Effects of collection zones and storage on hatchability and survival of feral helmeted guineafowl (*Numida meleagris galleata* pallas) eggs

Yusuf, A. A.,[3] **Jayeola, O. A.,**[1] **Osunsina, I. O. O.,**[1] and **Dedeke, G. A.**[2]
[1]Department of Forestry and Wildlife Management, Federal University of Agriculture, Abeokuta
[2]Department of Biological Sciences, Federal University of Agriculture, Abeokuta
[3]Department of Forestry and Wildlife Management, Bayero University, Kano
*Corresponding author: yabiodun33@yahoo.com

Abstract

The desire to shore up the shortfall in protein supply, the increased awareness of the importance of cholesterol free animal protein, like guineafowl, and the need to conserve their wild genes, have necessitated studies on improved captive breeding of feral helmeted guineafowl. Hence, this study was aimed at determining the effects of ecological zones and storage systems on the guineafowl eggs. Guineafowl eggs (n=214), were collected from identified and monitored-nests within the Kainji Lake National Park (KLNP) and Old Oyo National Park (OONP). Out of 91 eggs collected from KLNP, 32 and 38 were stored at room temperature (RT-21-25°C) and refrigerator (RF-17-20°C), respectively for five days prior to incubation while 21 eggs were not stored (NS-27-29°C), and out of 123 collected from OONP, 70 and 19 were stored for five days prior to incubation at (RT-21-25°C) and (RF-17-20°C), respectively while 34 eggs were (NS- 27-29°C). Prior to incubation, eggs were weighed, the height and width were measured. The process was repeated after incubation for unhatched eggs. Candling was done three days before hatching at day 29 of egg incubation. Embryo status of unhatched eggs was determined by cracking the eggs. Descriptive and inferential statistics were used to analyse the data. The NS eggs from Kainji (7.60%) and Oyo (2.01%) had the lowest percentage shrinkage in weight across the three storage systems. The order was reversed in height with RF eggs from Kainji (0.96%) and Oyo (0.46%) having lowest. The least shrinkage in width of eggs from Oyo was recorded in the RF eggs (0.00%) and in NS (0.59%) from Kainji. Eggs candling showed that presumed fertile (opaque) was highest (69.10%) in NS eggs followed by RT (45.00%). There was no significant difference (p>0.05) between the hatchability of eggs from the two parks though hatchability (7.60%) of Kainji eggs was higher than those of Oyo (7.40%). Further check on fertilization after incubation showed that RT (37.50%) eggs from Kainji were fertilized but were unable to hatch alive so also was RF eggs (21.10%). The study showed that the eggs sizes vary with ecozones while size of the eggs and storage systems affects hatchability and survival of feral helmeted guineafowl eggs in captivity.

Keywords: Guineafowl; ecozones; storage systems; incubation; candling; hatchability.

Accepted: 23 December, 2020.

Introduction

Losses from guineafowl production commonly arise from infertile eggs, poor egg handling, and incorrect storage and incubator settings (temperature, relative humidity and air flow). Despite guineafowl lay large quantities of eggs, it has been found that the average numbers of keets that are found with the mother hens are far less than expectation (Jayeola *et al* 2007).

Eggs fertility, hatchability and survival of the keets depend on environmental factors, and incubation system as well as internal and external characteristics of the eggs. It was reported by Saina *et al* (2005) that the external quality of the egg is determined by features such as the size and shape of the egg as well as the structure, thickness and strength of the shell. The internal quality is measured on the basis of the quality of the albumen as indicated by the Haugh unit (HU), the relative size of the various internal components and the integrity of the shell membrane.

Incubation periods vary for different species of birds, the larger the egg the longer the incubation period. However, there are individual differences which depend on physiological factors. In artificial incubation, the period can also vary with temperature and humidity within the incubator. Temperature is extremely important during incubation. Variations of more than one degree from the optimum will adversely affect the number of eggs that will successfully hatch (Saina *et al* 2005).

Moreover, eggs lose water during the incubation period, and the rate of loss depends on the relative humidity maintained within the hatching chamber. Metabolic balance

http://dx.doi.org/10.4314/tzool.v18i1.13
© *The Zoologist, 18:* 74-81 December 2020, ISSN 1596 972X.
Zoological Society of Nigeria

must be maintained throughout the incubation period. Thus, humidity outside a relatively narrow range will affect the number of successfully hatched eggs (Saina *et al* 2005). Many factors can affect hatchability, especially egg size and age of breeders, season of the year and nutrition, egg handling and storage, temperature and humidity throughout the incubation and hatching period (Wilson, 1997). Under normal circumstances, a fertile egg contains all the nutrients necessary for the development of the embryo to hatching. However, there are certain physical and chemical conditions of the egg that may lower or cause no hatchability at all. The physical characteristics of the egg play important role in the processes of embryo development and successful hatching (Narushine and Romanov, 2002). The most influential egg parameters are weight, shell thickness and porosity, shape index and the consistency of the content.

