Understanding farmers' preference for traits of chickens in rural Ethiopia

Abstract

Traditional poultry production plays an irreplaceable role in the sustenance of livelihoods in rural Ethiopia. Ironically, however, much has been done to replace indigenous poultry breeds with exotic genetic resources regardless of the importance producers and consumers attach to attributes of the resources. This study aims at informing policy to establish effective indigenous poultry breeding and conservation programs. Discrete choice experiment (DCE) was employed to generated data. Designing of the DCE involved identification, definition and measurement of attributes of adaptive, productive, and socio-cultural importance considering the multiple functions of village chickens. Random Parameters Logit and the Generalized Multinomial Logit (G-MNL) models were used to estimate taste parameters. Economic values of traits of chickens were estimated using the utility in willingness to pay (WTP) space approach, based on G-MNL model formulation. The results show that important traits of chickens to farmers are mothering ability, diseases resistance, and meat and eggs taste. These findings question the appropriateness, at least in the prevailing production system, of the Ethiopian national government's effort to improve productivity in village poultry by targeting specialized egg layer improved chickens. The findings also suggest that poultry breeding programs aiming to provide readily acceptable breed technology by farmers need to prioritize traits of adaptive importance, and mothering ability, instead of focusing on egg productivity only. The key implication is that the unique qualities of the indigenous poultry breeds need to be carefully identified and prioritized before resorting to those that proved to be successful in different production systems.

Key words: Economic value, choice experiment, WTP-space, poultry, genetic resources

Introduction

Livestock are an important component of the livelihoods of many poor households. Village poultry is livestock farm enterprise that plays significant role in boosting incomes and nutrition for the poorest rural households. This farm enterprise also plays key role in poverty alleviation, food security and the promotion of gender equality in developing countries (Alders and Pym, 2009; Bagnol, 2009; FAO, 2010a; Besbes *et al.*, 2012; Lindahl *et al.*, 2018). For many, home grown chickens and eggs are their only source of high-quality protein. Nearly all families in developing countries at the village level, including landless and the poorest, are owners of poultry (Wong *et al.*, 2017). In Ethiopia, particularly, poultry[1] production is an integral part of the mixed crop-livestock farming system practiced by most rural households. The total poultry population in the country is estimated to be 50.38 million out of which 96.9%, 2.56 %, 0.54% are indigenous, exotic and hybrid, respectively (CSA, 2013).

Village poultry production typically uses indigenous genetic resources, which are adapted to a specific harsh environment (FAO, 2010a; Wong *et al.*, 2017; Lindahl *et al.*, 2018). This is mainly why indigenous chickens in Ethiopia provide major opportunities for increased protein supply and income for smallholders. Village poultry also play a supplementary role in relation to other crop-livestock activities by providing cash. However, indigenous chicken breeds are claimed to be slow grower and poor producer of small sized egg (Wong *et al.*, 2017). Despite these disadvantages, indigenous birds are also characterized by many advantages such as good egg and meat flavor, good brooding and natural incubation capacity, high dressing percentages, and they require low cost with little care for production (Dana *et al.*, 2010; FAO, 2010a; Besbes *et al.*, 2012; Wong *et al.*, 2017). They are, therefore, well suited to the very limited input that poor producers can provide.

[1] In Ethiopia, poultry is typically chicken.

Development policy interventions in the past focused on introduction of exotic breeds of chickens. Those interventions mainly aimed to enhance productivity in a village production environment. However, the purposes of raising livestock go beyond their output functions and include other significant socio-economic and socio-cultural roles (Drucker and Anderson, 2004; FAO, 2010b). Multi-functionality and resilience are particularly important for many of the poor livestock farmers (Anderson, 2003; Kassie *et al.*, 2009; Wong *et al.*, 2017). Village poultry are often utilized for several purposes simultaneously (FAO, 2010a). Poultry in Ethiopia, especially in villages, are kept for a multiplicity of reasons. In addition to yielding animal protein and providing a surplus for sale to generate cash, they are reared for social and cultural reasons. Hence, the genetic resource base of indigenous chickens is crucial to meet the multiple production objectives of households.

Introduction of exotic chicken breeds to smallholder farmers have been undertaken for decades in order to improve productivity of poultry subsector in Ethiopia. However, increased productivity of the village poultry subsector by using exotic breeds has failed to become sustainable (Teklewold *et al.*, 2006; Dana *et al.*, 2010). Exotic breeds have not adapted well to harsh rural production environments. The extensive and unplanned distribution of exotic chicken breeds has also resulted in dilution of the indigenous genetic stock in developing countries. If this trend continues, it could result in a loss of potentially valuable genetic diversity of the indigenous chickens (Faustin *et al.*, 2010). This is the case in Ethiopia where there is a danger of losing valuable adaptive and production traits of indigenous chickens due to unplanned and indiscriminate distribution of exotic chicken (Wilson, 2010).

A possible intervention to improve village poultry production is to target indigenous breeds based on needs and preferences of smallholder farmers. Wilson (2010) argued that the oft-preferred route to higher output and productivity is to improve the local genetics followed by changes in management. This route to higher village poultry productivity requires diverse indigenous chicken gene pools. There exists a diverse indigenous chicken genetic resource base in Africa, and particularly in Ethiopia. A recent study by Psifidi *et al.* (2016) confirmed existence of genetic diversity and supports the feasibility of genetic improvement for enhanced antibody response, resistance to parasitism and productivity within and across indigenous chicken ecotypes in Ethiopia.

Well-thought-out plans for management of indigenous chicken genetic resources and breeding program are also crucial to improve productivity in village chickens using the local gene pools. The management of animal genetic resources requires many decisions that would be easier to make if information on the economic value of populations, traits and processes were available (Scarpa *et al.*, 2003). Markets provide important information about economic values and preference for traded goods and services. Many of the benefits derived from the existence of traits of indigenous chicken genetic resources are, however, not transacted in a market. Valuation studies for animal genetic resources are of interest in those contexts. Economic valuation of animal genetic resources (AnGR) is essential to guide decision makers, providing rational bases for priority setting for breed improvement programs and for conservation programs (Roosen *et al.*, 2005). In Ethiopia, however, there is no context specific empirical evidence on preferences and valuation of traits of indigenous chickens to make informed decision on management of chicken genetic resources and breeding programs. This paper addresses this evidence gap building on recent advancements in preference and valuation methodologies that are yet not applied in AnGR valuation studies.

Revealed and stated preference-based techniques are the two viable approaches to value non-marketed goods, like adaptive traits of chickens. Stated preference-based valuation is widely used in identifying preferred traits of livestock and economic valuation of animal genetic resources. Since its application in valuation of the hairless creole pigs genetic resources in Mexico by Scarpa *et al.* (2003), studies commonly employ discrete choice experiment (DCE) method in AnGR valuations. Studies made by Ouma *et al.* (2007), Zander and Drucker (2008) and Kassie *et al.* (2009), for example, used choice experiment data and random parameter logit model to examine farmers' preferences for traits of cattle in East Africa. Faustin *et al.* (2010) used the same approach to investigate preferred traits of chicken in rural Benin. More recent studies also used the DCE approach in valuation of animal genetic resources and conservation benefits (see Tada *et al.*, 2013; Zander *et al.*, 2013; Ragkos and Abas, 2015; Woldu *et al.*, 2016).

