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On Farm Performance Evaluation of Three Local Chicken Ecotypes in Western Zone of Tigray, Northern Ethiopia

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Abstract
The study aimed to assess performances of three local chicken ecotypes under free scavenging production system in western Tigray. Multi stage sampling procedure was applied for the study, hence three rural weredas, nine kebeles and 385 respondents were selected by purposive, stratified purposive and purposive random sampli ng techniques, respectively. Pretested questionnaire was employed to generate data. Household characteristics w ere analyzed using descriptive statistics and Kruskal Wall's of SPSS 16 was employed to test qualitative variable proportion difference across agroecologies. Performance traits were analyzed by GLM Procedures of SAS 9.2. Tukey test was used to compare means for significant traits. Significant differences were observed among chicken ecotypes in almost all studied performance traits. Lowland chicken ecotypes earlier to mature sexually, slaughter and onset egg laying in comparison to the other two ecotypes but yielded lower hatchability and egg yield. The overall mean age of sexual maturity of local chicken was 7.19±0.04 and 5.71±0.03 month for female and male respectively. Average age at first egg laying was 7.19±0.04 months. Egg yield / clutch / hen showed an increase trend from 1st to 3rd clutch in which optimal egg yield was attained and then started to decrease from 4th Clutch. Average egg laid/clutch and year/hen was 12.01±0.12 and 52.68±0.57 respectively. The average hatchability of local chickens was 74.37±0.57%. Performance differences among the local chicken ecotypes indicate genetic diversity exists among the three chicken ecotypes. Future sustainable improvement, utilization and conservation of the indigenous chicken genetic resources are dependent on the genetic variations present within and among the local chicken ecotypes. Thus, agro-ecologically friendly and community based holistic genetic improvement strategies should be designed and implemented to improve their performances and to enhance sustainable utilization and conservation of the indigenous chicken genetic resources. In depth studies on assessment of genetic variations of the chicken ecotypes are required to validate the detected performance discrepancies.
Key words: Hatchability, Performance, Age at first egg laying, Sexual Maturity

1. Introduction

Local chickens have played pivotal role in capital build up, poverty, malnutrition and hunger reduction among the resource poor rural households in developing countries because of their low input requirements for production, short generation intervals, scavenging ability and adaptability to harsh environment conditions (Besbes 2009).Village poultry are available asset to local populations throughout Africa and they contribute to food security, poverty alleviation and promote gender equality, especially in the disadvantaged groups (HIV and AIDS infected and affected people, women, poor farmers, etc) and less favored areas of rural Africa where the majority of the poor people reside **(**RSHD 2011). On top of these merits, village poultry can provide the start of the owner climbing the "livestock ladders'' leading to other livestock species such as goats and cattle or serve as "transport (transitional) bridge" from small livestock to large livestock species production (Dolberg 2003)**.**

Ethiopia has an estimated of 51.35 million with indigenous chicken of non-descriptive breeds accounting 96.83%, hybrid chicken 2.37% and exotic breeds 0.8% (CSA 2013). Moreover, 97.3% of indigenous chickens has been distributed in different agro-ecological zones of Ethiopia (CSA 2011) and their distribution indicate their adaptive potential to different environmental conditions, diseases and other stresses (Halima 2007).Village chicken fulfills many roles in the livelihood of resources poor households of Ethiopia such as food security, income generation and others.

However, the productive performance of local chickens is disproportional with their size and their low performances have masked their potential to boost the living standards of their owners and contribute to rural developments. Efforts to improve the performance of local chickens have been launched by Ethiopian government through introduction of exotic breeds since the early 1990 (Pagani & Abebe 2008). Nevertheless, it was ineffective because it was done as blanket recommendation by assuming homogeneous village chicken production systems and similar performances of village chickens in different parts of Ethiopia. Base line information pertaining to village chicken production environments and their performances (both productive & reproductive) is required for designing, planning and developing community based holistic genetic and

performance improvement strategies in order to ensure sustainable improvement, utilization and conservation of indigenous chicken genetic resources and to uplift their contribution to national rural based development strategies. Studies on performances evaluation of certain local chicken ecotypes, imported exotic breeds and their cross under extensive and intensive management systems (Universities, colleges and Research institutions) have been done by different Scholars in Ethiopia but agro-ecologically based information on performances of local chicken ecotypes is still scanty. However, no previous researches had been done on performance evaluation of local chicken ecotypes under scavenging production system in Tigray particularly in Western Zone of Tigray. The study was therefore aimed at fulfilling this gap by assessing the productivity and reproductive performances of local chicken ecotypes under extensive management system in Western Tigray.

2. Materials and Methods

2.1. Description of study area

The study was conducted in the three rural weredas (Kafta Humera, Welkait and Tsegede) of Western Zone of Tigray Regional State, North West Ethiopia. It is one of the five administrative zones of Tigray regional state and it has four (4) districts (Setit Humera, Kafta Humera, Welkait and Tsegede) comprising of 81 kebeles with 77 rural kebeles (24, 25 and 28 kebeles from Kafta Humera, Tsegede and Welkait weredas, respectively) and 4 urban kebeles with distance range of 580–750 km from Mekelle, the capital city of Tigray. Setit Humera was not included in the study because it is represented by Kafta Humera. It covers an area of 1.5 million hectare with Kafta Humera accounts 48.13%, Setit Humera accounts 0.82%, Tsegede accounts 23.43% and Welkait accounts 27.62% (HuARC 2013). The total cultivated land of the zone is 573,285 hectares (38.2%) while the uncultivated land accounts 927,000 hectares (62.8%). 341,195.25 hectares (36.8%) of the uncultivated land is covered by different plant species excluding Bowsellia and Acacia Senegal While 185,510 hectares (20%) of the unfarmed land is solely covered by both Bowsellia and Acacia Senegal. The zone consists of three agro-ecological zones (lowland, midland & highland).75%, 15.7% and 9.3% of the land coverage of the zone is Kolla(lowland), weynadegga (midland) and dega (highland), respectively. The geographical location of the zone is 13°42′ to 14°28′ north latitude and 36°23′ to 37°31′ east longitude (Mekonnen *et al*. 2011).The annual rainfall of the zone ranges from 600 mm to 1800 mm while the annual temperature ranges from 27^0c to 45 ^{0}c in the lowland areas (Kolla) and 10^0c to 22 ^{0}c in both midland and highland areas of the zone. The altitude of the zone ranges from 500- 3008 m.a.s.l. The zone shares borders with Tahtay Adibayo, Tselemti and Asgede Tsimbla in the East, Sudan in West, Amhara region in South and Eritrea in the North. The study area represents a remote, tropical climate where extensive agriculture is performed manually by large numbers of migrant laborers.