The most important problems in the production of guineafowls in Nigeria include low hatchability, high mortality up to 8 weeks of age, lack of reliable advice on veterinary complications, and a shortage of source of hatching eggs and young stock. In addition to early mortality which may be as high as 60% they are characteristically timid, but very active, their flighty and noisy temperament probably contributes to poor feed conversion efficiency through high energy output and feed wastage (Nwagu and Alawa, 1995). Although, monogamous in the wild (Nwagu and Alawa, 1995), a male to female ratio of 1 to 4 can give good fertility. Egg production is confined to the rainy season from April to October (Nwagu and Alawa, 1995). An evaluation of production zone environment and storage period impacts on egg size, hatchability and survival of guineafowl will contribute to the present knowledge about production, domestication and conservation of the bird in captivity. Therefore, it is necessary to unveil factors affecting hatchability and survival of the bird.

Methodology

Materials and methods

The eggs were collected in Kainji Lake (Figure 1) and Old Oyo (Figure 2) National Parks and were incubated at the FUNAAB/AP Leventis Commercial Hatchery, Abeokuta, while the keets were raised at the Federal University of Agriculture Abeokuta Wildlife Domestication unit.

Guineafowl eggs were collected from identified and monitored nests within the Kainji Lake National Park (KLNP) and Old Oyo National Park (OONP). Nesting points of guineafowls within the ranges of Kainji Lake and Old Oyo National Parks were identified and tagged for monitoring. Egg laying pattern of the birds were observed without disturbing their natural habitat. Eggs laid per day were counted and the rate of increase noted. Ten and eight nesting points identified in Old Oyo and Kainji Lake National Parks, respectively were tagged. After three weeks of monitoring the laying pattern in each National Park, 50% of the total eggs laid (n=214 eggs) were carefully collected from the nests. The eggs from each park were randomly divided into three treatments through the use of random numbers. Eggs (n=123) were collected from ten nests in Old Oyo National Park while 91 eggs were collected from the eight nests in Kainji Lake National Park. Each egg was weighed with standard electronic scale (Mettler Toledo Model BD 6000) to determine the weight while egg height and width were also measured with Mituyoyo (Japan) Vernier calliper before and after incubation.

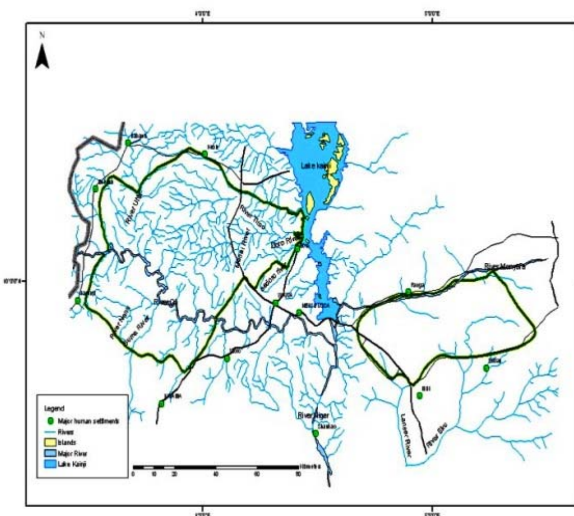

Figure 1: Map of Kainji Lake National Park.
Source: Kainji Lake National Park Management Plan.

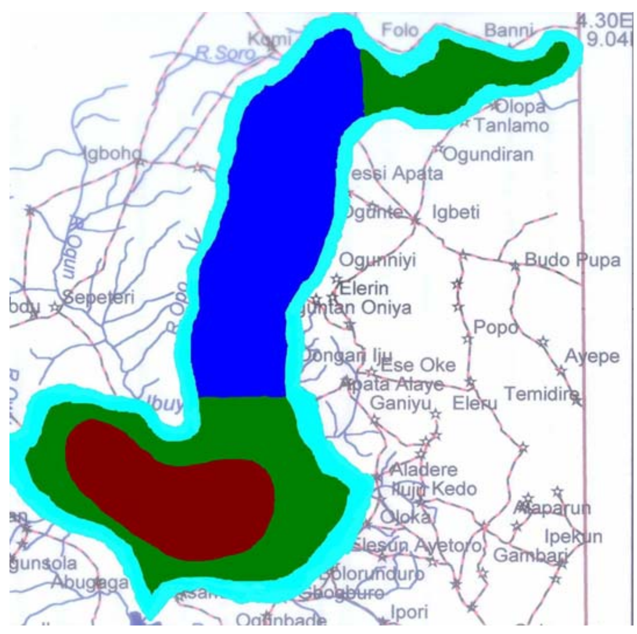

Figure 2: Map of Old Oyo National Park.
Source: Old Oyo National Park Management Plan.

