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On-farm evaluation of novel brood nest on hatchability of chicken egg and brooding practices at Gofa zone, South Ethiopia

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Abstract

This activity was conducted in order to assess native methods of incubation, brooding, egg selection, broody hen selection, reasons for hatchability failure and to evaluate novel brood nest on hatchability of chicken egg. A survey was carried out in selected districts of Gofa zone, South Ethiopia. Multi stage sampling procedures were employed to select study areas, sample study areas and participants were selected by purposive sampling technique. Pretested structured questionnaire and focused group discussion were employed to generate data. All generated survey data were analyzed using descriptive statistics of SPSS 16. For egg incubation and chick brooding, broody hens were the sole methods. Broody hens selected based on plumage color, egg yield, body weight (size) and mothering ability. Eggs Laid at home was the predominant sources of incubation and selected mainly based on egg type, egg age and egg size. Overall, the respondents replied that they used either of Clay pots (18.2%), Ground (8.2%), Plastic can (19.5%), Bamboo cages (25.7%), Cartons (20.6) and wooden crates (7.8) as brooding material. Straw was the most commonly used nesting material in Demba gofa district, Melo koza districts and Sawula town (35.3%, 33%, 33.3%, respectively). Most of the respondents (90.3%) incubate their chickens during dry season (Oct. – Dec). Regarding the hatchability of chicks 90.3% of the respondents said that they achieve best hatchability during dry season. A comparatively high number of chicks were hatched during the second phase (9-12) from the number of eggs set. Further research on hatchability performance evaluation of the indigenous chickens in both on farm and station as well as effect of the twelve months of the year on incubation and hatchability of eggs.

Keywords: Brooding; Mothering Ability; Nest Box; Bedding Material; Hatchability

1. Introduction

In tropical countries, the traditional method of raising poultry is scavenging. Chickens are the most crucial poultry species [1, 2]. Chickens are the most widespread, and almost every rural family owns chickens, which provide a valuable source of family protein, and income in Ethiopia. The latest estimate for chickens in Ethiopia is 56.05 million which consists of 49.44 million (88.19%) indigenous, 3.62 million (6.45%) exotic, and 3.004 million (5.36%) hybrid chickens respectively [3]. In spite of the higher number population of chicken, their contribution to individual households and national income is still meager (2-3%). The annual growth rates in egg and meat output were estimated at about 1.0 and 2.6% as compared to the sub-Saharan African countries, 5.7 and 6.8%, respectively [4, 5].

Because it provides food security and nourishment for a productive and healthy life on a global scale, the livestock industry makes a substantial contribution to both economic and physical growth. [6]. More specifically, livestock is a vital resource for rural livelihoods and economic diversification in a smallholding agricultural system, demonstrating that Ethiopia's current enormous potential has little bearing on its nutritional and economic worth to the general public.

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[7]. Feeding a diet that is balanced in all nutrients and at a level that fulfils the production goal while taking the animal's physiological condition into account is critical for attaining high and sustained livestock output [7].

Poultry has a significant economic impact, particularly in low-income and food-deficient nations. Animal production is hampered in the majority of developing nations, including Ethiopia, by a lack of feed ingredients and their erratic quantity and quality. On the contrary, world population is estimated to reach 8 billion by the year 2020 with most of the population growth coming from the developing countries [8]. This expected surge in population will definitely impact the animal industry as more animal protein is demanded. Moreover, the expected economic growth leads to increased demand for high-quality animal protein. The fastest way of meeting the growing demand for protein of animal origin is through increasing the productivity of poultry. Chicken meat is rich in protein, fats, minerals and vitamins and can be a good source of easily accessible nutrition for resource-poor households, the sick, malnourished and children under the age of five [9].

Due to their low labor requirements and little input requirements, village chickens are the most manageable livestock species for each family member worldwide. Through the diversification of consumable foods, they play a crucial role in improving children of small-scale farmers' growth, mental development, academic performance, and labor productivity as well as lowering the risk of disease [10].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 [11]. In addition, they have social, cultural and religious importance, and considered as "an entry point for poverty reduction and gate way to national food security" because it has potential in boosting living standards, social needs and improving family nutritional status [12].

Ethiopian households with little means rely on village chickens for a variety of purposes, including generating cash and ensuring food security. Because of the quality and taste of the products (meat and eggs), consumers typically favor local chicken products over exotic ones [13]. Despite their significant roles, their low performances masked their potential to uplift the living standards of their owners and contribute to rural developments in Ethiopia. This may be attributed to their low genetic potential, prevalence of diseases and parasites, limited feed resources, constraints related to institutional and socio-economic and limited skill management practices [14, 15, 16].

