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Effect of natural versus artificial incubation on embryonic development of Pekin, Muscovy and Sudani (Egyptian Muscovy) ducks crosses

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Abstract

This study aimed to investigate the incubation type (natural and artificial) on some incubation parameters for the Pekin, Muscovy and Sudani duck crosses. At sexual maturity, body weight and body measurements were recorded. Eighteen Fayoumi ducks females (*Carina moschata*) were used for natural incubation, each female brooded 15 eggs in one hatch. A total number of 299, 150 were collected from the mating from the cross between Muscovy male with Sudani females (MS), 281, 120 hatching eggs from the cross between the Pekin Males with Sudani females (PS) and 190 and 150 from mating between Sudani males with the same genetic females (SS) for artificial incubation (AI) and natural incubation (NI), respectively. The fertility, hatchability, embryonic mortality at 7, 14, 21 and 28 days and relative one-day duck weight were measured during the incubation period. Results revealed that Muscovy duck males had significantly higher body weight or body measurements at sexual maturity (P<0.0001) than other duck strains. Fertility was significantly higher (P<0.0001) in SS (Sudani x Sudani) compared to MS (Muscovy x Sudani) and PS (Pekin x Sudani) crosses. Early embryonic mortality (EEM) was significantly higher on the PS (P<0.0001); however the MS recorded higher embryonic mortality at 28 days (P<0.0001) in both natural and artificial incubation. The SS had significantly higher hatchability followed by MS and PS. In conclusion, the PS cross recorded lower fertility, hatchability and higher EEM in artificial and natural incubation compared to SS and MS crosses, this may be related to the genetic of the cross not incubation types or conditions.

Keywords: **Artificial incubation, Natural, incubation, Fertility, hatchability, Embryonic mortality, Sexual dimorphism, Duck hybrids.**

Introduction

Both of the fertility and hatchability are major problems in hybridized eggs in duck compared to eggs from pure genetic origin. High embryonic mortality is considered one of main problems reduces hatchability in the crosses duck egg in the artificial incubation. There are many factors effect on fertility and hatchability such as: Egg factors (egg quality and storage), breed flock (age, husbandry and sex ratio), sexual dimorphism (body weight and body measurements), incubation factors (temperature, humidity, egg turning and ventilation), sperm quality and genetic factors (Romanov, 1999; Bogenfurst, 2004; Wolanski *et al*., 2007; Kingori, 2011; England *et al*., 2012; Bogenfurst, 2017; Salamon, 2019; Ogbu and Oguike, 2019). When cross between two species from different genera the hybrids become sterile and effect on the incubation cause early embryonic mortality may the reason is incompatibility in the reproduction of hybrids is believed to be mainly caused by a difference in the karyotypes and/or chromosome structures of the parents (Takahashi *et al*., 2005; Borodin *et al*., 2006; Sakai *et al*., 2007; Oka *et al*., 2010; Islam *et al.,* 2013). Other study indicated that, the early embryonic mortality caused by chromosomal aberrations and lethal genes (Liptói and Hidas, 2006). Othe study by Webster, (1992) confirm that the succeed of mating depend on the body size of males, which the small males have a lower success rate than large males, also he indicated that, the large male with higher sexual dimorphism of body size might have a higher "environmental potential for polygeny than small males. This study aimed to investigate the incubation type (natural and artificial) on some incubation parameters for the Pekin, Muscovy and Sudani duck crosses.

Materials and Methods

Total number of 76 Sudani ducks female divided into three groups, first was 32 of Sudani female mated with 8 males of Pekin ducks, second was 28 of Sudani female mated with 7 Muscovy ducks males and the third was 16 of Sudani females mated with four Sudani ducks males. All ducks reared together but in different pens, at 18 weeks of age the females of Sudani ducks move into the males of each strain.