The eggs from OONP were randomly allocated as follows: 34 eggs were not stored (NS-27-29°C) prior to incubation, 70 eggs were stored for 5 days prior to incubation at room temperature (RT-21-25°C) and 19 eggs were stored for five days in the refrigerator (RF-17-20°C) prior to incubation. Those from KLNP were also distributed into the three treatments as follows: 21 eggs were not stored (NS-27-29°C) prior to incubation, 32 eggs were stored at room temperature (RT- 21-25°C) for five days prior to incubation and 38 eggs were stored for five days in the refrigerator (RF-17-20°C) prior to incubation.

The eggs were set and incubated using Petersime (P 1750-Belgium) incubator machine to hatch on day 29 at 20^{0}C with relative humidity of 75% as described (Galor, 1985; Belshaw, 1985; Binali and Kanengoni, 1998). Two eggs exploded during incubation among eggs collected from OONP stored at room temperature. Candling was done on days 10, 15 and 20 of the incubation and unhatched eggs were cracked and broken in order to ascertain the embryo development level. The weight, height and width of eggs from both Parks were recorded before and after incubation.

Parametres measured

The following measurements were taken and recorded before and after incubations:

Mean Weight of Eggs Set (g) = Total sum of weights ÷ Number of eggs set.
Mean Height of Eggs Set (cm) = Total sum of height ÷ Number of eggs set.
Mean Width of Eggs Sets (cm) = Total sum of width ÷ Number of eggs set.

The fertile eggs were the sum of the eggs whose embryos were seen to have been fertilized during candling by displaying an opaque rather than transparent feature through visual observation of the eggs.
Percentage fertility was calculated thus;
% fertility = (Number of fertile eggs ÷ Number of the eggs set) x 100.

Definition of terms

Egg shrinkage is gradual reduction in egg morphometry (weight, height and width). This occurred when the initial egg parameters were higher than the final parameters. Mean shrinkage is the average shrinkage of the eggs. It was calculated with the formula:

Mean Shrinkage = Mean weight before setting – Mean weight after setting.
The Percentage Shrinkage was calculated thus:
% Shrinkage = Mean Shrinkage ÷ Mean weight before setting x100.

Egg hatchability

Hatchability is the number of keets successfully produced from the eggs incubated. The percentage hatchability was calculated as follows:
% Hatchability = Number of hatched eggs ÷ Number of eggs set x100

Embryo status

Embryo status of eggs entail visual examination of eggs that could not hatch after prescribed incubation periods. Some eggs could be fertilized because their embryos could not develop while some could not be fertilized or rottened with chocking smell.

Results

Changes in morphometry of eggs

There was gradual decrease in the sizes of eggs collected from Old Oyo National Park after incubation (Table 1a). Mean shrinkage was highest at weight level (6.66g, 17.81%) in eggs stored at room temperature (T^{0}C) for 5 days and lowest (0.77g, 2.01%) in eggs NS prior to incubation. At the height category, mean shrinkage was highest in eggs that were stored at room temperature (T^{0}C) (0.13cm, 3.04%) and least in those NS prior incubation (0.04cm, 0.93%). Likewise, mean shrinkage (0.02cm, 0.59%) occurred most, in stored eggs prior to incubation and least, in eggs that were not stored prior incubation at the width category. In all the storage systems, there were convincing proven shrinkage which varied with storage systems and morphometric of eggs from the ecozone. The mean and percentage shrinkage occurrence took place most significantly at weight level compared to height and width levels. It means morphometrics of the eggs in weight is very sensitive and vulnerable to shrinkage compared to height and width. In other words, shrinkage occurred intermittently at fastest rate in weight of morphometrics of eggs and then followed in height and width.

Moreso, significant reduction in eggs collected from Kainji Lake National Park was obviously noticed (Table 1b). At weight level, mean shrinkage occurred in morphometrics of eggs stored for 5 days at room temperature (T^{0}C) prior to incubation and it was highest (6.32g, 18.17%) but lowest (3.17g, 7.60%) in eggs that were not stored at all prior incubation. Conversely, mean shrinkage at height level was highest (1.03cm, 24.94%) for eggs that were not stored prior incubation and lowest (0.03cm, 0.96%) in eggs that were stored in refrigerator for 5 days prior incubation while mean shrinkage was also highest (0.06cm, 2.71%) at width level for eggs that were stored at room temperature (T^{0}C) prior incubation and no shrinkage (0.00cm, 0.00%) at width level for eggs that were stored in refrigerator prior incubation.