The majority of Ethiopian farmers have traditionally raised chicks and incubated eggs using broody chickens [17, 18]. The hatchability of the breeding hens has a significant impact on the profitability of a particular poultry sector. Therefore, information on indigenous knowledge of egg selection practices, brooding practices, egg storage practices, incubation practices , brooding breaking techniques , fertility testing methods and factors associated with hatchability failure (constraints) have played key role in identification of key points of interventions so as to improve the hatchability of chickens and serve as baseline information or input for development of agro-ecologically based and holistic improvement programs in order to ensure sustainable improvement, utilization and conservation of chicken genetic resources. Research on the incubation behaviors of local chickens under on-farm and scavenging production systems in South Ethiopia, specifically in the Gofa Zone, has been scant or nonexistent.. Therefore, this study was presented in the Gofa zone with the hope that it would help close the knowledge gap in this field. Consequently, it was necessary to conduct this study with the following objectives:

- To improve the hatchability of chicken egg through novel brood
- To increase opportunity for brooding and hatching large number of egg at a time through broody hen
- To analyze the impact of hatchability via artificial methods and examine the consequences for the natural practice of egg hatching and the need for further studies
- To investigate brooding practices at the study area.

2. Material and Method

2.1. Description of Study Area

The study was conducted in Demba gofa District, Melo koza district and Sawula administrative town of Gofa Zone, South Ethiopia.

The Gofa Zone, which has about a million residents, which is located in South Ethiopia Region and borders the Gamo Zone to the east and southeast, Dawuro zone to the north, Konta zone to the northwest, Basketo zone to the southwest, and Ari Zone to the south. Gofa is made up of two town administrations, Sawla (Zonal Capital) and Bulki, as well as seven

Districts: Demba Gofa, Gezie Gofa, Zala, Melo Koza, Melo Gada, Uba Debre Tsehay, and Oyda. Gofa contains a large amount of arable land and a few perennial rivers, such as Maze, Ergino, Zenti, and Omo, the latter of which is the fourth largest in Ethiopia and has four hydro plants built along its bunks that generate half of the nation's current electricity supply. The Zone is endowed with a diverse agro-ecological climate and topography, ranging from the chains of "Woyla" and "Alba Zoma" escapements, which are elevated close to 4000m, to the Omo River Valley, which is only 700m above sea level.

2.2. Sample Size Determination

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

N_o= [Z^2pq] / e^2 , Where N_o= required sample size, **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

2.3. q= 1-p.

N_o= [Z^2pq] / e^2 == $[(1.96)^2 \times (0.5)\ (0.5)]$/ (0.05x0.05)

= [3.8416 x0.25]/ (0.0025)=0.9604/0.0025=385 farmers

The numbers of respondents (farmers) per single selected kebele were determined by proportionate sampling technique as follows:

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

The study was conducted in two districts (Demba gofa and Melo koza) and one town administration (Sawula) of the Gofa Zone, South Ethiopia. We randomly selected 12 farmers practicing egg incubation by broody hens from each study areas. A total of 36 farmers were selected and data were collected from 36 broody hens with a pretested questionnaire, direct measurement, and observation during the study period.

Data on brooding practices, incubation egg sources and selection criteria, egg setting materials, broody hen selection criteria, incubation practices and causes of hatchability failure, traditional methods of breaking broodiness and indigenous egg fertility testing techniques were collected through direct observation during data collection and individual interview using pretested structure questionnaire and this was augmented with one focused group discussion per each district with 10-12 discussants per each group. For novel brooder; the following datas were collected Number of egg set, Egg weight, Initial weight of hen , Number of eggs culled after candling, Chick hatched, Embryonic mortality, Chick weight and Final weight of hen after hatching and weight loss of hen.

Total number of prepared novel brood boxes were thirty six. Twelve boxes for each study area. Which are 13cm circumference punctured floor, 14cm circumference punctured floor, 15cm circumference punctured floor and brood without punctured floor. Fertile eggs were obtained from Ethio chicken breeding farm at wolaita soddo. During candling and after 21 day of natural incubation data's were collected. During the brooding period hens were fed on commercial ration. Feed and water was provided to hens using plastic cups that had been putted near to brooding nest.

Table 1 Treatments

Location	**Replication**	**Treatment (Punctured brood layer circumferences)**			
		T1(13cm)	T2(14cm)	T3(15cm)	T4(Control)
Demba Gofa district	1	12 egg	12 egg	12 egg	12 egg
	2	12 egg	12 egg	12 egg	12 egg
	3	12 egg	12 egg	12 egg	12 egg
Melo Koza district	1	12 egg	12 egg	12 egg	12 egg

	2	12 egg	12 egg	12 egg	12 egg
	3	12 egg	12 egg	12 egg	12 egg
Sawula Town	1	12 egg	12 egg	12 egg	12 egg
	2	12 egg	12 egg	12 egg	12 egg
	3	12 egg	12 egg	12 egg	12 egg

