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On-Farm Egg and Meat Production Performance of Commercial Hybrids

Dawud Ibrahim*[1] and Gebeyehu Goshu[2]
[1]*Ethiopian Institute of Agricultural Research*
Debre Zeit Agricultural Research Center
[2]*Addis Ababa University, College of Veterinary Medicine and Agriculture*

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Abstract

This study was carried out using progenies of 5 Parent-Stock (PS) chicken breeds introduced from 3 European companies and 1 local breed. The imported PS was Dominant Red Barred (DR), Dominant Sussex (DS), Lohmann Brown (LB), Novogen-Brown (NB) and Novogen-Color (NC). Koekoek (KK), a dual-purpose breed widely adapted in Ethiopia, was used as a local control. Commercial hybrid progenies of these five PS breeds and that of the local control were tested for their egg (females) and meat (males) production under on-farm management conditions in Debre Zeit, Ethiopia. Egg production, feed intake, body weight, and mortality of females were measured for 48 weeks for females and for 12 weeks for males. A total of 4200 females and males were evaluated, using seven replicated farmers per breed and sexes, in a completely randomized design. The analysis was done with 50% in egg production (females) and 76.2% in meat production (males) of the participant farmers due to dropped out circumstances. The main parameters considered to compare egg production performance were egg production on the

income side, feed intake on the costs side and their combination, feed conversion ratio (FCR). There was significant difference (P<0.05) among the hybrids, in hen-day egg production (%) and, body weight and feed intake (females and males). The NB was the best in terms of egg production, with the lowest feed intake, higher egg mass and better FCR, followed by LB and NC, while DS was the least in egg production, body weight and other performance parameters measured during the 30 weeks period. Significantly higher body weight of males (BW-M) and average body weight gain. (ABW-G) were recorded in DR, KK and NB (ranging from 1600 to 1620g), followed by NC (1525g). Males of LB and DS had intermediate body weight (about 1400g). In summary, the males of all the commercial hybrids evaluated under the current on-farm trial were found to be the best egg producers too.

Introduction

In Ethiopia, the past two decades, there has been a shift to commercial production with an increase in small and medium-scale producers that exploit mainly urban markets. But the expansion of commercial chicken production in Ethiopia and similar developing countries are limited by the shortage of adequate local supply of high performing chicken stocks. Efforts are currently being made to alleviate this problem by introducing, evaluating, and identifying suitable high-performing exotic breeds that can adapt to intensive and extensive management conditions in Ethiopia. Global primary (major) breeding companies tend to promote the breeds that are used under high-level management in developed countries, claiming that they are suitable for all environments (Pym, 2013). Hence, enhancing production and productivity of the poultry sector in developing countries by introducing, testing, and adapting such stocks along with the associated technologies like husbandry, feeding and health care packages are expected to speed up poultry development activities.

Genetically high-yielding specialized breeds of chickens have been bred exclusively for meat (broilers) or table-egg (layers) production, and they require high-level of inputs in terms of nutritional and health management, to fully express their genetic potential (FAO, 2014). Dual- purpose chicken breeds aim at uniting both of these production forms, i.e., hens lay eggs and males produce meat, but it may require a compromise from both sides because laying more eggs is negatively correlated with gaining more meat. Global breeding companies have attempted to achieve this balance by employing specific cross breeding schemes (Lohmann, 2016). These efforts aim also to address the current intensive ethical discussion of the practice of culling the day-old male brothers of the egg-type females. One solution to avoid this practice could be using dual-purpose types, where males are reared for meat and females used for egg production (Mueller et al., 2018). In the end increasing the egg and meat production will alleviate animal protein shortage and reduce poverty by increasing the income of poultry farmers.

Past attempts to improve the chicken productivity in Ethiopia through the introduction of high performing commercial breeds were very limited. For years, the Debre Zeit Agricultural Research Center was evaluating only a single imported breed (layers, broilers, or dual purpose) at a time, concluding that this single breed is accepted or not,

based on the results observed on-station and on-farm conditions, without valid comparisons to alternative breeds. In contrast, the present study is the first one in Ethiopia evaluates several imported and one local breeds in the same trial. This study is unique not only in comparing several Commercial Hybrids rather than a single one, but also that the hybrids represent a genetic range from medium-weight layers to specialized dual-purpose chickens, all evaluated for both egg and meat production. In light of these facts, the objective of this study was to evaluate six ComH for their body weight, feed consumption, egg production (females) and meat production (males) of six hybrids under on-farm management conditions common in Ethiopia and similar developing countries.

Materials and Methods

Study site

The study was carried out in Debre Zeit Town, which is located 45km southeast of Addis Ababa, at a latitude of 8°44' N and longitude of 38° 38'E with average altitude of about 1900 meters above sea level, and it is at the center of a poultry production area (CSA, 2017). Average high temperatures are between 24°C and 29°C during the day and average low temperatures are between 9°C and 14°C during the night, humidity ranges from 68% to 48%. Average high rainfall is from July to September (140mm) and average short and small shower is from December to March (16 mm).

Sex differentiation

Day old chicks (DOC) for this study was progeny of these six commercial PS breeds all reared and reproduced in DZARC. Except LD, all other breeds were segregated for genes allowing auto-sexing of DOC (Dawud et al., 2019).