Like in Old Oyo National Park, Kainji Lake National Park had all highest shrinkages in morphometrics of eggs that were stored at room temperature (T^{0}C) for 5 days prior incubation but clearly difference when its lowest shrinkages occurred at eggs stored in refrigerator for 5 days prior incubation. It was also noticed that highest shrinkage (1.03cm, 24.94%) only occurred at height level of morphometrics of eggs stored at room temperature (T^{0}C).

In Table 2, eggs collected from Old Oyo National Park and Kainji Lake National Park had weight, height and width (34.27± 0.44, 4.23± 0.04 and 3.27± 0.03) and (31.73±0.36, 3.34±0.23 and 2.17±0.02) respectively for the stored eggs at room temperature and refrigerator which were lower

Table 1a: Changes observed in morphometrics of eggs stored at different storage systems before and after incubation from Old Oyo National Park (OONP).

Egg size	Weight	Height	Width
Treatments	Before After Diff.	Before After Diff.	Before After Diff.
Room (T^0C)	37.39, 30.73, 6.66(17.81)	4.27, 4.14, 0.13(3.04)	3.33, 3.19, 0.14(4.20)
Refrigerator (4^0C)	37.24, 32.93, 4.31(11.57)	4.32,4.30, 0.02(0.46)	3.33, 3.30, 0.03(0.90)
No Storage	38.38, 37.61, 0.77(2.01)	4.32, 4.28, 0.04(0.93)	3.38, 3.36, 0.02(0.59)

Diff.: changes in egg sizes before and after incubation (Figures in parentheses are percentage).

Table 1b: Changes observed in morphometrics of eggs stored at different storage systems before and after incubation from Kainji Lake National Park (KLNP).

Egg size	Weight	Height	Width
Treatments	Before After Diff.	Before After Diff.	Before After Diff.
Room (T^0C)	34.79, 28.47, 6.32(18.17)	4.13, 3.10, 1.03(24.94)	2.21, 2.15, 0.06(2.71)
Refrigerator(4^0C)	34.95, 28.68, 6.27(17.94)	3.13, 3.10, 0.03(0.96)	2.16, 2.16, 0.00(0.00)
No Storage	41.70, 38.53, 3.17(7.60)	4.40, 4.29, 0.11(2.50)	3.52, 3.45, 0.07(1.99)

Diff.: Differences in egg sizes before and after incubation. Figures in parentheses are percentage.

than overall morphometrics of the eggs (36.05±0.40, 4.08±.0.06 and 3.09±0.03). Meanwhile, overall morphometrics of the eggs (36.05±0.40, 4.08±.0.06 and 3.09±0.03) were lower compared to weight, height and width of the eggs collected from Old Oyo National Park (38.06±0.31, 4.4.0±0.01 and 3.37±0.02) and Kainji Lake National Park (40.43±1.20, 4.36±0.03 and 3.46±0.01) respectively for morphometrics of eggs that were not stored prior to incubation.

Table 3 shows that candling gave exact number of transparent and opaque eggs during candling for eggs that were stored before incubation and those eggs that were not stored before incubation. Eggs collected from Kainji Lake National Park had 15(16.4%) assumed fertile eggs at room temperature, 14(15.7%) in refrigerator and 15(16.4%) eggs at no storage system. Conversely at OONP, 30(24.7%) eggs were assumed fertile at room temperature, 11(9.1%) eggs at refrigerator and 23(19.0%) eggs at no storage systems.

There were more proportion of unfertile eggs at room temperature (31.4%) and no storage (9.09%), and fertile eggs at room temperature (24.79%) and no storage (19.00%) from Old Oyo National Park than those unfertile eggs (18.68%) at room temperature and no storage (6.59%) and fertile eggs at room temperature (16.48%) and no storage (16.48%) from Kainji Lake National Park. During incubation, 2 eggs exploded in the incubator from those eggs collected in Old Oyo National Park.

In Table 4, all eggs stored for 5 days before incubation at room temperature and refrigerator (157 eggs) did not hatched but some eggs (55 eggs) that were not stored before incubation hatched (16 eggs). Thirty-two and 38 eggs did not hatched from eggs stored at room temperature and in refrigerator from Kainji Lake eggs respectively while 68 and 19 eggs from Old Oyo eggs at room temperature and refrigerator did not hatched respectively. 14 and 25 eggs that were not stored did not hatched but 7 and 9 eggs from these sets hatched to keets from the Kanji Lake and Old Oyo respectively.

