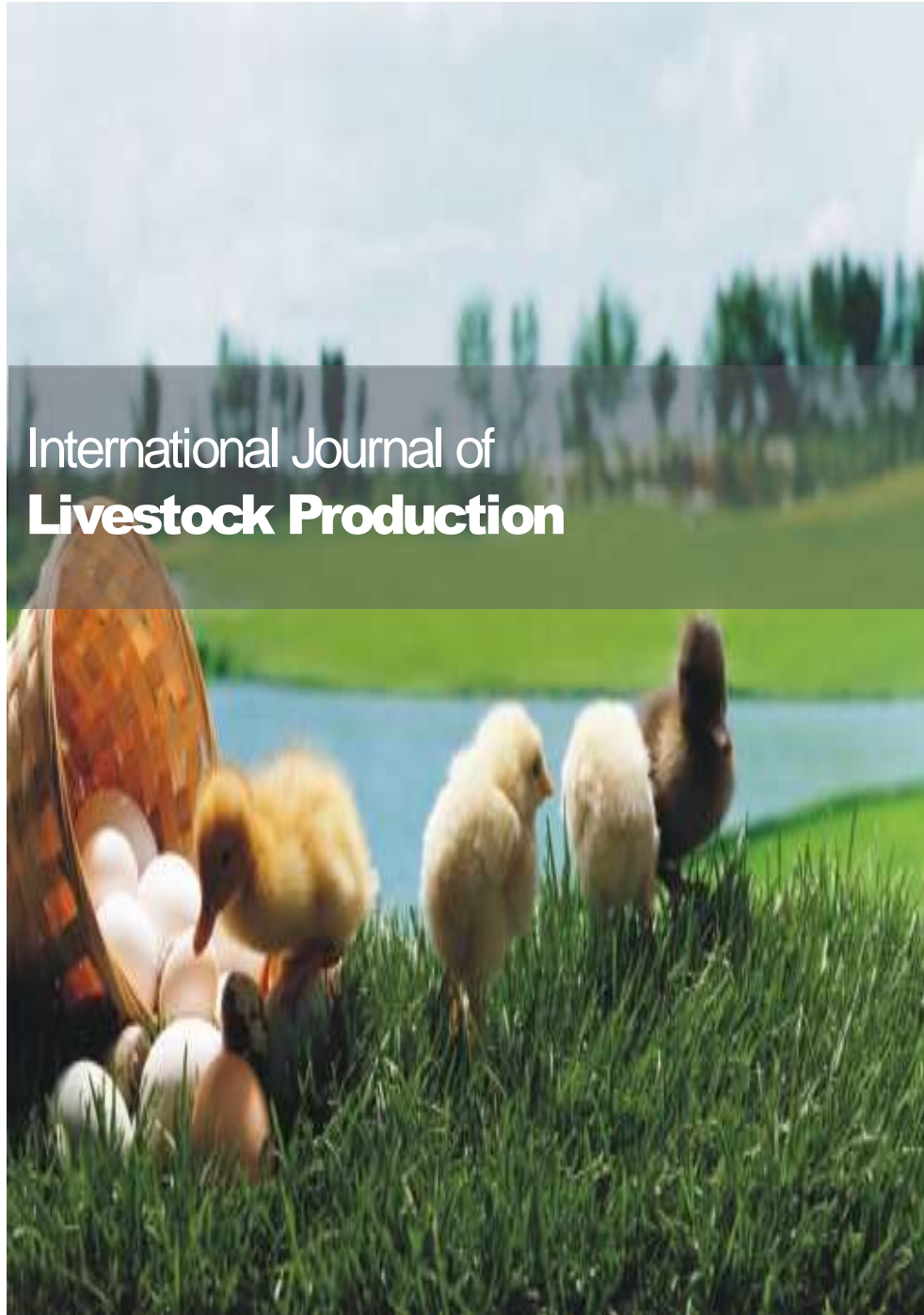


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Full Length Research Paper

The effect of physical feed restriction during the starter period on broilers' performance

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An experiment was conducted in a completely randomized design to study the effect of physical feed restriction on broilers' performance during the starter period. Two hundred and forty one-day-old unsexed (Hubbard) broiler chicks were randomly distributed in six treatments; there were five replicates with eight chicks per a replicate. Treatment A: fed ad libitum (control). Restricted groups were restricted at selected percentages of the ad libitum intake of the full fed controls. The percentages were: B= 90%, C= 80%, D= 70%, E= 60% and F= 50%. Feed restriction was applied from 8-28 days of age. The experiment lasted for six weeks. Control birds showed significantly ($p<0.05$) higher body weight and carcass cuts weight than restricted ones. Feed conversion ratio was not affected by feed restriction regimen applied in the present study. Restricted birds failed to compensate for the loss in weight due to prolonged feed restriction period.

Key words: Broiler chicks, performance, physical feed restriction, starter period.

INTRODUCTION

Eating to full gut capacity was believed to guarantee maximum weight gain during the rearing period. So, to achieve this goal, management practices concerning broiler nutrition and welfare are thus established (NRC, 1994). Broilers also were genetically selected to gain more weight in shorter time with better feed conversion. These broiler strains are characterized by fast growth rates ((Netshipale et al., 2012) and over-consumption of feed (Mirshamsollahi, 2013). This led to increased mortality and culls due to ascites and skeletal abnormalities (Yagoub and Babiker, 2008; Tumova et al., 2002; Netshipale et al., 2012) and increased fat deposition (Yu and Robinson, 1992). As a result, management practices concerning feed and feeding have

been changed to reduce the bad effects resulting from ad libitum feeding. Such practices aim to reduce the early growth rate of these modern strains. These practices include changing feed quantity and quality. Researches applied different early feed restriction programs to reduce growth rate. These programs may result in synchronizing the speed of growth of different body organs and decrease bad effects of rapid growth (Balog et al., 2000; Ozkan et al., 2006; Leeson and Summers, 2009), improve the efficiency of feed utilization and weight gain (Mahmood et al., 2007) and decrease the feed cost (Tolkamp et al., 2005; Zhan et al., 2007; Yang et al., 2009; Sahraei, 2012). Feed restriction means feeding chicks with a diet that does not meet the nutritional

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Table 1. Composition of the experimental diets (%).

Ingredients (%)	Starter	Finisher
Sorghum	67.5	71.65
Groundnut cake	25	20
Super concentrate	5	5
Lime stone	1.7	1
Lysine	0.15	Not added
Methionine	0.2	Not added
Tallow	0.2	2
Anti mycotoxin	0	0.1
Salt	0.25	0.25
Total	100	100

Reference: calculations were based on The Nutrient Composition of Sudanese Animal Feeds (1999).

requirements for normal growth. It is achieved by limiting feeding time, or reducing amount of feed offered to the birds or changing the quality of feed by reducing protein or energy or both. Early feed restriction depends on compensatory growth phenomenon (Leeson and Zubair, 1996) in which restricted birds compensate for the weight loss during restriction period when feed restriction is over. The objective of the present study is to evaluate how six levels of physical feed restriction during the starter period influence broiler chicks' performance.

MATERIALS AND METHODS

Experimental birds

Two hundred and forty 1-day-old (Hubbard) broiler chicks were tested for performance in this experiment. The birds were reared as one group for one week (adaptation period). At day 8 of their age, these chicks were weighed and distributed amongst cages so that the mean body weight in each cage and their variations were nearly identical. Then they were allotted randomly to six treatment groups such that each treatment received five replicates with eight chicks per a replicate. Each replicate was kept in a separate pen measuring $1 \times 1 \text{ m}^2$. The chicks in group A were fed *ad libitum* and served as control. The birds in groups B, C, D, E and F were kept on a feed restriction program from 8-28 days. The chicks were restricted at selected percentages of the *ad libitum* intake of the full fed controls. The birds were kept under similar management conditions like space, light, and vaccination in an open-sided poultry house up to the age of six weeks. Fresh and clean water was available *ad libitum* during the experimental period. The experiment was carried out at the Animal Production Research Center, Khartoum North, Sudan.

Restriction program

Broiler chicks were restricted at selected percentages of the *ad libitum* intake of the previous 24 h feed consumption of full fed controls (X% multiplied by amount of feed intake of controls at the previous 24 h); (A) *ad libitum* feeding; (B) 90% of *ad libitum*; (C) 80% of *ad libitum*; (D) 70% of *ad libitum*; (E) 60% of *ad libitum*; (F) 50% of *ad libitum*. The amount of feed is daily calculated and

offered to the chicks. At the end of the week the left overs are weighted and feed intake is calculated.

Experimental diets

All birds received the same pre-starter diet to 7-days of age. They received the starter diets to 28 days old, and the finisher diet from 29 to 42 days old (Tables 1 and 2). All diets were formulated to meet the nutrient requirements per NRC (1994) with sorghum and groundnut cake.

Data collection

Feed intake, body weight, weight gain were recorded weekly. Then, feed conversion ratio is calculated for all treatments. The data were collected in group basis. At day 42 after feed was withheld for 12 h, ten birds from each treatment were selected for carcass and carcass cut weights.

Statistical analysis

In this experiment, birds were assigned to the six dietary treatment groups following a completely randomized design (CRD). The experimental units were replicate cage means. All data were analyzed using the One- Way ANOVA procedure for analysis of variance. Significant differences among treatments were identified at 5% level by Duncan's Multiple Range Tests (1955).

RESULTS

Effect of physical feed restriction during 8-14 days-old

The results of the effect of physical feed restriction on performance during 8-14 days old are presented in Tables 2 and 3. The results showed that full fed birds had significantly higher ($p < 0.05$) body weight, weight gain and feed intake than restricted ones. Among restricted birds, 90% fed birds consumed more feed and gained more weight ($p < 0.05$) than the other restricted groups. Feed

Table 2. Calculated nutrients and determined analysis of the experimental diets.

Ingredients	Starter	Finisher
ME (kcal/kg)	2951	3121
Crude protein (%)	23	21
Crude fiber (%)	4.4	4.01
Ether extract (%)	3.81	5.54
Methionine (%)	0.54	0.59
Lysine (%)	1.27	1.01
Ca (%)	1.34	1.10
Available phosphorus (%)	0.55	0.53
Determined analysis		
ME (kcal/kg)	3086	2995
Dry matter (%)	94.10	92.20
Ash (%)	8.93	5.01
Crude protein (%)	21.92	16.81
Ether extract (%)	3.2	3.8
Crude fiber (%)	4.4	4.00

Composition of the super concentrate: ME =2300 kcal/ kg, CP =37%, EE = 4.5%, CF =7.5%, Ca=6.0, P=6.5, Lysine=11.0, Methionine =4.2.

restriction regimes used in the present study had no effect on feed conversion ratio except for 60% fed birds which showed the poorest feed conversion ratio ($p < 0.05$).

Effect of physical feed restriction during 15-21 days-old

The results of the effect of physical feed restriction on performance during 15-21 days old are presented in Tables 2 and 3. Control birds showed significantly higher ($p < 0.05$) body weight than restricted ones. Comparing restricted birds, the differences in body weight were significant ($p < 0.05$) and the 90% fed birds were the heaviest. During this week, the differences in weight gain and feed intake of control and 90% fed birds were not significant. The effect of feed restriction on feed conversion ratio was not significant ($p < 0.05$) between full fed and restricted birds and amongst the restricted ones.

Effect of physical feed restriction during 22-28 days-old

The results of the effect of physical feed restriction on performance during 22-28 days old are presented in Tables 2 and 3. At 28 days- old (the end of the restriction period), there were no significant differences in body weight between full fed and restricted birds ($p < 0.05$). There was no significant difference ($p < 0.05$) in weight gain between full fed and 90%, 70% and 60% fed birds. Control birds consumed significantly ($p < 0.05$) more feed

than restricted birds. The best feed conversion ratio was shown by 90% fed birds. There were no significant differences in feed conversion ratio among full fed, 80 and 60% fed birds.

Effect of physical feed restriction on carcass and cut weights

The results of the effect of physical feed restriction on carcass and cuts weights are presented in Table 4. The differences in carcass weight, breast, drumstick and wings weight between full fed and restricted birds were significant ($p < 0.05$). Restricted birds showed different breast, drumstick and wing weights.

Effect of physical feed restriction on overall performance (8-42 day old)

The results of the effect of feed restriction on performance during 8-42 days old are presented in Table 5. Different feed restriction regimes used in this study resulted in significantly ($p < 0.05$) lighter body weight of restricted birds than full fed ones. Among restricted birds, 90 and 80% fed birds showed the same weight ($p < 0.05$). Full fed birds gained significantly ($p < 0.05$) more weight than restricted birds, but the difference in weight gain among restricted birds was not significant. Full fed and 90% fed birds consumed the same ($p < 0.05$) amount of feed. There were no significant differences in feed intake among 80, 70 and 60% fed birds. The group fed 50% diet

Table 3. Effect of feed restriction on body weight and weight gain (g).