Commercial hybrid females and males

Day old chicks (DOC) used in this study were progenies of five commercial parent stock (PS) breeds and one local reference reared at Debre Zeit Agricultural Research Center (DZARC) poultry research farm. The commercial hybrids were DB, DS, LB, NB, and NC. The KK was used as a local reference as it has been used for dual-purpose in Ethiopia for more than 10 years, also used in South Africa and other African countries. The KK was selected based on good advantages as seen in DZARC farm, with 200 eggs per hen per year, 55.5 g mean egg weight, deep yellow skin, relatively high body weight (BW) of male (2.65 kg) and female (1.87 kg) at the end of production, and it carries sex-linked gene for color sexing of DOC (Dawud *et al*., 2019; Grobbelaar et al., 2010; Grobbelaar, (2008).

Health management

The birds were vaccinated against Marek's, New castle disease (NCD), Gumboro, Fowl Typhoid, and Fowl Pox at the appropriate age as recommended by veterinarians. In addition, the Ox tetracycline plus (OTC plus) was given when necessary. Standard vaccination and medication were strictly adhered to and strict sanitary measures followed during the experimental period (Dawud et al., 2018).

On-farm management

Seven replicated farmers were selected per breed and sex. Farmers were given a five days training on how to manage the chickens and keep records. Each farmer received 100 one-day-old chicks from each breed and per sex. Farmers that kept both females and males divided their chicken houses in to two pens for each female and male. The trial followed the housing and management recommendations developed by DZARC for 100 birds reared for egg production (females) and meat production (males). The same rearing and vaccination program as on-station was followed for chickens in the on-farm study.

The six lines of the female and male in each participant house were weighed and randomly allocated (100 birds per sex × seven farmers × six hybrids) using Completely Randomized Design (CRD). A total of 4200 progenies birds were used to evaluate egg production (females). Similarly, 4200 hybrids were used for evaluating meat productions (males). In these on-farm trials, 50% (21 out of 42) of the participant farmers in egg production (females) were dropped out at different times either due to Gumboro outbreak, high chicken mortality, economic problems for purchasing feeds, getting high price for the pullet or reduced motivation of the farmer.

In meat production (males), 23.8% (10 of f 42) of the participant farmers were dropped out due to economic problems for purchasing feeds and reduced motivation of the farmer. The analysis was done with 50% in egg production (females) (from 16 to 48 weeks of ages only) and 76.2% in meat production (males) (from 0 to 12 weeks of age) of the participant farmers due to dropped out circumstances.

Standard layer ration was fed with a diet purchased from local feed mill containing 15 to 20% crude protein (CP), 2700 to 2900 kcal/kg metabolizable energy (ME) based on the birds' requirements (Table 1). Feeders and waterers were placed in the house according to the recommendations of each breeder's manual. Water was given *ad-libitum* to all chickens without recording the amount consumed. Crude protein percent (%CP) and energy content in the feed for each of the progenies males at 0 to 4, 5 to 8 and 9 to 16 week of age, were 22, 20 & 20% CP respectively and 3000, 3100 & 3200 kcal/kg ME, respectively.

Table 1: Crude protein (CP) and energy content in the diets fed to the females of six commercial hybrids by age

Hybrid	Age	% CP	Energy kcal/kg ME	Source
DR and DS	0 to 8	19.5	2875	Dominant CZ, 2016.
	9 to 16	15	2750	
	17 to 39	17	2750	
	> 40	15.5	2700	
LB and KK	0 to 8	19.5	2800	Lohmann, 2016;
	9 to 16	17.5	2750	
	17 to 45	18.5	2800	
	> 46	17	2750	
NB and NC	0 to 8	20	2900	Novogen, 2016.
	9 to 16	17	2750	
	17 to 45	20	2750	
	> 46	19	2750	

[1]*DR = Dominant Red Barred; DS = Dominant Sussex; KK = Koekoek; LB = Lohmann Brown; NB = Novo Brown; NC = Novo Color.*

Data collection

Routine data recording from each participant house included weekly body weight (average of 50 % of both females and males), weekly number of all collected eggs (females), and number of dead birds per participant houses per sexes. Data on daily average feed intake (ADFI) was recorded and calculated every day for all the chickens reared in participant houses and averaged over the week. Additionally derived data were generated through calculation as follows.

- Weekly % lay (hen day) = (100 x eggs per week divided by (actual number of hens/pen x 7);
- Overall % lay (hen-day) = average weekly %lay from all the trial's 30 weeks (16 to 48);
- Total number of eggs/hen over 30wks = overall %lay x 210 (the number of days in 30 weeks);
- Average daily feed intake (ADFI) = pen's daily feed intake divided by number of birds in each participant houses;
- Age at first egg = when the first egg was found participant houses (Dawud *et al*., 2019);
- Age at 5% Lay = when the pen reached 5% lay (Dawud *et al*., 2019);
- Age at peak of lay = when participant houses reached maximal weekly %lay;
- Average % lay at peak of lay = participant house's maximal weekly %lay;
- Egg Mass (Kg/hen) = the total number of eggs per hen per participant houses over the entire trials multiplied by average egg weight per hen per participant houses divided by 1000;
- The female FCR = the total AFI is divided by the sum of total egg mass + BWF-F 16-48; and
- Males Average Feed Intake cumulative (AFI cumulative) = AFI weekly × 7 + AFI cumulative...

