Evaluation of heterosis, maternal and reciprocal effects on different traits of Fayoumi and White Leghorn crossbreeds

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Abstract

Several studies were conducted on evaluation of heterosis, maternal and reciprocal-effects for different chicken breeds. However, there is a limited information on the heterosis, maternal and reciprocal-effect for crossbreed of Fayoumi and White Leghorn. Therefore; this study was designed to evaluate the heterosis, maternal and reciprocal effects on different traits for crossbreed of Fayoumi and White Leghorn from day-old to age at first egg. A total of six hundred chicks were selected,150 from each genotype and evaluated simultaneously under the same management. The specific and general heterosis, maternal, and reciprocal effects were estimated for all traits. The heterosis of body weight ranged from 3.06 to 21.31% for the main and 1.35 to 14.89% the reciprocal crossbred, which is within the recommended range (-6.5-26.2%). The heterosis of weight gain ranged from -0.07 to 33.03%. The F1 of Fayoumi cocks and White Leghorn hens exhibited a higher positive heterotic recorded for the body weight at first egg. The main and reciprocal crossbreds had negative heterotic for age at first egg and lies within the recommended range of (-25 and 11.5 %). The effect of maternity on body weight was found to be more favorable at brooder age for Fayoumi breed while it was at grower age for White leghorn. Negative estimates were observed for maternal and reciprocal effects on body weight at day-old, 20 weeks, and age at first egg; weight gain at 8-12 and 16-20 weeks; feed intake at 0-4 and 12-20 weeks; feed conversion efficiency at 0-8 and 16-20 weeks; and egg weight at first egg. Generally, this study concluded that the crosses between WLH hen and Fayoumi cock produced progenies that are more feed efficient and produced heavier eggs than their main crossbred.

Keywords: Crossbreed; Fayoumi; Heterosis; Maternal; Reciprocal; White Leghorn

Introduction

Crossbreeding is an important instrument for breeders to improve important economic traits in farm animals (Oseni *et al.*, 1997). It combines different characteristics of genetically different animals. The crossbreed offsprings tend to be superior in some quantitative traits to either one or both parental lines. This is often referred to as hybrid vigor or positive heterosis (Baranwal *et al.*, 2012). However, negative heterosis may be desirable for crossbreds, particularly in traits like mortality and disease susceptibility, where merits are associated with lower values (Afolabi *et al.,* 2017). Heterosis for growth traits was found age-dependent (Momoh and Nwosu, 2008). High positive heterosis for body weight at different ages among crossbreds and their reciprocals were obtained in chickens (Mandour *et al*., 1996). Razuki and AL-Shaheen (2011) found the highest positive heterosis that occurred in crosses between Brown line and New Hampshire and New Hampshire and White Leghorn.

Heterosis is influenced by maternal and direct non-additive effects (Lui *et al*., 1995). The common practice in crossbreeding is to select and cross a cock breed of a desirable trait with different hen breeds (Afolabi *et al.,* 2017). However, the choice of a breed to serve as a cock or hen in a crossbreeding program should rather be done objectively to improve the targeted trait as some traits are linked to sex. Khalil *et al*. (1999) and Sabri *et al*. (2000) detected a significant maternal effect on the live weight of offspring at an early age (0-8 weeks). Positive maternal effects were reported for body weight in chicken crosses (Saadey *et al.,* 2008; Lalev *et al.,* 2014). Many literatures noted better overall performance for maternal-side in crossbreds (Khalil *et al.*, 1999; Sabri *et al.,* 2000; Khawaja *et al.,* 2012). The maternal-effects are accounted for the most important reciprocal-effects in chickens (Amira *et al*., 2013). Maternal-effect is useful in defining the extent of genetic dissimilarities between the combining breeds (Viana, 2007) and may also be due to a possible difference in the combining aptitudes between cocks and hens (Keambou *et al*, 2010). Reciprocal-effects were at least as important as heterosis and its magnitude tends to be greater when heterosis is small (Fairfull *et al.,* 1983; Razuki and AL-Shaheen, 2011). Positive reciprocal-effects for body weight in the different genetic groups of diallel crossing of Saso, Italian and Mandarah chickens were estimated for ages of 0-4, 4-8, 8-12 and 0 -12 weeks. Razuki and AL-Shaheen (2011) reported a significant reciprocal-effect on body weight at day-old. On the other hand, Khawaja *et al*. (2012) reported better performance in all traits for crossbreed of Fayoumi cocks and Rode Island Red hens than in its reciprocal crossbreed.