Parameter	Treatment					
	A	B	C	DE	F	
Bird age (days)	Body weight (g/b)					
8- 14	337.5±15.31 ^a	244.0±25.08 ^b	205.0±11.18 ^{bc}	241.25±33.54 ^b	165.0±78.76 ^c	202.5±9.48 ^{bc}
15- 21	650.25±31.87 ^a	530.25±45.98 ^b	431.5±25.39 ^{cd}	459.25±50.25 ^c	403.75±25.62 ^{ed}	361.5±22.03e
22- 28	611.8±464.1	882.8±61.28	745.00±38.78	796.2±59.29	724.00±34.52	675.00±15.98
Bird age (days)	Weight gain (g/b)					
8- 14	200.0±15.31 ^a	114.0±14.24 ^b	67.5±11.18 ^c	103.75±33.54 ^b	67.5±14.25 ^c	65.0±9.48 ^c
15- 21	312.75±23.39 ^a	286.25±42.4 ^a	226.5±20.34 ^b	218.0±29.43 ^b	198.8±14.18 ^b	159.0±18.08 ^c
22- 28	333.6±16.29 ^{ab}	352.6±41.37 ^a	313.8±15.99 ^b	337.00±20.29 ^{ab}	320.2±35.49 ^{ab}	313.8±14.69 ^b

Means within a row with different super scripts differ significantly ($p < 0.05$). Feed conversion ratio (gram feed intake/gram weight gain). A= 100%, B=90%, C=80%, D=70%, E=60%, F= 50%. Values are means ± Standard deviation.

Table 4. Effect of feed restriction on feed intake and feed conversion ratio (g).

Parameter	Treatment					
	A	B	C	D	E	F
Bird age (days)	Feed intake (g/b)					
8- 14	308.95±29.25 ^a	204.80±17.58 ^b	129.5±23.48 ^c	177.68±14.72 ^b	141.85±23.56 ^c	123.27±20.09 ^c
15- 21	577.0±63.7 ^a	577.96±138.1 ^a	460.42±38.95 ^b	426.29±76.81 ^b	408.78±86.37 ^b	296.6±20.84 ^c
22- 28	603.2±35.55 ^a	542.6±37.58 ^b	541.8±23.27 ^b	548.4±19.86 ^b	536.2±29.92 ^b	519.8±17.40 ^b
Bird age (days)	Feed conversion ratio (g/b)					
8- 14	1.55±0.14 ^b	1.76±0.06 ^b	1.92±0.19 ^{ab}	1.85±0.51 ^{ab}	2.14±0.37 ^a	1.9±0.17 ^{ab}
15- 21	1.86±0.11	2.00±0.29	2.02±0.11	1.95±0.19	2.05±0.39	2.05±0.11
22- 28	1.81±0.09 ^a	1.55±0.15 ^c	1.73±0.05 ^{ab}	1.63±0.10 ^{bc}	1.69±0.14 ^{ab}	1.66±0.07 ^{bc}

Means within a row with different super scripts differ significantly ($p < 0.05$). Feed conversion ratio (gram feed intake/gram weight gain). A= 100%, B=90%, C=80%, D=70%, E=60%, F= 50%. Values are means ± Standard deviation.

consumed the lowest amount of feed. There were no significant ($p < 0.05$) differences in feed conversion ratio between control and the other restricted groups except 50% fed group which had the poorest performance.

DISCUSSION

Performance at 14 days- old

At this early age, restricted birds' performance

was inferior to control birds. That might be due to the inability of the young birds to adapt to feed restriction. This inability of adaptation was evident in the performance of birds subjected to severe (60% and 50%) and mild (80%) levels of restriction.

Table 5. Effect of physical feed restriction on carcass weight (g).

Treatment	Carcass	Breast	Thigh	Drumstick	Wings
A	1310.000±60.21 ^a	390.70±27.03 ^a	198.40±16.29 ^a	189.20±26.34 ^a	147.80±5.76 ^a
B	1130.000±71.59 ^b	306.60±33.25 ^b	206.20±9.88 ^a	153.20±12.05 ^{bc}	134.60±10.97 ^b
C	1087.600±81.13 ^b	323.00±13.22 ^b	192.50±52.56 ^{ab}	148.00±4.08 ^{bc}	135.25±2.06 ^b
D	1090.000±195.74 ^b	279.75±16.80 ^c	194.50±15.42 ^{ab}	126.00±4.76 ^d	113.50±6.14 ^c
E	1045.000±54.20 ^b	276.80±27.98 ^c	164.80±7.53 ^b	160.20±13.44 ^b	126.00±8.94 ^b
F	1077.000±31.84 ^b	233.00±56.47 ^c	178.00±5.00 ^{ab}	137.40±8.17 ^{cd}	124.20±4.60 ^{bc}

Means within a column with different super scripts differ significantly ($p < 0.05$), A= 100%, B=90%, C=80%, D=70%, E=60%, F= 50%, Values are means \pm Standard deviation.

Restricted birds had significantly ($p < 0.05$) lower body weight than full fed ones. This result agrees with the findings of Mohebodini et al. (2009). The results of the present study showed that full fed birds gained higher weight than restricted ones. This result agrees with what reported by Jang et al. (2009) and Acheampong-Boateng et al. (2012). Reduced feed intake of restricted birds agrees with the findings of Santoso (2002) who found that feed intake was lower during feed restriction. It also follows the findings of Leeson et al. (1999), Jang et al. (2009), Mohebodini et al. (2009), Toghiani et al. (2014) and Dissanayake and David (2017). It seemed that longer duration and more severe feed restriction would significantly reduce feed intake (Santoso, 2002). That is clear in feed consumed by 90% fed birds in comparison to the restricted birds except for 80% fed ones. The reduced feed intake of restricted birds in this study does not follow the findings of Acheampong-Boateng et al. (2012). The results of the effect of feed restriction on feed conversion ratio in this study showed no effect of feed restriction on the ability of restricted birds to utilize nutrients at this age. This result does not follow the findings of Shariatmadari and Hosseni (2001) who found that the feed conversion efficiency of the birds subjected to early feed restriction was better than the control group. The results also do not follow the findings of Urdaneta-Rincon and Leeson (2002), but agrees with Lippens et al. (2000) and Yussefi et al. (2001) and Jang et al. (2009) who found that feed restriction did not affect feed conversion ratio.

Performance at 21 days- old

The results of the present study showed higher body weight and weight gain of control birds in comparison to restricted birds. The increased severity of feed restriction caused lower body weight. This result agrees with the findings of Mohebodini et al. (2009) and Vargas et al. (1999) who reported that the body weight and weight gain reduced in higher levels of feed restriction. Santoso (2002) reported that the level of feed restriction significantly influenced the body weight. This result

agrees with the findings of Jalal and Zakaria (2012) who found that *ad libitum* fed birds showed higher body weight and gained more weight than the restricted groups. El-Moniary et al. (2010) got different results. They found that 70% of fed birds had higher body weight and gained more weight than full fed birds at 21 days old. The present study showed that at 21 days old, 90% fed chicks consumed more feed than the control and other restricted groups, while other restricted groups consumed lesser quantities than full fed birds. This agrees with Santoso (2002), Mohebodini et al. (2009) and Acheampong-Boateng et al. (2012) who found that feed intake of restricted birds was lower during feed restriction. Dissanayake and David (2017) also reported that feed intake decreased with the severity of feed restriction. The effect of feed restriction on feed conversion ratio was not significant ($p < 0.05$) between full fed and restricted birds. Full-fed and 90% fed birds had superior feed conversion ratio, which indicates a good ability of these birds to utilize nutrients. This result agrees with the findings of El-Moniary et al. (2010).

Performance at 28 days old (the end of restriction period)

Even though there were no significant differences in body weight between full fed and restricted birds ($p < 0.05$), restricted birds showed higher body weight than control ones. This result does not agree with Butzen et al. (2013) who found lower body weight of restricted birds at the end of the restriction period. The results of Jang et al. (2009), Mohebodini et al. (2009) and Acheampong-Boateng et al. (2012) go in the same line with the present study. Feed intake of restricted birds was significantly ($p < 0.05$) lower than that of full fed birds. This result agrees with Leeson et al. (1999), Santoso (2002) and Dissanayake and David (2017) but disagrees with Leeson et al. (1991) and Mahmood and Mehmood (2007) who reported that restricted birds consume more feed than full fed birds. The results of the present study also do not follow the findings of Lippens et al. (2000) who found no significant difference in feed intake between

Table 6. Effect of physical feed restriction on overall performance (8-42 day old) (g).

Treatment	Body weight	Weight gain	Feed intake	*FCR
A	1725.00±106.07 ^a	1588.00±106.13 ^a	2943.40±159.19 ^a	1.85600±0.09 ^{ab}
B	1585.00±96.18 ^b	1454.60±96.76 ^b	2851.40±191.50 ^{ab}	1.96600±0.16 ^a
C	1525.00±107.53 ^b	1388.00±107.53 ^b	2554.00±162.47 ^c	1.84800±0.15 ^{ab}
D	1378.00±101.16 ^c	1335.20±77.31 ^b	2676.20±96.85 ^{bc}	2.00800±0.11 ^a
E	1474.00±57.60 ^{bc}	1337.00±57.60 ^b	2595.00±114.98 ^c	1.94200±0.09 ^a
F	1485.00±60.21 ^{bc}	1348.00±60.21 ^b	2335.20±123.90 ^d	1.73200±0.04 ^b

Means within a column with different super scripts differ significantly ($p < 0.05$), *FCR= feed conversion ratio (gram feed intake/gram weight gain), A= 100%, B=90%, C=80%, D=70%, E=60%, F= 50%, Values are means ± Standard deviation.

restricted and full-fed birds. The significant difference in feed intake combined with the same body weight of full fed and restricted birds reflects the improvement of feed conversion ratio of restricted birds due to restriction regime used in the present study. Similar results were reported by Vargas et al. (1999), Urdaneta-Rincon and Leeson (2002), Saleh et al. (2005), Ozkan et al. (2006) and Yagoub and Babiker (2008).

Carcass and cuts weight

Feed restriction procedure applied in this study clearly affected carcass and cuts weight (Table 4). Full-fed birds had the heaviest carcass and cuts weight. This result agrees with Vargas et al. (1999), Lippens et al. (2000), Urdaneta-Rincon and Leeson (2002) and Mohebodini et al. (2009), who found that carcass and cuts weight were depressed by feed restriction. Different results have been reported by Jalal and Zakaria (2012). They reported no significant differences were observed in carcass yield. Mirshamsollah (2013) found that feed restriction did not affect carcass cuts weight. Jahanpour et al. (2015) found that feed restriction did not affect breast weight. Tumova et al. (2002) and Jahanpour et al. (2015) found increased carcass weights of restricted birds compared to the control ones.

Overall performance

The results of the present study showed that restricted birds do not compensate for the loss in body weight (Tables 5 and 6). This result agrees with Fontana et al. (1992) who reported that broilers subjected to early feed restriction commencing at 4 days of age had significantly lower mean final body weight than control for all durations. The result of the present study also follows the findings of Santoso et al. (1995) who reported that restricted birds at 50% had lower body weight than control ones at 56 days old, Ramlah et al. (1996) who concluded no compensatory gain in restricted groups when providing 75% or restricted to 50% and Lanhui et

al. (2011) who reported that feed restriction for 70 and/or 80% decreased body weight significantly compared to full fed birds. Jang et al. (2009) reported the same result after 85 and 70% physical feed restriction at 35 days old. The significant ($p < 0.05$) difference in body weight between full fed and restricted birds reflected that the restriction was severe enough, that it did not allow for complete recovery at 42 days of age. This result indicated no compensatory growth occurred at this age. Past studies showed complete compensatory growth at 42 days of age after one week of feed restriction. Zubair and Leeson (1996) found complete compensatory growth when 50% was used, while Kumar et al. (1997) used 60%. Lippens et al. (2002) found that compensatory growth was substantial at 42 days old when 80% physical feed restriction was used.

Deaton (1995) applied 90, 80 and 60% levels and found complete compensatory growth at 41 days old. Bally et al. (1992) found that complete compensatory growth can be achieved in just 39 days after 6 days of feed restriction during the first 18 days of age. Many authors reported complete compensatory growth after longer re-feeding periods. Jones and Farrell (1992) reported that restricted birds showed body weight equivalent to that of control ones at 48 days old, Plavnik and Balnave (1992) at 47 days, Santoso et al. (1995) at 56 days, Attia et al. (1998) at 49 days, Santoso (2002) at 56 days, and Ozkan et al. (2006) at 56 days old.

According to study of Zubair and Leeson (1996), most weight loss during early feed restriction in birds can be normally compensated by 20 to 25 days of the re-feeding period. This indicates that mild feed restriction followed by long re-feeding period (6 weeks) allows restricted birds to compensate for the loss in body weight. That may be the reason for the failure of restricted birds in the present study to compensate for the loss in body weight. The results of this study showed significant differences ($p > 0.05$) in weight gain, feed intake and feed conversion ratio between full fed and restricted birds. Comparing restricted birds, 80, 70, 60 and 50% fed birds consumed lesser amounts of feed but gained significantly ($p > 0.05$) same weight. This indicated improvement in feed conversion ratio.

Conclusion

Early feed restriction depends on compensatory growth phenomena, in which restricted animals compensate for the weight loss during restriction period when feed restriction is over depending on duration of feed restriction and age of restriction. According to the study of Zubair and Leeson (1996), most weight loss during early feed restriction in birds can be normally compensated by 20 to 25 d of the re-alimentation period. The severity and prolonged period of feed restriction as well as the short re-feeding period (13 days) caused the restricted birds not to recover the loss of body weight due to feed restriction. It could be concluded that the severity and duration of feed restriction program applied in this study required a longer re-feeding period to allow complete compensatory growth.