Throughout the zone, livestock agriculture is the predominant economic activity with about 95% of the total population engaged directly or indirectly in it (Mekonnen *et al*. 2011). Main cattle breeds raised in the Western Zone are the local Arado (in both high land and mid land) and Begait cattle (in lowland). Semi-intensive production is practiced in Humera district, which is more urban, while extensive production system is dominant in the Welkait and Tsegede districts. The main crops cultivated in the lowland areas of the zone are sesame, cotton and sorghum while teff, wheat, barley, noug, lentils, finger millet, field peas and fababeans are cultivated crops in both midland and high land areas of the zone.

2.2. Sampling techniques:

Three rural (welkait, Tsegede & Kafta Humera) weredas were purposely selected. All kebeles (smallest administrative units in Ethiopia) of the three weredas were stratified in to three agro-ecological zones namely lowland, midland and highland kebeles. Based on the village poultry population density, chicken production potential and road accessissibilty, four, three and two kebeles were purposely selected from lowland, midland and highland agro-ecological zones, respectively. A total of 385 local chicken producers were selected from household package beneficiary's registration book of each selected kebele using purposive random sampling technique. The number of respondents per each sample kebeles was determined by proportionate sampling technique based on the households' size of the sample kebeles.

2.3. Sample size determination

Required total respondents were determined using the formula by Cochran (1963) for infinite population (infinite population ≥ 50,000**).**

$\mathbf{N_o = [\ \underline{Z^2pq}\ ] / e^2}$ **,** Where N_o= required sample size

$\mathbf{Z^2}$ =is the abscissa of the normal curve that cuts off an area at the tails (1-α)

(95%=1.96)

e = is the margin of error (eg. ±0.05% margin of error for confidence level of 95%)

p = is the degree of variability in the attributes being measured refers to the distribution of attributes in the population

q= 1-p.

Proportionate Sampling Technique: **W= [A/B] x N_o**, where **A**=Total number of households (farmers) living per a single selected kebele, **B**= Total sum of households living in all selected sample kebeles and **N_o** = the total required calculated sample size

2.4. Data collection

Data on household characteristics, productive and reproductive performances of village chicken under free scavenging production system were collected through individual interview using pretested questionnaire and some functional traits were also collected from thirty randomly selected local chicken owners (ten per agro-ecology) through regular monitoring with ten days interval for three months for validating trait values obtaining through the survey.

2.5. Statistical analysis

The qualitative household characteristics were analyzed using descriptive statistics of frequency procedures and cross-tabulation of SPSS version 16(2007). **Kruskal-Wallis Test** option of the **non-parametric tests** of **SPSS** was employed to test the effects of the agro-ecology on the proportion of each qualitative survey data. GLM procedure of SAS 9.2 (2008) was used to investigate the effects of agro-ecology difference on productive and reproductive trait performance of local chickens.

Statistical model

$$\mathbf{Y_{ij} = \mu + A_i + E_{ij}}$$

Where $\mathbf{Y_{ij}}$ = the value of the respective performance trait pertaining to the i^{th} agroecology; μ = overall mean of the respective trait, $\mathbf{A_i}$ = the fixed effect of i^{th} agroecology (i = 3, lowland, midland and highland and $\mathbf{E_{ij}}$ = random error term. Mean separation was carried using **Tukey test** for the traits that were statistically different across the agro-ecologies in the analysis.

3. Result and Discussion

3.1. Household Characteristics of the Respondents

Overall, 83.4% of the total respondents were male headed while the remaining 16.6% of the respondents were female headed households (Table 1). There was no variation with respect to the proportion of both sexes of the respondents across all agro-ecologies. However, the proportions of male headed households (80%, 86.3% and 85.1%) were higher than female headed house households (20%, 13.7% and 14.9%), respectively, in lowland, midland and highland agro-ecologies of the study area. However, contrasting results have been reported from Gomma district of Jimma zone (Meseret 2010), North West Ethiopia (Halima 2007) and Ada'a and Lume districts of East Shewa of Ethiopia (Tadesse *et al*. 2013) that the proportions of females (70%, 74.16% and 65.6% & 70%) were higher than males (30%, 25.84%, and 34.4%& 30%) headed households, respectively.

The result revealed that 97.1% of the total interviewed households were farmers where as the remaining 0.8%, 1.8% and 0.3% of the respondents were merchants, government workers and carpenters, respectively in the study area. Proportions of the respondents' occupations had not differed among agro-ecologies. However, highest proportions of the respondents were engaged in farming activities as a means of their livelihood in all agro-ecologies. Similar results have been reported from Gomma district of Jimma zone by Meseret (2010). The analysis for educational status of the respondents revealed that 41.3% of the respondents were illiterate while 24.4% of them were found to be capable of reading and writing in the study area. About 15.3%, 11.4%, 6.5% and 1% of the literate respondents had gone through primary first cycle (1 -4), primary second cycle (5-8), high school (9-12) and diploma program (12 +3), respectively. The proportions of the educational status of the respondents were significantly varied across agro-ecologies. The proportions of illiterate respondents in the lowland (34.4%) were lower than in midland (48.9%) and highland (42.6%). This indicates that lowland households may have better access to educational services as compared with either of the agro-ecologies. Generally, the highest proportions of the respondents were illiterate in each agro-ecology. Educational status identified under the current study was much better than illiterate (82.12%) reported from North West Ethiopia (Halima 2007). However, it was lesser than from those reported from Bure district of North West Ethiopia (Moges *et al*. 2010), Gomma district of Jimma zone (Meseret 2010) and both Ada'a and Lume districts of East Shewa of Ethiopia (Tadesse *et al*. 2013).

The survey also revealed that 93.5% of the total respondents were Orthodox Christian while the remaining 6.5% of them were Muslim in the study area. There were significant variations with respect to the proportions of respondents following both religious types among agro-ecologies. Higher proportions of Orthodox Christian followers were observed in lowland agro-ecology (97.5%) than in highland (92%) and midland (89.3%) agro-ecologies. However, higher proportions of Muslim followers were obtained from midland agro-ecology (10.7%) than highland (7.4%) and lowland (2.5%) agro-ecologies. In contrast, Meseret (2010) reported that 86.1% and 12.8% of the respondents were followers of Muslim and Orthodox Christian, respectively in Gomma district of Jimma zone.