Barbato and Vasilatos-Younken (1991) noted that the maternal-effect in chickens changed with time and its considerable influence is manifested.

As compared to White Leghorn, Fayoumi breed is characterized for its disease resistance, well-suited to hot climates, and surviving normally with farmers as a scavenger in Bangladish (Rajput *et al.,* 2005). However, it is a small-sized, lays smaller eggs, lower carcass yield and lower economic return (Ewonetu, 2017). Even though White Leghorn has a fast-growing performance with higher economic return as layers (Javed *et al.,* 2003), the breed is more susceptible to diseases as evidenced by high mortality rate (12.34 %) during the brooder stage (Ewonetu, 2017). Hence, combining of those two breeds were done with the expectation of complementing the deficient traits of Fayoumi with the best traits of White Leghorn and vice versa. Likewise, the study was conducted by crossing of other different breeds and evaluated for their heterosis, maternal and reciprocal-effects at brooder and grower ages (Yahaya *et al.,* 2009; Keambou *et al.,* 2010). However, there is a limited information on the heterosis, maternal and reciprocal-effect on growth performance and age at first egg for the crossbreeds of White Leghorn and Fayoumi breeds and crossing of those breeds were aimed to produce optimum crossbreds that adapted to semi scavenging and reared in small scale chickens productions. Therefore; this study was designed to evaluate the heterosis, maternal and reciprocal effects on different traits for crossbreed of Fayoumi and White Leghorn.

Materials and methods

Study area

The study was conducted at Haramaya University poultry farm, located at 505 Km east of Addis Ababa and situated at the distance of 5 Km from the nearby town of Haramaya, which is found on the main road connecting the capital, Addis Ababa with the eastern city of Harar. Its geographical location of the research site is at 9° 26' N latitude and 42° 3' E longitudes and an altitude of about 2010 meters above sea level. The area receives an average annual rainfall of 741.6 mm. The mean annual minimum and maximum temperatures of the site are 8.25 °C and 23.4 °C, respectively(quoted by Ewonetu, 2017).

Experimental house and parental flock management

All pens were cleaned and disinfected before start of the actual experiment but drinkers and feeders were washed every day in the morning throughout the study period. A total of three hundred fifty-two chicken (176 from each breed) were were purposively selected as a parental stocks at their peak egg production (34 weeks age) (Table 1). The parental stocks were grouped into four genotypes. Each genotype was reared in a deep litter house covered with *teff* straw and provided the same management. Those parental lines fed the same ration formulated to iso-caloric (2800-2900 Kcal ME/kg DM) and iso-nitrogenous (16-17% crude protein) from ingredients described in Table 2. The parental hens were reared for sixty days in separate pens with cocks in a ratio of one to ten to obtain hatching eggs which were used to produce day-old chicks.

Table 1: Breeding design and number of parent flocks used to produce day-old chicks

Genotypes	Number of parental flocks		
	Males	Females	Total
White Leghorn (female) x White Leghorn (males), purelines	8	80	88
Fayoumi (males) x Fayoumi (females), pure lines	8	80	88
White Leghorn (males) x Fayoumi (females), main cross	8	80	88
Fayoumi (males) x White Leghorn(female), reciprocal cross	8	80	88
Total	32	320	352

Egg collection, selection and incubation

Eggs produced by parental flocks were collected daily at 8:00 AM and 4:00 PM and medium egg size were selected (42.87-55.23g), oval shape, being free of shell cracks, and stored at room temperature for seven days. A total of one thousand eggs, 250 from each genotype was incubated using cabinet incubator (Pas Reform Hatchery technologies; Zeddam, Holland).

Day-old chick's management

All pens, watering and feeding troughs were cleaned, disinfected and the floor was covered using *teff* straw before the chicks were brought to experimental pens. Each pen was installed with two infrared light to provide heat during the brooder age for 24 hrs. A total of six hundred, 150 chicks were selected

from each genotype and each genotype was assigned to three replication, 50 chicks per replication and simultaneously evaluated until age at the first egg under the same environment. Day-old chicks were vaccinated for New Castle Disease and reared in deep litter pens up until age at first egg. The chicks fed on rations that were formulated for respective ages from different ingredients (Table 2). The diets formulated were to meet the nutrient requirements of 2800 kcal ME/kg DM for both age groups while 20 and 16 % CP of chicks (0-8) and growers (8-22), respectively (NRC, 1994).