CONFLICT OF INTERESTS

The author has not declared any conflict of interests.

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Full Length Research Paper

Determination of body weight from morphometric characteristics of guinea pigs (*Cavia porcellus*) reared in southern Benin

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In animal production, body weight is an important parameter for management, health and marketing decisions. This study is undertaken to determine the relationships between body weight and linear body measurements of guinea pigs. 120 guinea pigs (60 males and 60 females) were used. Body weight (BW), head-body length (HBL), chest circumference (CC), head circumference (HC), neck circumference (NC), left hind foot length (FL), and left ear length (EL) were the measured traits. The collected data were evaluated using multiple regression analysis. The obtained models of regression are : $BW = -397.374 + 10.817HBL + 16.440CC + 12.433NC - 19.039EL - 12.011FL + 12.458HC$; $BW = -560.601 + 4.531HBL + 21.649CC + 6.556NC - 6.632EL - 2.086FL + 34.370HC$; $BW = -477.178 + 7.941HBL + 17.672CC + 8.758NC - 10.383EL - 1.951FL + 22.884HC$, respectively for males, females and both sexes. In the regression model obtained for both sexes, the coefficients of HBL, CC and HC were significant ($p < 0.01$). The HC and CC coefficients for males and the CC and HC coefficients for females were also significant ($p < 0.01$). It was concluded that BW of guinea pigs was significantly influenced by CC, HBL, HC using multiple linear regression.

Key words: Body weight, morphometric traits, equation, multiple regression, guinea pigs.

INTRODUCTION

In developing countries such as Benin, the population explosion observed in recent years has led to food insufficiency and thus to a higher demand in animal protein. This situation exposes the population to protein-

energy malnutrition (PSDAN, 2009). Conventional livestock such as cattle, goat, sheep, pig and poultry cannot fill this need for protein. One solution is the breeding of unconventional animal species such as

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snails, grasscutters and guinea pigs. The guinea pig (*Cavia porcellus*) is a rodent considered as a microlivestock species that hold great promise for rural development because it requires little capital, equipment, space and labor (NR International, 2006). Caviaculture is according to Nkidiaka (2004), a solution to nutritional needs in general and proteins in particular. High prolificacy and diet flexibility, as well as a great adaptability to the wide range of housing and management approaches, are critical traits of guinea pig reared for meat production (Lammers et al., 2009).

The animal has a body weight ranging between 700-1200 g and can measure between 20-25 cm long (Vanderlip, 2003). Information on the weight of the animal is important for different management practices such as breeding, medication and supplementation. However, in rural zone where access to animal weighing is difficult, the most common methods for estimating the weight of the animal are the use of a regression equation developed from linear body measurements (Melesse et al., 2013). According to Khan et al. (2006), linear body measurements can be used as indirect selection criteria in the absence of weighing scale. Several studies have shown that there is a relationship between age and morphometric characters of animal (Chineke et al., 2006; Jayeola et al., 2009; Sacramento et al., 2013). Ozoje and Mberé (2002) reported on the use of skeletal dimensions such as shoulder width, heart girth and height at withers as good indicators of live weight. Heart girth was considered as the best indicator of live weight (Villiers et al., 2009).

The purpose of the present study is to attempt a prediction of live body weight of guinea pig from linear measurements namely head-body length (HBL), the chest circumference (CC), the head circumference (HC), the neck circumference (NC), the left hind foot length (FL) and the left ear length (EL) of guinea pigs.

MATERIALS AND METHODS

Study site

The study was conducted at the Application, Exploitation and Production Farm of the Faculty of Agronomic Sciences of the University of Abomey-Calavi in the south of Benin. The commune of Abomey-Calavi is located in the region where the sub-equatorial climate zone is marked by two rainy seasons and two dry seasons. The annual rainfall is 1,200 mm and the monthly temperatures mean vary between 27 and 31°C (INSAE, 2004).

Experimental animals

One hundred and twenty (120) guinea pigs composed of 60 males and 60 females were used for this study. These animals were bought on farms in the commune of Aplahoué and Allada. They belonged to different age categories, reflecting a variety in body weight values.

Once on the farm, the guinea pigs purchased were housed in cages made of wood with a grid bottom of 100 x 100 x 100 cm

raised 30 cm from the ground. The adult guinea pigs were put in groups of 10 while the young were put in groups of 15. They were fed *ad libitum* *Panicum maximum* supplemented with maize bran. Clean water was given *ad libitum*.

Data collection

Linear, curvilinear, weight, and other measurements were made on guinea pigs. These measurements were made following the method used by Sacramento et al. (2013). The different parameters measured are the head-body length (HBL), the chest circumference (CC), the head circumference (HC), the neck circumference (NC), the left hind foot length (FL), and the left ear length (EL). Linear measurements were taken using the tape measure while body weight was measured using a 10 kg measuring scale. The measurements were made as next described:

1. Head-body length (HBL): Length from the tip of the nose to the rump;
2. Left ear length (EL): Length from the point of attachment of the ear to the tip of the ear;
3. Left hind foot length (FL): Length from the heel to the longer finger without the claws;
4. Chest circumference (CC): Chest circumference taken by wrapping the tape around the chest just behind the fore legs;
5. Head circumference (HC): Head circumference by wrapping the tape around the head;
6. Neck circumference (NC): Circumference by wrapping the tape around the neck.

Statistical analysis of data

Data obtained were subjected to descriptive statistics (mean, standard deviation, minimum and maximum values). The inferential statistics (Student's t-test) were performed after checking the conditions of normality and homogeneity of the data respectively by the tests of Shapiro-Wilk and Leven. Multiple linear regressions were subsequently performed to model the body weight based on the explanatory variables of head-body length (HBL), the chest circumference (CC), the head circumference (HC), the neck circumference (NC), the left hind foot length (FL) and the left ear length (EL). For validation of the model, the following tests were carried out:

The Shapiro-Wilk test to check the normality of the residues; The Student's t-test to verify the nullity of the residues; The Breusch Pargan test to verify the independence of the residues; The Dubin Waston test to verify the homocedaticity of the residues; Analysis of variance (ANOVA) to verify the significance of the coefficients.

All these analyses were realized in the R version 3.5.0. Software. Regression test was carried out using with ime4 package. Analysis of variance realized during the test of regression was considered significant at the 5% level.

RESULTS

Characteristics of the physical measurements of guinea pigs according to the sex

Table 1 presents the mean values of body weight and morphometric parameters in relation to sex of the guinea pigs. For all traits considered, the mean values obtained

Table 1. Main morphometric parameters of guinea pigs.

Sex	Parameters : mean ± standard deviation (min ; max)						
	BW (g)	HBL (cm)	CC (cm)	NC (cm)	EL (cm)	FL (cm)	HC (cm)
Male	310.19±132.75 (41 ; 511)	25.26± 4.96 (12 ; 36.5)	14.57±2.86 (8 ; 23)	10.89± 2.09 (8 ; 16.4)	2.34±0.28* (1.7 ; 3.2)	3.42±0.51* (2.3 ; 4.2)	11.63±1.37 (8 ; 14)
Female	285.54±106.29 (62 ; 513)	24.61±3.91 (15 ; 31.3)	13.70±1.99 (8.8 ; 18)	10.75±1.84 (8 ; 14.5)	2.19±0.29* (1.5 ; 2.9)	3.35±0.41* (2.8 ; 4.2)	11.32±0.99 (8.5 ; 12.8)

BW, body weight; HBL, head-body length; CC, chest circumference; NC, neck circumference; EL, left ear length; FL, left hind foot length; HC, head circumference. * = statistically significant at 5% level.

Table 2. Results of the regression model coupled with variance analysis results.

Factors	Male		Female		Group (Male and female)	
	Coefficient	Standard errors	Coefficient	Standard errors	Coefficient	Standard errors
Constant	-397.374	59.946***	-560.601	75.048***	-477.178	43.971***
Head-body length	10.817	2.361***	4.531	3.790	7.941	1.977***
Chest circumference	16.440	3.003***	21.649	5.013***	17.672	2.604***
Neck circumference	12.433	4.790*	6.556	6.759	8.758	3.722*
Left ear length	-19.039	18.046	-6.632	21.626	-10.383	13.206
left hind foot length	-12.011	13.105	-2.086	1.505	-1.951	1.397
Head circumference	12.458	9.670	34.370	12.876**	22.844	7.572**
Degrees of freedom	57		57		120	
Adjusted R-squared	0.9255		0.8545		0.8993	
F-statistic	131.4***		62.66***		188.6***	

Signif. codes: 0; '***'0.001; '**'0.01, '*'0.05, '.' 0.1, ' '1.

in males were higher than those found in females. The results of inferential tests indicate that variables (EL and FL) are statistically significant at the 5% level.

Modeling: Equations of body weight prediction of guinea pigs

For males, the variations of the explained variable are explained by 92.55% of the variations of the explanatory variables. Three explanatory variables

presented in the model are significant after the variance test. These variables are head-body length (HBL), chest circumference (CC) and neck circumference (NC). The estimation coefficients reveal that when the weight of the guinea pig increases by 1 kg, the head-body length (HBL) of the guinea pig increases by 10.81 cm, the chest circumference (CC) increases by 16.44 cm and the neck circumference (NC) by 12.43 cm (Table 2).

The prediction equation for male body weight is: BW = - 397.374 + 10.817 HBL + 16.440 CC +

12.433 NC - 19.039 EL - 12.011 FL + 12.458 HC

For females, 85.45% of the variations of the explanatory variables presented in the model explain the variations in the explained variable. The significant explanatory variables after the analysis of the variance are the chest circumference (CC) and the head circumference (HC). The estimated model for predicting body weight of females is as follows:

BW = - 560.601 + 4.531 HBL + 21.649 CC + 6.556

NC -6.632 EL - 2.086 FL + 34.370 HC

According to this model a weight gain of 1 kg to the female would produce an increase of 21.649 cm of the chest circumference and an increase of 34.37 cm of the head circumference (Table 2).

In a general way without sex distinction, 85.45% of the variations in the explanatory variables presented in the model explain variations in the explained variable. The prediction equation for body weight of the animal (both sexes) is as follows:

$$BW = - 477.178 + 7.941 HBL + 17.672 CC + 8.758 NC - 10.383EL - 1.951 FL + 22.884 HC$$

The significant explanatory variables after analysis of variance in this model are the head-body length (HBL), the chest circumference (CC), neck circumference (NC) and the head circumference (HC). So a 1 kg increase in the animal weight would produce an increase in head-body length of 7.941 cm, an increase in chest circumference of 17.672 cm, an increase in neck circumference of 8.758 cm and an increase in head circumference of 22.884 cm (Table 2).

The Fischer F-values are high for the three established regression models. However, the higher values of F for the models estimated for males (131.4) and for the group (males + females) (188.6) prove the good reliability of these two models of prediction (Table 2).

DISCUSSION

From the study results, the mean values obtained in males were higher than those found in females for all traits considered. These results are similar to those reported in guinea pigs by Egena et al. (2010) except for length of ear. The observed difference between sexes cannot be attributed to the sexual dimorphism because ages of animal were not known. According to Mavule et al. (2013), the effect of ear length with body weight might be because ear length is determined by non-additive genetic effects and less affected by the environment.

The regression equations suggest that animal's weights are correlated differently with linear body measurements by sex. Similar results are reported by Egena et al. (2010) in guinea pigs, by Taye et al. (2016) in sheep and by Otoikhian and Kperegbeyi (2014) in goat. Heart girth was not the best variable for estimating body weight for female sheep, it was the height at rump and body length that were used to estimate weight for female sheep. In goats, the best predictors of body live weight for male and female is heart girth (Asefa et al., 2017).

The better association of body weight with heart girth was possibly due to relatively larger contribution of this parameter to body weight, which consists of bones,

muscles and viscera (Thiruvankadan, 2005). Likewise, heart girth is least affected by the posture of the animal (Asefa et al., 2017).

Egena et al. (2010) reported in guinea pigs high and significant correlation between body weight and body length, body weight and heart girth, and between body weight and trunk length. These morphometric parameters would be suggested as good for predicting live body weights in guinea pigs.

In females, Fisher's F value (F = 62.66) indicates that the equation model is not better and that it would be better to use the equation for the group (male + female) for easy prediction of weight. Sex dimorphism observed in guinea pig can explain the bad quality of the predicting model for female. Others linear body measurements such as width of the buttocks and pelvic width must be considered and included in regression model for the best predicting body weight equation for female. Pelvic width is an important trait affecting the productivity of the female through its effect on reproductive performances (Aliyari et al., 2012; Van Rooyen et al., 2012).

The body weight of the guinea pig is significantly influenced by HBL, CC, NC and HC. These parameters can be considered as good predictors of body weight. Parameters such as the EL and FL had a negative impact on the weight which leads to say that the light guinea pigs are characterized by large ears and long feet.