The analysis for the marital status of the respondents revealed that 82.1% of the total interviewed respondents were married where as the remaining 7%,10.6% and 0.3% of the respondents were divorced, widow/widower and unmarried , respectively in the study area. Proportions of the respondents' marital status were not varied across agro-ecologies. The occurrences of married respondents under the current study (82.1%) was lower than from the result reported from Gomma wereda of Jimma zone (97.2%) (Meseret 2010) and from western Amhara administrative region (90.3%) (Worku *et al*. 2012) but higher than from frequency of married respondents reported from selected chagni town, Awi-Administrative zone of Amhara region (71%) (Ayalew & Adane 2013).

The result also showed that the average age of the households in both midland (47.92±12.09 years) and lowland (47.46±12.3 years) was significantly higher than highland agro-ecology (42.95±10.82 years) (Table 1). Generally, the average age of the households in the study area was 46.51±12.05 years. This result was much higher than the 36.9 and 37.7 years reported by Tadesse *et al* (2013) in Ada'a and Lume districts of East Shewa, respectively. It was also slightly higher than 41.02, 40.86 and 43±10.9 years reported by Solomon et *al* (2013), Moges *et al* (2013) and Worku *et al* (2012) in Metekel zone of Northwest Ethiopia, Bure district of North West and west Amhara region of Ethiopia, respectively.

The mean family size with age of less than or equal to 14 years (younger unproductive age) in the midland (2.29±1.58) was significantly higher than from lowland (1.93±1.31) but not from highland agro-ecology (2.22±1.37). Similarly, the mean family size in the productive age category (≥15 and ≤ 60 years) was not significant different among the agro-ecological zones of the area. The mean family size in the older unproductive age category (> 60 years) in midland (0.26±0.97) did not statistically different from low land (0.13±0.39) but significantly greater than from highland agro-ecology (0.04±o.25). Overall, the average family size in the younger unproductive age (≥14 years age), productive age category (≥15 and ≤60 years age) and older unproductive age category (>60 years) was 2.12±1.43, 3.79±2.00 and 0.15±0.64, respectively in the study area. Regardless of the age category, the mean of total family size in the midland agro-ecology was 6.40±2.55 which was significantly different from lowland (5.67±2.12) but not from highland agro-ecology (6.06±2.38). In general, the mean of total family size in the study area was 6.01±2.35. This result was higher than the average family size (4.02) per household, reported by Solomon *et al* (2013) in Metekel zone of Northwest Ethiopia but comparable with the findings of both Worku *et al* (2012) and Moges *et al* (2013) who reported that 6.0±2.00 and 6.19±2.17 was the average family size in West Amhara region and Bure district of North West Ethiopia, respectively.

3.2. Reproductive Performance of Local Chickens

The result of the survey indicated that the overall mean age of sexual maturity of local chicken was 7.19±0.04 and 5.71±0.03 months for females and males respectively (Table 2). Ages at sexual maturity of both chicken sexes were significantly different among the three chicken ecotypes. Significantly highest age at sexual maturity of both male and female chickens was obtained from highland chicken ecotype (5.91±0.05 and 7.72±0.07 months) followed by midland (5.73±0.05 and 7.25±0.06 months) while the least age at sexual maturity of both sexes were attained from lowland chicken ecotype (5.48±0.05 and 6.61±0.06 months) which is the most desirable age for profitability of chicken production enterprise. This result was comparable with the findings of Meseret (2010) who reported that the male and female local chicken of Gomma wereda of Jimma Zone attained sexual maturity at 6.47±0.91 and 6.33±0.80 months, respectively. Sonaiya & Swan (2004) also reported similar findings that indigenous village chicken, in Ethiopia attains sexual maturity at an average of 7 months. However, this result was higher than from the findings of Addisu *et al* (2013) and Bogale (2008) indicated that the age of sexual maturity of indigenous male and female were (6.06±0.01 & 5.96±0.01 months) and (5. 87±0.003 &5.9±0.03 months), respectively in north Wollo zone and Fogera district of Amhara regional state of Ethiopia. Solomon *et al* (2013) also reported lower values on the average age sexual maturity/age at first mating/ of indigenous pullets and cockerels in Metekel Zone of North West Ethiopia were 5.2±1.16 and 5.44±1.3 months respectively. In Sudan, the age at sexual maturity of two Sudanese native chicken ecotypes of Dwarf (Betwil) and bare neck ecotypes was 5.46 and 6.16 months, respectively (Yousif & Eltayeb 2011).

The overall mean of slaughter age of local male and female chickens was 4.66±0.03 and 4.50±0.03 months respectively (Table 2). Slaughter age of female chickens significantly varied among the three chicken ecotypes. Significantly maximum marketable age was recorded from highland chicken ecotypes (4.86±0.05 months) followed by midland (4.68±0.05 months) while the least and most desirable marketable age for poultry meat industry was obtained from lowland chicken ecotypes (4.44±0.05 month). Similarly, significantly lesser slaughter age of male chickens was obtained from lowland agro-ecology (4.32±0.05 months) than both highland (4.60±0.05months) and midland (4.57±0.05 months) but no significant variation in slaughter age of male was observed between midland and highland chicken ecotypes. This result was lower than 8.62±1.92 months mean age at slaughter weight of 1.5kg of male chickens of Gomma wereda of Jimma zone under /scavenging conditions (Meseret 2010).

The survey revealed that the overall mean age at first egg laying for female local chickens in the study

area was 7.19±0.04 months. Ages at first egg laying ($p<0.05$) were significantly varied across the three chicken ecotypes. The significantly highest mean age at first egg laying of female chickens was obtained from highland chicken ecotypes (7.72±0.079 months) followed by midland (7.25±0.06 months) while the least and best for profitable chicken production enterprise was recorded from lowland chicken ecotypes (6.61±0.06 months).This result was in line with the report of Habte *et al* (2013) in which the mean age at first egg laying of indigenous pullets in the Nole Kabba wereda of Western Wollega was 7.02±0.22 months. It was also comparable with the findings of Mekonnen (2007) who reported that the mean age at first egg laying of young indigenous pullets in three districts of SNNPRs was 7.7 months. Moreover, Tadelle & Ogle (2001) also reported comparable result on age at first egg laying of indigenous female chickens (6.5±0.93 months ranging from 6.1-7.17 months) in the centeral highland of Ethiopia. Addisu *et al* (2013) also reported that the age at first egg laying of local chickens in North Wollo zone of Amhara region was 6.6±1.60 months. In Kenya, Okeno *et al* (2010) also reported similar figures on the average age at first egg laying of Kenyan indigenous chickens under scavenging conditions was 6.73±0.3 months ranging from 6-11 months. However, this result was longer than the average age at first egg laying of indigenous young pullets in North West Ethiopia (Halima 2007) and West Amhara region (Worku *et al* 2012) were 5 and 6.49±0.01 months, respectively.