Statistical analyses

Although the data of average feed intake (AFI), body weight of females (BW-F), body weight of males (BW-M) and egg production (%lay) were collected weekly, weeks are too short periods for reliable data. Therefore, the overall females trial duration of 30 weeks (from the beginning of week 16 to the end of week 48) was split to four age periods (16-24, 24-32, 32-40 and 40-48) except AFI (as it was split to six age periods), each of 8 weeks and the overall males trial duration of 12 weeks (from the beginning of week 0 to the end of week 12) was split in to three age periods (0-4, 4-8, and 8-12), each of 4 weeks.

The ANOVA model for females and males included age period as main effects and their interaction (genotype by age). Thus, the ANOVA was conducted according to the following model:

$$Y_{ijk} = \mu + G_i + A_j + X_k + (GA)_{ij} + E_{ijkl}$$

where: Y_{ijk} = the $_{ijk}$th observed response (AFI, BW-F, …),
μ = overall mean,
G_i = hybrids genotype effect,
A_j = Age effect,
X_k = covariate of initial body weight
$(GA)_{ij}$ = hybrids genotype × Age interaction effect,
E_{ijk} = random error.

Mean separation was determined using Tukey test with 5% probability. The JMP software Version 12 (SAS Institute Inc., 2014) was used to analyze the data.

Result and Discussion

The actual conditions of the participant farmers' houses were similar to those in small-scale commercial farmers in Ethiopia (and similar developing countries), and quite different from those in developed counties where the six commercial hybrid have been bred and tested. Therefore, absolute levels of performance are hardly comparable to those in the breeders' guidelines and in publications from high-level trained farmers in developed countries.

Egg production

Average means of age at first egg and 5% lay (days), % lay at peak of lay (from 16 to 48 weeks of age) are presented in Table 2 for all the six Commercial hybrids. There were significant effects ($P<0.05$) at 5% lay (days) and % lay at peak of lay in these egg production performance traits among the genotypes during the laying stages except for age at first egg (days). The earliest sexual maturity at 5% lay (days) was exhibited (119 days) in NC, followed by DR, KK and NB (126 days), while the DS and LB reached sexual maturity at an older age (135 days) during the study periods. NB was top in average % lay at peak of lay (86.4%) and DS was the lowest (62.4%). LB, NC, KK and DR were intermediates in average % lay at peak of lay as presented in Table 2.

Table 2: Means of age at first egg and at 5% lay and peak % lay of six commercial hybrids.

Day	DR	DS	KK	LB	NB	NC
Age at first egg	119.0	128.3	124.6	127.8	119.0	112.0
Age at 5% lay	126.0^{ab}	135.3^{a}	128.8^{ab}	134.8^{a}	126.0^{ab}	119.0^{b}
% lay at peak of lay	70.2^{ab}	62.4^{b}	76.2^{ab}	77.7^{ab}	86.4^{a}	77.5^{ab}

$^{a–b}$Means with different letters within rows differ significantly by the Tukey test at $p<0.05$.
[1]DR = Dominant Red Barred; DS = Dominant Sussex; KK = Koekoek; LB = Lohmann Brown; NB = Novo Brown; NC = Novo Color.

Average egg production performances % lay (hen-day) at 4 age periods, from the start (16 weeks) to the end (48 wks) of the trial, average egg weight, total number of eggs/hen/30wks, Egg Mass (Kg/hen) for the six hybrids is shown in Figure 1 and Table 3. The hybrids differed in % lay, especially during the 24-32 weeks period. NB was leading with an average of 67.4 %, followed by NC (60.4%), while DS (47.2%) was the lowest. LB, KK and DR were intermediate with an average of 51% lay during the 24-32 weeks period (Figure 1). Except one of the hybrid (DR), the laying rate of others continues to increase up to 32-40 weeks period. One of the notable performances observed in NC and NB was that laying continues to increase at a higher rate compared to others. Laying percent started to decline after 40 weeks of age for all as presented in Figure 1. The average egg production in hen-day (%) of NB (56.1%) was higher than all the rest, while LB, NC, KK and DR were intermediate. However, the lowest hen-day egg production was recorded in DS (41.9%) over the entire period as indicated in table 3. There were significant differences ($P<0.05$) among hybrids in age in periods and genotype by age interactions in % lay (hen-day) over the entire laying period (16-48 weeks).

The egg production performances of the five hybrids (DR, DS, LB, NB and NC) were low compared to the standards given by the respective breeding companies (Dominant, Lohmann and Novogen). All the five hybrids were similar with respect to the onset of lay. The KK showed earlier sexual maturity similar to the reports of and Grobbelaar et al. (2010). The differences between age at sexual maturity and the levels of egg production found in this study and the figures reported by the breeders and other studies could be attributed to differences in management and environmental conditions.