In the present study, the age of experimental animals was unknown and so the best predictors of body weight according to the age would not be defined with precision. However, Egena (2010) reports that in young guinea pigs aged 8 to 10 weeks, the best predictors of body weight are body length, trunk length and heart girth. Morphometric characters such as head-body length, tail length, ear length, left hind foot length without claws, neck circumference, head circumference, chest circumference and physical body weight are also used for age determination as reported by Sacramento et al. (2013) on grasscutters. The different predicting equations found by these authors could not be used for guinea pig which has no tail. In rabbits, the length between the nose and the shoulder, the length between the shoulder and the base of tail, chest circumference, height at wither, trunk length and ear length are used to predict live weight (Egena et al., 2012; Sakthivel et al., 2013). Donaldio et al. (2005) found that another parameter such as hind foot length has a good linear relationship with log-transformed weight of rabbits.

Conclusion

Significant relationship was observed between body weight and body morphometric measurements in guinea pigs. The prediction of body weight could be estimated from measurements of head-body length, chest circumference and head circumference using a multiple

regression predictive equation. Except for chest circumference, morphometric characteristics significantly influencing body weight in different regression models differ from sex to sex. Other studies may include guinea pigs whose ages will be controlled to better appreciate the effect of sex on the morphometric characteristics of the latter and thus on models of body weight prediction.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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Full Length Research Paper

Prevalence of bovine mastitis, risk factors, isolation and anti-bio gram of major pathogens in Mid Rift valley, Ethiopia

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Cross-sectional study design was implemented in Alage dairy farm to determine the overall prevalence of mastitis, its causative agents, susceptibility patterns and risk factors associated with it. A total of 111 milking dairy cows and 444 quarters were examined. Overall prevalence of mastitis at cow and quarter levels were 73 and 37%, respectively. Coagulase negative staphylococci (CNS) (37.7%) followed by *Staphylococcus aureus* (19.6%), *Escherichia coli* (9.4%), *Staphylococcus intermedium* (9.4%), *Bacillus* species (8%), *Streptococcus* species (5.8%), *Klebsiella pneumoniae* (5.8%), and *Enterobacter aerogenes* (4.3%) were isolated in that order of decreasing frequency. From a total of seven antibiotics tested, most isolates were sensitive to Norfloxacin but showed resistance to Ampicillin. Age, stage of lactation, milk yield, hygiene score, feet problems and udder conformation were found to be risk factors significantly ($P < 0.05$) associated with mastitis. The high prevalence rate of mastitis in a relatively well managed dairy farm implied that, it is the trickiest health problem of dairy cows that needs continued and concerted efforts in its fight.

Key words: anti-biogram, mastitis, pathogens, prevalence, risk factors.

INTRODUCTION

Various researchers, in different parts of the world, revealed mastitis as grievous disease in the dairy industry. The disease has been described as the most common and costly in dairy production (Seegers et al., 2003). The risk factors associated of the disease were also reported to be multi-factorial and multi faceted showing considerable differences with agro ecological zones and farming conditions. According to Getahun et al. (2008) loss in milk production, discarding abnormal milk and milk withheld from cows treated with antibiotics, decrease in milk quality and price due to high bacterial or

somatic cell count (SCC), costs of drugs, veterinary services and increased labor costs, increased risk of subsequent mastitis, herd replacement, and problems related to antibiotics residues in milk and its products are some of the major issues of concern for the cow, farmer and for the consumers.

According to Sharma et al. (2007) mastitis is one of the most significant health problems of dairy herds as it causes physical, chemical and bacteriological changes in the milk of dairy animals resulting in inferior quality and quantity of produced milk with possible public health

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importance. Therefore, conducting research on its prevalence and incidence will contribute to design appropriate preventive measures and treatment regimen in the specific dairy farm. Factors attributed to the prevalence of mastitis like parity was investigated by different authors in different parts of the country (Belayneh et al., 2013; Zeryehun et al., 2013; Katsande et al., 2013; Abrahmsén et al., 2014; Mureithi et al., 2016).

A.A.T.V.E.T.C. dairy farm which is located at mid-rift valley area of Ethiopia is the only source of milk and milk products for the total population of 10,000-15,000 residents in the community and provides milk products for nearby towns like Ziway, Bulbula, Shashemene and Awassa. Conducting research on the status of intra mammary infection, that can be considered as bottle neck to the production performance is of paramount importance. However, the information on the prevalence of the disease, associated risk factors, profiles of major mastitis causing pathogens and anti-bacterial susceptibility profiles of causative agents in this dairy farm is almost unknown. Therefore, the general aim of this study was: To determine the prevalence of mastitis and the associated potential risk factors in A.A.T.V.E.T.C. dairy farm, presumed to represent dairy herds with similar management practices and agro-ecological environment of the country.

Specific objectives of the study were:

- (i) To determine the prevalence of clinical and subclinical mastitis at quarter and cow level in A.A.T.V.E.T.C. dairy cows.
- (ii) To determine the associated risk factors with the outcome of interest.
- (iii) To isolate and identify the bacterial pathogens which cause both clinical and sub clinical mastitis and to conduct antimicrobial susceptibility profile of isolates.

The present study investigated the mastitis situation, causative agents, associated risk factors and antimicrobial efficacy in a college dairy farm, in the central rift valley agro- ecological zone, Ethiopia.

MATERIALS AND METHODS

Location

The study was conducted at the Alage Agricultural Technical Vocational Education Training College (AATVETC) dairy farm located in the central rift valley agro-ecological zone, 170 Km south of Addis Ababa, Ethiopia.

Study population and sample size

The study population consisted of all Holstein Friesian cows present at AATVETC dairy farm. A cross-sectional type of study was carried out on 111 lactating cows from October 2011 to May 2012.

Methodology

Farm inspection

A one-time inspection on the housing conditions, feeding practices and milking practices was conducted simultaneously with animal examination and milk sampling. The housing condition was qualified as "Poor" when one or more of the following were detected: bad smell, dirty barn, soiled animal flank, udder and belly. When none of the above defects were observed it was rated as "Good".

Animal examination

Animal examination was conducted to determine their body condition, presence or absence of feet and leg problems, soundness of udder and hygiene score. Body condition scoring was implemented using 1-5 point scale as per (Parker, 1989). Presence or absence of feet and leg problems were evaluated through visual inspection and palpation. Hygiene scoring of cows was determined based on a scale of 1 - 4 (Chaplin et al., 2000).

Udder examination

Visual inspection and palpation methods were used to identify atrophy of the tissue, udder attachment problems (asymmetry), quarter blindness, and cardinal signs of inflammation such as hotness, redness, swelling and painful sensation.

milk sample collection

Prior to milk sample collection, the udder, especially the teats, were thoroughly washed with tap water and cleaned with dry towel. Then the teats were disinfected with cotton soaked in 70% ethyl alcohol. Milk samples were collected by using standard milk sampling techniques (Quinn et al., 1999) from all lactating cows and quarters. To reduce contamination of the teat ends during sample collection, the near teats were sampled first followed by the far once. Approximately 10 ml of milk was collected from each quarter into labeled sterile screwed cap universal bottle after discarding the first three milking streams. Physical appearance of milk secretion from each mammary quarter was examined for the presence of clots, flakes, blood and watery secretions. Samples were then placed in ice box and transported to the Federal Microbiology laboratory of the college and processed in the same day of sample collection.

California mastitis test (CMT)

From each quarter of the udder, a squirt of milk sample was dropped in each of the strip cups on the CMT paddle and an equal amount of 3% CMT reagent was added to each cup and mixed gently. The test result was interpreted according to Quinn et al. (1999) based on the thickness of gel formed by CMT reagent and milk mixture and as 0 (negative), T (trace), 1(weak positive), 2(distinct positive) and 3(strong positive). Finally quarters with CMT score of 1 or above were judged as positive for sub clinical mastitis; otherwise negative.

Bacteriological isolation and identification

Milk samples were bacteriologically examined according to the procedures employed by Quinn et al. (1999). The milk samples, taken from infected quarters, were centrifuged so as to increase the

bacterial load and inoculated separately on to blood agar base enriched with 7% ovine blood using quadrant streaking method. The inoculated plates were incubated aerobically at 37°C for 24 to 48 h, after which presence or absence of bacterial growth, colony morphology, color and hemolytic characteristics were recorded on primary culture. Prior to further biochemical tests, the isolated bacteria were sub-cultured into nutrient agar. Each culture was subjected to gram staining to determine the shape, and gram reaction. Catalase test, using 3% Hydrogen per oxide (H₂O₂), was performed to identify catalase positive and catalase negative bacteria. Mannitol Salt Agar (Oxiod, UK) and purple base agar (Difco) with 1% maltose were used to differentiate *Staphylococcus* species. The culture was incubated at 37°C and examined after 24-48 h for mannitol and maltose fermentation respectively. Tube coagulase test, using rabbit plasma, was used to identify the coagulase positive and coagulase negative *Staphylococcus* species. *Enterobacteriaceae* species were identified using oxidase test. Other tests performed were SIM medium (Oxiod, UK) for sulfur production; indole test (after addition few drops of kovacs reagent) and motility test, (Triple Sugar Iron-Oxiod,UK) to detect sugar fermentation, sulfur and gas production; MacConkey agar (Oxiod, UK) for lactose fermentation and colony characteristics; and Simmon's citrate agar (Oxiod, UK) to differentiate bacteria based on citrate utilization.

Antibacterial sensitivity test

Kiby-Bauer disk diffusion method was employed to test *in vitro* antibiotic sensitivity test (Quinn et al., 1994). After identifying isolated colonies, each isolate was suspended in to Tryptose Soya Broth (TSB) (oxiod, UK) then incubated for 24 h. Finally, bacteria suspended in TSB media were spread in to Mueller Hinton agar and blood agar (oxiod, UK) using cotton swab. Seven different antibiotic discs namely, Norfloxacin, Ampicillin, Gentamicin, Doxycycline, Erythromycin, Trimethoprim- Sulfamethoxazole and Tetracycline were used, because these drugs were in use in the study area for treatment of different diseases. Finally, they are dispensed on the medium using forceps and incubated for 24 h. Diameter of zone of inhibition for each antibiotic disc was measured using a ruler in to the nearest millimeter and interpreted as resistant and sensitive according to the standard given by Quinn et al. (1994) and manufacturer (Oxiod) instruction.

Data entry and analysis

Data were coded, cleaned and entered into Microsoft Excel computer software. Statistical analysis was carried out using SPSS version 20. Data were analyzed using descriptive statistics and associations of the different variables with interest of outcome was analyzed using a Chi-squared (χ^2) test. The association was considered significant when odds ratio was greater than one and p-value was less than 0.05.

RESULTS

Cow data

Table 1 illustrates some of the physical and productive characteristics of dairy cows. The age of cows ranged from three to more than eight years with highest proportion (54%) being aged between 3 and 5 years. The majority (58.6%) of the cows were in their first and

second lactations. More than 82% of the cows had body condition score of 3-4. Milk yield per day varied from 4 L to more than 11 L with 53% of the cows producing 8-11 L per day.

Prevalence of mastitis

The overall prevalence of mastitis at cow level was found to be 73%. Prevalence of Sub clinical and clinical mastitis at cow level was found to be 56.8 and 16.2%, respectively. The overall prevalence of clinical and sub clinical mastitis at quarter level was 8.8 and 28.2%, respectively. Prevalence at right quarters and left quarters was also found to be 54.5 and 44.5%, respectively. The details of prevalence rates of clinical and sub-clinical mastitis at cow and quarter levels are presented in Tables 2 and 3, respectively. From a total of 444 quarters examined 23(5.2%) were blind quarters.

Bacteriological examination result

Table 4 illustrates the details of bacterial isolates. From a total of 156 quarter milk samples (37 clinical and 119 sub-clinical) cultured, 138 were positive. Ten (6.4%) of the cultured samples were rejected for contamination and 8 (5.1%) yield no bacterial growth. All the clinical mastitis and 101 of the sub-mastitis samples resulted in positive culture. Contagious pathogens like *Staphylococcus* bacterial species and environmental pathogens like *Escherichia coli*, *Klebsiella pneumoniae* and *Enterobacter aerogenes* were identified. The highly prevalent bacteria was coagulase negative staphylococci (CNS) (37.7%) followed by *Staphylococcus aureus* (19.6 %).

Animal and/or management factors associated with mastitis prevalence

Table 5 shows the relationship of animal and management related factors with mastitis prevalence at Alage Dairy Farm. Prevalence rate was 88, 77 and 63%, respectively in older, mid age and young cows. There was statistically significant difference among different age groups ($p < 0.05$). Cows in early lactation stage had highest mastitis prevalence (100%) than those at late (68%) and mid (43.3%) stages of lactation with highly significant statistical difference, $p < 0.01$. Feet problems were also significantly ($p < 0.01$) associated with mastitis prevalence. Pendulous udder, compared to high up udder had higher rate and the difference was statistically significant ($p < 0.01$). Animals with poor body condition score, multiple parities, and blind teats exhibited higher prevalence rate of mastitis (79, 80 and 91% respectively) compared to good body condition score, few parities and absence of blind teats ($p > 0.05$) (Table 5).

Table 1. Physical and productive characteristics of milking cows at Alage dairy farm (n= 111).

