like receptor control of the adaptive immune responses. Nature Immunology, 5:987-995.

Kinnucan, H., Hatch, U., Molnar, J. &Venkateswaran, M., 1990. "Scale neutrality of Bovine Somatotropin: Ex Ante Evidence from the southeast". Southern Journal of Agricultural Economics, 22:1-12.

Kosgey, I., 2004. Breeding objectives and breeding strategies for small ruminants in the tropics. PhD thesis, Wageningen University, Wageningen.

Lacin, E., Yildiz, A., Esenbuga, N. & Macit, M., 2008. Effects of differences in the initial body weight of groups on laying performance and egg quality parameters of Lohmann laying hens. Czech Journal of Animal Science, 53(11): 466–471.

Legesse, D., 1992. Analysis of factors influencing adoption and the impact of wheat and maize technologies, In Arsi Negele, Ethiopia. An MSc Thesis presented to the School of Graduate Studies of Alemaya University, Ethiopia

Lemma, M., &Hoffmann, V., 2006. Taking a systems approach to agricultural education, research and extension: Analysis of extension and the practical attachment program of Mekelle University, Ethiopia. Paper presented at the Conference on International Agricultural Research for Development, October 11–13, Bonn, Germany.

Masuku, M.B., 2013. Determinants of Profitability of Indigenous chickens in Swaziland. Business and Economic Research, 3(2).

Meuwissen, T.H.E., 1997. Maximizing the response to selection with predefined rate of inbreeding. Journal of Animal Science, 75: 937-940.

Nigussie Dana, Liesbeth H. van der Waaij, Tadelle Dessie, and Johan A. M. van Arendonk., 2010. Production objectives and trait preferences of village poultry producers of Ethiopia: implications for designing breeding schemes utilizing indigenous chicken genetic resources. Tropical Animal Health &Production, 42(7): 1519–1529.

Oladele, O.I., 2005. Determinants of adoption behavior of alkali soil reclamation technology a discriminate function approach". Journal of Indian Soil Conservation, 24(2):165-168.

Olesen, I., Groen, A.F.& Gjerde, B., 2000. Derivation of Sustainable Breeding Goals for Dairy cattle using selection index theory. Journal of Animal Science, 88: 1882-1090.

Quinton, M., Smith, C. & Goddard, M. E., 2014. Comparison of Selection Methods at the Same Level of Inbreeding. Journal of Animal Science, 70: 1060-1067.

Rauw, W.M., Kanis, E., Noordhuizen-Stassen, E.N.& Grommers, F.J., 1998. Undesirable side effects of selection for high production efficiency in farm animals: a review. Livestock Production Science, 56: 15-33.

Reddy, C.V., 1998. Towards sustainable poultry production. Indian poultry review, 29: 35-47.

Solkner, J., Nakimbugwe, H. & Valle Zarate, A., 1998. Analysis of determinants for success and failure of village breeding program. Proceedings of the 6th World Congress on Genetics Applied to Livestock Production. 25: 273-281.

Sonaya, E.B., Swan, S.E.J. 2004. Small–scale poultry production. FAO. Technical guide. Pp 109. Rome

Sorensen P., Ambrosen T.& Petersen, A., 1980. Scandinavian selection and crossbreeding experiment with laying hens. IV. Results from the Danish part of the experiment. Acta Agriculturae Scandinavica, 30: 288–308.

Star, L., Frankena, K., Kemp, B., Nieuwland, M. G. B. & Parmentier,H. K.,2007. Natural humoral immune competence and survival in layers. Poultry Science, 86:1090-1099.

Udo, H.M.J., Asgedom, A.H. & Viets, T.C., 2006. Modelling the impact of interventions on the dynamics in village poultry systems. Agricultural Systems, 88: 255-269.

University of California, 2003. An Egg Economics Update-Flock Indexing - Current Flocks - Strain Differences. Cooperative Extension, No.256.