The levels of peak laying rate (% lay at peak of lay, total number of eggs production) of the five European ComH (DR, DS, LB, NB and NC) were not similar to those indicated by the breeding companies (Lohmann, Dominant CZ and Novogen), Dawud et al. (2019) and Grobbelaar et al. (2010). These results suggest the relatively low levels of total number of egg production were mainly due to slow elevation and early dropping in laying rate before they reach to their genetic potential as presented in Figure 1. Especially in DS, the lowest total numbers of eggs/hen (about 98.2 eggs/hen) over the entire trial was recorded as presented in Table 4, due to poor laying consistency, with the lowest egg production (about 41.9 % lay). Higher % at peak of lay was recorded in KK than the reports of Dawud et al. (2019). The reason for the lower total number of eggs per hen in five European chickens as compared to the standards reported by the breeding companies may be that they require high-level inputs in terms of nutritional and health management, to fully express their genetic potential (FAO, 2014).

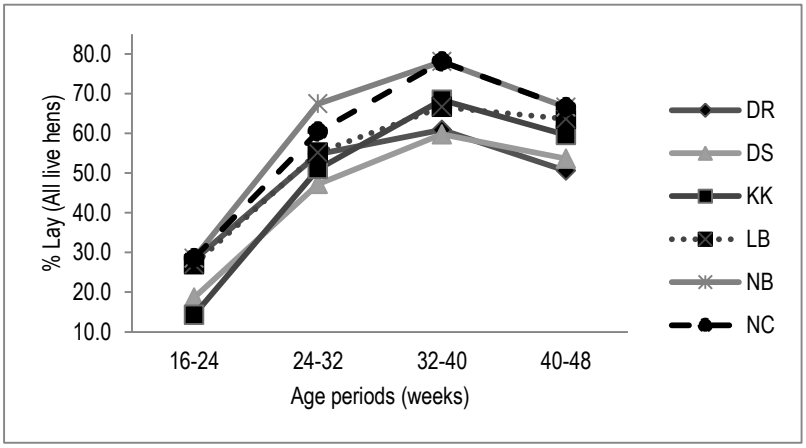

Figure 1. Average % lay (hen-day) from the six Commercial hybrids at 4 age periods, from the start (16 wks) to the end (48 wks) of the trial.

DR = Dominant Red Barred; DS = Dominant Sussex; KK = Koekoek; LB = Lohmann Brown; NB = Novo Brown; NC = Novo Color.

The highest average egg weight was recorded in NC (59.2g), followed by DS (58.3g), while DR, NB and LB were intermediate; however, the lowest average egg weight was recorded in KK (50.9g) during the laying stages. Relatively similar egg weight (60.1g), for Lohmann breeds was reported by Jana et al. (2014) with this finding but it was higher than the report of Dawud et al., (2011) for Lohmann Silver (52.9g). Desalew et al. (2015) reported lower egg weight for KK (47.8g) than this finding with similar age periods.

Significantly the highest number of eggs was recorded in NB (131.5 eggs/hen), followed by LB (116.4 eggs/hen) and NC (111.3eggs/hen), while DR and KK were intermediate during the 30 weeks of laying. The lowest total number of eggs was recorded in DS (98.2 eggs/hen) due to poor laying consistency (~ 41.9 % lay) Table 3.

The highest egg mass (Kg/hen) was recorded in NB (7.51kg/hen). Egg mass was the lowest in DS (5.73kg/hen) and KK (5.79kg/hen) and intermediate in NC, LB and DR (Table 3). The main parameters used to compare the female' as egg production performance of hybrids were egg production on the income side, feed intake on the costs side and their combination, feed conversion ratio (FCR). Considering these parameters NB was the best with higher egg production, lowest feed intake, higher egg mass and better FCR, followed by LB and NC, while DS was the least in egg production performance during these 30 weeks of age under on-farm trial.

Female body weight

The females' body weight (BW-F) at five ages, from the start (16 weeks) to the end (48 weeks) of the trial, onset of laying (16 weeks) and end of the trails of (48 weeks), average body weight gain (ABWG-F) between periods (16-48 weeks), total average feed intake (AFI kg/hen in 30 weeks) and FCR are presented in Table 4 and Figure 2.

The body weight of females (BW-F) exhibited differences ($P<0.05$) among hybrids, within age and (genotype by age interactions) in body weight and body weight gain during these 30 weeks of age. At the end of the trails (48 weeks of age), BW-F of NC was significantly the highest (2203.3g) and the lowest BW-F was recorded in DS (1926.7g). The KK female ranked second in body weight (2100g at 48 weeks of ages), while the others (NB, DR and LB) were intermediate. (Table 4). In NC body weight continues to increase remarkably after 32 weeks of age due to its genetic background from its broiler male parents (Figure 2). Significantly higher average body weight gain (BWG-F) was recorded in NC (88.9g) and KK (85.6g) females than other hybrids and the lowest BWG-F was observed in DS (52.5g), while the others DR, NB and LB were intermediate (Table 3).