The objective of this study is to identify preferred traits of indigenous chickens and to derive the value of these traits to farmers in rural Ethiopia where production system is semi-subsistent. We employ the discrete choice experiment and state-of-the-art econometric models to estimate economic value of productive and adaptive traits of chicken. This study, therefore, informs the breeding programs for improvement of indigenous chicken and management of genetic pool for future use in Ethiopia.

Methods

Discrete Choice experiment: Design and Application

Discrete Choice experiment (DCE) is an increasingly used stated preference method for non-market valuation. DCE method has a theoretical foundation in Lancastrian consumer theory

(Lancaster, 1966), which assumes that agents derive utility from characteristics of the goods instead of goods as a direct object of utility, and an econometric base in random utility theory (Luce, 1959; McFadden, 1974) as the random utility framework in dichotomous choice contingent valuation models (Hanemann, 1984). DCE arose from conjoint analysis but differs from this method in that individuals are asked to choose from alternative bundles of attributes instead of ranking them. Thus, DCE is consistent with random utility theory (Adamowicz *et al.*, 1998).

Unlike contingent valuation method, DCE enables estimation of values of attributes and provides the opportunity to identify marginal values of attributes rather than value of the good as a whole only (Hanley *et al.*, 1998a; Bateman *et al.*, 2002). The DCE approach is essentially a structured method of data generation (Hanley *et al.*, 1998a) and hence, it is a significant improvement over other popular stated preference based methods such as contingent valuation. Originally, DCE has been used in the transport economics (see Hensher and Truong, 1984) and marketing literature (see Louviere and Woodworth, 1983), but increasingly applied in other research areas, including: environment (Drake, 1992; Adamowicz *et al.*, 1998; Hanley *et al.*, 1998b; Danny, 2007); food safety and quality (Tonsor *et al.*, 2005; Loureiro and Umberger, 2007); and other related disciplines. There is also a growing literature in application of DCE in valuation of animal and plant genetic resources (see Scarpa *et al.*, 2003; Birol *et al.*, 2006; Ouma *et al.*, 2007; Eric *et al.*, 2008; Roessler *et al.*, 2008; Kassie *et al.*, 2009; Byrne *et al.*, 2012).

Attribute identification and DCE designing

Designing a DCE requires careful definition of the attributes and attribute level determination as well as generation of statistically efficient and practically manageable DCE design (Hanley *et al.*, 1998b; Kassie *et al.*, 2009). Hensher *et al.* (2005) also advises that sufficient time is spent in identifying and refining attributes, attribute levels and attribute labels to be used before proceeding to the formal design of DCE. This study involved a series of procedures to determine attributes of chicken and attribute levels used in DCE design. Participatory rural appraisal (PRA) and informal study and review of existing literature were used. PRA was conducted with local farmers to identify potential attributes of chicken and determine attribute levels in two local areas of Horro district. The PRA largely involved ranking exercises to identify traits and trait level that are relevant for the DCE. Discussants were asked to list attributes of chicken they would consider when buying poultry[2] and to rank them according to their importance. The informal study was very brief and involved local market observations and informal talk with individual farmers at their home. This aimed to have a better understanding of traits of chickens that farmers would focus on during usual transactions. Findings from the PRA and informal study was supplemented by a study on chicken production objectives and preferences using PRA by (Dana *et al.*, 2010). The attributes, attribute levels, and attribute level labels used to describe each attribute used in DCE were determined after thorough discussion and in consultation with poultry breeders and geneticists. Additionally, two focus group discussions were conducted in October 2012 in two villages of Horro to further examine how farmers would understand the levels of traits of birds we considered in our choice experiment.

The final attributes considered in designing of the DCE included traits with cultural significance, productive traits and adaptive traits. Plumage color is a trait of poultry with cultural significance. Three attribute levels were used for this trait; predominantly white, predominantly black and predominantly red. During the focus group discussion, we learned

[2] In Ethiopia, poultry is typically chicken.

that farmers had a range of views regarding plumage color of chicken. While predominantly black plumage color is disliked by some relating to ceremonial use of chicken, others believed chicken with black plumage color were less vulnerable to predators compared with birds with white plumage color. Productive traits considered in the DCE design were: number of eggs per clutch; body size; and mothering ability. For number of egg per clutch, typical values for the minimum, average, and maximum number of eggs per clutch that a given hen would normally lay was used as trait levels. Trait levels for 'body size' was presented using the usual local expression and had three levels; small, medium, and large. Mothering ability is the capacity to incubate, hatch an optimum proportion of eggs set for hatching and to look after chicks. From the two rounds of focus group discussions, we learned that farmers would normally set a proportion of laid eggs for hatching. On average farmers would set twelve eggs for hatching by a given hen at a time and they would either eat or sell the remaining eggs. This was due to the natural limits on the hen's ability to incubate beyond an optimal number of eggs, any more would mean some eggs remain unhatched and infertile. Accordingly, 'mothering ability' had three levels with maximum number of eggs set for hatching twelve; 'Hatch and raise 4 chicks from 12 eggs', 'Hatch and raise 8 chicks from 12 eggs', and 'Hatch and raise 12 chicks from 12 eggs". Diseases resistance is an adaptive trait considered in the DCE design. This had two trait levels; 'rarely gets sick', 'often gets sick and may die'. Meat and eggs taste was also included in the experiment as farmers realized differences in taste of meat and egg between local and exotic/ cross breed chicken. It had two attribute levels; poor and good. We used three levels for price of chicken; ETB 40, ETB 55 and ETB 70. These are averages of minimum, average and maximum price of mature chickens obtained during the focus group discussions and local market observation by the researchers. Throughout all profiles, the age of the hypothetical chickens was uniformly set at the age of five to six months, which is average maturity age in that specific area. The summary of attribute and attribute levels used in this DCE is given in Table 1.

(Table 1 about here!)

We used SAS software macros to combine identified attributes and attribute levels to generate generic chicken profiles where breeds of poultry were not included. There are 972 (i.e. 3^5*2^2) possible ways to combine the selected attributes and attribute levels to generate profiles. However, full-factorial design like this is too cost-prohibitive, tedious and cognitively demanding for respondents to make meaningful choice for most practical situations (see also Kuhfeld, 2010). Consequently, fractional factorial experimental design which focuses on orthogonality is commonly used in resource valuation studies (Rose and Bliemer, 2004). Therefore, an orthogonal fractional-factorial experimental design (Hensher *et al.*, 2005; Kuhfeld, 2010) was used to generate profiles based on the attributes and attribute levels in this study. The design was obtained based on common measures of design efficiency, D-efficiency and A-efficiency. D-Efficiency maximizes the determinant of the information matrix, while A-Efficiency attempts to minimize the sum of the variances of estimated coefficients (Kuhfeld, 2010). The final design had an optimal combination of high D-Efficiency, 99.64, and A-Efficiency, 99.7. The design generated 36 chicken profiles, which was too many judgments for an individual respondent to make. Therefore, these profiles were randomly grouped into 18 chicken choice sets, each choice sets having two profiles, and blocked into three: hence each respondent could be presented with six choice sets. An opt-out option was included into the choice sets to avoid forced choice so that the DCE was consistent with utility maximization and demand theory (Bateman *et al.*, 2002). Accordingly, respondents were presented with six choice sets, each containing three alternatives: two chicken profile and opt-out option. Choice sets were supplemented by visual aid (pictures) to help communicate information about attribute levels.