The weights of hens were recorded before and after the onset of broodiness to make a comparison of weight during incubation. Egg number and weight were recorded to measure the clutch size and hatching egg weight, respectively. The number of eggs set by the farmers was recorded and monitored the incubation process on a routine basis. The hatchability was calculated on the basis of the number of eggs set per broody hen by the following equation:

$$\text{Hatchability (\%)} = \frac{\text{number of chicks obtained per broody hen}}{\text{Total number of eggs set broody hen}} \times 100$$

Chick viability was calculated after one month of the rearing period. It was calculated on the basis of the following equation:

$$\text{Chick viability after one month(\%)} = \frac{\text{umber of chicks viable after a month of rearing period}}{\text{Total number of day} - \text{old chicks hatched}} \times 100$$

2.5. Data analysis

The percentage (%) data were based on the basis of total observations. Data were analyzed using the IBM SPSS version 20. Chi-square tests between variables of descriptive statistics were performed for getting significant levels. Differences between study areas were analyzed by using Tukey's honestly significant difference test and the significance level was declared based on $P< 0.05$. The survey data were analyzed using descriptive statistics of frequency procedures and cross-tabulation of SPSS version 16 (2007). For novel brood test; design is CRD with 3 replications.

3. Result and Discussion

3.1. Brooding Practices

The result of the current study revealed that all (100%) of the respondents at all study area hatch eggs using natural incubation, which is in agreement with the report of Hailu, [19] where eggs were incubated using broody hen at Sheka Zone of South Western Ethiopia.. Similarly farmers at western zone of Tigray region farmers used broody hens for incubation but not artificial incubator [20]. Farmers seem to have good practices of using egg-setting materials, which aimed at providing comfortable incubation environmental conditions for broody hens in the study area. The survey revealed that the proportions of farmers who used different egg setting materials were significantly different among the districts of the study area ($p<0.05$). Overall, the respondents replied that they used either of Clay pots (18.2%), Ground (8.2%), Plastic can (19.5%), Bamboo cages (25.7%), Cartons (20.6) and Wooden crates (7.8) (Table1). This result is in agreement with Tadelle *et al*. [1] who reported that clay pots, bamboo baskets, cartons or even simply a shallow depression in the ground are common materials and locations used as egg setting sites, and crop residues of Tef, wheat and barley straws were used as bedding materials in five different agro-ecological zones of Ethiopia. Earlier, Girish Kumar, P., & Richard Churchil, R. [21] reported that rubber baskets and steel pans commonly used in civil construction, plastic cans of 10 litre capacity with one side cut out, the bases of earthen pots, wooden crates (tomato boxes), and spathes of areca nut palm. Among these, plastic cans (23.81% in Kannur and 20.93% in Kozhikode), rubber baskets (28.57% in Kannur and 11.63% in Kozhikode), and steel pans (19.05% in Kannur and 11.63% in Kozhikode) were the most commonly used materials for nest boxes in natural egg incubation [21].

Similarly, Kumar et al. [22] reported similar nest box materials for incubating eggs in the same study area, including plastic cans (21.9%), rubber baskets (17.2%), and steel mortar pans (14.1%) commonly used in construction, broken earthen pots (12.5%), vegetable wooden crates (9.4%), and baskets made from the spathe of areca palm (1.6%). Kumar and Kumar [23] reported that people in Uttarakhand in India use basket from locally available material as nest box for

incubating the eggs. The use of bamboo baskets for this purpose has also been reported earlier in India [24, 25] and in other countries [26].

Straw was the most commonly used nesting material in Demba gofa district , Melo koza districts and Sawula town (35.3%, 33%, 33.3%, respectively), followed by paddy husk (16.5%, 38.3% and 16.8%) and Clothes (18.8%, 16% and 34.7%); while other materials such as sand, saw dust and coffee husks were less common. Earlier, Kumar et al. [22] also reported that sand (51.6%), paddy husk (15.6%), and straw (12.5%) as the most commonly used nesting materials for incubating eggs in the same study area. In a similar study from Bangladesh, Zalal et al. [27] reported that 13.3% of farmers used ash as nesting material, while 20, 10, 9, and 50.7% used straw, cloth, leaves, and mixed materials, respectively. A small proportion of farmers (4.76% in Kannur and 18.60% in Kozhikode) did not use any nesting material, instead allowing hens to incubate eggs directly on the floor. As reported by Vijh et al. [24], in indigenous Miri birds, paddy straw bedding was provided; whereas, in Zimbabwe it was grass [28] and in Bangladesh it was wood shavings or paddy straw [26].