The body weight of female (BW-F) of NC and KK were significantly highest compared to the standards reported by the breeder's company and Dawud et al., (2019), with similar age periods of this study whereas in the rest (DR, DS, LB and NB) BW-F were lower than the company standards. This may relate to the lowest feed intakes and low body weight gains of these hybrids under on-farm condition of this trial. The lower in body weight among few females of hybrid was due to the environmental factors as reported by Doni et al., (2015) that, temperature more than 28°C, weight gains are lowered. If condition remains for prolonged period, there may be loss in body weight. One of the remarkable BW-F was observed after 32 weeks of age in NC where continues to increase at higher rate than others due to the genetic background during their broiler male parents stocks combinations study, followed by KK until the end of the trials.

Table 3: Mean body weight (BW-F), average body weight gain (ABWG-F), and average daily feed intake (ADFI-F), % lay (hen-day), egg weight, total numbers of eggs, egg mass, total average feed intake (AFI-F) and feed conversion ratio (FCR) of females from six commercial hybrids

	Age (week)	DR	DS	KK	LB	NB	NC
Body weight (g)	16	1764.5^{a}	1753.3^{a}	1626.0^{b}	1692.5^{b}	1705^{ab}	1576.7^{c}
	48	2006.7^{b}	1926.7^{c}	2100.0^{ab}	2000.0^{b}	2026.7^{b}	2203.3^{a}
Average body weight gain (g)	16-48	77.0^{b}	52.5^{c}	85.6^{a}	73.3^{b}	74.1^{b}	88.9^{a}
Average daily feed intake (g/bird/day)	0-48	88.3^{b}	85.6^{c}	89.9^{ab}	88.1^{b}	88.3^{b}	91.1^{a}
% Lay (hen-day)	16-48	45.7^{ab}	41.9^{b}	45.9^{ab}	49.6^{ab}	56.1^{a}	47.3^{ab}
Source of variation							
Hybrids		****	****	****	****	****	****
Week		****	****	****	****	****	****
Hybrids x week		****	****	****	****	****	****
Average egg weight (g)[2]	16-48	57.8^{bc}	58.3^{ab}	50.9^{d}	56.7^{c}	57.1^{bc}	59.2^{a}
Total number of eggs/hen/30weeks	16-48	107.1^{c}	98.2^{d}	107.6^{c}	116.4^{b}	131.5^{a}	111.3^{b}
Egg Mass (kg/hen)	16-48	6.19^{b}	5.73^{c}	5.79^{c}	6.42^{b}	7.51^{a}	6.59^{b}
Total average feed intake (kg/hen)	16-48	23.0^{ab}	21.8^{b}	23.4^{a}	23.3^{ab}	22.7^{ab}	23.3^{ab}
Feed conversion ratio (FCR)	16-48	3.76^{bc}	3.85^{b}	4.08^{a}	3.77^{bc}	3.18^{d}	3.54^{c}

*$^{a–d}$Means with different letters within rows differ significantly by the Tukey test at p<0.05. ****P<0.0001; [1]DR = Dominant Red Barred; DS = Dominant Sussex; KK = Koekoek; LB = Lohmann Brown; NB = Novo Brown; NC = Novo Color. Wks = weeks; [2]Eggs weight was collected when the hens were at 28, 36 and 44.weeks of age only.*

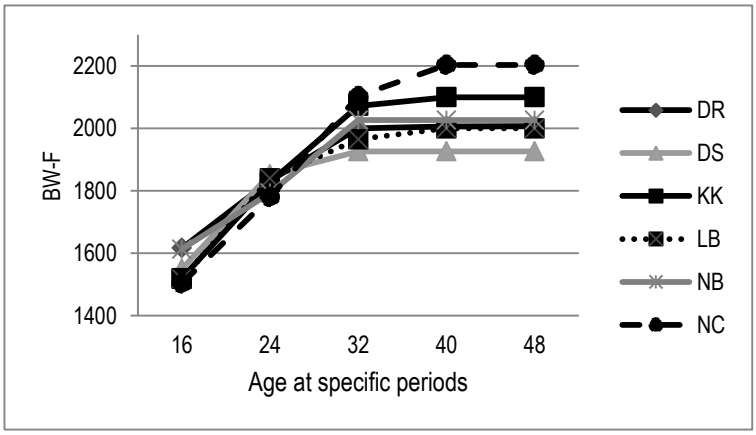

Figure 2. Average body weight of females from the six Commercial hybrids (ComH) at 5 ages, from the start (16 wks) to the end (48 wks) and at 3 ages.
DR = Dominant Red Barred; DS = Dominant Sussex; KK = Koekoek; LB = Lohmann Brown; NB = Novo Brown; NC = Novo Color.

Female average feed intake

The average daily feed intake (ADFI g/bird/day) at 6 age periods, from the start (0-8 weeks) to the end (40-48 weeks) of the trial, total average feed intake (AFI kg/hen) and

the feed conversion ratio (FCR) for the six hybrids is shown in Figure 3 and Table 4. The average feed intake during the study periods (0 to 48 weeks) was on average ~ 88.5g/bird per day in all hybrids. Those finding was much lower than the standards reported by the breeding companies (Lohmann, Dominant CZ, and Novogen) and Dawud et al. (2011). The results reported here and those reported by the breeders and other studies could be attributed to differences in management and environmental conditions. An environmental factor like temperature was found to contribute about 97.2% showing that it has the greatest effect on feed intake. Hence, a decrease in rate of feed intake in any poultry farms as reported by Obayelu et al., (2006). Significantly, higher ADFI difference was recorded after 16-24 weeks of age periods in all hybrids. During the study periods (0-8 to 40-48 weeks of age periods) all hybrids showed similar ADFI but DS was exhibited at lower rate compared to the others after 16-24 to 40-48 weeks of age periods (Figure 3). There was significant difference ($P<0.05$) among hybrids, within age and (genotype by age interactions) in ADFI (g/bird/day) of female due to the higher ADFI in NC during the laying stages.