The survey

The formal survey was conducted in Horro district of Ethiopia as part of a larger project working on reducing the impact of infectious diseases on village poultry production in Ethiopia. This study was approved by the University of Liverpool Committee on Research Ethics (reference-VREC76). Horro district is located at about 315 km west from Addis Ababa. The predominant agricultural practice in this area is a mixed crop-livestock farming system and livestock production is an integral part of the semi-subsistent farming. Farm activity in Horro district is rain-fed and staple crops occupy the farmland during the cropping season which serves as grazing land in dry season. The district receives an average annual rainfall of 1,685 mm (ranging from 1,300 to 1,800 mm) and the annual average temperature is 19 °C (ranging from 14 to 24 °C).

The formal survey was conducted in February and March 2013. The survey was conducted by well-trained and experienced enumerators who were postgraduate students from Haramaya University and Addis Ababa University with keen interest to learn DCE under close supervision of the researchers. The enumerators had good understanding of livestock development and extension. Training of enumerators included the principles of DCE, introduction to the study, and simulated interviews among enumerators. Prior to the formal survey, the questionnaire was extensively piloted and pre-tested with individuals and in focus group discussions during early January 2013.

The pilot survey for the DCE showed that communicating attribute and attribute levels was workable and that respondents could complete the choice exercise at ease. Following the feedback from pilot survey, only minor changes were made. The order of the questionnaire presentation was re-arranged by bringing some demographic questions to the beginning to help get respondent attention for the choice task. The DCE household survey was carried out in four '*Gandas*', lowest administrative unit in government structure consisting of several villages, selected by the project from two different market channels in the district. Sample respondents were randomly selected from the list of households provided by agricultural development agents. This DCE survey was administered on 450 farmers drawn by employing sampling with probability proportional to the population size of each *Ganda*.

Econometric model

The random utility framework is the theoretical basis for integrating behavior with economic valuation in the DCE. The basic assumption of random utility theory is based on the premise that agents behave rationally choosing the alternative that would yield the highest utility. Conditional logit (McFadden, 1974) and Random parameter logit (RPL) (McFadden and Train, 2000; Hensher and Greene, 2003) models are often used to estimate preference weights attached to attributes. The conditional logit, however, assumes that the taste parameters are homogeneous across respondents. It is also based on the more restrictive assumption of independence of irrelevant alternatives (IIA) (Hensher *et al.*, 2005). The RPL relaxes the IIA assumption. It is a highly flexible and computationally practical approach to discrete response analysis model that can approximate all random utility models (McFadden and Train, 2000; Train, 2003). In RPL, the utility of person n from chicken profile j in choice situation t is

$$U_{njt} = \beta'_n x_{njt} + \epsilon_{njt} \qquad (1)$$

Where, x_{njt} is a vector of observed variables related to chicken traits and respondent's socio-economic characteristics, β_n is a vector of coefficients of these variables for each n representing that person's taste, ϵ_{njt} is an unobserved random term that is independent and identically distributed (iid) extreme value.

One key aspect of choice analysis is capturing heterogeneity among respondents to a DCE, differences in taste and differences in scale variation. Though the RPL accounts for taste heterogeneity, the scale is generally normalized to one assuming that all individuals respond to the choice experiment with identical error variances. However, consumer behavior may depend not only on heterogeneity in preferences but also on differences in the scale of the idiosyncratic error term (Louviere *et al.*, 2002; Train and Weeks, 2005; Louviere and Eagle, 2006; Greene and Hensher, 2010). As a result of these growing evidences, Fiebig *et al.* (2010) have developed a generalized multinomial logit model (G-MNL) that is supposed to take taste and scale heterogeneity into account. In G-MNL framework, the individual utility is specified as:

$$U_{njt} = [\sigma_n\beta + \gamma\eta_n + (1-\gamma)\sigma_n\eta_n]x_{njt} + \epsilon_{njt} \qquad (2)$$

In this model, the scaling term, σ_n, is no longer assumed to be one for identification and it scales vector of utility weights up or down. The G-MNL framework nests several different well-known choice models as special cases when the preference weight, β_n, is specified as

$$\beta_n = \sigma_n\beta + \gamma\eta_n + (1-\gamma)\sigma_n\eta_n \qquad (3)$$

Where, $\gamma \in [0,1]$ is parameter that determines the level of interaction between σ_n and η_n.

The elements of β_n may deviate from the sample mean β by η_n, which is a random variable with zero mean and standard deviation to be estimated. η_n serves to account for random heterogeneity in preferences. Following Fiebig *et al.* (2010), σ_n could follow a log-normal distribution with mean 1 and standard deviation, τ. This parameter, τ , captures the scale heterogeneity across respondents. The G-MNL model is estimated by maximum simulated likelihood (Greene and Hensher, 2010; Greene, 2012). Let $y_{njt} = 1$ if person n chooses option j at choice occasion t, and 0 otherwise. Then simulated probability of observing person n choosing sequence of choices $\{y_{njt}\}_{t=1}^{T}$ using the G-MNL utility weight specification (Fiebig *et al.*, 2010) is

$$\hat{P}_n = \frac{1}{D}\sum_{d=1}^{D}\prod_{t}\prod_{j}\left(\frac{\exp(\sigma^d\beta+\gamma\eta^d+(1-\gamma)\sigma^d\eta^d)x_{njt}}{\sum_{k=1}^{J}\exp(\sigma^d\beta+\gamma\eta^d+(1-\gamma)\sigma^d\eta^d)x_{kjt}}\right)^{y_{njt}}, \quad (4)$$

Where, $\sigma^d = \exp\left(\bar{\sigma} + \tau\varepsilon_0^d\right)$, η^d is K-vector distributed $\text{MVN}(0, \Sigma)$ whereas ε_0^d a $N(0,1)$ scalar. The simulation involves drawing $\{\eta^d\}$ and $\{\varepsilon_0^d\}$ for $d = 1,2, \dots, D$ number of draws.

Another important part of this study is estimation of willingness to pay for the traits and trait levels in the DCE. Willingness to pay for attributes in valuation studies could be estimated using two approaches; the preference space and WTP space. Studies have shown that models in WTP space provide WTP distributions with a lower incidence of extreme values than models in preference space (see Train and Weeks, 2005; Scarpa *et al.*, 2008). The WTP-space approach provides more behaviorally plausible willingness to pay estimates and has also become appealing alternative (Train and Weeks, 2005; Scarpa *et al.*, 2008; Fiebig *et al.*, 2010; Hensher and Greene, 2011; Greene, 2012). Therefore, the WTP space approach was applied in this study to obtain reliable WTP estimates of chicken trait.