Table 2 Incubation, nest box and nesting materials

Variable	**Location**				**X^2 –test**	**p-value**
	Demba Gofa n (%)	Melo Koza n (%)	Sawula Town n (%)	Total n (%)		
Incubation of eggs					0.00(ns)	1.00
Broody hen	85(100)	94(100)	78(100)	257 (100)		
Nest box commonly used					47.36(*)	0.00
Clay pots	11(12.9)	28(29.7)	8(18.4)	47(18.2)		
Ground	5(5.88)	14(14.9)	2(1.7)	21(8.2)		
Plastic Can	17(20)	7(7.5)	26(3.4)	50 (19.5)		
Bamboo cages	23(27.12)	28(29.7)	15(62.6)	66(25.7)		
Cartoon	21(24.7)	5(5.4)	27(13.9)	53(20.6)		
Wooden crates	8(9.4)	12(12.8)	0 (0)	20(7.8)		
Nesting material commonly used					36.44(*)	0.00
No nesting material	0	0	0	0		
Sand	2 (2.3)	0(0)	0(0)	2(0.8)		
Straw	30(35.3)	31(33)	26(33.3)	87(33.7)		
Paddy husk	14(16.5)	36(38.3)	13(16.8)	63 (24.6)		
Clothes	16(18.8)	15(16)	27(34.7)	58(22.7)		
Saw dust	2(2.3)	0(0)	4(5)	6(2.3)		
Coffee husks	21(24.7)	12(12.7)	8(10.2)	41(15.9)		

3.2. Egg selection, Hatchability and Survival Rate of Chicks

As depicted in Table 3 in the study area the average number of eggs set for incubation per broody hen were 11.3 eggs for locals and 7.6 eggs for cross/exotic breeds with hatchability of local and cross breed eggs was 82.5% and 72.5% in Demba gofa, 82.5% and 72.5% in Melo koza and 88.9% and 85.5% in sawula town. This might be attributed to the high temperature in Demba gofa and sawula town that may affect the quality of the eggs and in addition broody hens would be restless during high temperature. This is in line with the reported 82.6% hatchability for local eggs in Bure wereda [29], in addition, 90% of egg hatchability in Eastern Uganda [30] and 83.6% hatchability in Tanzania was reported [31]

but higher than the reported 70.5% hatching rate [1] and 78.6 % hatchability of local eggs [32] for Northern Ethiopia, 61.8% hatchability in Botswana [33] and the hatchability ranged 77% to 81% in Kashmir [34].

The result also showed that 91.4% of the respondents had practices of selection of eggs before incubation while the remaining 8.6% of them did not practice egg selection at all in the study area (Table 2). The proportions of households who had practiced or had not practiced selection eggs for incubation were non significantly different among the districts. Generally, farmers selected eggs based on either of egg age (84.5%), egg type (9.7%), egg size (5.8%). In Fogera district, Bogale [35] reported that 84.7% of the farmers selected large eggs followed by medium eggs (9.7%) and small sized eggs (1.4%) for incubation. Addisu *et al* [18] also recently reported that 88.24% of the village chicken owners of North Wollo zone had a practice of egg selection based on egg size and blood content. Season /month of egg laying was used as selection criteria for eggs selection. Overall, farmers reported that eggs for hatching were stored until the time when the hen gets broody and ready to incubate but successful hatchability of eggs can be attained if they use eggs stored not more than a week. In Nigeria, eggs kept at high temperature of 40^{o}c deteriorated in quality very fast and were not fit for consumption after two weeks of storage, and in hot climate, where ambient temperature can reach 40- 45^{o}c; eggs should not be stored at room temperature for more than one week before consumption [36]. Moreover, reducing temperature marginally improved hatchability or egg viability in eggs stored for 9 to 11 days [37].

Table 3 Egg selection criteria, hatchability and survival of chicks

Variable	**Location**				**X^2 –test**	**p-value**
	Demba Gofa n (%)	Melo Koza n (%)	Sawula Town n (%)	Total n (%)		
Do you select eggs at time of /before incubation?					0.00(ns)	1.00
Yes	76(89.4)	88(93.6)	71(91)	235(91.4)		
No	9(10.6)	6(6.4)	7(9)	22(8.6)		
Eggs selection criteria					0.00(ns)	1.00
Egg age	71(83.5)	82(87.2)	64(82)	217(84.5)		
Egg type	10(11.8)	7(7.5)	8(10.2)	25(9.7)		
Egg size	4(4.7)	5(5.3)	6(7.8)	15(5.8)		
Egg storage for incubation					0.00(ns)	1.00
<1 week	81(95.3)	87(92.6)	68(87.2)	236(91.8)		
>1 week	4(4.7)	7(7.4)	10(12.8)	21(8.2)		
Average number eggs set for incubation					0.9706	0.0017
Local	11	10	13	-		
Cross/Exotic	7	8	8	-		
Hatchability						
Local	86	89	84	86.3	37.74	<0.0001
Cross/Exotic	74	80	69	74.3	21.06	0.0002
Survival of chicks to 8 weeks of age						
Local	68	65	67	66.7	8.39	0.0172
Cross/Exotic	61	63	66	63.3	10.06	0.0071