Wiener, G., 1994. Animal Breeding. The Tropical Agriculturalist. CTA; Wageningen: The Netherlands.

Wolday, A., 1999. Improve seed marketing and adoption in Ethiopia. Journal of Ethiopian Agricultural Economics, 3:41-80.

Woolliams, J.A., Gwaze, D.P., Meuwissen, T.H.E., Planchenault, D., Renard, J.P., Thibier, M. & Wagner, H., 1998. Secondary guidelines for development of national farm animal genetic resources management plan. Management of small population at risk. Initiative for domestic Animal diversity (IDAD). FAO.

Summary

Summary

The Major problems in poultry production systems in Ethiopia are disease, low nutrition, poor management, and poor genetic performance. One way of improving production level is by genetic selection (selective breeding). Crossbreeding to incorporate both the high genetic potentials of exotic birds and better adaptability and disease resistance of the indigenous birds was considered as an option to improve productivity. In **Chapter 2**, we examined factors that determine the probability and intensity of adoption of exotic chickens among rural poultry producers in Ethiopia. The objectives were to investigate the differences between adopters and non-adopters, and to identify factors that determine the probability and intensity of adoption of exotic chickens in the village poultry production system of Ethiopia. The differences between adopters and non-adopters were identified using descriptive statistics. Factors that affect the probability and intensity of adoption were identified using the Heckman selection two-step model. Adopters and non-adopters showed differences in few of the demographic or descriptive variables which were expected to affect adoption of exotic chickens. Similarly, the econometric analysis showed that the adoption and intensity of adoption of exotic chickens were affected by few income related variables. The perception of both adopters and non-adopters regarding input (breed) availability seemed to have negatively affected the adoption. The findings of the study suggest reconsidering the feasibility of the dissemination of exotic chickens to rural farmers who have no or little means to improve the management of exotic chickens. The gender of household head remains to be important as far as the intensity of adoption of exotic chicken is concerned. More women should also be considered to increase complete understanding about the adoption exotic chickens in rural areas.

The existing village poultry production system is known as low-input and low out-put system. Farmers are less interested in using inputs but keep poultry as a source of food and additional income. In **Chapter 3,** we determined the perceptions of rural farmers towards feasibility of interventions in their village poultry system, characterized the existing village poultry production system (base situation) and evaluated the impacts of individual and packaged interventions into the existing production system. We not only identified the perception of poultry farmers' on impact of interventions in village poultry production but also quantified the impacts of individual and packaged interventions on flock and economic performance using modelling. Farmers' perceptions affected their decisions regarding implementation of interventions. Simulated interventions increased productivity but only in a few cases the increased incomes outweighed the

additional costs. Interventions need to be tailored towards the local situation to ensure they lead not only to improved productivity but also to improved income.

A breeding programme utilizing indigenous chickens in Ethiopia was set up in 2008. The Horro breed (indigenous chicken from Horro region of Ethiopia) and the breeding objectives for this programme were identified using a participatory approach. Farmers identified the production traits: egg number (but not egg weight) and live weight (growth) as the most important economic traits and the type of chicken they seek is dual purpose where they can get both better number of eggs and meat. Traits that have no direct economic values such as feather color were also found to have high significance to farmers. The breeding program was ongoing and the 7th generation of improved indigenous chicken were compared with indigenous (unselected), a crossbred, and commercial layer breed both on-station and on-farm. In **Chapter 4**, Natural Antibody levels of improved chickens were compared in indigenous (unselected), a crossbred, and commercial layer breed. The objectives were to compare the NAb levels and survival rates in indigenous, improved indigenous, exotic and crossbred laying hens under confinement in Ethiopia and determine the phenotypic relation between NAb and survival of chickens. The chickens were followed from 20 to 45 weeks of age. Blood samples were drawn from the chickens and NAb binding KLH were determined using indirect ELISA technique. Keyhole limpet hemocyanin (KLH) is a large cooper-containing protein found in the hemolymph of the sea mollusk *Megathura crenulata* and antibodies in chickens to this protein are regarded as 'natural' as birds are unlikely to encounter KLH. Further Survival analysis was conducted to establish the relation between natural antibody levels binding KLH and survival. The time to die or survival time (time until death) were used during the follow up period of week 20 to 45. Survival is commonly characterized by a hazard function that represents the instantaneous death rate for an individual surviving to a particular time point. The result showed that Indigenous chickens had higher NAb levels at all ages. The cox-proportional hazard analysis showed increased hazard with increased levels of NAbs in the exotic layers. However, the reduced hazards with increased levels of NAbs were not significant in the improved indigenous and crossbred chickens. Indigenous chickens showed increased hazard with increasing levels of Nab. We concluded that not only the NAb levels but also the effect of NAbs on survival vary between indigenous and improved breeds. The results indicate that NAb levels are associated with survival in elite (improved) breeds, but are associated with increased hazard in indigenous chickens. It is very important to find out whether a selection program had resulted in the changes that were expected.