The result also indicated that the overall mean age of reproductive life of matured male and female local chicken ecotypes was 2.85±0.04 years and 3.31±0.05 years respectively in the study area (Table 2). The mean age of reproductive life of matured male local chicken did not differ among the three chicken ecotypes. However, slightly higher mean age of reproductive life of males was obtained from highland ecotypes (2.89±0.07 years) followed by lowland (2.88±0.07 years) and midland (2.78±0.07 years). However, significantly higher mean age of reproductive life of matured local female chickens was obtained from highland chicken ecotypes (3.61±0.09 years) than midland chicken ecotypes (2.91±0.08 years) but not different from lowland chicken ecotypes (3.43±0.08 years). This result was slightly lower than the average reproductive life span of males (3.79±0.15 years) & females (3.56±0.14 years) in Metekel Zone of North West Ethiopia (Solomon *et al* 2013).

The survey also indicated that the overall mean of number of clutches per hen per year of local chicken ecotypes was 4.42±0.04 in the study area. Significantly higher mean number of clutches per year per hen of local chicken ecotypes was obtained from midland ecotypes (4.57±0.06) than highland (4.35±0.07) and lowland (4.34±0.08) ecotypes but no significant variation was observed between highland and lowland chicken ecotypes. This result was comparable with the findings of Solomon *et al* (2013) in which the average number of clutches per hen per year of indigenous chickens in Metekel Zone of North West Ethiopia was 4.29±0.17. However, it was higher than the reports of Meseret (2010), Mekonnen (2007), Worku *et al* (2012) and Addisu *et al* (2013) in which the mean clutch number of indigenous chickens in Gomma wereda, three districts of SNNPRs, West Amhara region and North Wollo zone of Amhara regional state of Ethiopia was 3.43/year, 3.8/year, 3.24±0.60/year and 3.62±0.02/year respectively. But it was comparable with the findings of Yousif & Eltayeb (2011) in which the average number of clutches of Dwarf and Bare Neck indigenous chicken ecotypes of Sudan under scavenging conditions was 5 and 4 respectively. In Kenya, Okeno *et al* (2010) also reported that the average number of clutches per hen per year of Kenyan indigenous chickens under scavenging conditions was 3.1±0.7 ranging 2-4.

The overall mean number of incubated eggs, hatched chicks and wasted eggs per clutch of local chicken ecotypes were 10.9±0.12, 8.17±0.11 and 2.73±0.06 respectively from the survey phase of the study. Almost Similar results had been obtained on these traits during the monitoring phase of the study in which the overall mean of incubated eggs, hatched chicks and wasted eggs per clutch were 10.42±0.20, 8.14±0.18 and 2.24±0.10 respectively. The result from both phases revealed that the mean number of incubated eggs in the midland chicken ecotype from the survey (11.22±0.19) and monitoring (11.87±0.35) was significantly higher than lowland chicken ecotypes in both survey (10.40±0.18) and monitoring (9.57±0.35) and highland ecotypes from monitoring (9.83±0.35) but no significant variation was observed between midland (11.22±0.19) and highland (11.07±0.21) chicken ecotypes from the survey and there was no significant variation between lowland (9.57±0.35) and highland (9.83±0.35) from the monitoring phase of the study.

In the same way, the number of hatched chicks per clutch of lowland chicken ecotypes from both recalling data during the survey (6.40±0.18) and monitoring (5.80±0.31) was significantly lower than both midland ecotypes from survey (8.44±0.18) and monitoring (9.93±0.31) and highland chicken ecotypes from survey (9.68±0.20) and monitoring (8.70±0.31). Significantly higher number of hatched chicks per clutch was obtained from highland ecotypes (9.68±0.20) than midland (8.44±0.18) from the recalling data of the survey but significantly superior figure was obtained from midland to highland from the monitored data. There was highly significant deference in number of wasted eggs per clutch of local chickens among the agro-ecological zones. Significantly highest number of wasted eggs per clutch from both recalling data (4.00±0.10) and monitored data (3.70±0.18) was obtained from lowland chicken ecotypes while the least figure from both recalling data (1.39±0.12) and monitored data (1.10±0.18) was attained from highland chicken ecotypes. This result showed an

agreement with the report of Addisu *et al* (2013) in which the mean number of incubated eggs and hatched chicks per clutch of indigenous chickens in North Wollo Zone of Amhara Regional state was 11.36±0.09 and 9.60±0.10 respectively. Worku *et al*. (2012) also reported somewhat similar values of average number of eggs incubated and eggs hatched per clutch per hen of local chickens in West Amhara region of Ethiopia were 12.8±2.30 and 10.00±2.30 respectively. Likewise, Wondu *et al* (2013) reported closer values on the average number of incubated eggs and hatched eggs per clutch per hen of local chickens in the North Gondar Amhara regional state of Amhara was 10.95±0.22 (7-15) and 9.49±0.20 (7-14) respectively.

On the other hand, this result was lower than the average number of eggs set/clutch (13±2.2 ranging from 7-19) and number of hatched eggs/clutch (11±2.3 ranging from 4-16) of the indigenous chickens in Centeral highlands of Ethiopia (Tadelle & Ogle 2001). In Kenya, Okeno *et al* (2010) also reported similar findings on the average incubated eggs and hatched eggs per set of Kenyan indigenous chickens under scavenging conditions were 12.84±0.4(ranging 7-15) and 10.73±1.8(ranging 5-15) respectively.