3.3. Egg storage, egg source and egg treatment

The source of eggs to be incubated and egg selection practices of farmers are presented in Table 4. As the result indicates, the households responded that their sources of eggs for incubation were either home laid eggs (86%), purchased from neighbors (8.2%) or purchased from market (5.8%) in the study area. This result is in line with that of Meseret [17] who reported that home laid eggs (80.6%), purchased from market and home laid eggs (13.9%) and purchased from market, eighbors and home laid eggs (5.6) were the major sources of eggs for incubation in Gomma wereda of Jimma zone. Matiwos *et al* [38] also reported similar findings in which lay at home (65.1%) and both lay at lay and purchase (34.9%) were used as sources of incubated eggs in Nole Kabba wereda of Western Wollega of Ethiopia. Also the study by Mekonnen [39], who reported that 98.13% of the respondents incubate eggs laid at home. During the survey period respondents explained that most of the farmers rear cocks with their hens before incubation or they take a hen assumed to hatch eggs to neighbor for mating with cock. This will be done just before the hen start laying incubating eggs.

The current study was in line with Most of the respondents in all studied areas (34.6%) from Farmers practiced to store eggs inside clay pot with the perception of improving the shelf lives of eggs in the study area (Table 3). Eggs are usually stored inside bins or other containers containing grains. This result is in line with Tadelle *et al* [1] who reported that household stored eggs inside grains especially Tef (*Eragrostis tef)* mainly practiced and believed to increase egg shelf lives in five different agro-ecological zones of Ethiopia.

The survey revealed that there were significant variations with respect to the proportions of respondents who practiced or did not practice any special treatment of eggs. Overall, it was indicated that the respondents treated eggs with either of wash with cold water (2.7%), wash with warm water (11.7%) or clean eggs with clothes or other materials (28.4%) but most of the farmers do not treat (57.2'%). It is a good practice of incubating clean eggs but great emphasis should be taken towards keeping eggs not become wet during cleaning which ultimately create favorable conditions for microorganisms to enter and multiply inside the eggs and causing spoilage [40].

Table 4 Egg storage, egg source and egg treatment practices

Variable	**Location**				**X^2 -test**	**p-value**
	Demba Gofa n(%)	Melo koza n(%)	Sawula Town n(%)	Total n(%)		
Egg storage materials before incubation					7.856(*)	0.014
Clay pot	34(40)	39(41.5)	16(20.5)	89(34.6)		
Cartoon	9(10.6)	15(16)	30(38.5)	54(21)		
Bamboo basket	26(30.6)	36(38.3)	18(23)	80(31.1)		
Gerry cane	4(4.7)	2(2.1)	10(12.8)	16(6.3)		
Inside grain	12(14.1)	2 (2.1)	4(5.2)	18(7)		
Practice special treatment of eggs before incubation					31.25(*)	0.00
Yes	68(80)	72(76.6)	47(60.3)	187(72.7)		
No	17(20)	22(23.4)	31(39.7)	70(27.3)		
How do you treat eggs?					19.65(*)	0.00
Wash with cold water	0(0)	6(6.4))	1(1.3)	7(2.7)		
Wash with warm water	0(0)	23(24.5)	7(9)	30(11.7)		
Cleaning with clothes or other materials	5(5.9)	44(46.8)	24(30.7)	73(28.4)		
No treatment	80(94.1)	21(22.3)	46(59)	147(57.2)		
Sources of eggs for incubation					21.25(*)	0.00

Laid at home	72(84.7)	85(90.4)	64(82)	221(86)		
Purchased from neighbors	9(10.6)	4(4.3)	8(10.3)	21(8.2)		
Purchased from market	4(4.7)	5(5.3)	6(7.7)	15(5.8)		

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

3.4. Broody hen selection

In the current study all respondents have a habit of selecting the best hen before incubation. It was indicated that, some farmers select a hen with a bigger size due to an assumption that the bigger hens are able to incubate and hatch many eggs than smaller ones. This finding was in agreement with the report of FAO [40] where maximum of 14 to 16 eggs were brooded in one nest, but hatchability often declines with more than ten eggs, depending on the size of the hen. At all study areas with no significant difference, farmers select breeding hen depending on ample plumage, body weight, production, broody behavior and mothering ability, also combination of two or more criteria mentioned above. This report was consistent with that of Nigussie [41] who indicated that farmers select breeding hen based on plumage color, body weight, reproductive performances and mothering ability.