The genetic change achieved through selection can be monitored by comparing the unselected animals with the selected ones. It is also possible to compare the performance of the selected animals with commercial animals. In **Chapter 5**, we have compared Improved Horro chickens (selected) with both unselected and commercial chickens by subjecting them to the same environmental effects to measure the success or failure of the selection effort. The performance of improved indigenous chickens was, therefore, compared with commercial layer, crossbred and indigenous chickens both on-station and on-farm. The idea behind was comparing breeds or strains under different environments may reveal genotype by environment interaction and is important to translate findings on-station for farmers in the villages. A total of 870 chickens were used. 600 chickens (n=150 and n=120 from each breeds on-station and on-farm respectively) arranged in completely randomized design were followed on-station, and 270 (90 from commercial, crossbred and improved) were evaluated on-farm in Ada (n= 6 farms) and Horro (n=9 farms) districts in a split-plot design. 10 farmers out of 16 in the Ada district and 7 out of 16 in the Horro district dropped out either due to high chicken mortality or reduced motivation of the farmer. Better performance of improved chickens over indigenous both on-station and on-farm indicates that the selective breeding program has been successful. The level of performance of improved was still lower than that of commercial chickens or crossbreds. This difference in performance is expected to decrease with further generations of selection in the Improved Horro. Further study on the genotype by management level interaction is required to further optimize the selective breeding program of the Improved Horro. Additionally, it would be important to evaluate performance under harsher conditions and perform an economic analysis.

Samenvatting

Samenvatting

De voornaamste problemen in de pluimvee productie systemen in Ethiopië zijn ziekte, laag voerniveau, slecht management en slechte genetische aanleg. Een manier om het productieniveau te verhogen is door genetische selectie (selectieve fokkerij). Kruisen om de hoge genetische aanleg van exotische dieren te combineren met het betere aanpassingsvermogen en ziekteresistentie van de lokale dieren wordt gezien als een mogelijkheid tot productie verbetering. In **Hoofdstuk 2** hebben we de factoren onderzocht die de waarschijnlijkheid en intensiteit van adoptie van exotische kippen door lokale pluimvee producenten in Ethiopië bepalen. Het doel was omde verschillen tussen adopters en non-adopters te onderzoeken en om factoren te identificeren die de waarschijnlijkheid en intensiteit van adoptie van exotische kippen in het dorpse pluimvee systeem in Ethiopië. De verschillen tussen adopters en non-adopters zijn geïdentificeerd met behulp van beschrijvende statistiek. Factoren die de waarschijnlijkheid en intensiteit van adoptie beïnvloeden zijn geïdentificeerd met behulp van het Heckman tweestaps-selectiemodel. Adopters en non-adopters lieten verschillen zien in een aantal demografische of beschrijvende variabelen waarvan verwacht werd dat ze adoptie van exotische kippen zullen beïnvloeden. De economische analyse liet zien dat de adoptie en intensiteit van adoptie van exotische kippen beïnvloed wordt door inkomen gerelateerde variabelen. De perceptie van zowel adopters als non-adopters met betrekking tot de beschikbaarheid van de rassen lijkt adoptie negatief te beïnvloeden. De bevindingen suggereren dat de haalbaarheid van verspreiding van exotische kippen aan lokale boeren, die weinig mogelijkheden hebben om het management van de kippen te verbeteren, opnieuw bekeken moet worden. Het geslacht van het hoofd van het huishouden blijft belangrijk voor zover het de intensiteit van adoptie van exotische kippen betreft. Meer vrouwen zouden moeten worden betrokken om het inzicht in de adoptie van exotische kippen in landelijke gebieden te vergroten.