Table 2. Feed ingredients and nutrient composition (% for DM)

Feed ingredient (%)	Management stages (weeks)		Mean Nutrient composition (% for DM) a					ME kcalkg-1
	Brooder (0-8]	Grower (8-22]						
			DM	CP	EE	Ash	CF	
Ground corn	55.00	45.15	89.00	7.10	5.30	2.30	8.00	3436.88
Soybean meal	12.00	15.00	93.20	38.50	8.90	8.00	9.00	3310.46
Peanut meal	9.00	13.00	94.70	37.30	9.60	6.20	12.00	3155.88
Wheat Short	20.00	25.00	90.30	12.00	3.30	6.80	6.2.00	3303.14
Limestone	3.15	1.00	-	-	-	-	-	-
Vitamin premix	0.50	0.50	-	-	-	-	-	-
Salt	0.35	0.35	-	-	-	-	-	-
Average			91.80	23.73	6.78	5.83	8.80	3301.34

[a] DM = Dry Matter; CP = Crude Protein; EE = Ether Extract; CF = Crude Fiber and ME = Metabolizable Energy.

Cockerels and pullets were reared together until 12 weeks of age and then after only pullets were evaluated for body weight and gain, feed intake and conversion, body weight, egg weight and age at first egg. Besides, heterosis, maternal and reciprocal effects were estimated for each parameters.

Data collection

Body weight and body weight gain

The body weight was taken at hatch and subsequently measured at monthly intervals by weighing chicks in a group and a total weight was divided by total number of chicks in each replication to obtain weight of each chick. The body weight gain of each chicken was calculated by the following formula.

$$\text{Body weight gain (g)} = \frac{\text{Final body weight} - \text{Initial body weight}}{\text{Number of days between two consecutive measurements}}$$

Feed intake and feed conversion ratio

A weighed amount of feed was offered once on the daily basis at 8:00 AM and refusal was collected next day at the same time. Then, the daily feed intake of each chick was estimated by subtracting feed refusal from offered and divided to total number of chicks in each replication. The feed conversion ratio (FCR) was measured by dividing the average daily feed intake of each chick by their live weight gain.

Performance at first egg (age, body weight and egg weight)

Age and body weight at first egg was evaluated for each genotype when their egg production reached 5% (North, 1978; as cited by Shafik *et al.*, 2013). A total of thirty-six eggs, 3 per replication, at first egg was randomly selected and evaluated at the same stage of production.

Statistical methods and experimental design

The effect of specific and general heterosis, maternal and reciprocal was calculated for all traits using the following formulae as cited by Emad and Amin (2015).

$$\text{Specific Heterosis (\%)} = \left[\frac{F1 - \left[\frac{P_1+P_2}{2}\right]}{\frac{P_1+P_2}{2}}\right] \times 100$$

Where:
F1– average values of traits of hybrid lines, $P_{1,2}$ –average values of traits of parents 1 and 2.

$$\text{General Heterosis} = \frac{(\text{Heterosis of Main crossbred}) + (\text{Heterosis of Reciprocal crossb}}{2}$$

Maternal effect = [White Leghorn Cock * Fayoumi hen] – [Fayoumi Cock * White leghorn hen]

$$\text{Reciprocal effect (RE)} = \frac{[PF1(WLm\ X\ Fff) - PF1(Ffm\ X\ WLf)}{2}$$

Where,

PF1 (WL_m X FF_f) - the mean performance of the F1 from a White Leghorn cock and Fayoumi hen crossings,

PF_1 (FF_m **X** WL_f) - the mean performance of the F_1 from a Fayoumi cock and White Leghorn hen crossings

Results

Heterosis Effect

Table 3 describes the heterosis of main and reciprocal progenies of White Leghorn and Fayoumi crosses. The estimates of heterosis percentages of White Leghorn cocks x Fayoumi hens (main cross) and its reciprocal crossbred gave positive heterotic effect for body weight throughout the study period. Therefore, the use of cocks or hens as a sire or dam in crossbreeds of White Leghorn and Fayoumi produces offspring that are heavier than either of their pure lines.