As suggested by Greene and Hensher (2010), the G-MNL model can be reparametrized to estimate taste parameters in WTP space. The utility function as separable in price, P, and non-price, X , attribute can be written as:

$$U_{njt} = \sigma_n\left(-\beta_{p,n}P + \beta'_n X_{njt}\right) + [\gamma\eta_n + (1-\gamma)\sigma_n\eta_n]X_{njt} + \epsilon_{njt} \quad (5)$$

$$U_{njt} = \sigma_n\beta_{p,n}\left(-P + \left(\frac{\beta'_n}{\beta_{p,n}}\right)X_{njt}\right) + [\gamma\eta_n + (1-\gamma)\sigma_n\eta_n]X_{njt} + \epsilon_{njt} \quad (6)$$

Normalizing the price coefficient, $\beta_{p,n}$, of –p to 1 yields the WTP space specification:

$$U_{njt} = \sigma_n\left(-P + (\beta_n'^{*})X_{njt}\right) + [\gamma\eta_n + (1-\gamma)\sigma_n\eta_n]X_{njt} + \epsilon_{njt} \quad (7)$$

where, $\beta_n'^{*}$ directly gives the individual-specific WTP estimates. In this formulation, WTP distribution can be specified directly and the model produces generally reasonable estimates of willingness to pay for individuals in the sample (Train and Weeks, 2005; Greene and Hensher, 2010; Hensher and Greene, 2011). This WTP estimates, or implicit price, for changes in an attribute provides a measure of the relative importance that respondents attach to attributes within the chicken profiles.

Result and discussion

Farmers' characteristics

Farmers' basic demographic characteristics and the codes used in the random parameter logit estimation are reported in Table 2, below. The average age of the respondent farmers was about 42 years. The mean family size was more than 6 persons and ranges from 2 to 16 persons. On average, farmers had one child below five years and the average number of children below 17 was more than 3 in the research sample. Data was also collected on religion of the respondent, as religion is believed to influence farmers' preference for traits of chickens. More than 55% of responding farmers were followers of Ethiopian Orthodox Christianity, about 38% of them were evangelical Christians, and the remaining were followers of other religions (including traditional and Muslim). About 38% of farmers had attended elementary school and 16% of them had attended high school and 12% of them could read and write; however, a significant proportion of farmers (31%) had no any form of education. About 80% of respondents were male farmers and 20% were female. This large disparity was observed because we targeted head of the household for whom the list of farmers was available for sampling.

(Table 2 about here!)

Empirical result

Attributes of chickens and attribute levels together with codes used in model estimation are given in Table 1. Following Hensher *et al.* (2005), effects coding was used for DCE traits to measure nonlinear effects in the trait levels to avoid confounding in the grand mean. In both RPL and G-MNL models, the utility parameters for all attributes were entered as random assuming normal distributions. The models were estimated using NLOGIT version 5 and estimates were obtained utilizing 200 Halton draws for the simulations. The simulated maximum likelihood estimates for both RPL and G-MNL models are reported in Table 3.

The estimation results of both models are broadly comparable in terms of the sign and statistical significance of the coefficients of parameters. The goodness-of-fit measures for both, RPL and G-MNL, models provided similar result with very slight difference. The two models were highly statistically significant, ($x^2_{24} = 2581.7$ and p<0.001 for the RPL) and ($x^2_{25} = 2581.3$ and p<0.001 for the G-MNL). The Akaike Information Criterion (AIC) and pseudo R^2 obtained from the two models are also comparable (Table 3). The pseudo R^2 values also suggest the goodness-of-fit of the models are adequate. Discussion of results will be based on G-MNL as results from the two models are comparable and the WTP-space result reported in Table 4 is also estimated based on the G-MNL model. The model results show that all traits were highly significant determinants of choice and the signs of all attributes were as expected. The constant variable in the model result represents the opt-out option in the alternatives provided for choice. It had negative and statistically significant mean coefficient indicating respondents preferred to choose from the two alternatives associated with various trait levels instead of opting out.

The coefficient of price, the monetary attribute, was significant and negative, as expected. This implied that it is unlikely that that respondents preferred and chose chicken profiles with higher prices. Farmers preferred chickens with predominantly white plumage color, compared with predominantly red plumage colored chicken, as indicated by positive and statistically significant coefficient. The predominantly black plumage color was, however, not preferred as indicated by negative and significant coefficient. As this trait is mainly of cultural importance, the explanation may be the fact that farmers in the area use poultry for ceremonial purpose during various festive periods where plumage color plays important role. Chickens with white plumage color are preferred during most holidays (example, for New Year), and chickens with predominantly black plumage color are generally believed to cause misfortune. This result was consistent with a previous study that analyzed preference for chicken traits in African (Faustin *et al.*, 2010).

The trait 'eggs per clutch' had a positive mean parameter indicating farmers' preference for hens that lay larger numbers of eggs per clutch, which is not unexpected. Likewise, the trait 'large body size' had positive and significant coefficient. This suggests farmers preferred chickens with larger body size compared with smaller ones. Similarly, the traits 'good mothering ability' and 'good meat and egg taste' had positive coefficients and were significant indicating farmers' preference for these attributes. Chickens that were characterized by poor mothering ability were not preferred, as indicated by negative and significant coefficients of the respective traits. The result also revealed that farmers prefer chickens with good disease resistance, as indicated by the positive and significant coefficient. Mothering ability, disease resistance and meat and egg taste were typical attributes of indigenous breeds of poultry which previous attempts to enhance productivity of village poultry sector, through distribution of exotic chickens, in Ethiopia have failed to consider.

(Table 3 about here!)

The magnitudes of parameter estimates revealed that good mothering ability, the ability to hatch the optimum proportion of eggs set for hatching and to look after the chicks, is the most important traits in chicken profile choice among rural farmers, while number of eggs per clutch was the least. This finding was interestingly contrary to the previous efforts by the government of Ethiopia to enhance village poultry productivity by introducing improved poultry breeds which mainly specialize in egg laying. This is likely due to the lack of market for eggs and poor linkage to urban markets in these areas. Hence, farmers in rural Ethiopia keep poultry primarily for local sale of live birds targeting various national and religious festive periods (New Year, Christmas, and Easter). Under the prevailing production system farmers completely rely on mother hens to incubate and hatch eggs, in contrast to the situation for commercial poultry farms. Therefore, farmers are rational in their choice given prevailing production system and poor market in rural Ethiopia. The weight attached to mothering ability which is an important trait of the indigenous chicken, may imply farmers' interest in preserving the local genetic pool, though the risk of losing this genetic resource is always there due to poorly planned interventions.