Natural incubation: Eighteen Fayoumi ducks (*Carina moschata*) females with five males move into the same place of Sudani ducks, but in different pens, the age of the males and females of Fayoumi ducks ranged from 2-3 years, the place is equipped with numbered nests. When the female of Fayoum ducks lay their eggs and before brooded them we replaced these eggs in other fertile eggs from the Three groups. The female of Fayoumi ducks was brooded 15 fertile eggs in each time until finished the experimental, all eggs were numbered and weight before incubated. The Fayoumi females brooded the eggs more times, which total brooded egg was 420 in natural incubation

Artificial incubation: The eggs were collected from the nests and storage for 3 days. All eggs were weighted and numbered before the incubation, all eggs were incubated in the incubation machine.

Measurements:

Body weight and body measurements: Body weight and body measurements were measured at 28 wks of age.

Body measurements: These measurements included shank length (SL from the top of hock joint to the foot pad), keel length (KL the keel bone length supporting the breast fillet) were measured with a digital caliper, body circumference (BC taken under the wings at the edge of the sternum) and body length (BL longitude body beginning from beak to termination bird foot) were measured by a measuring tape.

Sexual dimorphism: Sexual dimorphism (Sx) was calculated for live body weight and body measurements according to the equation of Smith, (1999) using the following equation:

Sexual dimorphism = (male value- female value) / female) X 100 or (Male value/ female value) - 1) X 100.

Pairs number: Number of pairs used to calculate the sexual dimorphism of body weight and body measurements, were ten males of each strains with ten females of Sudani ducks.

Egg Quality: Total number of 30 eggs was used before incubation of eggs and starting the experiment, an evaluation was made of the egg quality inside and an evaluation of the characteristics of eggshell (Table 1). This is to ensure that the characteristics of eggs suitable for incubation, because the character of egg play important role in the embryo development and successful hatch and this to be sure the incubation parameters are affected by the two facto of the experiment (incubation types and the cross effect).

Egg quality measurements: Egg weight, Egg width, Egg length, White high, Yolk high, Yolk diameter, Yolk weight and Shell weight.

Measurements of egg quality calculated: Shape index (Egg width / Egg length) X 100, Yolk index (Yolk high/ Yolk diameter) X 100, Egg surface area = 3.9782 (Egg weight)$^{0.7056}$, Haugh unit = 100 log (H+7.57-1.7 W 0.37), Shell index = (Egg surface area/ Shell weight) X 100 and The shell breaking strength (kg/cm2) was determined using quasistatic compression method (Fathi and El- Sahar 1996).

Incubation measurements: A total of 299 and 150 hatching eggs from the cross between Muscovy males with Sudani females (MS), 281 and 120 hatching eggs from the cross between Pekin males with Sudani females (PS) and 190 and 150 hatching eggs from mating between Sudani males with the same genetic females (SS) were obtained for artificial and natural incubation, respectively.

Fertility and hatchability:

Hatchability on fertile eggs (%) = No of eggs hatched out/Total no of fertile eggs × 100.

Hatchability on set eggs (%) = No of eggs hatched out/Total no of eggs set × 100.

Embryonic mortality: At 7, 14, 21, 28 days of incubation period, embryonic mortality was determined using egg candling.

Relative 1-day duck weight: Eggs were weighted before incubation and after hatch directly all hatched ducks were weighted. Relative one-day duck weight was calculated according to the following formula:

Relative 1-day duck weight = duck weight / egg weight x 100.

Statistical analyses: Data related developed body weight, body measurements and sexual dimorphism analysed using one-way Analysis of variance with the strain effect using General Linear Model (GLM) procedure of SAS (2001). According to the following model (I);

$Y_{ij} = \mu + S_i + e_{ij}$

Where; Yij= Trait measured, μ = Overall means, Si = Strain effect eij = Experimental error.

Data other than those subjected to stastical analysis using two-way analysis of variance with incubation types and the cross with interaction using General

Linear Model (GLM) procedure of SAS (2001) as following model (II); Yij= μ + Ii + Tj + [IxT]ij + eijk

Where; Yij = Trait measured, μ = Overall mean, Ii= incubation types Tj = cross effect (j=1 and2)

[IxT]ij = Interaction between incubation types and cross effect, eijk = Experimental error.