The overall mean weaning age of chicken ecotypes was 2.55±0.53 months in the study area. Significantly earlier mean weaning age (2.33±0.04 months) was obtained from lowland chicken ecotypes than both highland (2.67±0.05 months) and midland (2.66±0.04) chicken ecotypes but no significant variation was observed between midland and highland chicken ecotypes. This was in line with the findings of Meseret (2010) in which the average weaning age of indigenous chickens of Gomma Wereda of Jimma zone was 2.61±0.45 months. However, it was higher than from the findings of Solomon *et al* (2013) showed that the average weaning age of local chickens in Metekel Zone of North West Ethiopia was 2.13±0.10 months.

The overall mean of the hatchability (%) and number of weaned chicks per clutch and survival rate to weaning age (%) of the local chicken ecotypes were 74.37±0.57, 5.92±0.08 and 73.06±0.51 respectively from recalling data and 77.58±0.89, 3.60±0.17 and 44.56±1.17 respectively from monitored data in the study area. There was significant difference in hatchability of eggs across the three chicken ecotypes. Signicantly least hatchability of eggs was obtained from lowland chicken ecotypes in both recalling data (61.34±0.92) and monitored data (60.43±1.54) while the highest was attained from highland chicken ecotypes in both recalling data (87.29±1.06) and monitored data (88.67±1.54) though the hatchability of eggs from the monitored data was not significantly different between highland and midland chicken ecotypes. In similar context, significantly least number of weaned chicks per clutch was obtained from lowland chicken ecotypes in both recalling data (4.76±0.14) and monitored data (2.70±0.20) whereas the highest number of weaned chicks per clutch was recorded from highland chickens in the recalling data(6.72±0.16) and from midland chicken ecotypes in the monitored data(4.27±0.20) though there was no significant variation between midland and highland chicken ecotypes in both recalling and monitored data. However, least survival rate to weaning age was obtained from highland chicken ecotypes in the recalling data (69.83±0.95) while highest survival rate was attained from midland chicken ecotypes (75.01±0.86) even if no significant variation was observed between midland and lowland chicken ecotypes from the recalling data. This result was somewhat similar with the findings of Okeno *et al* (2010) in which the average number of weaned chicks or survive to weaning was 6.04±1.4 (2 -8).

The survey also revealed that the overall mean numbers of chicks survive to adulthood, survival rate to adulthood, incubation frequency per year and number days per clutch were 4.13±0.08, 50.45±0.64, 2.94±0.03 and 22.19±0.16 days respectively in the study area. Significantly lower number of chicks survive to adult hood was obtained from lowland chicken ecotypes (3.30±1.03) while higher number was recorded from highland chicken ecotypes (4.65±0.15) though no significant variation was observed between midland and highland chicken ecotypes. Worku *et al* (2012) also reported slightly greater values of average number of survive chicks to adulthood per clutch per hen and survivability to adulthood of local chickens in West Amhara region of Ethiopia were 5.50±1.70 and 58.25±2.30 respectively. The mean number of incubation frequency per year did not differ among the three chicken ecotypes. This result was comparable with the reports of Wondu e*t al* (2013) in which the mean number of times the hen hatches eggs year of local chickens in North Gondar Amhara regional state was 2.59±0.05 (2-3). However this result was higher than the number of times the indigenous hen hatches per year of 1.85±0.51 reported by Meseret (2010) in Gomma Wereda. The mean number of days per clutch in the lowland chicken ecotypes was significantly lower than both midland (23.01±0.18) and highland (22.96±0.30) chicken ecotypes but no significant variation was observed between midland and highland chicken ecotypes. This result was slightly lower than the report of Meseret (2010) in which the average number of days per clutch of indigenous chickens of Gomma Wereda of Jimma zone was 25.29±4.39 days. Similarly, Yousif & Eltayeb (2011) also reported lower figures on the average clutch length of Dwarf and Bare Neck indigenous chickens of Sudan under scavenging management conditions was 14.44 days and 20.04 days respectively.

The result of the monitoring phase of the study indicated that the overall mean approximate age of local chicken layers, number of chicks survive to 30 days, survival rate to 30 days, number of chicks survive to 60 days and survival rate to 60 days of local chicken ecotypes was 2.21±0.10 years, 5.06±0.14, 63.24±1.24, 4.10±0.13 and 51.02±1.22 respectively in the study area. There was no significant variation in the mean of approximate age of local layers. There was significant difference in the mean number of survive chicks to 30

days across the three agro-ecological zones in which the highest mean of survive chicks to 30 days was obtained from midland chicken ecotypes(6.20±0.24) while the least was obtained from lowland chicken ecotypes (3.97±0.24). Similarly, the least mean number of survive chicks to 60 days was obtained from lowland chicken ecotypes (3.17±0.22) whereas highest mean number of survive chicks to 60 days was recorded from midland chicken ecotypes 4.83±0.22) even if no significant variation was observed between midland and highland chicken ecotypes.

The result of the monitoring phase of the study indicated that the overall mean number of survive chicks to 90 days and the survive rate to 90 days (%) was 3.11±0.10 and 39.84±1.10 respectively in the study area. Significantly lower number of survive chicks to the 90 days was obtained from lowland chicken ecotypes (2.70±0.16) than midland chicken ecotypes (3.73±0.16) but not significantly different from highland chicken ecotypes (2.90±0.16). In the reverse context, significantly higher survival rate to the 90 days (%) was obtained from lowland chicken ecotypes (47.78±1.91) than both highland (33.54±1.91) and midland (38.18±1.91) chicken ecotypes but no significant variation was observed between highland and midland chicken ecotypes.

This result slightly agreed with the findings of Halima (2007), Habte *et al* (2013) and Tadelle & Ogle (2001) in which the average hatchability of eggs of indigenous chickens under scavenging management condition was 60.7% to 82.1%, 82.74 % and 81±11% (ranging 44-100) in North Western of Ethiopia, Nole Kabba wereda of Western Wollega and Central highlands of Ethiopia respectively. On the other hand, this result was higher than from the findings of Meseret (2010) and Yousif & Eltayeb (2011) who reported that the average hatchability of indigenous chickens in Gomma wereda (22%) and the mean hatchability of Dwarf(65.6%) and Bare Neck(59.09%) indigenous chickens of Sudan under scavenging conditions respectively. In Kenya, Okeno *et al* (2010) also reported a similar finding on the hatchability of Kenyan indigenous chickens under scavenging conditions was 83.6%. Worku *et al* (2012) also reported slightly similar figures on the egg hatchability of local chickens in West Amhara region of Ethiopia was 79.1±17.0 %. However, this result was lower than the findings of Solomon *et al* (2013), Wondu *et al* (2013), Nebiyu *et al* (2013) in which the average egg hatchability of local chickens in Metekel Zone of North West Ethiopia, North Gondar Amhara regional state and Halaba wereda of southern Ethiopia were 84.74%,87.29±0.999 and 83.72% respectively.