Category	Variable	Frequency	Percent
Age	Young (3-5 years)	60	54.05
	Mid age (6-8 years)	18	16.22
	Old age (>8 years)	33	27.73
Parity	Few (1-2 lactations)	65	58.56
	Many (\geq 3 lactations)	46	41.44
Stages of lactation	Early (1-3 months)	41	36.94
	Medium (4-6 months)	30	27.03
	Late (>6 months)	40	36.04
Average daily milk yield	High (> 11 liter)	35	31.53
	Medium (8-11 L)	59	53.15
	Low (4-7 L)	17	15.32
BCS (on a scale of 1-5)	Good (3-4)	92	82.88
	Poor (1-2)	19	17.12
Feet problems	Yes	43	38.73
	No	68	61.26
Udder conformation	High up	45	40.54
	Pendulous	66	59.46
Blind teat	Yes	23	20.72
	No	88	79.28
PETM	Yes	54	48.65
	No	57	51.35
Hygiene score (On a scale of 1-4)	Good (1-2)	65	58.56
	Poor (3-4)	46	41.44

Table 2. Cow and quarter level mastitis prevalence at Alague Dairy Farm (n= 111).

Variable	Total number of positive	Prevalence rate
Types of mastitis		
Clinical	18	16.2%
Sub clinical	63	56.8%
Total	81	73%
Quarter level blind teats distribution (n=444)		
Right fore	4	3.6
Right hind	4	3.6
Left fore	7	6.3
Left hind	8	7.2
Total	23	5.2

Table 3. Quarter level mastitis prevalence at Alague Dairy Farm (n=421).

Types of mastitis	Quarter level prevalence				Total
	Right front	Right hind	Left front	Left hind	
Clinical	11(2.6%)	8(2%)	7(1.7%)	11(2.6%)	37(8.8%)
Sub clinical	30(7.1%)	36(8.6%)	26(6.2%)	27(6.4%)	119(28.2%)
Total	41(9.7%)	44(10.5%)	33(7.8%)	38(9%)	156(37%)

Table 4. Frequency of occurrence of bacterial isolates from CMT positive milk samples at Alage Dairy Farm.

Types of bacteria isolated	Status of mastitis			Proportion (%)
	Clinical mastitis	Sub clinical mastitis	Total frequencies	
*CNS	15(10.9%)	37(26.8%)	52	37.7
<i>Staphylococcus aureus</i>	5(3.6%)	22(16%)	27	19.6
<i>Escherichia coli</i>	2(1.4%)	11(8%)	13	9.4
<i>Staphylococcus intermidius</i>	2(1.4%)	11(8%)	13	9.4
<i>Bacillus species</i>	4(2.9%)	7(5.1%)	11	8
<i>Streptococcus species</i>	2(1.4%)	6(4.4%)	8	5.8
<i>Klebsiella pneumoniae</i>	4(2.9%)	4(2.9%)	8	5.8
<i>Enterobacter aerogens</i>	3(2.174%)	3(2.174%)	6	4.3
Total	37(26.8%)	101(73.2%)	138	100

*CNS (coagulase negative staphylococci).

Antimicrobial susceptibility profile of mastitis isolates

Table 6 shows anti-biogram test results of seven antimicrobial drugs namely, (Norfloxacin (NOR10 µg), Ampicillin (AMP10 µg), Gentamicin (CN10 µg), Doxycycline (DO30 µg), Erythromycin (E15 µg), Trimethoprim-Sulfamethoxazole (SXT1.25 µg) and Tetracycline (TE30 µg) tested on seven different bacterial isolates, namely CNS, *S. aureus*, *E. coli*, *K. pneumonia*, *Staphylococcus intemidius*, *Enterobacter aerogens*, *Bacillus* spp. and *Streptococcus* spp.

Among antibiotics tested *in vitro* Norfloxacin was the most potent drug followed by Trimethoprim-Sulfamethoxazole Gentamicin, Doxycycline, Tetracycline and Erythromycin with the efficacy rate of 97, 94 and 89, 84 82 and 70% respectively. On the other hand, Ampicillin was found to be the least potent drug in the overall tested bacteria (55%). CNS isolates were susceptible to Gentamicin (100%), Tetracycline (100%), Trimethoprim-Sulfamethoxazole (95%), Norfloxacin (90%), Erythromycin (87%), Doxycycline (70%) and Ampicillin (40%). *S. aureus* isolates were also susceptible to Gentamicin (100%), Erythromycin (100%), and Trimethoprim-Sulfamethoxazole (100%, Norfloxacin (87%), Tetracycline (80%), Ampicillin (55%) and Doxycycline (43%) with trend of decrement in efficacy. *E. coli* was 100% susceptible to Norfloxacin and

Trimethoprim-Sulfamethoxazole but less commonly affected by Erythromycin, Ampicillin, Tetracycline and Gentamicin with the potency rate of ≤50%.

DISCUSSION

Prevalence of mastitis at cow and quarter level

The overall prevalence of mastitis at cow level was found to be 73% which is in line with the report of Regasa et al. (2010b) and Bishi (1998), who found the prevalence rate of 71 and 69.8%, in dairy farms of Holeta town and Addis Ababa and its vicinity, Ethiopia respectively. This is slightly lower than the report of Matios et al. (2009) who reported the prevalence rate of 64.5% in dairy farms of and Asella, Ethiopia. In contrast, our results was found to be by far greater than the prevalence report of Getahun et al. (2008), Gizat et al. (2008), Mekonnen and Tesfaye (2010), Sori et al. (2005) and Mungube et al. (2005) who reported mastitis prevalence as 33.6, 56, 48.1, 52.78 and 52.3% in the dairy farms of Selalle, Bahir dar, Adama and Sebeta and cross breed dairy cows in Ethiopia respectively.

The overall prevalence of clinical and sub-clinical mastitis at quarter level was found to be 8.8 and 28.2% respectively. Matios et al. (2009) also reported a sub clinical mastitis of 30.4% in Asella area. Getahun et al.

Table 5. Association of animal and management related risk factors with Mastitis at Alage Dairy Farm (n= 111).

Risk factor	Total No of cows	Status of mastitis			χ^2	df	P-value	OR	95% CI
		Clinical (%)	Sub-clinical (%)	Over all (%)					
Age¹									
Young	60	18.3	45	63.3	6.728	2	0.000**		
Mid age	18	0	77.8	77					
Old age	33	21.2	66.7	87.8					
Stages of lactation²									
Early	41	22	78	100	16.14	2	0.000**		
Medium	30	10	33.3	43.3					
Feet problems									
Yes	43	19	74	93	12.83	1	0.000**	5.5	2.05-14.68
No	68	15	46	60					
Udder conformation									
Pendulous	66	18	71	89	22.32	1	0.000**	7.5	3.11-18.085
High up	45	13	36	49					
Body condition score ³									
Good	92	20	52	72	0.79	1	0.32	3.4	1.06-11.15
Poor	19	0	79	79					
Lactation number (parity)⁴									
Many	46	715	65	80	2.3	1	0.1218	1.89	0.828-4.307
Few	65	17	51	68					
Previous exposure to Mastitis									
Yes	54	19	70	89	8.98	1	0.003**	3.52	1.516-8.165
No	57	14	44	58					
Average daily milk yield⁵									
High	35	17	74	92	13.44	2	0.001		
Medium	59	74	54	71					
Low	17	12	29	42					
Presence of blind teat									
Yes	23	21.7	69.5	291	2.012	1	0.156	2.2	0.747-5.323
No	88	14.7	53.4	68					
Cow's hygiene score⁶									
Bad	46	12(26)	34(74)	46(100)	19.05	1	0.000	0.118	0.041-0.337
Good	65	6(9)	29(45)	35(54)					

** : highly significant difference; Age¹: in years 3-5 (young) 6-8 (mid-age) and (>8) (old age);

Stages of lactation²: in months 1-3 (early), 4-6 (medium) and >6 (late)

Body condition score ³: in 1-5 scale; 1-2 (poor) and (3-4) good

Lactation number (parity)⁴: 1 and 2 = few, More than 2 = many

Average daily milk yield⁵: in 1-4 scales 1-2 (good) and 3-4 (bad)

Cow's Hygiene Score⁶: in 1-4 scales 1-2 (good) and 3-4 (bad).

(2008) and Mekonnen and Tesfaye (2010), however recorded lower level of sub clinical mastitis prevalence in Selalle (13.6%) and Adama area dairies (22.7%). Regasa et al. (2010a), on the other hand reported 34.8% sub

clinical quarter wise prevalence which is higher than our finding. Variations in husbandry practices between different areas might, at least, partly explain the differences in prevalence rates reported by different

Table 6. Anti-bio gram test result.

Bacterial isolates	Frequency	Anti-bio gram susceptibility test in percent						
		NOR10 µg	AMP10 µg	CN10 µg	DO 30 µg	E15 µg	SXT1.25 µg	TE 30 µg
CNS	52	90	40	100	70	87	95	100
<i>S.aureus</i>	27	87	55	100	43	100	100	80
<i>Escherichia coli</i>	13	100	38	50	88	30	100	45
<i>Klebsiella pneumoniae</i>	8	100	33	98	100	45	96	70
<i>Staphylococcus intermidius</i>	13	100	100	100	89	78	94	100
<i>Enterobacter aerogens</i>	6	100	48	60	100	55	90	78
<i>Bacillus spp.</i>	11	100	48	100	100	70	85	80
<i>Streptococcus spp.</i>	8	100	78	100	80	90	95	100

NOR= norfloxacin, AMP= ampicillin, CN= gentamicin, DO= doxycycline, E= erythromycin SXT= trimethoprim-sulfamethoxazole and TE=tetracycline.

authors. Quarter level clinical mastitis prevalence in this study was in line with what was reported by Regasa et al. (2010b), (10% of clinical prevalence at quarter level). But our findings is higher than those of Mekonnen and Tesfaye (2010) and Getahun et al. (2008) who reported quarter wise clinical mastitis prevalence of 2.4 and 0.9% respectively. Matios et al. (2009) reported clinical mastitis prevalence level as high as 14.9%.

The 5.2% of the mammary glands examined were found to be blind in the study animals which is slightly higher than the report of Matios et al. (2009) who found 4.5% of blind quarters. Getahun et al. (2008) and Mekonnen and Tesfaye (2010) reported 2.3 and 3.6% blind quarters respectively in their study herds. Currently, it is a well-accepted fact that agro-ecology, milking practice, breed difference, management practices and other risk factors influence mastitis prevalence, which might explain the observed differences between the reports of different authors in mastitis prevalence. In the present study, the higher prevalence level of sub-clinical mastitis compared to clinical form; indicate the magnitude of subclinical mastitis problem and low level of attention that given to it in terms of diagnosis and treatment.

Bacterial isolation and anti-bio gram susceptibility test

In this study the bacteria with the highest prevalence was coagulase negative staphylococci (CNS), followed by *S. aureus*, *Escherichia coli*, *Staphylococcus intermidius*, *Bacillus* species, *Streptococcus* species, *Klebsiellae pneumoniae*, and *Enterobacter aerogens* with prevalence rates of 37.7, 19.6, 9.4, 9.4, 8, 5.8, 5.8 and 4.3% respectively. Among isolated bacteria, the majority of them were retrieved from sub clinically infected quarters. This finding is comparable with the report of Mekonnen and Tesfaye (2010) and Gizat et al. (2008) who found CNS as the predominant bacteria among isolates in Adama and Bahirdar dairies, respectively. On the other hand, in different previous studies, *S. aureus* was the

most frequently isolated bacteria as per the reports of Regassa et al. (2010a), Matios et al. (2009) and Getahun et al. (2008) in dairy farms of Holeta, Asella and Selalle towns, respectively.

The preponderance of contagious mastitis in this study may be ascribed to the lack of proper milking procedure before milking, during the time of milking and post milking. For instance absence of pre- and post teat dipping using antiseptics, washing of milkers' hands and using teats secretion as a lubricant of teats at the time of milking which is often practiced in the study area might contributed to the spread of these pathogens from infected teats to healthy ones.

In the present study interestingly environmental bacteria like *E. coli* was isolated in high proportion (9.4%). This is in congruence with the reports of Mekonnen and Tesfaye (2010) and Matios et al. (2009) who found 7.5% of the total isolates. In contrast, this figure is higher than the one reported by Regassa et al. (2010b), Sori et al. (2005) and Getahun et al. (2008) who reported 4.57, 0.75 and 0.5% in different parts of Ethiopia, respectively. The presence of environmental bacteria might be an implication of unhygienic milking practice and contamination of cows' teats and environment with their dung in the study area. Antibiotic susceptibility testing of 138 bacterial isolates was performed using a panel of seven antimicrobial drugs (Oxoid, UK) anti-biotic discs used for the test were Norfloxacin (NOR10 µg), Ampicillin (AMP10 µg), Gentamicin (CN10 µg), Doxycycline (DO30 µg), Erythromycin (E15 µg), Trimethoprim-Sulfamethoxazole (SXT1.25 µg) and Tetracycline (TE30 µg).