Het bestaande dorpspluimveesysteem staat bekend als een low-input en low-output systeem. Boeren zijn minder geïnteresseerd in het gebruik van extra input, maar houden hun kippen als een bron van voedsel en extra inkomen. In **Hoofdstuk 3** hebben we de perceptie van lokale boeren bepaald met betrekking tot de haalbaarheid van inmenging in hun dorpspluimveesysteem, door de impact te evalueren van individuele en pakket inmenging op het bestaande dorpspluimveesysteem (basis situatie). We hebben niet alleen de perceptie van de pluimveehouders op de impact van interventie in dorpspluimveesystemen geïdentificeerd, maar ook de impact van individuele en pakket interventies op de economische en kippenkoppel prestaties, door middel van modelering. De

perceptie van boeren beïnvloedde hun beslissingen met betrekking tot implementatie van de interventies. Gesimuleerde interventies deden de productiviteit toenemen, maar alleen wanneer de toename in inkomen groter was dan de extra kosten. Interventies moeten worden toegespitst op de lokale situatie om er zeker van te zijn dat ze niet alleen tot verbeterde productie, maar ook tot verhoogd inkomen zullen leiden.

In 2008 is in Ethiopië een fokprogramma opgezet voor lokale kippen. Het Horro ras (lokale kippen uit de Horro regio in Ethiopië) is daarvoor ingezet. Fokdoelen voor dit programma zijn vastgesteld door boeren. Zij wezen aantal eieren (maar niet ei gewicht) en levend gewicht (groei) aan als de economisch meest interessante kenmerken. Het type kip dat zij zoeken is een dubbeldoelkip, waardoor ze zowel meer eieren als meer vlees kunnen krijgen. Kenmerken zonder directe economische waarden, zoals veerkleur, werden door de boeren ook als belangrijk aangemerkt. Het fokprogramma loopt nog steeds en de 7^{e} generatie verbeterde kippen zijn vergeleken met ongeselecteerde kippen, met een kruising, en met een commerciële leghen, zowel op het onderzoeksinstituut als bij boeren thuis. In **Hoofdstuk 4** is het Naturalantibody (NAb) niveau van de verbeterde Horro kippen vergeleken met dat van de andere groepen kippen. Doel van de studie was om het NAb niveau en de overlevingsgraad tussen de vier groepen kippen te vergelijken en om de fenotypische relatie tussen NAb en overleving te bepalen. De kippen werden gevolgd van 20 tot 50 weken leeftijd. Bloedmonsters werden genomen om NAb bindende KLH te bepalen met behulp van de ELISA techniek. Keyhole limpet hemocyanin (KLKH) is een groot cooper-bevattend eiwit dat in de hemolymfe van de zeeslak *Megathura crenulata* voorkomt en antilichamen tegen dit eiwit bij kippen worden als 'natuurlijk' aangemerkt, omdat het erg onwaarschijnlijk is dat kippen dit eiwit al eerder in hun leven zijn tegengekomen. Een survival analyse is uitgevoerd om de relatie tussen NAb bindend aan KLH niveaus en overleving te bepalen. De tijd tot sterfte is gebruikt in de erop volgende periode van 20 tot 45 weken leeftijd. Overleving wordt vaak weergegeven door middel van een hazard functie die sterfte weergeeft voor een individu met overleving tot een bepaald moment in de tijd. Het resultaat liet zien dat lokale kippen een hoger NAb niveau hadden op alle leeftijden. De cox-proportionele risico analyse liet een toename in risico met toenemende NAb niveaus in de exotische leghennen. Echter, de verminderde risico's met een toegenomen NAb niveau waren niet significant in de verbeterde lokale en gekruiste kippen. Lokale kippen lieten een toegenomen risico zien met een toename in NAb niveau. We concludeerden dat niet alleen de NAb niveaus, maar ook het effect van NAbs op overleving, variëren tussen de lokale en de exotische kippen. De resultaten laten zien dat NAb niveaus geassocieerd zijn aan overleving in exotische kippen, maar dat ze zijn geassocieerd met toegenomen risico in de lokale kippen. Het is erg belangrijk om uit te vinden of een selectieprogramma heeft geresulteerd in de veranderingen die verwacht werden.