Embryo status of eggs that were not hatched was examined by breaking the eggs (Table 5). One hundred and ninety-six eggs were not hatched after incubation and were cracked according to the embryo status perceived with visual and olfactory sense. Seventy-one eggs were

Table 2: Mean weight, height and width of stored and unstored guineafowl eggs collected at different ecozones.

National park	Weight (g) (Mean ± SD)	Height (cm) (Mean ± SD)	Width (cm) (Mean ± SD)
Stored eggs			
Kainji Lake	31.73±0.36	3.34±0.23	2.17±0.02
Old Oyo	34.27±0.44	4.23±0.04	3.27±0.03
No storage			
Kainji Lake	40.43±1.20	4.36±0.03	3.46±0.01
Old Oyo	38.06±0.31	4.4.0±0.01	3.37±0.02
Overall	36.05±0.40	4.08±.0.06	3.09±0.03

Table 3: Candling examination of eggs from Kainji Lake and Old Oyo National Parks under different storage systems.

	Observable features						
	Room Temperature (T^0C)		Refrigerator		No storage		
Vegetation zones	Transparent	Opaque	Transparent	Opaque	Transparent	Opaque	Total
Kainji Lake National Park	17	15	24	14	6	15	**91**
Old Oyo National Park	38	30	8	11	11	23	**121**
Total	55	45	32	25	17	38	**212**
% Candling	25.7	21.0	14.9	11.7	7.9	17.8	**99.0**

Table 4: Hatchability of eggs collected under different storage systems from ecozones.

Vegetation zones	Kainji Lake National Park			Old Oyo National Park		
Storage system	Hatched	Not Hatched	Total	Hatched	Not Hatched	Total
Room (T^0C)	0	32	**32**	0	68	**68**
Refrigerator	0	38	**38**	0	19	**19**
No storage	7	14	**21**	9	25	**34**
Total	7	84	**91**	9	112	**121**
%	7.7	92.3	**100**	7.4	92.6	**100**

fertilized but their embryos were not developed, 94 eggs were not fertilized and 31 eggs were rotten. It was observed that 12 eggs at room temperature and 11 eggs each at refrigerator and eggs that were not stored, were fertilized but their embryos could not develop to hatch into keets from Kainji Lake National Park. All eggs that were not stored prior to incubation were not rotten but 9 and 2 eggs were rotten at room temperature and refrigerator respectively.

From Old Oyo National Park, it was observed that 17, 4 and 14 eggs that were stored at ambient temperature, refrigerator and eggs that were not stored respectively, were fertilized but their embryos did not develop to hatch into keets, There were no rotten eggs for those eggs that were not stored prior to incubation but 13 and 7 eggs stored at ambient temperature and refrigerator were rotten respectively.

In Table 6, effects of storage systems on egg sizes prior to incubation were significant ($p<0.05$) for eggs stored in refrigerator had height (3.52) and width (2.55) and after incubation had height (3.49) and width (2.54) which were also significant ($p<0.05$).

Meanwhile, effect of egg sizes was significant ($p<0.05$) at weight (38.83) and width (3.18) before incubation and only at weight (38.25) after incubation for eggs that were not stored before incubation. Also, there was no significant ($p>0.05$) for eggs stored at ambient temperature before and after incubation except at width (2.97) before incubation which was significant ($p<0.05$).

Effects of vegetation zones on egg morphometric (Table 7) was only significant ($p<0.05$) for eggs that were not stored prior to incubation within and between Old Oyo and Kainji Lake National Parks.

From Old Oyo National Park, weight (42.27), height (4.43) and width (3.49) before incubation were significant ($p<0.05$) within the vegetation zone while, weight (41.70) was also significant ($p<0.05$) in the vegetation zone after incubation and Kainji Lake National Park eggs had weight (37.29), height (3.80) and width (3.04) which were significant ($p<0.05$) before incubation and weight (36.72), height (3.72) and width (2.87) which were also significant ($p<0.05$) after incubation. It was confirmed that the morphometrics of eggs collected from Kainji Lake National Park were more significant than those eggs collected from Old Oyo National Park.

Effects of weight of keets hatched were not significant ($p>0.05$) on weight, height and width before incubation of eggs collected from Old Oyo and Kainji Lake National Parks (Table 8).

Table 5: Embryo status of unhatched feral helmeted guineafowl eggs after incubation.

National Park	Kainji Lake				Old Oyo			
Storage system	Room (T^0C)	Refrigerator	No Storage	Total	Room (T^0C)	Refrigerator	No Storage	Total
Fertilized not developed	12	11	11	34	17	4	16	37
Unfertilized	11	25	3	39	38	8	9	55
Rotten	9	2	0	11	13	7	0	20
Total	**32**	**38**	**14**	**84**	**68**	**19**	**25**	**112**

Table 6: Effects of storage systems on eggs sizes before and after incubation.