In this study CNS isolates were susceptible to Gentamicin, Tetracycline, Trimethoprim-Sulfamethoxazole, Norfloxacin, Erythromycin, Doxycycline and Ampicillin with efficacy rates of 100, 100, 95, 90, 87, 70 and 40% in decreasing order respectively. *S. aureus* isolates were also susceptible to Gentamicin (100%), Erythromycin (100%) Trimethoprim-Sulfamethoxazole (100%) Norfloxacin (87%), Tetracycline (80%), Ampicillin (55%) and Doxycycline

(43%) with trend of decrement in potency. *E. coli* were 100% susceptible to Norfloxacin and Trimethoprim-Sulfamethoxazole, but less commonly affected by Erythromycin, Ampicillin, Tetracycline and Gentamicin with the potency of $\leq 50\%$. Among antibiotics tested *in vitro* Norfloxacin was the most potent drug followed by Trimethoprim-Sulfamethoxazole, Gentamicin, Doxycycline, Tetracycline and Erythromycin with the efficacy rate of 97, 94 and 89, 84, 82 and 70% respectively. On the other hand, Ampicillin was found to be the least potent drug in the overall tested bacteria (55%). Anti-bio gram testing results in this study is in line with the report of Getahun et al. (2008) who found 100% susceptibility to ampicillin and tetracycline whereas in case of *S. intermedium* and *S. aureus* there was a susceptibility rate of 45.3% for ampicillin which is in line with the report given by Nibret et al. (2011) who indicated tetracycline showed 40% susceptibility rate for *E. coli* and 44% for CNS but in case of CNS it is higher than the report given by Nibret et al. (2011) who found susceptibility rate of 60% for Erythromycin and 18.5% for *S. aureus* for Ampicillin. The differences in susceptibility patterns of bacteria to different antibiotics might be attributed to differences in utilization of anti-microbial agents for treatment regimen and development of resistance due to repeated use of similar antibiotics in different farms for longer period.

Associated risk factors and the status of mastitis

Among assessed potential risk factors to the prevalence of mastitis, higher infection rates were observed in cows with advanced age, cows with pendulous udder conformation, and multiple parity, poor body condition score, bad hygiene score, high milk producers, early lactation stage, previous exposure to mastitis and blind teats.

The prevalence rate of mastitis at cow level was higher as the age advances; 88, 77 and 63% in older, mid age and young cows respectively. There was statistically significant difference among different age groups. This finding is in broad agreement with reports made by different authors in different parts of the country (Demelash et al., 2005), Regassa et al. (2010b) and Mungube et al. (2004) who reported age considered as potential risk factor to mastitis and older cows were more affected by mastitis than younger cows. The increase in prevalence rate with the advancing age may be due to gradual suppression of immune system of the body, structural changes in udder and teats and repeated exposure to milking practices.

Parity was considered as associated risk factor for mastitis in this study in which cows with multiple parities showed higher prevalence (80%) than cows in their first or second lactations (68%). This is in agreement with Mungube et al. (2004), Demelash et al. (2005) Matios et al. (2009), Gizat et al. (2008), Girma (2010) and Molalegn

et al. (2010) who identified parity as risk factor for mastitis in the study conducted at different parts of Ethiopia.

More cows which had experienced mastitis problem before, were found to be positive to clinical or/and sub clinical form of mastitis at current investigation than non-exposed ones, 89 and 58% respectively. This is comparable with the findings of Demelash et al. (2005) and Mekonnen and Tesfaye (2010) who indicated cows with previous exposure to udder infection were more likely to be re-infected than those never exposed. This might be attributed to possibility of previously exposed cows which remained in carrier state and impotency of drugs used for mastitis treatment in the study area.

Lactation stage was found to be a risk factor to mastitis and the prevalence was highest in early lactation (100%) than mid (43.3%) and late (68%) which is in agreement with Demelash et al. (2005) who reported mastitis prevalence was higher in early lactation (45.8%) than mid lactation (25.8%). But in some research findings, prevalence of mastitis was higher in late stage of lactation than early lactation (Getahun et al., 2008; Gizat et al., 2008). The difference in reports of different authors concerning the stage of lactation in which mastitis is most prevalent, could be attributed to different managements practiced in different study areas. The highest prevalence rate during the early lactation is an indication of infection, probably prior to freshening. It may also be reflection of important changes that occur prior to parturition period in endocrine, nutritional and metabolic status which compromise the immunity of the cow. In this stage of lactation, milk yield is increasing this can cause impairment of the immune system due to metabolic stress. When cows are in negative energy balance, body fat is converted to ketone bodies, and hyper ketonemia has been suggested to be one of the most important factors causing impairment of the udder defense mechanisms and it is likely that the impaired immune system in cows in early lactation results in reduced ability to battle infection (Suriyasathaporn et al., 2000).

Hygiene of the cow in this study was found to be one of the risk factors. Cows with bad hygiene score had higher prevalence rate (100%) than good hygiene score (54%) which is in line with Matios et al. (2009) and Molalegn et al. (2010). In case of this investigation there was highly significant difference in cows with pendulous udder conformation than the cows with high up udder conformation with prevalence rate of 89 and 49% respectively. This is in agreement with Sori et al. (2005) and Girma (2010) reports. This might be attributed to more exposure to the injurious materials and presence of more contact with contaminated environment.

Interestingly in this investigation, there was strong association between feet problems and presence of mastitis with prevalence rate of 93 and 60% in the cows that had problem of feet than none respectively. This might be partly due to longer time the lame cow spends in horizontal (laying) position that might increase the

contact with environmental pathogens and will be prone to mastitis than none affected ones. Body condition score was considered as risk factor to mastitis in this report. Cows with poor body condition had more prevalence rate (69.2%) than those with good body condition (72%) though the difference was not statistically significant. This is in congruent with the investigation by Mekonnen and Tesfaye (2010) and Mungube et al. (2004) who found body condition as one of associated risk factors to mastitis. Animal with poor body condition might experience their immune system not functioning well, thus making them more susceptible to mastitis.

Conclusion

Contagious and environmental mastitis pathogens were isolated from both clinical and subclinical quarter milk samples. Among contagious pathogens the highest prevalent bacteria was found to be Coagulase negative staphylococci (CNS) followed by *S. aureus*. *E. coli* was also the predominant environmental bacteria. The presence of considerable proportion of *Enterobacteriaceae* suggested that contamination of mammary gland and its environment with animal dung. Moreover, dominant number of contagious microbial agents indicated that improper milking procedures were experienced in the farm.

Among anti-biotics tested *in vitro* Norfloxacin was the most potent drug followed by Trimethoprim-Sulfamethoxazole. On the other hand, Ampicillin was found to be the least potent drug in the overall tested bacteria. Among assessed potential risk factors to the prevalence of mastitis; higher infection rates were observed in cows with advanced age groups, pendulous udder conformation, and multiple parity, poor body condition score, bad hygiene score, high milk producers, early lactation stage, previous exposure to mastitis and blind teats. The high prevalence rate of mastitis, in a dairy farms believed to be better managed compared to others, calls for continued enhanced efforts in combating this major obstacle of the dairy industry.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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Full Length Research Paper

Productive and reproductive performance of indigenous chickens in Gena Bossa District of Dawro Zone, Ethiopia

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This study was conducted in Gena Bossa district with the objective of assessing the productive and reproductive performance of indigenous chickens. Multistage stratified purposive and random sampling methods were used and a total of 138 households were interviewed in the study area. Fifteen, fifty four and sixty nine farmers selected for interviews from highland, midland and lowland agro-ecologies, respectively. From the interviewed farmers, 47, 47 and 44 farmers were poor, medium and rich wealth leveled, respectively. Farmers were categorized to their education level and 34, 34, 35 and 35 respondents were interviewed from illiterate, reading and writing, primary first and primary second cycle education level, respectively. Age at sexual maturity of pullets and cockerels were 5.64 and 5.25 months, respectively. The clutch number, eggs per clutch and total eggs/hen/year were 3.04, 12.78 and 38.53, respectively. In this survey, hatchability and survival rate of chicks were 81.72 and 38.85%, respectively. Sexual maturity, number of eggs per clutch and hatchability were significantly ($p < 0.05$) different at different agro-ecology and education levels but not significantly ($p > 0.05$) different at different wealth levels of farmers. Generally, low productive and reproductive performance of indigenous chickens were recorded under farmer's management condition in Gena Bossa District of Dawro Zone which needs further improvement from the government by organizing trainings for farmers on disease control, housing and feeding of chickens to improve productive and reproductive performance.

Key words: Agro-ecology, education level, wealth status, productive and reproductive performance, Indigenous chickens, Gena Bossa.

INTRODUCTION

Agriculture dominates the Ethiopian economy and contributes 45% of gross domestic product (GDP) and provides more than 80% of employment. Ethiopia has the highest livestock populations in Africa and accounts for 17, 20, 13 and 55% of cattle, sheep, goats and equines,

respectively (CSA, 2016). Livestock production accounts for about 32% of agricultural GDP and 61% agricultural total export (NABC, 2010; PIF, 2010; Tsegaye, 2014).

The global poultry population has been estimated to be about 16.2 billion, of which 71.6% is found in developing

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countries (Gueye, 2005). In Africa, village poultry contributes over 70% of poultry products and 20% of animal protein intake (Kitalyi, 1998). In East Africa, over 80% of human population live in rural areas and over 75% of these households keep indigenous chickens. The Ethiopian poultry population is estimated to be about 60.5 million, of which 94.33, 2.47 and 3.21% is indigenous, exotic and hybrid chickens, respectively (CSA, 2016). According to CSA (2016) report, 83.5, 7.1 and 9.4% meat and egg product come from indigenous, hybrid and exotic breeds of chickens in Ethiopia, respectively.

The Ethiopian indigenous chickens are known to possess desirable characters such as thermo tolerant, resistance to some diseases, good egg and meat flavor, hard egg shells, high fertility and hatchability as well as high dressing percentage (Aberra, 2000). According to Abubakar et al. (2007), the impact of the Ethiopian village chicken in the national economy and its role in improving the nutritional status, family income, food security and livelihood of many smallholders is significant owing to its low cost of production. The diverse agro-ecology and agronomic practices prevailing in the country together with the huge population of livestock in general and poultry in particular, could be a promising attribute to boost up the sector and increase its contribution to the total agricultural output as well as to improve the living standards of the poor livestock keepers (Aleme and Mitiku, 2015; Hunduma et al., 2010). Poultry production, as one segment of livestock production, has a peculiar privilege to contribute to the sector. Poultry is small in size and rapid in human food production due to its short reproductive cycle compared to other livestock kept in Ethiopia. Poultry fits well with the concept of small-scale agricultural development. Moreover, it goes eco-friendly and does not compete for scarce land resources (Mekonnen, 2007; Sonaiya, 1997).

In Ethiopia, the contribution of indigenous chickens to farm household and rural economies is not proportional to their large numbers. The production systems are affected by different constraints which cause low productive and reproductive performance of chickens. The constraints which affect chicken production include diseases, poor management practices, predation and lack of organized markets. Of these constraints, diseases, poor housing and predation are the most important among village chicken production systems in Ethiopia (Aberra, 2000; Halima, 2007; Nebiyu et al., 2013; Solomon et al., 2013).

To understand the productivity status/potential of village chicken in various parts of Ethiopia, several studies have been conducted. There are numerous chickens existing in the study area but still now producers got little products from their chickens. However, the productivity of indigenous chicken and the production system has not been studied extensively in Gena Bossa district of SNNPR. Cognizant of this, this research was

designed with the objectives of assessing the productive and reproductive performance of indigenous chickens in the Gena Bossa district of SNNPR.

MATERIALS AND METHODS

Description of the study area

This study was conducted in the district of Gena Bossa. The district is found in Dawro zone of South Nation Nationalities and Peoples Region State (SNNPRS). Karawo is the town of the district which is located at about 508 km south west of Addis Ababa across Shashemene and Wolayita, 303 km from Hawassa Town of SNNPRS. The total surface area of the district is 90,122 ha. The total population of Gena Bossa district is about 109,401 and from this 54,870 is male and 54,531 is female. The livestock resources of the district are 287,046 cattle, 77,350 sheep, 84,750 goats, 277 horses, 4,440 mules, 4,000 donkeys and 147,780 chickens (Livestock Office of the District, 2016).

Selection of study households

Multistage stratified purposive and random sampling methods were used to study population that rears indigenous chickens. Based on the number of chicken population and the potential of each *kebeles* and its representativeness to the district, three *kebeles* from lowland, two *kebeles* from midland and one *kebele* from highland were selected to collect data. Farmers were categorized to different wealth levels (poor, medium and rich) based on land ownership, livestock number and kilo calorie intake per day to select farmers for PSNP according to ICRA (1991) and Temesgen et al. (2016) wealth level classification bases. Then, those farmers separated by wealth status were re-categorized by education level. Finally, 138 respondents randomly selected from different agro-ecologies which were categorized based on wealth and education level (Table 1).

Fifteen, fifty four and sixty nine farmers were selected from highland, midland and lowland agro-ecologies, respectively to determine the effect of agro-ecology on productive and reproductive performance of indigenous chickens. This is also divided to wealth status and 47, 47 and 44 farmers were selected from poor, medium and rich wealth leveled farmers, respectively to determine the effect of wealth on chicken productive and reproductive performance of indigenous chickens. Finally, 34, 34, 35 and 35 farmers from illiterate, reading and writing, primary first cycle and primary second cycle education level, respectively were selected from those farmers classified by wealth status to determine the effect of education level of respondents on indigenous chicken productive and reproductive performance.