De genetische verandering die door selectie is bereikt kan worden beoordeeld door de geselecteerde dieren te vergelijken met ongeselecteerde dieren. Het is ook mogelijk om de prestaties van de geselecteerde dieren met die van commerciële dieren te vergelijken. In **Hoofdstuk 5** hebben we de verbeterde Horro kippen (geselecteerde dieren) vergeleken met zowel ongeselecteerde als commerciële kippen door ze bloot te stellen aan hetzelfde milieu. De prestatie van de verbeterde kippen is daarom zowel op het onderzoeksinstituut als bij boeren thuis vergeleken met die van de ongeselecteerde, gekruiste en exotische kippen. Het idee was dat het vergelijken van de groepen kippen onder verschillende omstandigheden mogelijk op een genotype-milieu interactie zou wijzen en omdat het belangrijk is om de vindingen op het onderzoeksinstituut te vertalen naar de boeren in de dorpen. In totaal zijn 870 kippen gebruikt. Daarvan zijn 600 kippen (n=150 en n=120 voor elk van de groepen dieren op het instituut en bij de boeren) in een compleet random ontwerp gevolgd. Bij de boeren zijn er 270 kippen, maar niet van de ongeselecteerde groep, gevolgd in de Ada regio (n=6 per boerderij) en Horro (n=9 per boerderij) in een split-plot ontwerp. In de Ada regio zijn 10 van de 16 boeren en in de Horro regio 7 van de 16 boeren gestopt voor het eind van het experiment vanwege hoge sterfte of afgenomen motivatie van de boer. Betere prestaties van de verbeterde kippen boven die van de lokale kippen, zowel op het onderzoeksinstituut als bij de boeren, geeft aan dat het fokprogramma succesvol is geweest. Het absolute niveau van productie was nog steeds lager dan dat van de commerciële kippen of van de gekruiste dieren. Dit verschil in prestaties zal naar verwachting afnemen met een toename in het aantal generaties selectie in de verbeterde Horro. Verder onderzoek naar de genotype bij management interactie is nodig om het fokprogramma van de verbeterde Horro verder te optimaliseren. Daarnaast is het belangrijk om de prestatie onder moeilijkere omstandigheden te evalueren en om een economische haalbaarheidsstudie te doen.