Eggs sizes	Room Temperature (T^0C)	Refrigerator (4^0C)	No Storage
Before incubation			
Weight (g)	36.57^{NS}	35.71^{NS}	38.83*
Height (cm)	3.92^{NS}	3.52*	3.99^{NS}
Width (cm)	2.97*	2.55*	3.18*
After incubation			
Weight (g)	30.01^{NS}	30.09^{NS}	38.25*
Height (cm)	3.81^{NS}	3.49*	3.89^{NS}
Width (cm	2.86^{NS}	2.54*	3.07^{NS}

NS: Not significant. *: Significant at 0.05 of probability.

Table 7: Effects of vegetation zones on eggs sizes in different storage systems.

Eggs sizes	Old Oyo National Park (OONP)			Kainji Lake National Park (KLNP)		
	Ambient	Refrigerator temperature	No storage	Ambient	Refrigerator temperature	No storage
Before incubation						
Weight (g)	37.38^{NS}	37.23^{NS}	42.27*	34.79^{NS}	34.94^{NS}	37.29*
Height (cm)	4.27^{NS}	4.31^{NS}	4.43*	3.14^{NS}	3.12^{NS}	3.80*
Width (cm)	3.32^{NS}	3.33^{NS}	3.49*	2.20^{NS}	2.16^{NS}	3.04*
After incubation						
Weight (g)	30.72^{NS}	32.92^{NS}	41.70*	28.47^{NS}	28.68^{NS}	36.72*
Height (cm)	4.14^{NS}	4.30^{NS}	4.29^{NS}	3.10^{NS}	3.09^{NS}	3.72*
Width (cm)	3.18^{NS}	3.30^{NS}	3.52^{NS}	2.15^{NS}	2.16^{NS}	2.87*

NS: Not significant. *: Significant at 0.05 of probability.

Table 8: Effect of egg morphometrics on weight of the keets hatched.

National Park	OONP			KLNP		
Model (Regression)	B	SDE	Significant	B	SDE	Significant
Keets hatched						
Weight (g)	61.73	26.10	0.06^{NS}	36.03	25.39	0.25^{NS}
Before Incubation						
Weight (g)	0.72	0.37	0.11^{NS}	0.45	0.65	0.54^{NS}
Height (cm)	-13.83	5.35	0.05^{NS}	-0.17	3.37	0.96^{NS}
Width (cm)	-2.19	7.13	0.77^{NS}	-7.47	6.44	0.33^{NS}

Note: B – Coefficient. SDE – Standard Error.

Discussion

Change in egg morphometrics varies from different ecozones and storage system of eggs before and after incubation. Eggs from KLNP, Kainji, reduced significantly more in morphometrics compared to eggs from OONP. This was due to ecozones differences and climatic factors which determine the nature of vegetation zones. Despite variation in storage system of eggs before incubation, reduction in eggs morphometrics were consistently higher in eggs from KLNP than OONP. Several studies have been shown by researchers that egg storage duration before incubation affects eggs quality and hatchability of chickens (Lapaˆo *et al* 1999; Tebesi *et al* 2002; Tona *et al* 2003; Tilki and Saatchi, 2004; Dudusola, 2009).

Shrinkage usually takes place at the weight or mass of the eggs of the guineafowl. It is also effective at the height and width. It simply meant that increase in size led to increase in the shrinkage in morphometrics of the eggs.

Moreover, on a rare occasion the situation may be reversed due to some ecozones and storage systems. Shape and size of eggs usually influence morphometric of eggs irrespective of storage or no storage system before and after incubation of eggs. Also, weight, height and width of guineafowl eggs, before and after incubation for stored eggs and eggs that were NS before incubation, varied with overall weight, height and width. Those eggs that were not stored before incubation were larger than stored eggs before incubation and reduction in mean weight, height and width were greater for stored eggs. Thus, it is advisable that the eggs should not be delayed after collection from the wild but should be set for incubation to improve desirable hatchability and reduction in shrinkage. Kouame *et al* (2019) testified that storage time is well known as an important factor affecting bird egg quality and consequently embryonic development, incubation duration, and post-hatch and hatchability.

In addition to these, eggs explosion at the setting of incubation period emergence was due to stress, handling and temperature at storage system. It showed that the internal and external stress within the albumen and yolk as well the egg shell had been exposed to handling and the temperature over certain period of time. It could also be fungi infections from the wild where the eggs were collected or inability of eggs to exchange enough carbon dioxide.