When significant differences among means were found, means were separated using Duncan's multiple range tests.

Results and Discussion

Body weight, body measurements and sexual dimorphism: Body weight and body measurements at sexual maturity for male of Sudani, Muscovy and Peking duck are presented in Table 2. Data presented the superiority Muscovy duck males either for body weight or body measurements at sexual maturity (p<0.0001) than other duck strains. However Sudani duck was intermediate and Pekin duck occupied the last position of the mentioned traits of males. With respect for sexual dimorphism, the same trend was noticed for all traits, the sexual dimorphism was higher between Muscovy males with Sudani females (SX_{MS}) followed by the sexual dimorphism between the Sudani males and the same females (SX_{SS}), however the sexual dimorphism between Pekin males and Sudani females (SX_{PS}) recorded lower value for all traits.

Incubation: Data presented in Table 3 showed that the fertility and hatchability among different crosses and incubation types (artificial and natural) our result noticed that there was significant differences between SS (Sudani x Sudani) compared to MS (Muscovy x Sudani) and PS (Pekin x Sudani) ones, however, the fertility was significantly higher for SS compared either for PS while, MS cross was intermediate. With respect to the embryonic mortality, the results indicated a higher significant differences in early embryonic mortality at 7 days PS compared to MS and SS ones, however the MS recorded higher mortality at 14, 21 and 28 day compared to SS and PS as showed in Figure (1). Concerning hatchability from all eggs and fertile eggs, SS and MS crosses gave significantly higher values compared to PS ones. Embryonic weight was significant lower for SS compared to MS and PS cross ones; however theirs was no significant differences in relative e embryonic weight.

For incubation types, as expect the natural incubation was lower for embryo mortality at all ages than artificial incubation, also the natural incubation was significantly higher for hatchability percent compared to artificial incubation, however, theirs was no significant effect of incubation types on the relative embryo weight. The interaction was not significant between the incubation types and the cross effect for all traits except the embryo mortality at 2 weeks of incubation, the interaction was significant.

The correlation: Data presented in Table 4 showed that the correlation among the fertility with body weight, body measurements and sexual dimorphism among different crosses. The correlation for body weight and body measurements was negative except shank length was positive in Sudani male with fertility parentage. However the correlation between keel length and body length eas negative in the male of Muscovy ducks, the most of traits was negative value in the Pekin male. The correlation between the fertility and sexual dimorphism was positive in the cross between Pekin and Muscovy males with Sudani female, opposite trend was found in the mating between the males and females of Sudani ducks.

Sexual dimorphism is the difference in body weight between males and females, this is important in natural mating, the cross among species to produce hybrids affecting in body size, behavior of the parents (Tai Liu and Tai, 1991; Mignon-Grasteau et al., 1998). The higher different between male and female for body weight and size obstacle for natural mating. Female Muscovy ducks are often injured in the leg and chest upon supporting the much heavier male (Ismoyowati et al., 2017). The Sexual differences in external morphology are of interest in studies of reproductive biology and descriptively, to analyse the population composition (Norman and Robert, 1984; Piersma, 1988; Yakubu, 2011).

Other studies indicated that the lower of fertility related to physical characterises of males, body weight, muscular and skeletal conformation and musculoskeletal conformation, all this factors can cause difficulty translate the sperms into the females (Duncan et al., 1990; Kirby et al., 1998; Bowling et al., 2003; McGary et al., 2003; Bilcik et al., 2005) whereas sperm motility and mobility are negatively associated with body weight (Bowling *et al.,* 2003; Bilcik *et al.,* 2005).

However, the Muscovy had a greater dimorphism in body size between males and females. Males grew faster and yielded heavier body weight than females (Vander Sluis, 1993; Bochno et al., 1994).