The overall feed intake was significantly higher in four hybrids of KK, NC, LB and DR over the trial period (16-48 weeks) ranging from 93.5 to 120 g/hen/day, accumulating to mean total average feed intakes (AFI) around 23kg/hen in 210 days. The lowest overall total average feed intakes (AFI) was exhibited by DS (21.8kg/hen), while hybrids of NB was intermediate in total average feed intakes (AFI) (22.7kg/hen) (Table 3).

The female bird's ability to convert nutrients to an important aspect of overall performance is expressed in feed conversion ratio (FCR). Significantly better FCR was recorded in NB (3.18), followed by NC (3.54) and in contrast poor FCR was recorded in KK (4.08), while DR, LB and DS were intermediate over the entire trial (Table 3). The poor FCR observed in this trial was due to causes related to poor feeding management practices prevalent under small farmers management conditions (feeder management will affect flock FCR through its effect on feed intake and feed spillage). Other causes may include measurement failures (over-estimation of actual feed usage and / or under-estimation of actual live weight will certainly lead to reduction of FCR), water management problems (the provision of adequate drinking space and a source of clean water are essential). A reduction in water intake will lead to a reduction in feed intake and an increase in FCR All the five European and one local hybrids much lower as compared to the standards reported by the breeding companies (Lohmann, Dominant CZ and Novogen) and Dawud et al. (2019) due to lowest feed intakes and egg productions in general in these on-farm trails.

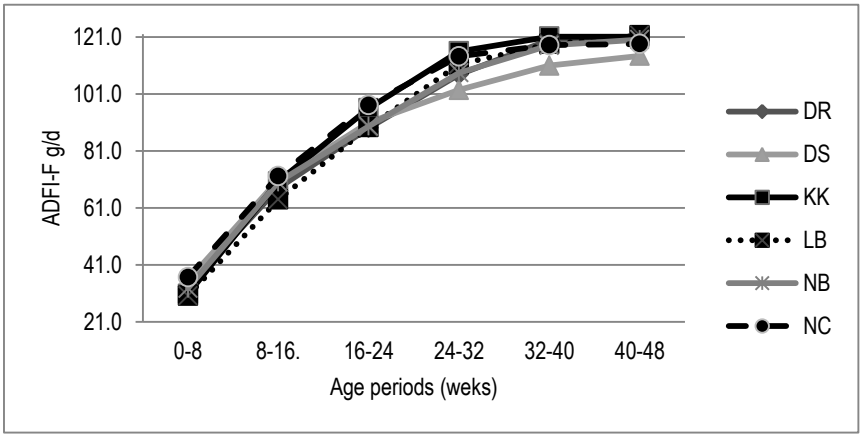

Figure 3. Average daily feed intake (ADFI) per chicken from the six Commercial hybrids females at 6 age periods, from the start (0 -8 weeks) to the end (40-48 weeks) of the trial.
DR = Dominant Red Barred; DS = Dominant Sussex; KK = Koekoek; LB = Lohmann Brown; NB = Novo Brown; NC = Novo Color.

Female mortality

In these on-farm (females' egg) production trials, significantly higher average % mortality was recorded in DS (1.15%) than other hybrids, followed by DR, NB and NC females. The lowest average % mortality was recorded in KK (0.29%) and LB (0.20%) females. The performance of egg production (females) on-farm females' mortality trials, lowest average % mortality results were found in all hybrids of females as compared to the standards reported by the breeder's company. In a study with KK (22.2 %) in South Africa (Grobbelaar et al., 2010) mortality was higher than our findings. In most of the farmers' houses occurred Gumboro out- break at growing stages even though the chickens were vaccinated though out the trials and then the farmers predominantly reason out to these mortalities to drop out from these trails and also their second intention was the economic problems to purchase feeds for their chickens. There were significant ($P<0.05$) effects of hybrids and ages but the genotype by age interactions effect on the average % mortality of the females during the laying phases.

Table 4: Least square means of average % mortality over the entire trial (Week 16 to 48) of females from six commercial hybrids.