Table 3. Heterosis of different traits at 4 ,8, 12, 16 & 20 weeks of age in cross-breeds

Traits (g)	Heterosis (%)		
	General	Main crossbred	Reciprocal crossbred
Weight at 0 wk	4.44	3.73	5.16
W4	11.70	19.36	4.02
W8	12.09	21.31	2.87
W12	8.85	12.41	5.29
W12*	3.06	3.06	3.06
W16*	3.13	4.91	1.35
W20*	14.72	14.55	14.89
BWG 0-4	18.03	33.03	3.03
BWG4-8	12. 15	21.61	2.68
BWG8-12	12.48	9.78	15.17
BWG12-16*	-3.26	6.44	-0.07
BWG16-20*	23.15	22.87	23.43
Feed Intake at 0-4wk	-3.48	-0.84	6.11
FI4-8	-1.93	3.81	-0.04
FI8-12	-0. 65	3.13	-0.17
FI12-16*	-3.18	2.82	-3.54
FI16-20*	-1.56	-0.40	2.71
Feed Conversion Ratio at 0-4 wk	-20.69	-32.76	-8.62
FCR4-8	-27.78	-33.33	-22.22
FCR8-12	-5.00	0.00	-10.00
FCR12-16*	-10.00	-10.00	-10.00
FCR16-20*	-20.84	-25.00	-16.67
Body Weight at First Egg	11.77	11.45	12.08
AAFEL	-4.49	-2.39	-6.59
EWAFE	-2.64	-2.22	3.06

Means within a row with different lowercase letters are significantly different at P<0.05. W0, 4, 8, 12, 16, 20 = body weight at hatch, 4 ,8, 12, 16 & 20 weeks of age; BWG 0-4, 4-8,8-12,12-16 & 16-20=Body weight gain from 0-4, 4-8,8-12,12-16 &16-20 weeks; FI0-4, 4-8,8-12,12-16,16-20 =Feed Intake from 0-4, 4-8,8-12,12-16 & 16-20 weeks; FCR0-4,4-8,8-12,12-16 & 16-20= FCR with 0-4,4-8,8-12,12-16 & 16-20 weeks; BWAFEL-Body weight at age at first egg lay; *AAFEL-Age at first egg; EWAFE-Egg weight at first egg; Main crossbred-White leghorn cock X Fayoumi Hen*; **Parameters taken only for females.*

The heterotic effect was positive for weight gain in main crossbred throughout the study period while it was positive in reciprocal crossbred during brooder age but it was negative during the grower at the age of 12-16 weeks. Moreover, the general heterosis for body weight gain were positive starting from day-old to 20 weeks of age except at 12-16 weeks in growers. This positive heterosis demonstrated that the tremendous higher mean body weight gain in the crosses than the pure lines. The heterosis for feed intake in the main crossbred was reverse to the reciprocal and the main crossbred was better than their parents by their lower feed intake at brooder age (0-4 week) and at grower age (16-20 week) whereas the reciprocal crossbred was lower in feed consumption than parents from the age of 4-16 weeks. Overall, the general negative heterotic for feed intake demonstrated that the lower feed consumption of the crossbreds than the pure lines. Besides, the general negative heterotic for feed conversion efficiency throughout the study period. Estimates of heterosis percentages in main and reciprocal crossbreds were -2.39 and -6.59% for age at first egg, respectively. While lower heterotic effect was attained for the progeny of White Leghorn hens and Fayoumi cocks. Moreover, the F1 of White leghorn hens and Fayoumi cocks had a higher and positive heterotic for egg weight at first egg than its main crossbred. Hence, the F1 of White leghorn hens and Fayoumi cocks is preferred to reduce the age at first egg and produce heavier egg weight first egg.

Maternal and reciprocal effects

An estimate of maternal and reciprocal effects for body weight, feed intake, feed conversion ratio, body weight gain, age, body weight and egg weight at at first egg are given in Table 4. The results showed that the F1 of White Leghorn cocks and Fayoumi hens achieved positive estimates of maternal and reciprocal effects for body weight at all the studied stages except at day-old and 20th week. Similarly, the main crossbred noted that positive maternal and reciprocal effects for body weight gain except at 8-12 and 16-20 weeks. The negative estimates of maternal and reciprocal effects in this study indicated that the chicks mothered by White Leghorn are preferred for body weight and weight gain compared to chicks mothered by Fayoumi. Thus, it is recommended to use White leghorn as a hens in crossbreeding programs to improve body weight and weight gain. The results showed that the F1 of Fayoumi hens and White Leghorn cocks had a positive and higher maternal and reciprocal effects for feed intake at brooder ages, except within 0-4 weeks while its reciprocal was positive at the grower stage within the age of 12-20 weeks. This demonstrated