Raji et al, (2009) reported that body length of matured local Muscovy ducks in Nigeria for male and female were 59.25 and 45.51 cm, respectively. Ogah (2011) reported that body length (BL) and shank length (ShL) for male and female Muscovy duck at 15 weeks of age were 26.1 and 24.5 cm for BL and 5.5 and 5.27 for ShL, respectively. In the present study, we find the sexual dimorphism was higher between

Muscovy males and females followed by the Sudani males with same females and the different between Pekin males and Sudani females was lower.

Table 1. Egg quality of Sudani duck

Traits	Maximum	Minimum	Average
Egg weight (g)	68.29	48.62	61.22
Egg width (cm)	44.32	39.13	42.7
Egg length (cm)	61.85	54.09	58.32
Shape index%	78.58	69.86	73.26
White high (cm)	60.57	27.29	36.46
Haugh unit%	99.3	88.8	94.7
Yolk high (cm)	20.55	15.37	18.82
Yolk diameter (cm)	46.64	35.35	44.21
Yolk index%	0.52	0.33	0.43
Yolk%	39.48	23.84	35.18
White%	62.34	48.79	52.83
Shell%	13.82	9.95	11.99
Shell strength kg cm^2	11.93	3.52	8.56
Egg surface area (cm^2)	78.33	61.66	72.32
Shell index %	10.91	8.50	9.92

Table 2. Body weight, body measurements and sexual dimorphism for the parents used in this study

Strains (Males)	Traits				
	LBW	ShL	KL	BC	BL
Sudani (S)	3212.50^{b}±157.36	8.22^{a}±0.18	15.76^{a}±0.20	47.0^{ab}±0.63	82.60^{ab}±0.62
Muscovy (M)	5034.50^{a}±52.17	9.21^{a}±0.17	17.57^{a}±0.23	55.10^{a}±0.59	89.40^{a}±0.16
Pekin (P)	2666.0^{c}±86.37	6.29^{b}±1.11	12.09^{b}±2.14	38.0^{b}±6.50	66.65^{b}±11.21
Probability	**0.0001**	**0.01**	**0.01**	**0.01**	**0.05**
Sudani Females					
Sudani (Females)	1983.0±53.0	5.70±0.09	10.98±0.04	37.0±0.60	65.0±0.47
***Sexual Dimorphism (SX) (%)**					
SX_{SS}	61.22^{b}±3.95	44.14^{b}±1.54	43.49^{b}±1.23	26.76^{b}±0.87	27.08^{b}±0.39
SX_{MS}	155.24^{a}±6.11	62.39^{a}±3.63	61.26^{a}±2.29	47.53^{a}±2.99	37.61^{a}±1.13
SX_{PS}	35.11^{c}±5.09	23.43^{c}±2.93	21.15^{c}±2.49	18.31^{c}±1.88	22.37^{c}±1.32
Probability	**0.0001**	**0.0001**	**0.0001**	**0.0001**	**0.0001**

$^{a,\ b\ and\ c}$ Means within the same row with different letters are significantly differed NS = Non-significant

LBW= live body weight, SL= shank length, KL= keel length, BC= body circumference and BL= body length.

SX_{SS}= Sexual dimorphism between Sudani males and their females, **SX_{MS} =** Sexual dimorphism between Muscovy males and Sudani females and **SX_{PS} =** Sexual dimorphism between Pekin males and Sudani females**.**

***Sexual dimorphism** = ((Male value/ female value) - 1) X 100

Thus, **positive values** (> 0) mean the male is greater than the female for that trait, a **zero value** means males and females are equal, and **negative values** (<0) mean the female is greater than the male for that trait

Table 3: Artificial and natural incubation measurements among Sudani duck and the cross either with Muscovy or Pekin males