Disease resistance was also found to be very important, second only to white plumage color. Previous studies on preference for traits of chickens and other livestock species similarly report the importance of disease resistance (see Ouma *et al.*, 2007; Kassie *et al.*, 2009; Faustin *et al.*, 2010). The importance of the trait ‘disease resistance’ may be a consequence of the economic importance of poultry diseases in rural Ethiopia and lack of poultry health services. The magnitude of the parameter for white plumage color indicates that the cultural significance of plumage color which is even more pronounced than trait of productive importance. This finding is consistent with previous studies in African countries including Benin, Somalia, Cameroon and in Zambia (Guèye, 2000; Faustin *et al.*, 2010). Meat and egg taste was also identified as a very important influential trait in chicken profile choice – again more so than the productive traits (eggs per clutch and body weight). Guèye (2000), from a review of studies in Senegal and Nigeria, also reported that eggs and chicken meat from indigenous stocks are preferred by African consumers to those derived from commercial flocks of imported stocks. Good meat and egg taste is mainly attributes of indigenous chickens and it is recognized in the study area (Dana *et al.*, 2010). Therefore, preference for good meat and egg taste suggests an opportunity for improvement of village poultry productivity based on indigenous gene pool and conservation programs by participating local farmers.

Preference heterogeneity was examined based on the mean and standard deviations of the random parameters and mean coefficients of the interaction terms. Random parameters in the model were interacted with socio-economic variables (Table 2) to investigate the possible sources of heterogeneity around the mean. Although all possible interactions were tried in preliminary estimation, only significant ones were used in the final model estimation and the results are reported in Table 3. Statistically significant estimates for derived standard deviations for random parameters suggest existence of heterogeneity in the parameter estimates over the sample population. The estimated means and standard deviations of each of the random taste parameters gives information about the share of the population that places positive values or negative values on the respective attributes or attribute levels (Train, 2003). In our estimation result, the standard deviation of ‘predominantly white plumage color’, ‘large body size’, and ‘poor mothering ability’ had statistically significant standard deviations. The attribute ‘predominantly white plumage color’ was statistically significant with mean parameter of 0.472 and standard deviation of 1.336, such that 64% of respondents preferred chicken profiles with predominantly white plumage color while 36% of the respondents preferred chickens with predominantly red plumage color. The trait ‘large body size’ had mean 0. 388 and standard deviation 1.787. This implied 59% of the respondents preferred chicken profiles with large body size.

Chickens with predominantly white plumage color were not preferred by followers of the Orthodox religion. This could be due to the cultural significance of chickens with predominantly red plumage color (the base attribute level) during various festive seasons among respondents with Orthodox religious background. Parameter estimate for interaction variable between ‘good meat and egg taste’ and ‘education level’ is positive and significant. This implies as education level increases, preference for chickens with ‘good meat and egg taste’ increases. One possible explanation for this finding may be that more educated farmers could realize the preference for good meat and egg taste in the market and hence they preferred to choose chicken with good meat and egg taste for reproduction. The model also revealed that, as respondent age increases, preference for diseases resistant chickens increases. Animal health services in rural Ethiopia are very limited and older farmers may not have had experience of poultry health service use. It is also likely that older farmers recognize the limitations of these services, when available, and may therefore place greater value on disease resistant chickens, adapted to the local environment.

Willingness to pay estimates for chicken traits

Willingness to pay (WTP) estimates represent the marginal rate of substitution between prices and traits levels of the chicken profiles used in the DCE. The coefficients of attributes in WTP-space provide estimates of mean WTP for each trait levels. The WTP-space model was estimated based on the G-MNL formulation (equation 7). WTP estimates from the WTP-space model result are presented in Table 4. The pseudo R^2 is 0.411 suggesting the goodness-of-fit of the model is adequate. The model result also provided reliable WTP estimates for traits of chickens given the price levels used in the DCE and the prevailing market price of chicken in the study area during the survey. Trait level determination for price and model estimations were carefully conducted using the recent development in WTP estimations. However, the absolute magnitudes of WTP still needs to be interpreted carefully due to the volatility of chicken prices based on different seasons of the year, as price increases over the festive periods or following the wet season when diseases outbreak is highly likely. In this study, therefore, marginal WTP for changes in an attribute levels provides a measure of the relative importance that respondents attach to attributes within the chicken profiles.

(Table 4 about here!)

Estimates of the willingness to pay for trait levels indicated that farmers attach the highest value to the trait ‘good mothering ability’ of chickens. Chickens with good mothering ability fetched a welfare gain of ETB 38.83, and the welfare loss from chickens with poor mothering ability was about ETB 50.5. This finding is consistent with Faustin *et al.* (2010), who found that better mothering ability was highest valued trait of chickens in Benin. The WTP values estimates also show that the implicit price of ‘disease resistance’ is higher than all other traits of chicken, next to 'good mothering ability'. The WTP for disease resistant chicken was ETB 22.04 higher than susceptible ones. Previous animal genetic resources valuation studies, in developing countries also reported similar results (see Ouma *et al.*, 2007; Kassie *et al.*, 2009; Faustin *et al.*, 2010). Farmers' willingness to pay higher for diseases resistant chickens is justifiable given chicken infectious diseases are widespread and animal health service is very limited in Ethiopia (Bettridge *et al.*, 2014; Terfa *et al.*, 2018). The WTP estimates also revealed that farmers are willing to pay a premium that is ETB 15.34 for chickens that had good meat and egg taste, compared with poor meat and egg taste, everything else kept constant. The implicit price attached to the trait level 'good meat and egg taste' is even higher than the values attached to productive traits of chickens, body size and number of eggs per clutch. The value that farmers attach to 'good meat and egg taste' is 2.55 times the value attached to 'eggs per clutch' and 1.6 time the value attached to large body size. The WTP-Space result also revealed heterogeneity in the mean willingness to pay estimates with respect diseases resistance and plumage color.

Generally, farmers were willing to pay way more for good mothering ability, diseases resistant and good meat and egg taste, but less for the traits body size and egg per clutch. Based on mean WTP estimates, farmers' preference for traits of the resource in question can generally be ordered from most preferred to least preferred. For the traits of chickens, this order of prioritization is: good mothering ability; diseases resistance; good meat and egg taste, large body size, larger number of eggs per clutch, and white plumage color. However, it should be noted that this study was conducted in a semi-subsistent farming system where there is limited market access for eggs and chicken. In areas where there are adequate markets and well-established poultry value chains involving smallholder farmers, different ranks for these attributes could be obtained. Under similar production system, however, the findings reported in this paper are consistent with previous studies (Faustin *et al.*, 2010)

Conclusion

The government of Ethiopia and international research systems run different programs to improve village poultry productivity, mostly by introducing improved chickens. It is important to understand if the aims of these programs are in line with farmers' preferences in the prevailing production and market system. This is especially so as the programs could lead to loss of indigenous genetic resources that are valuable to farmers. This study aims to understand farmers' preferences for traits of chicken in rural areas of Ethiopia, in semi-subsistent mixed farming system. This study analyzed preferences for indigenous poultry traits elicited using discrete choice experiment. The study used RPL and G-MNL models to estimate the taste parameters. The WTP-space, based on G-MNL model formulation, was used to estimate mean WTP for traits of chicken.