that chicks mothered by the Fayoumi hens consumed more feed during brooder age after 4th weeks onward whereas White Leghorn mothered chicks consumed more during the brooder stage. The main crossbred exhibited all negative results of maternal effect for feed conversion ratio except for 8-16 weeks while the reciprocal effect was all negative except at 12-16 weeks. Chicks mothered by Fayoumi demonstrated that more feed efficient than chicks mothered by White Leghorn. The positive maternal and reciprocal effects for age and egg weight at first egg were indicated that chicks from White Leghorn hens started egg production at an earlier age with heavier eggs than chicks mothered by Fayoumi.

Table 4. Maternal and reciprocal-effects on the performance of Fayoumi and White Leghorn crossbreeds

Traits	Maternal Effects		
	WLH cock x Fayoumi Hen	WLH Hen x Fayoumi cock	Reciprocal Effect
BW0	-0.42	0.42	-0.21
BW4	9.69	-9.69	4.85
BW8	84.66	-84.66	42.33
BW12	31.54	-31.54	15.77
BW12*	0.00	0.00	0.00
BW16*	31.45	-31.45	15.73
BW20*	-3.25	3.25	-1.63
BWG0-4	74.97	-74.97	37.49
BWG4-8	85.08	-85.08	42.54
BWG8-12	-21.58	21.58	-10.79
BWG12-16	31.45	-31.45	15.73
BWG16-20	-3.16	3.16	-1.58
FI0-4	-0.83	0.83	-0.425
FI4- 8	1.69	-1.69	0.85
FI 8-12	1.35	-1.35	0.68
FI8- 12*	2.98	-2.98	1.49
FI 12-16*	-2.05	2.05	-1.03
FI 16-20*	-1.47	1.47	-0.74
FCR0-4	-0.14	0.14	-0.07
FCR4-8	-0.01	0.01	-0.01
FCR8-12	0.01	-0.01	-0.005
FCR12-16*	0.00	0.00	0.00
FCR16-20*	-0.01	0.01	-0.01
BWAFEL	-7.67	7.67	-3.50
AAFEL	7.00	-7.00	3.50
EWAFE	-2.00	2.00	-1.00

Means within a row with different lowercase letters are significantly different at P<0.05. W0, 4, 8, 12, 16, 20 = body weight at hatch, 4 ,8, 12, 16 & 20 weeks of age; BWG0-4, 4-8,8-12,12-16 & 16-20=Body weight gain from 0-4, 4-8,8-12,12-16 &16-20 weeks; FI0-4, 4-8,8-12,12-16,16-20 =Feed Intake from 0-4, 4-8,8-12,12-16 & 16-20 weeks; FCR0-4,4-8,8-12,12-16 & 16-20= FCR with 0-4,4-8,8-12,12-16 & 16-20 weeks; BWAFEL-Body weight at age at first egg lay; AAFEL-Age at first egg; EWAFE-Egg weight at first egg; Main crossbred-White leghorn cock X Fayoumi Hen; *Parameters taken only for females.

Discussion

Specific and general heterosis

The positive heterotic observed for body weight at different ages (Table 4) which was in line with reports of many scholars (Iraqi *et al.*, 2002; Saadey *et al.,* 2008; Razuki and AL-Shaheen, 2011). On the contrary, Nawar *et al.* (2003) reported negative heterosis for body weight at different ages. The heterosis for body weight was ranged from 3.06 to 21.31% and 1.35 to 14.89% for main and reciprocal crossbreds, respectively that fall within the range -6.5-26.2% that reported by Afifi *et al.* (2002). The positive heterotic effects during the grower ages (12-20 weeks) implied the betterment of crossbreds over their parents in body weight. There was no definite heterosis trend observed for body weight and it was varied with age which is in agreement to Lamont and Deeb (2001). The positive heterotic for body weight at all age groups indicated the compatibility of the two parental breeds which is in line with Iraqi *et al.* (2002).