Acknowledgments

Acknowledgments

Had it not been for the support and encouragement of many people around me, finalizing this PhD study in time would have been impossible. First of all, I would like to extend my sincere thanks to Prof. Dr Ir Johan van Arendonk for his willingness to accept me as his student, being so kind to teach, encourage and guide me through the highest level of education. You have been so special and real human being. I will never forget your word “do not hesitate to ask for support”. You always made time from your extremely busy schedule to read and shape my papers. I would like also to extend my heartfelt thanks to Dr Ir Liesbeth, my daily supervisor. Thank you so much for your honest and direct comments. I have huge respect for that. I always admired your analytical thinking and interesting sometimes tough questions. Lisette, Ada and Monique, thank you so much for your help at various times. Dr Tadelle, my supervisor from ILRI, thank you for facilitating my stay as graduate fellow at ILRI and field activities. Thank you for your encouragement and support. My friends from WUR, Tere, Delelegn, Kip, I thank you so much for good times we had. Mandy, thank you so much for the nice Chinese food and excellent discussions. Linda, thank you so much for allowing me to stay a night with your lovely family. The visit at Koepon farm and the nice dinner after that was an excellent distraction from a busy work. Isa thank you for inviting me to watch a football game. Akle, Melat, Selam, Belay, thank you for the nice time we had together and national dish at various times. I have enjoyed your friendship so much. My friends at EIAR, Alex, Tadi, Adi, Kas, Fitse, thank you so much for your assistance and encouragement. Alexo, Dave, Lishan, Mok, Shewaye, Amsale thank you for your assistance during the on-farm and on-station experiment. My excellent friends, Richo, Yeti, Micky and Eshe thank you so much for making my stay at ILRI interesting and memorable. Yeti and Richo thank you so much for the breakfasts and nice discussions. Micky you were a nice friend. Ato Wubshet and Ato Ameha thank you for your help in facilitating importation process for my experimental chickens. Jasmine thank you so much for reading and improving the language of the general introduction and discussion part of my thesis Our mutual friends, Dessu, Hanicho, Goji, Yodit and many of you at Orbis, I thank you so much for your encouragement. My sisters and family members: Belen, Mimi, Tedi, Etye Almaz, Asefa, Gash Fiseha and the rest thank you so much for your encouragement. My king Aaron, thank you for being the source of my excitement. You are my blessing. I did enjoy your innocent smile and “talk” over Skype. My wife Selam, you have done excellent job by taking care of our son while I was away. I thank you so

much for that and I love you. I dedicate this thesis to my late parents Mrs. Kelemua Muluneh and Mr. Esatu Woldegiorgiss.

Curriculum vitae

About the author

Wondmeneh Esatu Woldegiorgiss was born on the 14th of March 1975 in Addis Ababa, Ethiopia. He studied Animal Production and range land management and received a BSc with distinction from the then Awassa College of Agriculture. After that he first joined the Ministry of Agriculture (MOA) and then the Ethiopian Institute of Agriculture Research (EIAR). He studied poultry production and Animal feeds, an international diploma program at Barneveld College, the Netherlands and got a diploma with outstanding rank. After serving as poultry researcher and later as poultry research coordinator and department head at Debre Zeit agricultural research center of EIAR, he joined Addis Ababa University, faculty of veterinary medicine, department of biomedical sciences to pursue a MSc study. He studied Animal physiology. His thesis that covered the effect of microorganisms on the performance, antibody, and serum cholesterol levels in indigenous and exotic chickens was awarded excellent grade. In March 2011 he started a Ph.D. in the Animal Breeding and Genomics Centre in Wageningen University. He worked on an indigenous chicken improvement program, a joint project between the Ethiopian institute of agricultural Research, International Livestock Resarch Institute and Wageningen University. Currently he is working at the International Livestock Research Institute in the African chicken genetic gains project (ACGG) project as consultant.

Publications

Journal Articles / manuals:

- **E. Wondmeneh**, E. H. van Der Waaij, D. Tadelle, H. M. J. Udo & J. A. M. van Arendonk, 2015.Adoption of exotic chicken breeds by rural poultry keepers in Ethiopia, Acta Agriculturae Scandinavica, Section A — Animal Science, DOI: 10.1080/09064702.2015.1005658.
- Dessie, T., **Esatu, W**., Waaij, L.V., Zegeye, F., Gizaw, S., Mwai, O. and van Arendonk, J. 2013. Village chicken production in the central and western highlands of Ethiopia: Characteristics and strategies for improvement. Nairobi, Kenya: International Livestock Research Institute.
- Mekonnen, G., Pal, M., Tadelle, D., **Wondmeneh**, **E.,** Wondu,M. &Simenew, K., 2013. Sero-prevalence of Newcastle diseases in poultry under backyard systems in Villages of Bishoftu town, Ethiopia. Research Journal of poultry Science, 6:38-42.
- Desalew T., Harpal, S., Ashenafi, M., **Wondmeneh, E.** & Tadelle, D., 2013. Study on productive performances and egg quality traits of exotic chickens under village production system in East Shewa, Ethiopia. African Journal of Agricultural Research. Vol. 8(13), ISSN 1991-637X.
- **Wondmeneh E**., Dawud Ibrahim, Alemayehu Amare and Tadios Habte, 2011. Experiences on Hybrid Chicken scaling up in East and Central Shewa. Ethiopian Institute of Agricultural Research, Addis Ababa. ISBN 978-99944- 53-52-8.
- **Wondmeneh, E**., Getachew, T. & Tadelle, D., 2011. Effect of Effective Microorganisms (EM®) on the Growth Parameters of Fayoumi and Horro Chicken. International Journal of Poultry Science 10 (3): 185-188.
- **Wondmeneh E**., Adey M.&Tadelle, D., 2011 Effect of Effective Microorganisms on Growth Parameters and Serum Cholesterol Levels in Broilers. African Journal of Agricultural Research. 6(16), ISSN 1991-637X.
- **Wondmeneh.** E.**,** I. Dawud, & M. Adey., 2011. Comparative Evaluation of Fertility and Hatchability of Horro, Fayoumi, Lohmann Silver and Potchefstroom Koekoek Breeds of Chicken. Asian Journal of Poultry Science, 5: 124-129. DOI: 10.3923/ajpsai.
- **Wondmeneh E.**, Getachew T.& Tadelle, D., 2011. Immunomodulatory effect of effective microrganisms in Chickens. Research Journal of Immunology, 1994-7909. DOI:10.3924/rij.

- **Wondmeneh, E**. & Seyoum, B., 2010. Small scale commercial Layer & Broiler Packages, Ethiopian Institute of Agricultural Research. ISBN: 978-99944-53-47-4.
- **Wondmeneh, E**., 2006. Poultry Production and Management. Ethiopian institute of Agricultural Research. ISBN 99944-53-04-1.
- Alemu, Y., Negussie D., Fedlu H.&**Wondmeneh, E**., 2005. Performance of Broilers fed on rations with increasing dietary replacement of Noug cake by grass pea. Ethiopian Journal of Agricultural Sciences. Vol. 18 No.2. Pp145-152.
- Reta D., Alemu Y., Negussie D., Fedlu H.&**Wondmeneh, E**., 2005. Marek's disease in Local strains of Ethiopian Chickens under confined Management Regime in central Ethiopia, Revue. Med Vet. 156 (11): 541-546.
- Alemu Y., Negussie D., Taddele D., Fedlu H.&**Wondmeneh, E**., 2005. The Effect of incremental replacement of noug cake (Guiziota abyssinica) in the diet by grass pea on the performance of broilers. Ethiopian Journal of Agricultural Sciences. Vol. 18 No.2. Pp145-152.