Parameter	DR	DS	KK	LB	NB	NC
Average females mortality (Weeks 16 to 48)	0.70^{ab}	1.15^{a}	0.29^{b}	0.20^{b}	0.31^{ab}	0.41^{ab}
Source of variation						
Hybrids	****	****	****	****	****	****
Week	****	****	****	****	****	****
Hybrids x week	----	----	----	----	----	----

*$^{a-d}$Means with different letters within rows differ significantly by the Tukey test at $p<0.05$. ****$P<0.0001$; ^{1}DR = Dominant Red Barred; DS = Dominant Sussex; KK = Koekoek; LB = Lohmann Brown; NB = Novo Brown; NC = Novo Color.*

Males body weight and feed intake

The males' body weight (BW-M) for meat production curves from six Commercial hybrids at 3 ages, from the start (4 weeks) to the end (12 weeks) of the trial are presented in Figure 4. Average males BW-M at the end of the trials (12 weeks), body weight gain (BWG-M) between periods (0-12 weeks), and cumulative average feed intake (g) (CFI) (between 0-12weeks) are presented in Table 5. The most economic criterion for marketing male chickens in Ethiopia was live body weight (since selling live body was common) especially at holidays to prepare the traditional '*Doro wet*' (chicken stew). Significantly higher BW-M was recorded in DR, KK and NB with the range of 1600 to 1620g, followed by NC (about 1525g); while LB and DS was intermediate about 1400g (Table 5). There were differences ($P<0.05$) among hybrids males, within age and genotype by age interactions in average feed intake (AFI cumulative). BW-M and BWG-were significantly ($P<0.05$) affected by genotype and not by hybrids x Age interactions.

Like BW-M, significantly higher BWG-M was recorded in NB, KK and DR with the range of 525.2 to 530g, followed by NC (497.6g); while LB and DS were intermediate about 458.5g (Table 5). Generally, it was observed that the commercial hybrid males tested in this trial could be used as alternative to broiler chickens for meat production in Ethiopia. Significantly higher cumulative feed intake (CFI) was in NB (4626.2g) and the lowest cumulative feed intake (CFI) was in DR (4403.8) throughout the trials; while others were intermediate in CFI cumulative (Table 5) over the entire trials (0 to 12 weeks of age).

The BW-M and BWG-M of DR, KK and NB were the highest compared to the standards reported by the breeder companies and Dawud et al., (2019), while, BW-C of NC, LB and DS were comparable with the standards reported by the breeder companies (Lohmann, Dominant CZ and Novogen), Dawud et al. (2019) and Grobbelaar et al., (2010). As expected, the BW-M of the six hybrids were significantly lower than reported by (Lichovníková et al., 2009) of fast-growing broiler types of Ross 308 (6000g). The BW-M of DR, NC, KK and NB were higher than reported by (Lichovníková et al., 2009) of ISA Brown males and lower results recorded in NC, LB and DS when compared with the 30 weeks of age only. The BW-M of all the six hybrids were lower than all the experimental hybrids done in Europe with better management and feeds in comparing to commercial fast-growing and slow-growing broiler types as well as males from a commercial layer hybrids reported by Mueller, et al., (2018). In addition these hybrids was not comparable with Sasso 51 (2423g), Ross PM3 (2415) and Lohmann dual (2161g), but the three hybrids of DR, KK and NB were comparable with Belgian Malines (1718g), whereas they were higher than the Schweizerhuhn (1317g) and Lohmann Brown plus (1227), as reported by Muller, et al., (2018).

The average feed intake of all the hybrids was comparable with the standards reported by the breeding companies (Lohmann, Dominant CZ and Novogen), Dawud et al. (2019) and Grobbelaar et al., (2010) but much lowers than the same experimental hybrids reared in Europe. However, the feed intake of hybrids in this trial was higher than the Lohmann Brown plus and Schweizerhuhn but lower than the fast and slow-growing broiler types of Ross PM3, Sasso 51 and Lohmann Dual (Mueller, et al.,2018); however, fed for the males

were differs from the breeding companies.

This study showed that males from commercial hybrids (dual purpose breeds) are suitable for meat productions under small holder farmers' conditions of Ethiopia. additionally this trial could be the real solutions to avoid the practice of culling day-old layer types of males and also good news for the Ethiopian local people especially at holidays and events to enjoy the traditional 'Doro wet' (chicken stew) with these males, again it could be economical in both side, for the user (with cheap price) and for the business man (selling live or dressed).

Table 5: Least square means of average body weight gain, final body weight and cumulative feed intake (CFI) of males from six commercial hybrids.

	Age (weeks)	DR	DS	KK	LB	NB	NC
Average body weight gain (g)	0-12	522.0^{a}	455.0^{b}	523.7^{a}	462.6^{b}	530.0^{a}	497.6^{ab}
Body weight (g)	12	1600.0^{a}	1400.0^{b}	1600.0^{a}	1420.0^{b}	1620.0^{a}	1525.0^{ab}
Cumulative feed intake (g)[2]	0-12	4403.8^{b}	4448.1^{ab}	4462.1^{ab}	4471.6^{ab}	4626.2^{a}	4559.8^{ab}
Source of variation							
Hybrids		****	****	****	****	****	****
Week		****	****	****	****	****	****
Hybrids x week		----	----	----	----	----	----

*$^{a–b}$Means with different letters within rows differ significantly by the Tukey test at $p<0.05$; [1]DR = Dominant Red ; Barred; DS = Dominant Sussex; KK = Koekoek; LB = Lohmann Brown; NB = Novo Brown; NC = Novo Color. Wks = weeks. [2] hybrids *Age interaction was significant*