The higher heterosis for body weight gain was observed in F1 of Fayoumi hens and WLH cocks as compared to the reciprocal from hatch to 8 weeks (Table 4). Likewise, Jeremiah *et al.* (2017) reported a higher heterotic-effect for weight gain in main cross (57.37%) than reciprocal cross (45.39%). The heterosis of weight gain in this study was ranged from 0.07 to 33.03%. The negative heterotic-effect could be due to the higher weight gain of parents than their crossbreds. Similarily, Keambou *et al*. (2010) reported positive (67.2) and negative (-14.9) heterosis for weigh gain in main and reciprocal crossbreds, respectively. The positive heterotic-effects for body weight gain suggested that the superiority of the crossbreds over the parents being a good indicator of faster growth rate in F1 generation through the positive or negative heterosis can biologically be the phenotype that is preferred depending on the trait interested in.

The positive heterosis for body weight at first egg seen in crossbred of Fayoumi cock and White Leghorn hen (Table 3) which was in line with the study reported by Iraqi (2002) and Lalev *et al.* (2014). On contrary, negative heterosis of age at first egg for the main and reciprocal crossbreds were reported at different age groups (Table 3) though it was within the recommended range (-25 to 11.5 %) as reported by Williams *et al.* (2002). The negative heterotic indicated the improved hybrid vigor concerning the age of sexual maturity for the crossbred. The variation was due to heavier body weight and the maternal-effect of White Leghorn which is in line with report of Lalev *et al*. (2014). The negative

heterotic for age at sexual maturity observed for the F1 of WLH and Fayoumi chickens , this implied the desirable direction for age at first egg.

The White Leghorn hen and Fayoumi cock crossbred revealed positive heterosis for egg weight at age at first egg. This is inconsistent with the study of Saadey *et al.* (2008) who reported positive heterosis for egg weight produced by main and reciprocal crossbreds. Besides, Yahaya *et al.* (2009) reported positive heterosis of egg weight for the main (2.06 to 5.60%) and reciprocal (0.64 to 1.95%) crosses. This study indicated that the cross between WLH hen and Fayoumi cock produced progenies that have the potential to yield heavier eggs than their main crossbred.

Negative and positive heterotic was noted for feed intake in the main and reciprocal crossbreds, respectively (Table 3). Likely, the negative heterotic effect was reported in Mandarah x El-salam cross for feed intake (Taha and Abdei, 2013). The main crossbred was better than their parents by their lower feed intake at brooder ages (day-old to end of 4^{th} weeks) and at grower ages (16-20^{th} weeks) whereas the reciprocal crossbred was better than parents from the age of 4-16^{th} weeks. From this result, it can be concluded that the main crossbred revealed an inverse feed intake to its reciprocal crossbred at different ages. The negative heterotic estimates for the progeny of reciprocal crossbred was observed for FCR at all developmental ages (Table 4). The better efficiency in feed utilization of reciprocal progenies could be due to the inheritance of paternal genetic effect. The negative values of heterosis in either of the main or reciprocal crossbred implied the superiority of parents in efficient feed utilization than F1.

Maternal effect

The positive maternal-effect of body weight for Fayoumi hen and WLH cock crossbreds (Table 4) indicated their heavier body weight. Similarly, positive maternal-effects for body weight were reported by many researchers (Saadey *et al.,* 2008; Lalev *et al.,* 2014). On the contrary, Khalil *et al.* (1999) found that maternal-effects were in favor of White Leghorn for body weight in crossed between Saudi chickens and White Leghorn. A significant maternal effect on the live weight of offspring at an early age (0-8 weeks) was reported by Sabri *et al.* (2000). The F1 of main crossbreed resulted higher positive maternal-effects for weight gain at 0-8 and 12-16 weeks whereas reciprocal crossbred demonstrated positive maternal-effects at 8-12 and 16-20 weeks. The maternal-effect

was more favored the Fayoumi hens during the brooder age but favored the WLH hens during the grower period. This finding disagrees with Taha and Abdei (2013) who reported low and neglected maternal-effects in hybrid chickens for body weight gain. However, Ouyed and Brun (2008) reported negative maternal genetic-effect of daily weight gain. The negative maternal effect for body weight gain indicated that the reciprocal crossbreed progenies performed lower than main crossbred.