Similarly, A study conducted in Fogera district disclosed that 66.7% and 19.4% of local chicken owners selected large and medium sized hens for incubation, respectively [35]. This result is also in parallel with the findings of Meseret [17] which revealed that farmers selected hens for incubation based on either of large body size (21.1%), ample plumage /feather cover (3.3%), previous hatching history (6.7%), broodiness (19.4%) or large body size, ample plumage and previous hatching history (49%) in Gomma wereda of Jimma zone. Besides, the result of a survey conducted in North Wollo zone disclosed that 88.24% of village chicken owners had a practice of broody hen selection based on body size (26.84%) and broodiness ability history (73.16%) [18].

Table 5 Broody hen selection

Variable	**Location**				**X^2-test**	**p-value**
	Demba gofa n(%)	Melo koza n(%)	Sawula Town n(%)	Total n(%)		
Broody hen selection criteria					9.32(*)	0.007
Plumage	5(5.9)	6(6.4)	9(11.5)	20(7.8)		
Body weight	10(11.7)	8(8.5)	2(2.6)	20(7.8)		
Egg yield (production)	7(8.2)	5(5.3)	-	12(4.7)		
Broody behavior	32(37.7)	46(49)	35(44.9)	113(43.9)		
Mothering ability	31(36.5)	29(30.8)	32(41)	92(35.8)		
Preference of mothering ability characteristics					7.85(**)	0.009
Good hatching history	28(32.9)	38(40.4)	22(28.2)	88(34.2)		
Good protector from predators/ aggressive weaning	31(36.5)	39(41.5)	29(37.2)	99(38.5)		
Good feeder & hatching history	26(30.6)	17(20)	27(34.6)	70(27.3)		

3.5. Incubation and Hatchability Failure

Incubation practice and causes of hatchability failure are presented in Table 6. There is no significant difference between the study areas on season of incubation of chickens. Most of the respondents (90.3%) incubate their chickens during dry season (Oct. – Dec). Regarding the hatchability of chicks 90.3% of the respondents said that they achieve best hatchability during dry season. The respondents replied that they did not incubate eggs throughout the year and every season in the study area because of fluctuation of environmental conditions. The result indicated that there were significant variations in line with seasons of egg incubation across the districts (Table 5). Higher proportions of local chicken owners incubated eggs from Oct. – Dec. but none of the respondents have incubated eggs during July – Sep.

Because of poor survivability of young chicks due to heavy rains, extreme colds an disease outbreak and prevalence of predators in Spring.

Halima [42] reported that 95.6% respondent look for season to incubate their chicken. The present study was in agreement with the study by Meseret [17], where respondents chose the time between October and January as the best season to get better hatchability. Ermias (2015)[43] also reported that farmers do not incubate eggs during rainy seasons due to the reason that incubated eggs do not get enough warmth from broody hen and eggs would rot and chicks die due to cold stress. In the study by Ermias [43] respondents indicated that the sound of thunder storm cause eggs to rot and chicks will die due to the fear of thunder storm. The result indicated that, 55.1% of the respondents believed that the handling problem was main reason for failure of hatchability. Another 28.5% of the respondents said that the problem of brooding hen was main issue for the failure of hatchability. The rest of the respondents (16.4%) did not know the reason to failure in hatchability. King'or [44] reported on the review that size, age and management of broody hens, and also storage condition of incubating eggs affect the hatchability of eggs

Table 6 Incubation Practices and Causes of Hatchability Failure

Variable	**Location**				**X2 -test**	**p-value**
	Demba Gofa n(%)	Melo koza n(%)	Sawula town n (%)	Total n (%)		
When do you usually incubate eggs?					32.14(*)	0.001
July – Sep.	-	-	-	-		
Oct. – Dec.	81(95.3)	79(84)	72(92.3)	232(90.3)		
Jan. - -Mar.	4(4.7)	10(10.6)	4(5.1)	18(7)		
Apr. – Jun.	0(0)	5(5.4)	2(2.6)	7(2.7)		
Is there seasonal variability on hatchability?					0.0(ns)	0.000
Yes	85(100)	94(100)	78(100	257(100)		
No		-	-	-		
When do you achieve the best hatchability?					11.785(*)	0.001
July – Sep.		-	-	-		
Oct. – Dec.	81(95.3)	79(84)	72(92.3)	232(90.3)		
Jan. - -Mar.	4(4.7)	10(10.6)	4(5.1)	18(7)		
Apr. – Jun.	0(0)	5(5.4)	2(2.6)	7(2.7)		
Major causes of failure of hatching					0.00(ns)	0.00
Lack of proper laying nest	19(22.4)	31(33)	23(29.5)	73(28.4)		
Temperature	56(65.9)	50(53.2)	46 (59)	152(59.1)		
Post handling	10(11.7)	13(13.8)	9(11.5)	32(12.5)		

Furthermore, the survey indicated that all respondents (100%) also replied that there was seasonal variability on the hatchability of eggs (Table 4). It was also found that seasons (months) of both best and worst hatchability achievements were significantly different across agro-ecological zones of the study area ($p<0.05$). The optimum incubation temperature of 37.8^{o}c is the thermal homeostasis in the chick embryo and gives the best embryo development and hatchability [44]. Best hatchability of chickens mainly attained from Oct. – Dec. (84.9%) followed by Apr. – Jun. (8.8%). In a study conducted in Fogera district, 81.9% and 26.4% of the households replied that the preferred season of incubation was dry and rainy season, respectively [35]. The result showed that the respondents confirmed that lack of

proper laying nest (42.4%), temperature (48.7%), post handling (8.9%) were the major factors that cause failure of hatchability of chickens in the study area (Table 5).