The results of the study revealed that in this semi-subsistent farming system, where chickens are kept for multiple purposes under low/no input, adaptive traits are of considerable importance to farmers. Diseases resistance attracted the highest mean WTP implying the economic importance of adaptive traits of chickens. In Ethiopia, there exists diverse indigenous chicken gene pool and genetic improvement for enhanced antibody response, resistance to parasitism and productivity within and across chicken ecotypes is achievable (Psifidi *et al.*, 2016). Therefore, an alternative way to improve village poultry productivity is to target locally adaptable genetic resources that farmers value the most. This approach could potentially provide improved chickens that are readily acceptable by farmers and facilitates conservation of locally adaptable chicken genetic resources.

The trait mothering ability, which entailed high production performance, measured by ability to hatch an optimum proportion of incubated eggs and looking after chicks, was ranked above the traits of egg production performance and body size of chickens. This is likely because poultry keeping in rural Ethiopia is semi-subsistence oriented; farmers have limited access to markets and hence place less value on egg production. This finding is contrary to the Ethiopian government's ongoing efforts to enhance productivity of village poultry by introducing commercial and specialized egg layer improved chickens. This effort is likely to be driven by a traditional economic analysis that focuses on egg and meat production with little or no attention to the adaptive importance of chickens. This suggests the need to revisit the national strategy to enhance village poultry productivity and rural livelihood. It is important to understand farmers' preferences and production objectives in the prevailing production system to achieve increased productivity in village poultry. Good mothering ability, a preferred trait of chickens by farmers, is characteristic of indigenous chicken in rural Ethiopia. Therefore, future breeding programs could achieve better chicken productivity and wider adoption of new breed technologies by targeting indigenous chicken genetic resources. Noticeably, meat and egg taste, a typical attribute of indigenous chicken, was also among the highly preferred and valued traits of chicken. This is an incentive for farmers to keep indigenous chicken and an opportunity to preserve local genetic pool at farm level. Our results suggest that in the prevailing production system, future breeding programs need to consider indigenous genetic resource, targeting the preferred and most valued traits of chicken, to enhance village poultry productivity. This approach considers the preference and production objectives of farmers and could be widely adoptable by farmers. Therefore, this approach could help achieve the twin goals of enhanced productivity and conservation of adaptable local chicken gene pool. An alternative to local genetic resources is introduction of chicken strains that are adaptable to the tropics and resemble the local chicken traits that are preferred and highly valued by farmers.

The findings also revealed the existence of heterogeneity in preferences for the attributes and mean WTP. Farmers' religious background, age, and education levels were found to be a source of preference heterogeneity. Chickens with predominantly white plumage color were not preferred by followers of the Ethiopian Orthodox Christianity, reflecting the socio-cultural significance of chicken with predominantly red plumage color. Disease resistant chickens were preferred by older respondents and this could be because older farmers have more risk aversive behavior and lack of access to animal health services. Similarly, farmers with higher education level preferred chicken profiles with good meat and egg taste. Good meat and egg taste is mainly attributes of indigenous chickens in the study area (Dana *et al.*, 2010). This suggests that educated farmers realize preferences for local chickens in the market.

This research identified the most preferred and valued traits of chickens to smallholder farmers. These findings give important insight into the reason for the unsuccessful adoption of improved chickens, despite long term effort made by government to introduce such birds, mainly aimed at enhancing egg production in rural Ethiopia. These results also have important implications for the need to better understand smallholder farmers' preferences, as they have multiple production objectives in the prevailing production and marketing system. Hence, an effective and sustainable breeding program that aims to improve rural livelihood through enhancing village poultry productivity needs to maintain traits of chickens important to smallholder farmers. Specifically, traits of chickens like disease resistance, mothering ability, meat and egg taste, body size and eggs per clutch should be prioritized in effective chicken breeding program.

On the other hand, the risk of loss of the indigenous chicken genetic pool necessitates a conservation program to preserve economically important genetic resources. Therefore, for an effective and successful breeding and conservation programs, these identified traits of chickens need to be maintained.

References

Adamowicz, W., Boxall, P., Williams, M., Louviere, J., 1998. Stated preference approaches for measuring passive use values: choice experiments and contingent valuation. Amer. J. Agr. Econ. 80, 64-75.

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

Anderson, S., 2003. Animal genetic resources and sustainable livelihoods. Ecolog. Econ. 45, 331-339.

Bagnol, B., 2009. Gender issues in small-scale family poultry production: experiences with Newcastle Disease and Highly Pathogenic Avian Influenza control. World's poultry science journal 65, 231-240.

Bateman, I.J., Carson, R.T., Day, B., Hanemann, M., Hanley, N., Hett, T., Jones-Lee, M., Loomes, G., Mourato, S., Özdemiroḡlu, E., Pearce, D.W., Sugden, R., Swanson, J., 2002. Economic valuation with stated preference techniques: a manual. Edward Elgar Publishing Ltd Cheltenham, UK.

Besbes, B., Thieme, O., Rota, A., Guèye, E., Alders, R., Sandilands, V., Hocking, P., 2012. Technology and programmes for sustainable improvement of village poultry production. In: Sandilands, V., Hocking, P. (Eds.), Alternative systems for poultry: Health, welfare and productivity. Carfax Publishing Company, Abigdon, Oxfordshire, UK, pp. 110-127.

Bettridge, J.M., Lynch, S.E., Brena, M.C., Melese, K., Dessie, T., Terfa, Z.G., Desta, T.T., Rushton, S., Hanotte, O., Kaiser, P., Wigley, P., Christley, R.M., 2014. Infection-interactions in Ethiopian village chickens. Preventive Veterinary Medicine 117, 358-366.

Birol, E., Smale, M., Gyovai, Á., 2006. Using a choice experiment to estimate farmers' valuation of agrobiodiversity on Hungarian small farms. Environ. Resource Econ. 34, 439-469.

Byrne, T.J., Amer, P.R., Fennessy, P.F., Hansen, P., Wickham, B.W., 2012. A preference-based approach to deriving breeding objectives: applied to sheep breeding. Animal 6, 778-788.

CSA, 2013. Agricultural sapmle survey: Report on livestock and livestock characterstics. Central statistical agency, Addis Ababa, Ethiopia.

Dana, N., van der Waaij, L.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 and Production 42, 1519-1529.

Danny, C., 2007. Willingness to Pay for Rural Landscape Improvements: Combining Mixed Logit and Random-Effects Models. J. Agr. Econ. 58, 467-483.

Drake, L., 1992. The non-market value of the Swedish agricultural landscape. Europ. Rev. Agr. Econ. 19, 351-364.

Drucker, A.G., Anderson, S., 2004. Economic analysis of animal genetic resources and the use of rural appraisal methods: lessons from Southeast Mexico. International Journal of Agricultural Sustainability 2, 77-97.