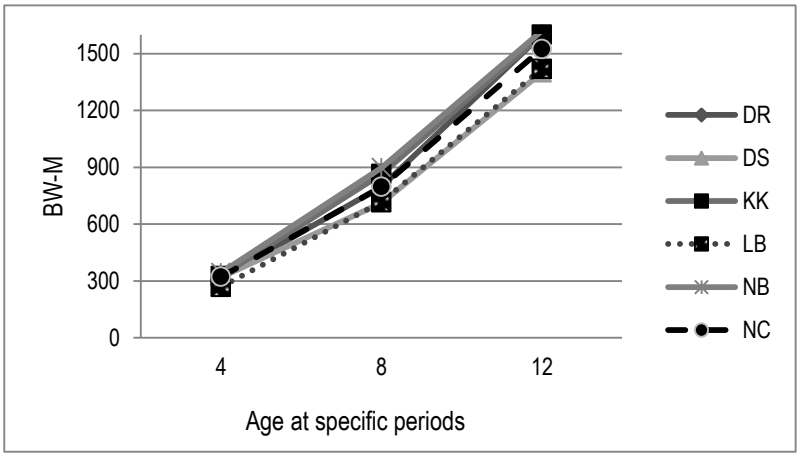

Figure 4. Average body weight of males from the six Commercial hybrids at 3 ages of specific periods, from the start (4 wks) to the end (12 wks) of the trial.

DR = Dominant Red Barred; DS = Dominant Sussex; KK = Koekoek; LB = Lohmann Brown; NB = Novo Brown; NC = Novo Color. Wks = weeks.

Males' mortality

The least square means of average % mortality over the entire trial (Week 0 to 12) of males from six Commercial layers are presented in Table 6. During (males' meat) production trials, significantly very low mortality (0.40%) was recorded in NB males. The highest average % mortality was recorded in DR (4.25%) followed by LB (2.80%) males, while DS (1.35%), NC (1.25%) and KK (1.00%) males were intermediates over the entire trials (weeks 0 to 12). There were significant ($P<0.05$) effects of hybrids and ages but the genotype by age interactions effect on the average % mortality of the females during the laying phases and males growth stages was not significant ($P>0.05$).

In these meat production (males) on-farm males' mortality trials, significantly very low average % mortality (from the least NB (0.40%) to the higher in DR (4.25%) in all hybrids were found as compared (from the least NC (4.2%) to highest KK (22.2%) to the standards reported by the breeder's company and Grobbelaar et al. (2010) with similar age periods of the study. In these males trial for meat productions, very low average % mortality was recorded in all hybrids than the mortality till 90 days of age (9.1% in ISA Brown) males and (8% in Ross 308) report of Lichovníková et al. (2009). This trial would suggest for the production of meat from males in Ethiopia is economical and truthful. In general, the mortality of females and males on these on-farm trial was mostly due to mismanagement, Gumboro out-break at growth stages, under feeding systems, inadequate drinking space and a source of clean water and also in case of males, when the superior in body size or the aggressive one was try to mate the smaller in body size and then these smaller in body size males was restrained itself in one corner side of the house without feed and water and tend to die finally unless they are fed by the persons as seen under on-station.

Table 6: Least square means of average % mortality of females and males from six commercial layers

Parameter	DR	DS	KK	LB	NB	NC
Average males' mortality (%) (Weeks 0 to12)	4.25^{a}	1.35^{c}	1.00^{cd}	2.80^{b}	0.40^{d}	1.25^{cd}
Source of variation						
Hybrids	****	****	****	****	****	****
Week	****	****	****	****	****	****
Hybrids × week	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*

*$^{a-d}$Means with different letters within rows differ significantly by the Tukey test at $P<0.05$. ****$P<0.0001$; ^{1}DR = Dominant Red Barred; DS = Dominant Sussex; KK = Koekoek; LB = Lohmann Brown Classic; NB = Novogen Brown; NC = Novogen Color.*

Conclusion

The main parameters related to Commercial Hybrids performance were egg production on the income side, feed intake on the costs side and their combination, feed conversion ratio (FCR) were considered to compare the female' as egg productions. The NB was the best in terms of egg production; with the lowest feed intake higher egg mass and better FCR, followed by LB and NC, while DS was the least in egg production performance during these 30 weeks of age under on-farm trials. The causes may attribute to the poor adaptability of the chickens under on-farm conditions. These results suggest the relatively low levels of total number of egg production were mainly due to slow elevation and early

dropping in laying rate before they reach to their genetic potential as presented. At the end of the trails (48 weeks of age), BW-F of NC was significantly the highest (about 2203.3g) than others hybrids due to the genetic background during their male parents stocks combinations study and the lowest BW-F was recorded in DS (about 1926.7g). The KK female ranked second heavier BW-F (about 2100g at 48 weeks of ages), while the others (NB, DR and LB) were intermediate in these egg production (females) trials. The average feed intake during the study periods (0 to 48 wks) was 88.5g/bird per day in all hybrids. In Ethiopia, live body weight is preferred especially at holydays and events for local market success. Significantly higher BW-M and ABW-G were recorded in DR, KK and NB with the range of 1600 to 1620g, followed by NC (about 1525g); while LB and DS was intermediate about 1400g and making all the six ComH better male meat producers due to similar results was exhibited in these on-farm trials.

Acknowledgments

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