A positive and higher heterotic for feed consumption at (4-12 weeks) for F1 of main crossbred which is consistent with Taha and Abdei (2013). The study exhibited that the negative maternal-effect was observed for feed intake which was in line with the report of Emad and Amin (2015). An estimated result of feed conversion ratio was positive maternal influence at all ages except at grower (8-12) weeks of age for F1 of reciprocal crossbred (Table 5). This indicated that the use of WLH as hens and Fayoumi as cocks in crossing would produced the progenies that are less efficient in feed conversion at the respective ages. The negative maternal-effects in chickens for FCR were also reported by Taha and Abdei (2013). The F1 of White Leghorn as hen and Fayoumi as cocks had negative maternal-effect at age at first egg in Table 4. This indicated that the age at first egg was advanced over the pure line genetic groups and this has shown the evidence of maternal influence on age at first egg. Many scholars also found that the evidence of maternal-effects on traits of age at first egg (-1.9; Nawar and Abdou, 1999) and (-8.5; Iraqi *et al.,* 2007) in Dandarawi chickens. The body weight at the first egg for F1 of reciprocal crossbreed had positive maternal-effects than its reciprocal (Table 5).

This was consistent with the finding of Saadey *et al.* (2008) who reported superior maternal-effects for bodyweight at the first egg for Baladi Saudi and White Leghorn cross but Nawar and Abdou (1999) found a negative maternal-effect for body weight at first egg (-4.36) in the crossbreed progenies of White Leghorn and Baladi Saudi chicken. Further, Iraqi *et al.* (2007) reported negative maternal effect for the body weight at first egg (-6.3) in Rhode Island Red in Egypt. The positive heterotic effect of egg weight in main crossbred was superior performance than their parents. A positive maternal-effect for egg weight was also reported by Saadey *et al.* (2008). Besides, Sola-Ojo (2011) observed positive maternal-effect in egg weight for the cross between exotic egg-type strain Dominant Black and Fulani ecotype chickens.

Reciprocal effect

The negative reciprocal-effects were observed (RE) for body weight at day-old, 20th week and age at first egg (Table 4). The use of WLH as a cocks and Fayoumi as a hens would resulted higher body weight from the 4th to the end of 16th weeks. Consistently, Waleed *et al.* (2011) reported positive RE for body weight at hatch. The negative RE for body weight gain at 8-12 and 16-20 weeks was revealed lower weight gain in F1 of WLH as cocks and Fayoumi as hens. On the contrary, the positive and negative reciprocal-effects were reported for body weight gain at different ages in diallel crosses of Saso, Italian and Mandarah chickens at 0-4, 4-8, 8-12 and 0-12 weeks (Emad and Amin, 2015).

The positive RE was observed for feed intake at age of 4-12 weeks for F1 of WLH cocks and Fayoumi hens (Table 4). Consistently, a positive reciprocal effect also noted for feed intake by Jeremiah *et al.* (2017) for progienies of naked neck and Frizzle crossbreed. Furthermore, many scholars observed positive RE for feed intake at various ages (Nwachukwu *et al.,* 2006; Laxmi *et al.,* 2009; Razuki and Al-Shaheen, 2011). However, the negative RE was observed for feed conversion ratio the crossbreed of WLH cocks and Fayoumi hens except at 8-12 and 12-16 weeks of age, this implies that the F1 of White Leghorn as cocks and Fayoumi as hens generate offsprings with better FCR than reciprocal crossbreed. The negative RE was observed when WHL as hens and Fayoumi as cocks crossbreed for age at first egg and this indicate that the earlier maturity of reciprocal crossbred than the progenies obtained from main cross. Similarly, the negative RE for age at sexual maturity also reported by (Bahie *et al.,* 1998). The positive and higher RE was illustrated for body weight and egg weight at the first egg of WLH as a hens and Fayoumi as a cock crossbreed. This implied that the crossbreed progenies were higher in body weight and produced heavier eggs than pure lines at age at first egg.

Conclusions

In conclusions, Fayoumi hens crossbreed with White Leghorn cocks progenies were the highest body weight; where it's reciprocal crossbreed progenies were the most feed efficient. The progenies obtained from White Leghorn hens crossed with Fayoumi cocks had negative reciprocal effect on age at first egg and it had positive and higher reciprocal effect for body weight at first egg. This study was conducted from hatch to age at first egg and it recommends the crossbred of Fayoumi cocks and White Leghorn hens should be used for their earlier sexual maturity.

Acknowledgment

The authors are greatly thankful and appreciate the staffs of Poultry farm who assisted during the study. Moreover, the authors also thanks to Haramaya University for research grant.

Conflict of interest

No potential conflict of interest among the authors.

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