Eric, R., Guy, G., Riccardo, S., 2008. Valuing animal genetic resources: a choice modeling application to indigenous cattle in Kenya. Agr. Econ. 38, 89-98.

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

FAO, 2010b. Smallholder poultry production – livelihoods, food security and sociocultural significance, by K. N. Kryger, K. A. Thomsen, M. A. Whyte and M. Dissing. FAO Smallholder Poultry Production Paper No. 4. Rome.

Faustin, V., Adégbidi, A.A., Garnett, S.T., Koudandé, D.O., Agbo, V., Zander, K.K., 2010. Peace, health or fortune?: Preferences for chicken traits in rural Benin. Ecolog. Econ. 69, 1848-1857.

Fiebig, D.G., Keane, M.P., Louviere, J., Wasi, N., 2010. The generalized multinomial logit model: accounting for scale and coefficient heterogeneity. Marketing Sci. 29, 393-421.

Greene, W., 2012. NLOGIT 5 Reference Guide. Econometric Software. Inc., Plainview, NY.

Greene, W.H., Hensher, D.A., 2010. Does scale heterogeneity across individuals matter? An empirical assessment of alternative logit models. Transportation 37, 413-428.

Guèye, E., 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.

Hanemann, W.M., 1984. Welfare evaluations in contingent valuation experiments with discrete responses. Amer. J. Agr. Econ. 66, 332-341.

Hanley, N., Wright, R., Adamowicz, V., 1998a. Using Choice Experiments to Value the Environment. Environmental and Resource Economics 11, 413-428.

Hanley, N., Wright, R.E., Adamowicz, V., 1998b. Using choice experiments to value the environment. Environ. Resource Econ. 11, 413-428.

Hensher, D.A., Greene, W.H., 2003. The Mixed Logit model: The state of practice. Transportation 30, 133-176.

Hensher, D.A., Greene, W.H., 2011. Valuation of Travel Time Savings in WTP and Preference Space in the Presence of Taste and Scale Heterogeneity. Journal of Transport Economics and Policy (JTEP) 45, 505-525.

Hensher, D.A., Rose, J.M., Greene, W.H., 2005. Applied choice analysis: a primer. Cambridge University Press.

Hensher, D.A., Truong, T.P., 1984. valuation of travel time savings from direct experimental approach. Journal of Transport Economics and Policy 19, 237-261

Kassie, G.T., Abdulai, A., Wollny, C., 2009. Valuing Traits of Indigenous Cows in Central Ethiopia. J. Agr. Econ. 60, 386-401.

Kuhfeld, W.F., 2010. Marketing research methods in SAS. Experimental Design, Choice, Conjoint, and Graphical Techniques. Cary, NC, SAS-Institute TS-722. Available at http://support.sas.com/techsup/technote/mr2010.pdf.

Lancaster, K.J., 1966. A new approach to consumer theory. J. Polit. Economy 74, 132-157.

Lindahl, J.F., Young, J., Wyatt, A., Young, M., Alders, R., Bagnol, B., Kibaya, A., Grace, D., 2018. Do vaccination interventions have effects? A study on how poultry vaccination interventions change smallholder farmer knowledge, attitudes, and practice in villages in Kenya and Tanzania. Tropical Animal Health and Production, 1-8.

Loureiro, M.L., Umberger, W.J., 2007. A choice experiment model for beef: What US consumer responses tell us about relative preferences for food safety, country-of-origin labeling and traceability. Food Pol. 32, 496-514.

Louviere, J., Street, D., Carson, R., Ainslie, A., Deshazo, J.R., Cameron, T., Hensher, D., Kohn, R., Marley, T., 2002. Dissecting the Random Component of Utility. Marketing Letters 13, 177-193.

Louviere, J.J., Eagle, T., 2006. Confound it! That pesky little scale constant messes up our convenient assumptions. Sawtooth Software Conference. Sawtooth Software Inc, pp. 211–228.

Louviere, J.J., Woodworth, G., 1983. Design and analysis of simulated consumer choice or allocation experiments: an approach based on aggregate data. J. Marketing Res., 350-367.

Luce, R.D., 1959. Individual Choice Behavior a Theoretical Analysis. John Wiley and sons.

McFadden, D., 1974. Conditional logit analysis of qualitative choice behavior. In: P. Zarembka (Ed.), Frontiers in Econometrics. Academic Press, New York, pp. 105–142.

McFadden, D., Train, K., 2000. Mixed MNL models for discrete response. J. Appl. Econometrics 15, 447-470.

Ouma, E., Abdulai, A., Drucker, A., 2007. Measuring Heterogeneous Preferences for Cattle Traits among Cattle-Keeping Households in East Africa. Amer. J. Agr. Econ. 89, 1005-1019.

Psifidi, A., Banos, G., Matika, O., Desta, T.T., Bettridge, J., Hume, D.A., Dessie, T., Christley, R., Wigley, P., Hanotte, O., Kaiser, P., 2016. Genome-wide association studies of immune, disease and production traits in indigenous chicken ecotypes. Genetics Selection Evolution 48, 74.

Ragkos, A., Abas, Z., 2015. Using the choice experiment method in the design of breeding goals in dairy sheep. Animal 9, 208-217.

Roessler, R., Drucker, A.G., Scarpa, R., Markemann, A., Lemke, U., Thuy, L.T., Valle Zárate, A., 2008. Using choice experiments to assess smallholder farmers' preferences for pig breeding traits in different production systems in North–West Vietnam. Ecolog. Econ. 66, 184-192.

Roosen, J., Fadlaoui, A., Bertaglia, M., 2005. Economic evaluation for conservation of farm animal genetic resources. Journal of Animal Breeding and Genetics 122, 217-228.

Rose, J.M., Bliemer, M.C., 2004. The design of stated choice experiments: The state of practice and future challenges. Institute of Transport Studies Working Paper.

Scarpa, R., Drucker, A.G., Anderson, S., Ferraes-Ehuan, N., Gómez, V., Risopatrón, C.R., Rubio-Leonel, O., 2003. Valuing genetic resources in peasant economies: the case of ‘hairless’ creole pigs in Yucatan. Ecolog. Econ. 45, 427-443.

Scarpa, R., Thiene, M., Train, K., 2008. Utility in willingness to pay space: a tool to address confounding random scale effects in destination choice to the Alps. Amer. J. Agr. Econ. 90, 994-1010.

Tada, O., Muchenje, V., Madzimure, J., Dzama, K., 2013. Determination of economic weights for breeding traits in indigenous Nguni cattle under in-situ conservation. Livestock Science 155, 8-16.

Teklewold, H., Dadi, L., Yami, A., Dana, N., 2006. Determinants of adoption of poultry technology: a double-hurdle approach. Livestock Research for Rural Development 18

Terfa, Z.G., Garikipati, S., Kassie, G., Bettridge, J.M., Christley, R.M., 2018. Eliciting preferences for attributes of Newcastle disease vaccination programmes for village poultry in Ethiopia. Preventive Veterinary Medicine 158, 146-151.

Tonsor, G.T., Schroeder, T.C., Fox, J.A., Biere, A., 2005. European preferences for beef steak attributes. J. Agr. Resource Econ., 367-380.