3.3. Productive Performance of Local Chicken Ecotypes.

The results of both recalling data and monitored data revealed that the average number of eggs laid per clutch of indigenous chicken ecotypes in the study area was 12.01±0.12 and 14.53±0.35 respectively (Table 2 and 3). Significantly lower average number of eggs laid per clutch was obtained from lowland chicken ecotypes in both recalling data (11.41±41) and monitored data (12.90±0.61) than highland (12.56±0.23) but not significantly different with midland ecotypes (12.07±0.21) from the recalling data, and the lowland chicken ecotypes was not significantly different highland ecotypes (13.0±0.61) but significantly lower than midland chicken ecotypes (17.73±0.61) from the monitored data. This result was in line with the reports of Meseret (2010), Addisu *et al* (2013), Wondu *et al* (2013) and CSA (2003) in which the mean egg number laid per clutch per hen of local chickens in Gomma wereda, North Wollo Zone North Gondar Amhara region and Ethiopia were12.92, 12.64±0.1, 11.53±0.21 (8-15) and 12(national average of egg yield/hen/clutch) respectively. However, it was lower than from the reports of Solomon *et al* (2013), Bogale (2008), Mekonnen (2007), Worku *et al* (2012) and Tadelle (2003) in which the average number of eggs laid per clutch of local chickens in Metekel Zone of North West Ethiopia, Fogera district, Southern Ethiopia(Dale,Wonsho,Loka Abaya wereda), West Amhara region of Ethiopia and five agro-ecological zones of Ethiopia were 13.56±0.26 eggs,16.6 eggs,14.9 eggs, 14.1±3.25 and 17.7 eggs, respectively. In Kenya, Okeno *et al* (2011) also reported higher values of average number of eggs laid per clutch of the Kenyan indigenous chickens under scavenging conditions was 15.37±0.6 (7-18).

The result of the survey indicated that the mean annual egg production per hen in the study area was 52.68±0.57 (Table 2). Significantly lower mean annual egg yield per hen was obtained from lowland chicken ecotypes (48.98±0.92) than both highland (54.20±1.07) and midland chicken ecotypes (54.87±0.97) but no significant variation was observed between highland and lowland chicken ecotypes. This was comparable with the mean annual egg yield per hen of indigenous chickens of Fogera district (53 eggs) and Dale district (55 eggs) (Fisseha *et al* 2010) and Loka A district (54.9±3.27 eggs) and Dale district (51.44±1.40 eggs) (Mekonnen 2007). However, this result was higher than the reports of Meseret (2010), Halima (2007), Ayalew & Adane (2013) and Addisu *et al* (2013) in which the mean annual egg yield per hen of indigenous chickens in Gomma wereda of Jimma zone, North West Ethiopia, Chagni town in Awi administrative Zone Amhara and North Wollo zone of Amhara was 43.8 eggs, 18-57 eggs, 27-45 eggs and 49.51±0.38 eggs respectively. On the other hand, this result is lower than the mean annual egg yield of indigenous chickens in Bure district (60 eggs) (Fisseha *et al* 2010), Wonsho district (62.95±2.29 eggs) (Mekonnen 2007) and Enebsie Sar Midir Wereda of Eastern Gojjam (65 eggs) (Yitbarek & Zewudu 2013). Worku *et al* (2012) also reported lower values of mean annual egg production per hen of local chickens in West Amhara region of Ethiopia was 45.7±9.80 eggs. Solomon *et al* (2013) also

reported a greater value on the average annual egg production per year per hen of local chickens in Metekel Zone of North West Ethiopia was 59.51±2.66 eggs.

The result of the survey also indicated that clutch number had significant effect on average egg production per hen per clutch (Table 4). The overall average egg production per clutch of local chicken ecotypes in the first clutch, second, third, fourth and fifth were 11.32±0.14, 12.21±0.13, 14.42±0.3, 11.33±0.15 and 9.25±0.12 respectively in the study area. Average egg yield per clutch per hen shows a trend of increasing from first clutch up to third clutch in which the maximum average egg yield per clutch was attained and then started to decrease from Clutch four. This result is in line with the findings of Addisu *et al* (2013) in which the average egg production per clutch per hen in North Wollo Zone in the first, second, third, fourth and fifth clutch was 10.11±0.15, 12.85±0.17,14.41±0.08, 13.76±0.17 and 11.12±0.20 respectively. Tadelle *et al* (2003) also reported similar findings on the trend of overall mean egg laying performance of indigenous hens for the first, second and third clutches were 17.0, 20.9 and 24.8 eggs respectively and layers laid 8 eggs more by the third clutch compared to the first clutch.

The result of the monitoring phase of the survey also indicated that the overall mean weight of day old, one week, one month, two month and three month old of local chicken raised under extensive management of the study area were found to be 37.96±0.18 gram, 40.19±0.19 gram, 144.13±0.19, 303.04±1.23gram and 517.25±1.25 gram, respectively (Table 3). The average weight of day old, one week, one month and three month of the local chickens were significantly different among the three agro-ecological zones of the zone. Significantly superior average weight of day old and one week chickens were obtained from highland ecotypes followed by midland while the least was recorded from lowland ecotypes. This may be due to extreme temperature difference among the three altitudes. However, significantly highest mean weight of one month and two month old chickens were attained from lowland chicken ecotypes followed by midland ecotypes whereas the least was obtained from highland chicken ecotypes. Similarly, the highest mean weight of three month old chickens was recorded from midland ecotypes followed by lowland ecotypes while least was obtained from highland ecotypes. This might be due to genetic difference and other management level discrepancies.