Sample size determination

The total size for household was determined by using probability proportional size-sampling technique Cochran's (1963).

$$n_0 = \frac{Z^2 * (P)(q)}{d^2}$$

where n_0 = desired sample size according to Cochran's (1963) when population greater than 10,000; Z = standard normal deviation (1.96 for 95% confidence level); P = 0.10 (proportion of population to be included in sample, that is, 10%); q = 1-P, that is, 0.90; d = degree of accuracy desired (0.05).

Table 1. Sampling frame of households in the study area.

Agro-ecology	Number of respondents based on agro-ecology	Number of respondents based on wealth status			Number of respondents based on education level			
		Poor	Medium	Rich	Illiterate	R&W	PFC	PSC
Highland	15	5	6	4	4	3	3	5
Midland	54	20	17	17	13	15	14	12
Lowland	69	22	24	23	17	16	18	18
Total	138	47	47	44	34	34	35	35

PFC: Primary first cycle (grade 1-4), PSC: primary second cycle (grade 5-8), R&W: reading and writing.

Table 2. Demographic structures, land size and livestock number of the respondents.

Household profile	Frequency	Percentage
Sex of respondents		
Male	79	57.2
Female	59	42.8
Marital status		
Married	101	73.2
Divorced	15	10.9
Widows	22	15.9
Farming system		
Mixed farming system (crop-livestock)	138	100
Total land and livestock		Mean±SE
Total land per household (ha)		2.02±0.16
Livestock per household (No.)		13.22±0.45

Data collection methods

Questionnaire survey

The data were collected by using both primary and secondary source of data. The primary data were collected by using semi-structured pre-tested questionnaire. The parameters like productive and reproductive performances were gathered by using questionnaire. The secondary data (total population of chickens and other relevant data) were collected from written document of Gena Bossa Agricultural and Natural Resource Development Office, Animal and Fisher Development Office of the district and other sources.

Data management and analysis

Descriptive statistics such as percentage and mean were calculated and all survey data were analyzed by using SPSS (Version 20). The descriptive statistics (mean, standard error of mean) for numerical survey data were calculated to analysis of variance (ANOVA) using the general linear model procedure of SPSS. ANOVA model statement was used to investigate the effects of altitude difference, wealth status and education level of respondents on various performances related parameters.

Statistical model for this study (Model for survey).

$$Y_{ijk} = \mu + A_i + W_j + E_k + A_i \times W_j + A_i \times E_k + W_j \times E_k + A_i \times W_j \times E_k + \epsilon_{ijk}$$

where Y_{ijk} = the value of the respective variable mentioned above pertaining i^{th} agro-ecology, i^{th} wealth status, k^{th} educational level and interactions; μ = over all mean of the respective variable; A_i = the effect of i^{th} agro-ecology ($i=3$, highland, midland or lowland) on the respective variable on flock size, productive and reproductive performance of chickens; W_j = the effect of j^{th} wealth of producer ($j=3$, poor, medium or rich) on the respective variable on flock size, productive and reproductive performance of chickens; E_k = the effect of k^{th} educational level of producer ($k=4$, illiterate, reading and writing, primary first cycle or primary second cycle) on the respective variable on flock size, productive and reproductive performance of chickens; $A_i \times W_j$, $A_i \times E_k$, $W_j \times E_k$ and $A_i \times W_j \times E_k$ = the interaction effects agro-ecology, wealth and education level on the respective variable on flock size, productive and reproductive performance; ϵ_{ijk} = random error term.

RESULTS AND DISCUSSION

Demographic characteristics, land size and livestock number of households

Demographic data like land size and livestock numbers of the study area as shown in Table 2. According to the data collected, 57.2% were males and the rest 42.8% were

females. The average ages of respondents were 37.66 years and the mean family size per household was 6.8. About 63.8% of respondents were the followers of protestant followed by Orthodox and Catholic religious followers. Regarding to marital statuses of respondents, 73.2% were married and the rest were divorced and widows.

Productive performance of indigenous chickens

Productive performances of indigenous chickens were evaluated under farmer management conditions. The productive performance of indigenous chickens at different agro-ecology, wealth status and education level of respondents is shown in Table 3.

Clutch number

The overall mean clutch number of chicken in the study area was 3.04 ± 0.10 per year (Table 3). This result was similar to Melkamu and Wube (2013) in Debsan Tikara Kebele at Gonder Zuria Woreda in which average clutch number was 3 per year. This result was comparably lower than the clutch numbers of 3.8 and 3.7 reported in Bure and Dale districts, respectively (Fisseha et al., 2010a). This result was also lower than reported by Meseret (2010) in Gomma Wereda (3.43) and CSA (2015/2016) the national average of Ethiopia (4).

The clutch number was not significantly different ($p > 0.05$) at different agro-ecologies, wealth status and educational levels of the respondents (Table 3).

Egg production

The average numbers of egg per clutch in this study was 12.78 ± 0.29 (Table 3). This study is in line with Melkam and Wube (2013), Meseret (2010) and Bikila (2013) in Debsan Tikara Kebele at Gonder Zuria Woreda, Gomma woreda and Chelliya district where the average egg numbers was 13, 12.92 and 12.93, respectively. This result agrees with that of Solomon et al. (2013) in which the average eggs per clutch were 14.72, 13.98, 13.46 and 12.15 in Pawe, Dibate, Wombera and Guba district of Metekel zone, respectively. On the contrary, the present result was lower than that of Fisseha et al. (2010b) who reported the average number of eggs per clutch were 15.7, 13.2 and 14.9 in Bure, Fogera and Dale districts, respectively. The average day per clutch for egg production was 25.27 ± 0.54 for indigenous chickens and total mean egg produced annually per hen was 38.53 ± 1.37 . According to Alem (2014) report in Central Tigray, the average numbers of eggs produced annually were 43.4 and the average days per clutch was 21.6. This result was lower than Fisseha et al. (2010a); who

reported an average of 60 eggs per hen per year in Bure district.

Average number of eggs per clutch and average number of days per clutch were significantly ($p < 0.001$) different at different agro-ecologies and educational levels (Table 3). In this study, average numbers of eggs per clutch were 11.92 ± 0.33 , 13.77 ± 0.69 and 12.66 ± 0.15 at highland, midland and lowland agro-ecologies, respectively. Significantly ($p < 0.001$), the highest number of eggs was produced at midland (13.77 ± 0.69) agro-ecology. This difference might be due to farmer's providing better management (health care, feed type and feeding frequency) and proper weather conditions of midland agro-ecology which improves chickens egg production performance. The highest and lowest temperature of lowland and highland agro-ecology also decreases egg production performance of indigenous chickens, respectively. Shishay et al. (2015) reported that the average number of eggs per clutch were 12.56, 12.07 and 11.41 at highland, midland and lowland areas of western Tigray, respectively. This result was slightly higher than Matiws et al. (2013) results in Nole Kabba Woreda of western Wollega, the average number of eggs per clutch were 11.17, 11 and 11.52 at highland, midland and lowland agro-ecologies, respectively. In this study, the average numbers of days per clutch were 23.67 ± 0.74 , 27.18 ± 0.38 and 24.95 ± 0.33 in highland, midland and lowland agro-ecologies, respectively. According to Gebreegziabher and Tsegay (2016), the average numbers of days per clutch were 24.6, 27.2 and 26 at highland, midland and lowland areas in Wolaita zone of Southern Ethiopia, respectively.

The average number of eggs produced and average days per clutch were significantly ($p < 0.001$) different at different education level. The average numbers of eggs per clutch were 11.54 ± 0.26 , 12.02 ± 0.27 , 13.35 ± 0.27 and 14.22 ± 0.24 at illiterate, reading and writing, primary first and second cycle education level, respectively. Also, average numbers of days per clutch were 23.11 ± 0.59 , 23.91 ± 0.63 , 26.65 ± 0.62 and 27.39 ± 0.55 at illiterate, reading and writing, primary first and second cycle education level, respectively (Table 3).

The mean annual egg production was significantly ($p < 0.001$) different only at different educational levels of the farmers. The average number of eggs per hen per year was 32.02 ± 1.51 , 36.85 ± 1.59 , 42.04 ± 1.58 and 43.21 ± 1.40 at illiterate, reading and writing, primary first and second cycle education level of respondents, respectively (Table 3). The average numbers of egg per clutch, average days per clutch and total average number of eggs per hen per year were the highest at PFC and PSC educated farmers than illiterate and R&W education level of respondents. This difference might be due to better management practice given (feeding, housing and health care) from educated farmers to their chickens which they got from different training. In agreement with the current study, Adebayo and Adeola (2005) and

Table 3. Productive performances of the indigenous chickens (Mean±SE).

Variable	NCPY	ANEPC	ANDPC	ANEL/H/Y	AWC (kg)	M/SAC (M)	M/SAH (M)
Agro.							
HL	3.08±0.14	11.92±0.33 ^b	23.67±0.74 ^b	36.42±1.89	1.46±0.03	8.17±0.24 ^a	7.62±0.31 ^a
ML	2.95±0.07	13.77±0.69 ^a	27.18±0.38 ^a	40.45±0.97	1.51±0.02	7.50±0.13 ^b	6.81±0.16 ^b
LL	3.07±0.06	12.66±0.15 ^b	24.95±0.33 ^b	38.73±0.85	1.47±0.01	7.96±0.11 ^{ab}	7.37±0.14 ^{ab}
p-value	0.40	0.001	0.001	0.13	0.19	0.01	0.01
Wealth							
Poor	2.99±0.09	12.91±0.23	25.63±0.52	38.54±1.31	1.49±0.02	7.92±0.17	7.09±0.21
Med.	3.16±0.09	12.71±0.23	24.97±0.49	39.70±1.26	1.49±0.02	7.94±0.16	7.44±0.21
Rich	2.96±0.10	12.73±0.24	25.20±0.54	37.35±1.38	1.45±0.02	7.76±0.18	7.24±0.23
p-value	0.31	0.79	0.65	0.46	0.09	0.45	0.74
Educ.							
Illit.	2.82±0.11	11.54±0.26 ^b	23.11±0.59 ^b	32.02±1.51 ^b	1.36±0.03 ^c	7.96±0.19	7.38±0.25
R&W	3.08±0.12	12.02±0.27 ^b	23.91±0.63 ^b	36.85±1.59 ^b	1.36±0.03 ^c	8.04±0.21	7.33±0.26
PFC	3.14±0.12	13.35±0.27 ^a	26.65±0.62 ^a	42.04±1.58 ^a	1.50±0.02 ^b	7.69±0.20	7.09±0.26
PSC	3.10±0.10	14.22±0.24 ^a	27.39±0.55 ^a	43.21±1.40 ^a	1.69±0.02 ^a	7.80±0.18	7.26±0.23
p-value	0.19	0.001	0.001	0.001	0.001	0.60	0.86
A×W	NS	NS	NS	NS	NS	NS	NS
A×E	NS	NS	NS	NS	NS	NS	NS
W×E	NS	NS	NS	NS	NS	NS	NS
A×W×E	**	NS	NS	**	NS	NS	NS
Overall	3.03±0.10	12.78±0.29	25.27±0.54	38.53±1.37	1.48±0.02	7.87±0.18	7.26±0.23

^{a, b, ab, c}Least square means with different superscript within a column are significantly different ($p < 0.05$). NCPY: Number of clutch per year, ANEPC: average number of eggs per clutch, ANDPC: average number of days per clutch, ANEL/H/Y: average number of eggs laid per hen per year, AWHCAM (kg): average weight of hens and cocks at 6 months(Kg), M/SAC: market/slaughter age of cocks, M/SAH: market/slaughter age of hen, SE: standard error, HH: highland, ML: midland, LL: lowland, Agro.: agro-ecology, Edu.: education, Med.: medium, PFC: primary first cycle, PSC: primary second cycle, R&W: reading and writing, M: month, kg: kilo gram, A×W: interaction of agro-ecology and wealth level, A×E: interaction of agro-ecology and education, W×E: interaction of wealth and education, A×W×E: interaction of agro-ecology, wealth and education, NS: Not Significant, **Significant.

Nebiyu (2016) reported that educational level of farmers had effect on average egg production, which implies the higher educational level; the better would be in understanding of farm operation and efficiency.

The mean total eggs produced per hen per year was not significantly different ($p > 0.05$) at different agro-ecologies. Mean total eggs produced per hen per year were 36.42±1.89, 40.45±0.97 and 38.73±0.85 at highland, midland and lowland agro-ecologies, respectively (Table 3). This result was lower than Fisseha et al. (2010a) results in Bure district. Average eggs produced per clutch were 16.7, 16.1 and 14.4, and also total eggs produced per hen per year were 60, 61 and 59 at highland, midland and lowland agro-ecologies, respectively. Shishay et al. (2015) reported the highest number of eggs per hen per years from indigenous chickens of western Tigray, in which annual eggs produced per hen were 54.2, 54.87 and 48.98 at highland, midland and lowland areas, respectively. Also, Gebreegiabher and Tsegay (2016) reported highest number of eggs per hen per year from local chickens of Wolaita which were 66.2, 60 and 51.1 at highland,

midland and lowland areas, respectively.