Train, K., 2003. Discrete Choice Methods with Simulation. Cambridge University Press, Cambridge.

Train, K., Weeks, M., 2005. Discrete choice models in preference space and willingness-to-pay space. Applications of simulation methods in environmental and resource economics. Springer, pp. 1-16.

Wilson, R., 2010. Poultry production and performance in the Federal Democratic Republic of Ethiopia. World's Poultry Science Journal 66, 441.

Woldu, T., Markemann, A., Reiber, C., Kassie, G.T., Valle Zárate, A., 2016. Combining revealed and stated preferences to define goat breeding objectives in Ethiopia. Livestock Science 191, 179-186.

Wong, J.T., de Bruyn, J., Bagnol, B., Grieve, H., Li, M., Pym, R., Alders, R.G., 2017. Small-scale poultry and food security in resource-poor settings: A review. Global Food Security 15, 43-52.

Zander, K.K., Drucker, A.G., 2008. Conserving what's important: Using choice model scenarios to value local cattle breeds in East Africa. Ecolog. Econ. 68, 34-45.

Zander, K.K., Signorello, G., De Salvo, M., Gandini, G., Drucker, A.G., 2013. Assessing the total economic value of threatened livestock breeds in Italy: Implications for conservation policy. Ecolog. Econ. 93, 219-229.

Tables

Table 1 Attributes and attribute levels included in the DCE

Attributes	Attribute levels	Reference level
Plumage color	Predominantly white	
	Predominantly black	Predominantly red
	Predominantly red	
Eggs per clutch	12	
	16	Used as continuous
	20	
Body size	Small	
	Medium	Medium
	Big	
Mothering ability	Poor: Hatch 4 and raise chicks from 12 eggs	
	Moderate: Hatch and raise 8 chicks from 12 eggs	Moderate
	Good: Hatch and raise12 chicks from 12 eggs.	
Diseases resistance	Good: Rarely gets sick	
	Poor: Often gets sick and may die	Poor
Meat and egg taste	Poor	Poor
	Good	
Price	ETB 40	Used as continuous
	ETB 55	
	ETB 70	

Table 2 Respondents' descriptive statistics and code used in random parameter logit model

Variables	Code /unit	Descriptive
Age	Years	Mean=41.62 (SD=14.87)
Family size	Number of persons in the family	Mean=6.43(SD= 2.24)
Children below 5 years	Number of children	Mean= 1.1 (SD= 0.9)
Children below 17	Number of children	Mean= 3.6 (SD= 2.0)
Ethiopian Orthodox	1 if religion is orthodox 0 otherwise	55.3%
Protestant	1 if religion is protestant 0 otherwise	37.8%
Other religion followers	(-1) reference level	6.8%
Education	1= illiterate	31.3%
	2= read and write	12.0%
	3 =elementary	37.8%
	4 =secondary	16.0%
	5 =above secondary	2.9%
Sex	Male	80.4%
	Female	19.6%

Table 3 RPL and G-MNL model results from simulated likelihood estimation

	RPL		G - MNL	
	Mean	**SE**	**Mean**	**SE**
Random parameters (RPs)				
Predominantly black plumage color	-0. 206	0. 149	-0.253*	0.129
Predominantly white plumage color	0. 339*	0. 201	0.472**	0.194
Eggs per clutch	0. 113**	0. 053	0. 173***	0.045
Small body size	-0. 706***	0. 238	-0.740***	0. 175
Large body size	0. 335***	0. 153	0. 388***	0. 128
Good meat and egg taste	0. 331*	0. 181	0. 370**	0. 173
Disease resistance	0. 455**	0. 232	0. 425**	0. 214
Poor mothering ability	-2. 133***	0. 698	-2.219***	0. 384
Good mothering ability	1. 274***	0. 352	1.425***	0. 240
Price	-0. 031**	0. 013	-0.020***	0.006
Non-random parameters				
Constant	-4. 506***	1. 675	-2.850***	0. 625
Heterogeneity in mean parameters				
Predominantly white *Orthodox	-0. 514**	0. 206	-0.588***	0. 193
Meat and egg taste * Education	0. 102	0. 068	0.106*	0.062
Disease resistance * Age	0. 008	0.003	0.009*	0. 005
Standard deviation of RPs				
Predominantly black plumage color	0. 050	0. 419	0. 157	0.390
Predominantly white plumage color	1. 075**	0. 488	1.336***	0. 400
Eggs per clutch	0. 065	0.076	0.038	0.060
Small body size	0. 464	0. 702	0.361	0.454
Large body size	1. 720***	0. 622	1. 787***	0. 387
Good meat and egg taste	0. 018	0. 293	0. 039	0. 259
Disease resistance	0. 318	0. 546	0. 191	0. 356
Poor mothering ability	1. 711**	0. 740	1.323***	0. 409
Good mothering ability	1. 009	0. 744	0. 729	0. 448
Price	0.008	011	0.009	0.008
Tau (τ)			0.5	(fixed)
Gamma (γ)			0.375	0. 289
Sigma(*i*)			0.999*	0.532

Table 3: continued

Number of respondents	450	450
Number of observations	2,700	2,700
Number of Halton draws(D)	200	200
Log likelihood function	-1675.398	-1675.603
$x^2(df = 24)$	2581.709	2581.299
McFadden Pseudo R-square	0.4352	0.4351
AIC/N	1.259	1.260

Table 4 Willingness to pay estimation result using WTP-space

	G-MNL: WTP-space	
	Mean	**SE**
Parameters		
Predominantly black plumage color	-2.459**	1.202
Predominantly white plumage color	2.255*	1.186
Eggs per clutch	6.004***	1. 414
Small body size	-18.714***	4. 545
Large body size	9.530***	2. 424
Good meat and egg taste	15.338***	0. 181
Disease resistance	22.044***	4. 901
Poor mothering ability	- 50.489***	11.174
Good mothering ability	38.831***	8. 686
Price	1	(fixed)
Constant	- 1.815***	0. 178
Heterogeneity in mean parameters		
Predominantly white *Orthodox	- 2.784***	1. 073
Meat and egg taste * Education	0. 225	0. 368
Disease resistance * Age	.099***	0.03
Tau (τ)	1	(fixed)
Gamma (γ)	0	(fixed)
Sigma(*i*)	3.258	14.275
Standard deviation of parameters		
Predominantly black plumage color	0. 007	1.521
Predominantly white plumage color	0. 017	1. 268
Eggs per clutch	0. 421	0. 493
Small body size	0. 042	2.507
Large body size	0. 069	1.474
Good meat and egg taste	0. 069	1.739
Disease resistance	0. 056	1. 626
Poor mothering ability	0. 042	3. 015
Good mothering ability	0. 058	1. 910
Price	0	(fixed)

Table 4: continued

Number of respondents	450
Number of observations	2,700
Number of Halton draws(R)	200
Log likelihood function	-1732.473
McFadden Pseudo R-square	0.416
AIC/N	1.334