Traits	Incubation (I)	Strain (S)			Overall	Probability		
		SS*	MS**	PS***		S	I	S*I
Fertility%	**Artificial**	80.1±0.62	76.3±0.92	63.9±1.73	**73.4[a]**			
	Natural	79.3.±4.22	62.5±1.22	60.0±2.22	**67.2[b]**			
	Overall	**79.5[a]**	**67.0[b]**	**61.1[b]**		**0.0001**	**0.03**	**NS**
Embryonic mort 1wk, %	**Artificial**	14.43±1.2	12.71±0.8	34.49±0.38	**20.5[a]**			
	Natural	0.74±0.74	2.5±1.22	23.33±4.36	**9.6[b]**			
	Overall	**4.95[b]**	**5.09[b]**	**26.52[a]**		**0.0001**	**0.0001**	**NS**
Embryonic mort 2wk, %	**Artificial**	3.67±0.08	4.68±0.38	2.82±0.32	**3.7[a]**			
	Natural	0+0	0±0	0±0	**0.0[b]**			
	Overall	**1.13[b]**	**1.56[b]**	**0.81[a]**		**0.0001**	**0.0001**	**0.0001**
Embryonic mort 3wk, %	**Artificial**	2.61±0.15	3.34±0..38	2.48±0.13	**2.8[a]**			
	Natural	0+0	1.68±1.1	0.67±0.67	**0.74[b]**			
	Overall	**0.80**	**2.23**	**1.19**		**NS**	**0.003**	**NS**
Embryonic mort 4wk, %	**Artificial**	17.40±0.15	30.8±1.1	10.26±0.71	**19.5[a]**			
	Natural	13.3±2.48	22.5±1.22	8.0±1.94	**14.1[b]**			
	Overall	**14.58[b]**	**25.26[a]**	**8.65[c]**		**0.0001**	**0.01**	**NS**
Hatch from all egg, %	**Artificial**	42.0±0.49	24.8±1.98	13.9±0.19	**26.9[b]**			
	Natural	65.19±3.97	34.2±2.0	25.3±3.11	**41.2[a]**			
	Overall	**58.1[a]**	**31.0[b]**	**22.01[c]**		**0.0001**	**0.0001**	**NS**
Hatch from fertile egg, %	**Artificial**	52.5±1.01	32.4±2.21	21.7±0.29	**35.5[b]**			
	Natural	82.6±3.57	52.5±1.01	42.9±5.37	**59.7[a]**			
	Overall	**73.3[a]**	**47.3[b]**	**36.9[c]**		**0.0001**	**0.0001**	**NS**
Chick weight	**Artificial**	30.2±2.9	37.4±0.8	39.1±1.1	**63.7**			
	Natural	40.3±1.5	38.9±2.03	39.7±1.22	**65.8**			
	Overall	**35.4[b]**	**37.9[ab]**	**39.4[a]**		**NS**	**NS**	**NS**
Chick%	**Artificial**	63.2±1.87	64.5±0.82	63.5±1.10	**35.7**			
	Natural	63.9±1.33	64.6±3.0	67.8±0.73	**38.7**			
	Overall	**63.6**	**64.5**	**65.9**		**0.03**	**NS**	**NS**

[a, b and c] Means within the same row with different letters are significantly differed NS = Non-significant
* Sudani male With Sudani female ** Muscovy male with Sudani female *** Pekin male with Sudani female

Table 4: The correlation of fertality with body weight, body measurments and sexual dimorphism among Sudani duck and the cross either with Muscovy or Pekin males

Strains		Traits				
		LBW	ShL	KL	BC	BL
SS*	**Fertality**	-0.259	0.409	-0.058*	-0.222	-0.161
MS**	**Fertality**	0.319	0.220	-0.572	0.373	-0.072
PS***	**Fertality**	-0.140	-0.121	-0.073	-0.421	0.188
Types of fertile eggs		**Sexual dimorphism (SX)**				
		SX_{LBW}	**SX_{ShL}**	**SX_{KL}**	**SX_{BC}**	**SX_{BL}**
SS*	**Fertality**	-0.163	-0.253	-0.473	-0.173	0.086
MS**	**Fertality**	0.165	0.119	-0.176	0.197	0.079
PS***	**Fertality**	0.474	0.468	0.089	0.499	0.695*

LBW= live body weight, SL= shank length, KL= keel length, BC= body circumference and BL= body length.