Candling examination revealed that fertile eggs were more appreciable for the eggs that were not stored prior incubation and were usually opaque due to embryos developmental stage while unfertile eggs were more from stored eggs prior incubation in either in refrigerator or at room temperature. The unfertile-eggs were often transparent and no embryos developmental stage occurred. Most of the stored-eggs were rotten due to prolong periods of exposure to fallowing and protracted storage at different stages. It meant eggs fallowing for long periods tend to lose their viability and finally rot. This was because there was indication that the eggs which were NS prior to incubation were not rottened-eggs at all.

Similarly, the eggs that were stored for five days before incubation at room temperature and in refrigerator were not hatched. This meant there was no single egg hatched to keet among those stored prior to incubation. The hatchability was only possible for eggs that were NS before incubation commenced. This showed that the storage of eggs before incubation had direct influence on hatchability. Galor (1985), Nwagu and Alawa (1995) and Banali and Kanengori (1998) reported that hatchability decreased with storage time. Petek and Dikmen (2006), and Romao *et al* (2008) confirmed to this based on their researches that long storage time prior to incubation decreased hatchability. The storage time and hachability of guineafowl eggs have an inverse relationship.

Incubation on the 29th day of the bird was consistent with Ayorinde (1989b) who indicated that the incubation period ranges from 25-30 days but slightly different from that of Majewska (2001) who indicated that the normal incubation period for guineafowl eggs ranges from 26-28 days.

The mean weight, height and width after incubation shrank. They were greater than the overall mean weight, height and width of eggs before and after incubation. This showed that eggs that were not stored before incubation tended to lose minimum available water through their shell spores. The sizes of the stored-eggs also influence loss of minimum water after incubation of the eggs. Loss in weight of guineafowl egg was in agreement with findings by Petek and Dikmen (2006) who found significant difference in egg weight losses in broiler breeders during storage. Tilki and Saatchi (2004) also reported from their findings that there was increased egg weight loss with increased storage time. In contrast, Moreki and Ditshupo (2012) said eggs weight at transfer decrease with the length of storage and that higher (22.26%) and lower (17.94%) egg weight losses were obtained for eggs stored for 0 and 14 days.

Eggs stored differently in storage systems before incubation had variations in term of sizes and shapes of the eggs which were important factor in determining internal and external features of eggs. Numbers of fertile eggs were higher than those eggs that were not fertile from the vegetation zones but eggs that hatched were in smaller proportion compared to available eggs.

Comparing feral to captivity, the same factors applied that if eggs were not fertilized they would not hatch. In the wild, guineafowls lay large number of eggs but these eggs would not be fertilized until end of raining season in which the eggs might have lost their fertility.

This results in wastage of large number of eggs every season. Laying of eggs for a long period and fertilization at the end of the season is similitude to storage of eggs which is not desirable for fertility and hatchability of the eggs. Some eggs were fertilized but refused to hatch. This confirms Ayorinde (1999) said that eggs of guineafowl with visibly porous shell or those with abnormal shape often fail to hatch.

Also, Narushine and Romanov (2002) said that under normal circumstances, a fertile egg contains all the nutrients necessary for the development of the embryo to hatching but certain physical and chemical conditions reduced or caused no hatchability. The rate at which hatchability declined is high in freshly laid eggs and reduces with time. Ayorinde (1987a, 1988) declared that hatchability declined in freshly laid eggs from 83% to 57% after 7 days and to 29% after 14 days of storage. It should be noted that freshly laid eggs should be incubated within shortest period of time after laying.

Brooding method affects survival of keets and the physiological factors cannot be overemphasized. Nwagu and Alawa (1995) posited that poor conversion efficiency through high energy output and feed wastage contributes to high mortality rate at early stage of the keets.

Effect of egg size which is highly significant (p<0.05) on eggs that were not stored before incubation reveals that egg size, incubation method and storage system before incubation has direct effect on hatchability. Eggs that are large and incubated within shortest period will boost hatchability. Also, vegetation zone significance (p<0.05) on no storage eggs shows that from any vegetation zone eggs collected should be incubated without storing them prior to incubation. This will directly or indirectly affect hatchability and survival of the keets. A well selected vegetation zone for eggs collection, incubation method and factors of incubation chamber will definitely improve loss of keets during hatching and survival of keets, ecological stability and for sustaining yearning of the teeming population for alternative protein source.

Conclusion and recommendation

The study revealed that considerable challenges facing future improvement efforts in productivity of guineafowl are mainly due to infertility of eggs at the time of collection, low hatchability and excessive keet mortality. The collection of guineafowl eggs from the wild should be scheduled between May and August because these months coincide with peak fertility of eggs.

Guineafowl eggs should not be stored under storage system prior to incubation in order to improve egg fertility and hatchability of keets.

Well planned brooding system should be carried out for four weeks to test whether mortality rate may be reduced to minimal level or not.

Proper handling of eggs should be ensured during collection, transportation and period of setting for incubation.