4. Conclusion

Significant ($P<0.05$) differences were observed among chicken ecotypes in almost all performance traits studied. Lowland chicken ecotypes earlier to mature sexually, slaughter and onset egg laying in comparison to the other two ecotypes but lower hatchability and egg yield performance were obtained from lowland chicken ecotypes. The overall mean age at sexual maturity of male and female chicken was 5.71±0.03 and 7.19±0.04 months respectively. The average age at first egg laying was 7.19±0.04 months. Average egg yield / clutch / hen showed an increase trend from 1st clutch up to 3rd clutch in which optimal egg yield / clutch was attained and then started to decrease from 4th Clutch. The overall mean egg laid/clutch/hen and egg yield/year/hen were 12.01±0.12 and 52.68±0.57 respectively. The average hatchability of local chickens was 74.37±0.57. Performance differences among the local chicken ecotypes indicate genetic and phenotypic diversity existences among the three chicken ecotypes that will serve as row material for indigenous chickens' genetic potential improvement through appropriate breeding programs. Future sustainable improvement, utilization and conservation of the indigenous chicken genetic resources are dependent on the genetic variations present within and among the local chicken ecotypes. Thus, agro-ecologically friendly and community based holistic genetic and performance improvement strategies should be designed and implemented to improve their performances and to enhance sustainable utilization and conservation of the indigenous chicken genetic resources. In depth studies on assessment of phenotypic and genetic variations of the chicken ecotypes are required to validate the detected performance differences among chicken ecotypes.

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Table 1: Demographic characteristics of households (% of respondents)

Household characteristics	Agro-ecological zones				X^2-test	P - value
	High (n=94)	Mid (n=131)	Low (n=160)	Total (N=385)		
Sex of households					2.299(ns)	0.317
Male	80(85.1)	113(86.3)	128(80)	321(83.4)		
Female	14(14.9)	18(13.7)	32(20)	64(16.6)		
Household occupation					5.459(ns)	0.065
Farmer	89(94.7)	126(96.2)	159(99.4)	374(97.1)		
Merchant	-	2(1.5)	1(0.6)	3(0.8)		
Government worker	4(4.2)	3(2.3)	-	7(1.8)		
Carpenter	1(1.1)	-	-	1(0.3)		
Educational status					6.126(*)	0.047
Illiterate	40(42.6)	64(48.9)	55(34.4)	159(41.3)		
Read and write	21(22.3)	31(23.7)	42(26.3)	94(24.4)		
1^{st} -4^{th}	15(16)	15(11.5)	29(18.1)	59(15.3)		
5^{th} -8^{th}	9(9.6)	14(10.7)	21(13.1)	44(11.4)		
9^{th} -12^{th}	6(6.4)	6(4.6)	13(8.1)	25(6.5)		
12 +3	3(3.2)	1(0.8)	-	4(1)		
Religion of households					8.116(*)	0.017
Orthodox	87(92.6)	117(89.3)	156(97.5)	360(93.5)		
Muslim	7(7.4)	14(10.7)	4(2.5)	25(6.5)		
Marital status of households					3.058(ns)	3.058
Married	80(85.1)	111(84.7)	125(78.1)	316(82.1)		
Divorced	7(7.4)	7(5.3)	13(8.1)	27(7)		
Widow /widower	7(7.4)	13(9.9)	21(13.1)	41(10.6)		
unmarried	-	-	1(0.6)	1(0.3)		
Age (years)	42.95 ± 10.8^{b}	47.92 ± 12.1^{a}	47.46 ± 12.4^{a}	46.51±12.1		
≤14 years	2.22 ± 1.4^{ab}	2.29 ± 1.6^{a}	1.93 ± 1.3^{b}	2.12±1.4		
≥15 and ≤ 60	3.81 ± 2.1^{a}	4.02 ± 2.2^{a}	3.59 ± 1.8^{a}	3.79±2.0		
> 60 years	$0.04\pm o.3^{b}$	0.26 ± 1.0^{a}	0.13 ± 0.4^{ab}	0.15±0.6		
Total Family size	6.06 ± 2.4^{ab}	6.40 ± 2.6^{a}	5.67 ± 2.1^{b}	6.01±2.4		

***(P<0.05), ns (P>0.05) and n = number of respondents interviewed per agro-ecology**

Table 2: Least square means for reproductive and reproductive traits of local chicken ecotypes in three agro-ecological zones of Western Tigray (Ls-Mean±SE): **survey**

Traits	Agro-ecological zones				
	Highland	midland	lowland	overall	CV
Age of sexual maturity(month)					
Female	7.72 ±0.07^{a}	7.25 ±0.06^{b}	6.61 ± 0.06^{c}	7.19±0.04	10.13
Male	5.91 ±0.05 ^{a}	5.73 ±0.05^{b}	5.48 ±0.05^{c}	5.71±0.03	9.90
Slaughter/marketable age(month)					
Female	4.86 ±0.05^{a}	4.68 ±0.05^{b}	4.44 ±0.05^{c}	4.66±0.03	11.92
male	4.60 ± 0.05^{a}	4.57 ±0.05^{a}	4.32 ±0.05^{b}	4.50±0.03	12.16
Age at first egg laying (months)	7.72 ±0.07^{a}	7.25 ±0.06^{b}	6.61 ±0.06^{c}	7.19±0.04	10.13
Reproductive life (years)					
male	2.89 ±0.08 ^{a}	2.78 ±0.07^{a}	2.88 ±0.07^{a}	2.85±0.04	28.40
female	3.61 ±0.09^{a}	2.91 ±0.08^{b}	3.43 ±0.08^{a}	3.31±0.05	28.70
Egg laid/clutch/hen	12.56±0.23^{a}	12.07±0.21^{ab}	11.41±0.20^{b}	12.01±0.12	20.16
No of clutches/year/hen	4.35±0.07^{b}	4.57 ±0.06^{a}	4.34 ±0.06^{b}	4.42±0.04	16.09
Annual egg yield/hen	54.20 ±1.07^{a}	54.87 ±0.97^{a}	48.98 ±0.92^{b}	52.68±0.57	21.22
No of incubated eggs /clutch	11.07 ±0.21^{a}	11.22 ±0.19^{a}	10.40± 0.18^{b}	10.90±0.12	19.71
No of hatched chicks/set	9.68 ±0.20 ^{a}	8.44 ±0.18 ^{b}	6.40 ±0.18^{c}	8.17±0.11	26.38
No of wasted eggs/clutch	1.39 ±0.12^{c}	2.79 ±0.11^{b}	4.00 ±0.10^{a}	2.73±0.06	43.84
Hatchability (%)	87.29±1.06^{a}	74.47 ±0.97^{b}	61.34 ±0.92^{c}	74.37±0.57	15.17
No of weaned chicks/clutch	6.72 ±0.16^{a}	6.27 ±0.14^{a}	4.76 ±0.14^{b}	5.92±0.08	27.95
Survival rate to weaning age (%)	69.83±0.95^{b}	75.01±0.86^{a}	74.34 ±0.82^{a}	73.06±0.51	13.49
Weaning age(months)	2.67± 0.05^{a}	2.66 ±0.04^{a}	2.33 ±0.04^{b}	2.55±0.03	19.87
No of chicks survive to adulthood	4.65±0.15^{a}	4.44 ± 0.14^{a}	3.30± 0.13^{b}	4.13±0.08	38.76
Survival rate to adulthood (%)	47.62± 1.17^{b}	52.49± 1.08^{a}	51.26 ±1.03^{ab}	50.45±0.64	24.46
Incubation frequency /year	3.01 ±0.06^{a}	3.06 ±0.06^{a}	2.76 ±0.05^{b}	2.94±0.03	21.87
No of days /clutch	22.96 ±0.30^{a}	23.01±0.28^{a}	20.61 ±0.26^{b}	22.19±0.16	14.41