3.6. On farm evaluation of novel brood nest

The total number of eggs incubated using a novel nest was 12 eggs. In indigenous chicken, the average clutch size and the number of eggs set per hen have been reported 15 eggs [45] and 14 eggs [46], respectively. The number of eggs set for incubation purpose was reported to 12.46 in Ethiopia [47]. A comparatively high number of chicks were hatched during the second phase (9-12) from the number of eggs set. This study was in agreement with previous works of Asefa [48] at Awassa Zuria who reported setting of 9.8 egg.

The egg hatchability by the broody hens was 41.6%, 80.6%, 50% and 58.3% at Demba gofa for T1, T2, T3 and T4 respectively. Which seems to be similar to various studies conducted in Bangladesh (Sarkar, 2022). Even the hatchability by broody hens was found higher when compared with an electric and rice husk incubator [54]. The hatching efficiency of a broody hen might be compared with the commercial egg incubator. Broody chicken has enough experience to manage ideal humidity and temperature levels by themselves and might be acknowledged as natural egg incubator [49].

The body weight of the hen decreased significantly after egg incubation. Probably, this phenomenon is common in hens raised under traditional management with an average loss of 35% of initial body weight during egg incubation and gained it back at an average rate of 5 g each day [45]. The loss of body weight might be due to decreases feed consumption during the incubation period, the loss of broody weight is also associated with the number of eggs set for hatching purposes [46].

To minimize the loss of body weight, balanced ration and safe drinking water is needed during the incubation process. When the hens had no chicks to raise, the intake after incubation was higher. We investigated the survivability (%) of the chicks after hatching found of 98%. The chick's viability depends on several factors, such as management, diseases, and predators. Chick viability for newly hatched chicks after one week was reported to be 50.7% in Ethiopia [50]. According to the research findings of [46], the average survivability was 43.1% up to the age of 10–12 weeks. In Bangladesh, major rural poultry farmers do not vaccinate their chicks. The major reasons of chick mortality was reported due to outbreak of diseases and attack of predators [51]. The chick separated from the mother hen was almost 2 months (52.3 days). The average number of days of chick separation was reported as two months in Bangladesh [46].

Table 7 Results from Demba gofa district

Data collected	**Demba Gofa**											
	Replication 1				Replication 1				Replication 1			
	T1	T2	T3	T4	T1	T2	T3	T4	T1	T2	T3	T4
Number of egg set	12	12	12	12	12	12	12	12	12	12	12	12
Ave. egg weight during setting (in gm)	47	49	48	47	46	46	49	46	47	45	45	48
Initial weight of hen (in Kg)	1.31	1.29	1.07	1.11	1.23	1.18	1.15	1.23	1.11	1.25	1.21	1.33
Number of egg broken at incubation	4	1	2	0	2	2	0	1	3	0	2	0
Number of eggs culled during candling	2	2	3	5	2	1	4	4	1	0	3	1
Embryonic mortality	2	0	1	3	2	1	2	1	3	0	1	0
Chick hatched	4	9	6	4	6	8	6	6	5	12	6	11
Hatchability percentage	33.3	75	50	33.3	50	66.7	50	50	41.7	100	50	91.7
Ave. weight of chicks	37.5	39.1	39	39.2	38.1	38.6	37.9	39	36.9	38.1	39	37
Chicks dead after hatched	0	0	0	0	1	0	0	0	2	0	2	1
Ave. Weight of hen after hatching	1.15	1.09	0.95	1.12	0.97	0.91	0.98	1.16	1.01	1.02	0.99	1.12