References

Ayodele, I. A. 1988. An ecological basic for the management of Old Oyo National Park, Oyo State, Nigeria. Ph.D Thesis, University of Ibadan.

Ayorinde, K. L. 1987a. Effect of holding room, storage position and duration on hatchability of guinea fowl eggs. *Trop. Agric. (Trinidad), 64:* 188-190.

Ayorinde, K. L. 1987b. Physical and chemical characteristics of the eggs of four indigenous guinea fowls in Nigeria. *Nig. J. Anim. Prod. 14:* 125-128.

Ayorinde, K. L. 1989a. Carcass yield and chemical composition of four indigenous guinea fowl varieties at different ages. *Bull. Anim. Hlth. Prod. Afr., 37:* 361-366.

Ayorinde, K. L. 1989b. Effects of semen dosage and insemination frequency on the fertility of local pearl guinea fowl in Nigeria. *Trop. Agric. (Trinidad), 66 (2):* 135-136.

Ayorinde, K. L. 1999. Guinea fowl production systems in Africa. *FAO Reports,* 24-33.

Binali, W. and Kanengoni, E. 1998. *Guineafowl production and training manual produced for the use by the farmers and rural development agents. Agritex, Harare,* pp. 35-36.

Dudusola, I. O. 2009. Effects of storage methods and length of storage on some quality parameters on Japanese quail eggs. *Tropicultura 27:* 45-48.

Galor. 1985. Notebook for the keeping of guineafowl broilers. *The Technical Service*, Amboise, France, p. 17.

Jayeola, O. A., Ademolu, K. O.,Ogunjinmi, A. A. and Meduna, A. J. 2007. Effect of disturbance on laying pattern and hatchability of feral helmet guineafowl (Numida meleagris galleata Pallas) egg. *The Zoologist, Vol. 5:* 54-59.

Kouame, Y. A. E., Nideou, D, Kouakou, K and Tona, K. 2019. Effect of guineafowl (*Numida meleagris*) eggs storage duration on embryonic and physiological parameter and keet juvenile growth. *Poultry Science, 98:* 6046-6052.

Lapao, C., Gama, L. T. and Soares, M. C. 1999. Effects of broiler breeder age and length of egg storage on albumen characteristics and hatchability. *Poultry Science, 78:* 640-645.

Majewska, D. 2001. The influence of emu (*Dromaius-novae hollandieae*) egg storage time on hatchability and survival. *Electronic Journal of Polish Agricultural Universities, 4(2):* 123-136.

Moreki, J. C. and Ditshupo, T. 2012. Effect of storage time on hatchability of guineafowl eggs. *J. Anim. Sci. Adv., 2(7):* 631-636.

Narushine, U. G. and Romanov, M. N. 2002. Egg physical characteristics and hatchability. *Proc. 26th Annual Conf. Nigerian Society for Animal Production*, pp. 337-339.

Nwagu, B. I. and Alawa,C. B. I. 1995. Guineafowl production in Nigeria. *World's Poultry Science Journal, 51:* 261-269.

Petek, M. and Dikmen, S. 2006. The effects of Pre-storage incubation and length of storage of broiler breeder eggs on hatchability and subsequent growth performance of progeny. *Czech J. Anim. Sci., 51(2):* 73-77.

Romao J. M., Moraes, T. G. V., Teixeira, R.S.C, Cardoso, W. M. and Buxade, C. C. 2008. Effects of egg storage and egg weight loss on hatchability. *Braz. J. Poult. Sch. Sci., 10(3):* 143-147.

Saina, H., Kusina, N. T., Kusina, J. F., Bhebhe, E. and Lebel, S. 2005. Guineafowl production by indigenous farmers in Zimbabwe. *Livestock Research for Rural Development, Volume 17, Article 101.*

Tebesi, T., Medibela, O. R. and Moreki, J. C. 2002. Effect of storage time on internal characteristics of guineafowl (*Numida meleagris*) eggs. *J. Anim. Sci. Adv. 2:* 234-542.

Tilki, M., and Saatci., M. 2004. Effect of storage time on external and internal characteristics in patridge (Alectoris graeca) eggs. *Revue Med.Vet., 155(11):* 561-564.

Wilson, H. R. 1997. Effects of maternal nutrition on hatchability. *Poultry Science, 76:* 134-143.

Citation: Yusuf, A. A., Jayeola, O. A., Osunsina, I. O. O. and Dedeke, G. A.
Effects of collection zones and storage on hatchability and survival of feral helmeted guineafowl (*Numida meleagris galleata* pallas) eggs
http://dx.doi.org/10.4314/tzool.v18i1.13

The Zoologist, 18: 74-81 December 2020, ISSN 1596 972X.
Zoological Society of Nigeria.