***** Sudani male With Sudani female ****** Muscovy male with Sudani female ******* Pekin male with Sudani female
SX_{LBW} = the sexual dimorphism of live body weight between Sudani female withe each males of other strains, **SX_{ShL}** = the sexual dimorphism of shank length between Sudani female withe each males of other strains, **SX_{KL}** = the sexual dimorphism of keel length between Sudani female withe each males of other strains, **SX_{BC}** = the sexual dimorphism of body circumference between Sudani female withe each males of other strains and **SX_{BL}** = the sexual dimorphism of body length between Sudani female withe each males of other strains

Figure 1: Embryonic mortality at 28 day.

The correlation between fertility with body weight and body measurements was negative for the all traits except shank length was positive in the Sudani male ducks, however it was positive for all traits in the Pekin ducks, this indicate that the trend of the correlation related to the type of the ducks (Mallard or Muscovy), however the sexual dimorphism of body length ($SX_{BL)}$ was positive in all the crosses, This confirms that the higher percentage of the body length of the male to female led to increased fertility in all types of crosses. Males that are larger in size have a greater success rate at fertilization compared to males that are smaller in size (Webster, 1992)

From the present results, the PS cross was lower fertility and hatchability in both natural and artificial incubation, although, the high embryo mortality was found in the PS cross at first weeks, however the same result found in the MS cross at 4 weeks of incubation period. The SS was higher significantly for fertility, hatchability and lower embryo mortality in booth natural and artificial incubation, followed by MS and PS.

Hatching failure due to embryonic mortality may result from a variety factors, including exposure of eggs to variable temperature, humidity and microbial infection prior to the onset of full incubation (Meijerhof 1992, Cook et al., 2003, Beissinger et al., 2005, Cook et al., 2005a, b), poor female condition or genetic incompatibility between the male and female, such as that resulting from inbreeding or out breeding, including inter specific crosses (Bensch et al., 1994, Etches, 1996, Brillard et al., 1998, Christensen, 2001, Sellier et al., 2005).

Some studies indicated that the lower hatchability in the artificial incubation in ducks related to the temperature of the incubation machine not suitable for the egg ducks (Makram and AbdelAzim, 2018; Makram et al., 2019) the same studies found that the hatchability ratio in natural incubation was 95% from fertile eggs in Fayoumi ducks, also, the egg temperature in natural incubation was lower 7 C0 than artificial incubation. Other studies indicated that the most embryos of hybrids in poultry die from the 2-8 day of the incubation period, which revealed that combination with different sperm eggs couldn't obtain rational incubation, and could possibly result in hybrid sterility or due to chromosome recombination and partnership of different poultry (Yoshihiro, 1982; Zhao et al., 2003 and 2005; Li , 2010). Rashid et al, (2009) found that the fertility was 80.96%, 86.69% and the hatchability from the fertile egg was 62.9% and 54.21% for Pekin and Muscovy ducks, respectively. Also, found the difference between the fertile egg and the hatchability were 22.7 and 32.48% of the Pekin and Muscovy ducks, respectively.

All domestic ducks divided into two types, first ducks descended from Carina genus called Muscovy types (*Carina moschata*) and the second from the Anas genus, called mallard types (*Anas platyrhynchos*), the two types of domestic ducks have the same number of chromosome, but different in the size. The French Muscovy and Sudani duck descended from Carina genus and Pekin ducks descended from Anas genus (Akinlade and Sonaiya, 1994; Adeyeye et al., 2012, Makram, 2016). The karyotype of No.1 and No.2 chromosome in Muscovy duck and domestic duck was responsible for hybrid sterility resulting from the failure of good match during the period of chromosome meiosis. this called the robertsonian ectopia (Sun et al., 2007 and Li 2010). The fertility and embryo mortality were 43% and 19%, respectively, from 2-12 after artificial insemination in the cross between the Muscovy drakes with common duck (Brun et al., 2008). Chen et al, (2016) confirm that the sperm viability and plasma membrane related to early embryo mortality, which the embryo mortality decreased if the viability of sperm higher.