Table 8 Results from Melo Koza district

Data collected	**Melo koza**											
	Replication 1				Replication 1				Replication 1			
	T1	T2	T3	T4	T1	T2	T3	T4	T1	T2	T3	T4
Number of egg set	12	12	12	12	12	12	12	12	12	12	12	12
Ave. egg weight during setting (in gm)	45	45	47	46	42	45	45.5	43	49	46	47.4	46.9
Initial weight of hen (in Kg)	1.28	1.31	1.30	1.41	1.31	1.24	1.09	1.22	1.25	1.31	1.29	1.26
Number of egg broken at incubation	0	2	3	1	3	0	2	0	2	0	3	2
Number of eggs culled during candling	4	0	4	3	0	1	1	3	2	1	4	3
Embryonic mortality	1	0	0	2	4	1	2	4	3	0	1	0
Chick hatched	7	10	5	6	5	10	7	5	7	11	4	7
Hatchability percentage	58.3	83.3	41.7	50	41.7	83.3	58.3	41.7	58.3	91.7	33.3	58.3
Ave. weight of chicks	34	36.3	39	38.7	36.2	37.1	38	38.8	42.1	42	43.5	41.7
Chicks dead after hatched	1	0	2	2	3	1	2	0	0	0	1	1
Ave. Weight of hen after hatching	1.01	1.18	1.15	1.23	1.11	1.05	0.97	1.08	1.11	1.25	1.03	0.98

Table 9 Results from Sawula Town administration

Data collected	**Sawula Town**											
	Replication 1				Replication 1				Replication 1			
	T1	T2	T3	T4	T1	T2	T3	T4	T1	T2	T3	T4
Number of egg set	12	12	12	12	12	12	12	12	12	12	12	12
Ave. egg weight during setting (in gm)	41	43.1	43.5	43	43.4	44	44.8	40	44.2	43.8	42.8	44.3
Initial weight of hen (in Kg)	1.38	1.33	1.35	1.39	1.26	1.28	1.11	1.24	1.19	1.22	1.17	1.23
Number of egg broken at incubation	2	1	2	0	0	0	1	0	3	1	2	0
Number of eggs culled during candling	0	0	3	4	5	0	0	3	0	0	0	4
Embryonic mortality	4	1	1	3	4	0	4	0	4	0	4	4
Chick hatched	6	10	6	5	3	12	7	9	5	11	6	4
Hatchability percentage	50	83.3	50	41.7	25	100	58.3	75	41.7	91.7	50	33.3
Ave. weight of chicks	36.1	36.8	37.9	36.7	38.7	38.2	31.4	37.2	39.6	38.5	39.0	40.3
Chicks dead after hatched	1	1	1	3	0	0	0	0	1	0	0	1
Ave. Weight of hen after hatching	1.20	1.15	1.22	1.29	1.14	1.11	0.96	1.11	0.97	1.01	0.99	1.09

The farmers do not have enough knowledge about egg candling and they usually do not practice the egg candling. Most of the respondents chose the spring season for incubation purposes due to availability of feed and high chick survivability. Though high hatchability was found during the winter season [52], the farmers had a preference to incubate eggs during the spring season due to the availability of feed and high chick survivability [53].

4. Conclusion

The farmers traditionally practice egg incubation by broody hens over years. While the capacity of broody hens to incubate a large quantity of eggs is limited, they can still be recognized as a natural incubator with high efficiency and effectiveness in hatching eggs. To enhance the yearly egg yield or the number of broody cycles, poultry specialists should provide training to farmers. Implementing a balanced diet, effective management practices, and creep feeding for chicks could boost overall poultry production in rural regions.

In the study location, broody hens were the only way to incubate eggs and brood chicks. The selection criteria for broody hens included plumage color, egg output, body weight (size), and mothering abilities. The primary factor used by farmers (91.4%) to choose eggs for incubation was egg age. The most common source of incubation eggs in the research area was eggs laid at home. In order to have clean eggs for incubation, farmers practiced washing eggs in both cold and warm water and cleaning them with clothing or other items beforehand. Local chicken farmers prepared bedding and egg settings in an effort to create a cozy incubation environment. Egg setting items included clay pots, plastic, bamboo cages, and cartons; bedding supplies included grasses, straws, cotton seeds, broody hen feathers, and clothing. The months of July through September were the worst for egg incubation and hatchability due to high temperatures, the prevalence of diseases and predators, and a lack of feed for scavenging. In contrast, October through December were the most preferred months of the year for broody hens to incubate eggs and achieve the best hatchability of eggs. Egg hatchability failure in the research area was primarily caused by environmental temperature, improper laying nest, and post handling. The majority of responders were able to determine an egg's fertility before it was incubated.

Twelve eggs in all were incubated utilizing a novel brooder nest. From the amount of eggs set, a relatively large number of chicks hatched at treatment 2 in all study areas (9–12). In order to boost their financial returns, chicken producers must be trained in improving hatchability performances through the preparation of appropriate brooding or laying nests, egg selection, feeding, housing, health care, proper post handling storage, egg setting, and bedding materials. To enhance the genetic potential through selective breeding and the preservation of native chicken genetic resources, community-based holistic improvement programs are also crucial. Further research on hatchability performance evaluation of the indigenous chickens in both on farm and station as well as effect of the twelve months of the year on incubation and hatchability of eggs.

Compliance with ethical standards

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Disclosure of conflict of interest

There are no conflicts of interest in this research.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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