Average number of eggs per clutch, average number of days per clutch and average eggs per hen per year were not significantly ($p > 0.05$) different at different wealth level of the respondents (Table 3). There were significant ($p < 0.001$) difference on mean number of eggs per hen per year at the interaction point of agro-ecology, wealth status and education level of the farmers. This might be when agro-ecology were proper for chicken production and educated farmers had the highest level of wealth they provide necessary things (feeding, watering, constructing separate house and clean chicken house, treating by using modern medicine and vaccinating chickens) which they got by education and different training to improve the mean numbers of eggs per hen per year.

Market/Slaughter age of chickens

The mean market or slaughter age of cocks and hens were 7.87±0.18 and 7.26±0.23 months in the study area,

respectively (Table 3). According to GAIN (2017), the average slaughter age of Ethiopian indigenous chicken ranges from 8 to 12 months. But in this finding, chickens reach slaughter age earlier than Aman et al. (2017) report in three agro-ecologies of SNNPR indigenous chickens reach slaughter age at 9.9 months. On the contrary, eastern Tigray indigenous chickens were reported to reach an earlier slaughter age of 4.66 and 4.5 months for male and female chickens, respectively (Shishay et al., 2015).

The market/slaughter age was significantly different ($p < 0.01$) for cocks and hens at different agro-ecology of the study area (Table 3). Chickens require significantly longer time to reach market age at highland and compared to the ones at midland agro-ecology. The reason might be chicken uses more energy for maintaining their body temperature in the highland than midland. This difference also might be due to midland farmers provide different types of feed (maize, sorghum, wheat and others) at different times of the day as well as they provide better health care. On other hand, longest time was recorded from indigenous male chickens of Wolaita zones in southern Ethiopia in which chickens reach slaughter age at 8.6, 9.4 and 8.9 months at highland, midland and lowland areas, respectively (Gebreegziabher and Tsegay, 2016). Late slaughter age also reported by Aman et al. (2017) from three agro-ecologies of SNNPR, the average slaughter age of chickens were 9.8, 7.0 and 10.4 months in highland, midland and lowland areas, respectively. The mean market age of cocks and hens were not significantly ($p > 0.05$) different at different wealth status and education levels of the respondents.

Average weight of chickens at six months

The mean weight of chickens (hens and cocks) at 6 months of the ages in the study area was 1.48 ± 0.02 kg (Table 3). According to Fisseha et al. (2010b) report at Fogera and Dale district, the mean weight of cockerels was 1125 and 1600 g as well as pullets were 933 and 1300 g, respectively. Also Fisseha et al. (2014) reported other result from selected districts of north western Amhara region in which the average weight of local hens ranges from 0.6 to 2.1 kg and local cocks ranges from 0.6 to 2.5 kg. According to Bogale (2008) report, the mean weight of cocks was 1.5 kg and hens were 30% less to male weight at 6 months of the age. Average weight of hens and cocks chickens at 6 months of ages in the study area was not significantly different ($p > 0.05$) at different agro-ecologies and wealth levels of the respondents (Table 3).

The mean weight of chickens at 6 months of ages was significantly different ($p < 0.001$) at different education level of the respondents. The mean weight of chickens was highest (1.69 ± 0.02 kg) at primary second cycle educated farmers than the others. Lowest chicken weight

(1.36 ± 0.03 kg) was observed at 6 months of ages from illiterate, and reading and writing education levels of farmers. This weight variations might be due to primary second cycle educated farmers provide better managements in terms of feeding, watering and health care which improves weight of chickens.

Reproductive performance and survival rate of indigenous chickens

Age at sexual maturity

Age at sexual maturity was measured age at first egg and age at first mate for female and male chickens, respectively. Age at sexual maturity in the study area was 5.63 ± 0.22 and 5.25 ± 0.15 months for pullets and cockerels, respectively (Table 4). Sexual maturity depends on management and overall production systems of farmers mainly on feeding, watering and disease control mechanisms. This result agrees with Endale et al. (2017) in Mezhenger, Sheka and Benchi-Maji zones in which the first egg laying and first mating age of pullets and cockerels were (5.59 and 5.00), (5.19 and 4.90) and (5.14 and 5.28) months, respectively. Chickens in this study reach sexual maturity earlier than that of Fisseha et al. (2010a) result in Bure district cockerels reach sexual maturity at 6.06 months (24.6 weeks) and pullets reach at 6.87 months (27.5 weeks) and Kugonza et al. (2008) in Eastern Uganda the sexual maturity of cockerels requires 5.5 months and pullets require 6.5 months.

There were significant differences ($p < 0.001$) in sexual maturity of cockerels and pullets at different agro-ecologies of the study area. The ages of sexual maturity of pullets and cockerels were earlier in midland than both highland and lowland agro-ecologies. This difference might be the weather condition in midland was good for fast growth and the farmers in midland provided better management (feeding different types of feed and health care) for chickens. Comparable sexual maturity age of chickens were reported by Gebreegziabher and Tsegay (2016), the sexual maturity age of male and female chickens were (5.9, 5.9), (5.5, 5.2) and (5.5, 5.4) months at highland, midland and lowland agro-ecologies in Wolaita zones of southern Ethiopia, respectively. In this study, chickens reach sexual maturity earlier than Aberra et al. (2013) report in which the average sexual maturity of pullets at first egg laying were 6.94, 6.43 and 6.57 months in highland, midland and lowland agro-ecologies, respectively. There was no significant ($p > 0.05$) difference of sexual maturity of pullets and cockerels between different wealth status and education levels of respondents (Table 4).

Hatchability and survival rate of chicks

The average number of eggs incubated per broody hen

Table 4. Reproductive performance and survival rate of indigenous chickens (Mean \pm SE).

Variable	HAFEL (M)	CAAFM (M)	NEI	NCHPS	H%	SRC(5M)%
Agro.						
HL	5.92 \pm 0.20 ^a	5.67 \pm 0.21 ^a	11.92 \pm 0.33 ^b	8.67 \pm 0.33 ^b	72.56 \pm 1.36 ^b	38.06 \pm 2.13
ML	5.21 \pm 0.10 ^b	4.79 \pm 0.11 ^b	13.77 \pm 0.69 ^a	12.00 \pm 0.17 ^a	87.04 \pm 0.70 ^a	39.14 \pm 1.09
LL	5.78 \pm 0.09 ^a	5.29 \pm 0.09 ^a	12.66 \pm 0.15 ^b	10.85 \pm 0.15 ^a	85.57 \pm 0.61 ^a	39.35 \pm 0.95
p-value	0.001	0.001	0.001	0.001	0.001	0.86
Wealth						
Poor	5.55 \pm 0.14	5.18 \pm 0.14	12.91 \pm 0.23	10.74 \pm 0.23	82.89 \pm 0.95	36.55 \pm 1.48
Med.	5.74 \pm 0.13	5.36 \pm 0.14	12.71 \pm 0.23	10.43 \pm 0.22	81.38 \pm 0.91	38.76 \pm 1.45
Rich	5.63 \pm 0.15	5.21 \pm 0.15	12.73 \pm 0.24	10.34 \pm 0.24	80.89 \pm 1.00	41.23 \pm 1.56
p-value	0.60	0.60	0.79	0.46	0.31	0.09
Educ.						
Illit.	5.62 \pm 0.16	5.36 \pm 0.16	11.54 \pm 0.26 ^b	9.32 \pm 0.26 ^b	80.70 \pm 1.09 ^b	37.81 \pm 1.7 ^b
R&W	5.71 \pm 0.17	5.27 \pm 0.17	12.02 \pm 0.27 ^b	9.59 \pm 0.27 ^b	79.59 \pm 1.15 ^b	32.88 \pm 1.79 ^b
PFC	5.64 \pm 0.17	5.27 \pm 0.17	13.35 \pm 0.27 ^a	11.14 \pm 0.27 ^a	82.86 \pm 1.15 ^a	31.87 \pm 1.78 ^b
PSC	5.55 \pm 0.85	5.09 \pm 0.15	14.22 \pm 0.24 ^a	11.96 \pm 0.24 ^a	83.75 \pm 1.02 ^a	52.83 \pm 1.58 ^a
p-value	0.91	0.69	0.001	0.001	0.03	0.001
A \times W	NS	NS	NS	NS	NS	NS
A \times E	NS	NS	NS	NS	NS	NS
W \times E	NS	NS	NS	NS	NS	NS
A \times W \times E	NS	NS	NS	NS	NS	NS
Overall	5.63 \pm 0.22	5.25 \pm 0.15	12.78 \pm 0.29	10.50 \pm 0.24	81.72 \pm 0.99	38.85 \pm 1.55

a, b, ab, c] Least square means with different superscript within a column are significantly different ($p < 0.05$). HAFEL: Hen (pullet) age at first egg laying, CAAFM: cockerels age at first mating, NCHPS: number of chicks hatched per set, H%: hatchability, NEI: number of eggs incubated, SRC(5M): survival rate of chicks at 5 months, SE: standard error, HH: highland, ML: midland, LL: lowland, Agro.: agro-ecology, PFC: primary first cycle, PSC: primary second cycle, R&W: reading and writing, M: month, A \times W: interaction of agro-ecology and wealth level, A \times E: interaction of agro-ecology and education, W \times E: interaction of wealth and education, A \times W \times E: interaction of agro-ecology, wealth and education, Educ.: education, Illit.: illiterate, NS: not significant.

was 12.7 \pm 0.29 and the hatchability in this study was 81.72 \pm 0.99% (Table 4). According to Fisseha et al. (2010b), the hatchability of the egg was 82.6, 78.9 and 89.1% at Bure, Fogera and Dale woredas, respectively. This result was higher than Melkam and Wube (2013) report in Debsan Tikara Kebele at Gonder Zuria Woreda (72%) and Aganga et al. (2000) among indigenous chickens in Botswana (61.8%). In this result, the survival rate of chicks up to 5 month of ages was 38.85 \pm 1.55%. The survival rate in present result was lower than Fisseha et al. (2010b) report in which the survival rate of chicks were 60.5, 74.3 and 54.2% at Bure, Fogera and Dale woredas, respectively. These low survival rate of the study area might be due to highest prevalence of diseases, predators and lack of vaccination practice of the farmers.

Hatchability was significantly different ($p < 0.001$) at different agro-ecologies and educational levels in Gena Bossa district (Table 4). Significantly, the lowest percent hatchability was recorded at highland agro-ecology and this might be due to low temperature of the highland. At low temperature, broody hen gave great time to maintain

body temperature by searching feed which affects hatchability of the egg. According to Fisseha et al. (2010a) report in Bure district, the hatchability was 85.7, 84.6 and 76.9% at highland, midland and lowland agro-ecologies, respectively. On the other hand, Gebreegziabher and Tsegay (2016) reported the hatchability of indigenous chickens in Wolaita zone of southern Ethiopia was 83.6, 74.1 and 79.5% at highland, midland and lowland areas, respectively. Comparably, the lowest hatchability was reported by Ahimedin and Mangistu (2016) from Gorogutu district of Eastern Hararghe, the percent hatchability was 57.78, 58.86 and 66.68% at highland, midland and lowland, respectively. Significantly, the highest percent hatchability was recorded from PFC and PSC educated farmers. This difference might be due to better feeding and watering management given to the broody hen at incubating time. Scavenging for feed and water at incubation time decreases the hatchability of chicks due to the fact that broody hen wastes time by searching feed and water. There was no significant difference ($p > 0.05$) of hatchability at different wealth level.

There was no significant ($p > 0.05$) difference on survival rate of chicks up to five months of ages at different agro-ecologies and wealth status of the farmers (Table 4). However, the survival rate of chicks up to five months of ages was significantly ($p < 0.001$) different at different education levels of the farmers. The chick's survival rate was 37.81 ± 1.70 , 32.88 ± 1.79 , 31.87 ± 1.78 and $52.83 \pm 1.58\%$ at illiterate, reading and writing, primary first and second cycle education level, respectively. Comparably, the highest survival rate of chicks was recorded from primary second cycle educated respondents. This difference might be due the fact that educated farmers give better management in terms of feeding, providing separate house and clean house, and health care.

CONCLUSION AND RECOMMENDATION

Average clutch number and annual numbers of eggs produced per hen were 3.04 and 38.53, respectively in Gena Bossa district. Survival rate of chicks were 38.85% and which was the lowest and requires further improvement to increase survival rate of chicks. Also, average weights of chickens (hens and cocks) at six months of age were (1.48 kg). So, the result of this study indicated that lower production performance of indigenous chickens under farmer management system was recorded. Educated farmers confirmed that indigenous chicken produces more number of eggs through appropriate management (feeding, watering, housing and health care) but other farmers could not provide recommended management for chickens. There is a lot of challenges which decreases the reproductive and productive performance of indigenous chickens in Gena Bossa district such as diseases, predators, feed shortage and lack of proper market.

The following recommendations are suggested based on the result of the current study: full package vaccination reduces the outbreak of different diseases which hinder chicken production and it also increases survival rate of chickens. So, government should provide vaccination for chickens to prevent loss of chickens by disease outbreak especially ND. Training improves farmer's awareness in order to improve ways of feeding, housing and vaccinating chickens to increase chicken production performance. So, government should organize training for farmers on disease control, housing and feeding of chickens to improve chicken productivity.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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