LS-means with the same letter in the same row are not significantly different (p>0.05)

Table 3: Productive and reproductive traits (functional traits) of local chicken ecotypes collected through **monitoring** in three agro-ecological zones of western Tigray

Traits	Agro-ecological zones				
	Lowland	Midland	Highland	Overall	CV
Egg laid/clutch	12.90 ±0.61^{b}	17.73± 0.61^{a}	13.0 ± 0.61^{b}	14.53±0.35	22.93
Eggs incubated(no)	9.57 ±0.35^{b}	11.87±0.35^{a}	9.83 ±0.35^{b}	10.42±0.20	18.43
Hatched chicks(no)	5.80 ±0.31^{c}	9.93 ±0.31 ^{a}	8.70 ±0.31^{b}	8.14±0.18	20.94
Hatchability (%)	60.43± 1.54^{b}	83.64±1.54^{a}	88.67± 1.54^{a}	77.58±0.89	10.87
Wasted eggs (no)	3.70 ±0.18 ^{a}	1.93± 0.18^{b}	1.10 ± 0.18^{c}	2.24±0.10	43.48
Weaned chicks(no)	2.70 ±0.20 ^{b}	4.27 ±0.20^{a}	3.83±0.20 ^{a}	3.60±0.12	30.71
Survival rate to weaning (%)	45.84 ±2.03^{a}	43.67± 2.03 ^{a}	44.18±2.03^{a}	44.56±1.17	24.93
Approximate age of layer(years)	2.05 ±0.17 ^{a}	2.35±0.17 ^{a}	2.24 ±0.17 ^{a}	2.21±0.10	42.42
Survive chicks to 30 days(no)	3.97 ±0.24^{c}	6.20± 0.24^{a}	5.00± 0.24^{b}	5.06±0.14	25.95
Survival rate to 30 days (%)	68.87±2.13^{a}	63.35±2.15^{ab}	57.51±2.15^{b}	63.24±1.24	18.62
Survive chicks to 60 days(no)	3.17±0.22^{b}	4.83± 0.22^{a}	4.30 ±0.22 ^{a}	4.10±0.13	28.96
Survival rate to 60 days (%)	54.38 ±2.10^{a}	49.12±2.10 ^{a}	49.56±2.10 ^{a}	51.02±1.22	22.59
Survive chicks to 90 days(no)	2.70 ±0.16^{b}	3.73 ±0.16^{a}	2.90± 0.16^{b}	3.11±0.10	29.01
Survival rate to 90 days (%)	47.78± 1.91^{a}	38.18±1.91^{b}	33.54 ±1.91^{b}	39.84±1.10	26.29
Weight of chickens (gram) at the age of					
Day old	41.05± 0.33^{a}	38.57± 0.27^{b}	34.28 ±0.3^{c}	37.96±0.18	5.63
One week	43.13 ±0.35^{a}	39.99 ± 0.28^{b}	37.45 ±0.3^{c}	40.19±0.19	5.71
One month	135.44± 0.98^{c}	144.94±0.78^{b}	152.02±0.98^{a}	144.13±0.53	4.39
Two month	294.07±2.28^{b}	305.48±1.83^{a}	309.58±2.28^{a}	303.04±1.23	4.86
Three month	465.97±4.62^{c}	572.93±3.71^{a}	512.85±4.62^{b}	517.25±2.50	5.69

LS-means with the same letter in the same row are not significantly different (p>0.05)

Table 4: Egg yield of different clutch numbers of local chicken ecotypes in the three agro-ecological zones of Western Tigray (from survey)

Traits	Agro-ecological zones				
	Lowland	Midland	Highland	Overall *	CV
Clutch number /year/hen	4.28 ±0.02^{c}	4.60±0.03 ^{a}	4.46 ±0.03^{b}	4.44±0.02	15.92
Egg yield at clutch number					
One	10.69 ±0.20^{b}	12.01 ± 0.23^{a}	11.27± 0.27^{ab}	11.32±0.14 ^{c}	22.95
Two	11.84 ±0.20^{a}	12.37 ±0.22 ^{a}	12.40± 0.26^{a}	12.21 ± 0.13^{b}	20.4
Three	13.79 ±0.46^{a}	14.01 ± 0.51^{a}	15.48 ±0.60^{a}	14.42± 0.30^{a}	40.76
Four	10.22± 0.22^{c}	11.32 ±0.25^{b}	12.48 ±0.29^{a}	11.33± 0.15^{c}	24.37
Five	8.25 ±0.32^{b}	9.71 ±0.26^{a}	9.79 ±0.36^{a}	9.25± 0.12 ^{d}	24.82
Annual egg no at clutch					
One	45.35 ±0.95^{c}	54.49 ±1.05^{a}	49.91 ±1.24^{b}	49.92 ±03^{bc}	24.22
Two	50.38 ±0.93 ^{b}	56.08 ±1.03^{a}	54.74 ±1.21 ^{a}	53.73±0.61^{b}	22.01
Three	58.76± 2.33^{b}	63.67 ±2.57^{ab}	68.97± 3.04^{a}	63.80 ±1.54^{a}	40.76
Four	41.51± 1.50^{b}	49.27 ±1.65^{a}	53.16 ±1.95^{a}	47.98±0.99 ^{c}	40.29
Five	13.42± 1.92^{b}	28.89 ±2.12^{a}	22.52±2.50^{a}	21.61± 1.27^{d}	46.13

LS-means with the same letter in the same row are not significantly different (p>0.05) and
Overall*= indicate LS-means with the same letter in the same column are not significantly different (P>0.05)

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