Proceeding papers/ oral presentations

- Diriba Geleti, Adugna Tolera, Solomon Mengistu, Ketema Demisse and **Wondmeneh Esatu**, 2012. Improving the Fodder Contribution of Maize-Based Farming Systems in Ethiopia: Approaches and Some Achievements. Proceedings of the Third National Maize Workshop of Ethiopia. Mexico, DF: CIMMYT. Meeting the Challenges of Global Climate Change and Food Security through Innovative Maize Research. In Proceedings of the Third National Maize Workshop of Ethiopia April 18–20, 2011, Addis Ababa, Ethiopia. .
- **Woldegiorgiss, W.E**., Tadelle D., Elisbeth, van der Waaij and Van Arendonk, J.A.M. 2012. Adoption of exotic chickens in the rural areas of Ethiopia: implication for breed introduction. In: Book of Abstracts of the 63rd Annual Meeting of the European Association for Animal Production, 27-31 August 2012.Bratislava, Slovakia.
- **E. Wondmeneh**, E.H, Van der Waaij, D. Tadelle, M. Okeyo, J.A.M Van Arendonk. 2014. A running breeding program for indigenous chickens in Ethiopia: evaluation of success. In Proceedings, 10th World Congress of Genetics Applied to Livestock Production 10th World Congress on Genetics Applied to Livestock Production (WCGALP) held from 17 – 22 August 2014, Vancouver, British Columbia, Canada.
- **E. Wondmeneh**, E.H, Van der Waaij, D. Tadelle, H.M.J. Udo, and J.A.M. Van Arendonk. 2014. Productivity and economic impacts of selected intervention in

the rural poultry production system. In Proceedings, the 6th All Africa Conference on Animal Agriculture held from 27 -30 October, 2014, Nairobi, Kenya.

Training and supervision plan

Training and Supervision Plan

The Basic Package (3 ECTS)	**Year**
WIAS Introduction Course, Wageningen	2013
Course on philosophy in Life sciences, Wageningen	2014
Scientific Exposure (10.9 ECTS)	
International conferences	
5th All Africa Conference on Animal Agriculture, Addis Ababa, Ethiopia	2010
63rd EAAP annual meeting , Bratislava, Slovak Republic	2012
10th World congress on Genetics Applied to Livestock Production, Vancouver, Canada	2014
6th All Africa Conference on Animal Agriculture, Nairobi, Kenya	2014
The 4th National conference on research for development, Dessie, Ethiopia	2015
Seminars and workshops	
International Master class on Hatcheries business development, Addis Ababa, Ethiopia	2012
Presentations	
oral presentation at 63rd EAAP annual meeting, Bratislava, Slovakia	2012
oral presentation at 10th WCGALP, Vancouver, Canada	2014
6th All Africa Conference on Animal Agriculture, Nairobi, Kenya	2014
oral presentation at the 4th conference on research for development, Dessie, Ethiopia	2015
In-Depth Studies (12.6 ECTS)	
Disciplinary and interdisciplinary courses	
Social genetic effects: Theory and genetic analysis, Wageningen	2013
Summer School EGS-ABG, ILRI-Addis, Ethiopia	2013
Introduction to theory and implementation of Genomic Selection, Wageningen	2014
Statistics for the Life Sciences, Wageningen	2013
Advanced Statistics course: Design of Experiments, Wageningen	2014
Genetic improvement of Livestock, Wageningen	2011
Professional skill courses (2.8 ECTS**)**	
Information literacy course, Wageningen	2014

Writing in the sciences: Online Stanford University	2013
Scientific integrity, Wageningen	2013
Research Skills Training (6.3 credits)	
Getting started with ASReml, ABG-WIAS, Wageningen	2012
Preparing own PhD research proposal	2011
Didactic Skills Training (4.2 ECTS)	
Training of trainees on Artificial Insemination in Chickens, Egerton, Kenya	2013
co-supervising 2 MSc students in Ethiopia	2013
co-supervising 1 MSc student in ABG	2014
Management Skills Training (7.4 ECTS)	
Organizing a course on the importance and methods of data collection and management for genetic improvement of chickens	2012
Committee member for Animal society of Ethiopia (2009-2011)	2011
Organizing committee member international conference on All Africa society of Animal production	2010
Education and Training Total (minimum 30, maximum 60 credits)	**44.4**

Colophon

The study in was conducted through a joint project between WUR-EAIR-ILRI and funded by Koepon foundation.

Cover picture by Wondmeneh Esatu

This thesis was printed by GVO drukkers & vormgevers B.V. | Ponsen & Looijen, Ede, the Netherlands.