From the present study all conditions were suitable for the incubation as egg quality (shape index, shell characters, internal egg) as showed in Table 1. Also, incubation condition (natural and artificial incubation) was suitable and sexual dimorphism was lower between Pekin males with Sudani females, although, the lower fertility and hatchability found in the cross between Pekin males with Sudani females, this may related to the different of karyotypes in the chromosomes between the two ducks species.

In conclusion, the PS cross recorded lower fertility, hatchability and higher early embryonic mortality in artificial and natural incubation compared to SS and MS crosses, this may be related to the genetic of the cross not incubation types or conditions.

Declaration of interest

There are no conflicts of interest.

References

Adeyeye, E. I., Adebayo, W. B. and O. O. Ayejuyo. 2012. The amino acid profiles of the yolk and albumen of domestic duck (Anas platyrhynchos) egg consumed in Nigeria. Elixir Food Science 52: 11350-11355.

Akinlade, O.R. and. Sonaiya, E.B. 1994. A paper, 19th Annual Conference of NSAP, University of Benin.

Beissinger, S. R., Cook, M. I.and Arendt, W. J. 2005. The "shelf life" of birds eggs: testing egg viability using tropical climate gradient. Ecology. 86: 2163-2175.

Bensch, S., Hasselquist, D .and Schantz, T.1994. Genetic similarity between parents predicts hatching failure: non- incestuous inbreeding in the Great Reed Warbler? Evolution 48: 317–326.

Bilcik, B, Estevez, I and. Russek-Cohen, E. 2005. Reproductive Success of Broiler Breeders in Natural Mating Systems: The Effect of Male-Male Competition, Sperm Quality, and Morphological Characteristics. Poultry Science 84:1453–1462.

Bochno, R., Lewczuk, A and Wawko, E. 1994. Comparison of growth and feed conversion efficiency of Muscovy and Pekin ducks, Poultry Abstract 1994 Volume 20. Number3, 18 CAB International.

Bogenfurst, F. 2004. The hatching handbook. Gazda Kiado Publ, Budapest, Hungary, ISBN. 9789637445507, pages: 278 (In Hungarian).

Bogenfurst, F. 2017. Handbook of Goose Breeders. Forum publisher, Udine, Italy (In Hungarian).

Borodin, P.M, Barreiros-Gomez, S.C., Zhelezova, A.I., Bonvicino, C.R and'Andrea, P.S. 2006. Reproductive isolation due to the genetic incompatibilities between Thrichomys pachyurus and two subspecies of Thrichomys apereoides (Rodentia, Echimyidae). Genome, 49: 159-167.

Bowling, E. R., Froman, D. P. Davis, A. J and Wilson. J. L. 2003. Attributes of broiler breeder males characterized by low and high sperm mobility. Poultry Science. 82:1796–1801.

Brillard, J.P., Beaumont C, Scheller, M.F. 1998. Physiological responses of hens divergently selected on the number of chicks obtained from a single insemination. J Reprod Fertil, 114:111-117.

Brun, J.M, Mialon-Richard, M-M, Sellier, N, Batellier F and Brillard, J.P. 2008. Duration of fertility and hatchability of the common duck (Anas platyrhynchos) in pure- or crossbreeding with Muscovy drakes (Cairina moschata). Theriogenology, 69: 983-989.

Chen, Y.C., Liu, H.C., Wei, L.Y., . Huang, J.F., Lin, C.C., Blesbois, E and Chen. M. C. 2016. Sperm quality parameters and reproductive efficiency in Muscovy duck (*Carina moschata*). J. Poultry. Science. 53: 223-232.

Christensen, V. L. (2001. Factors associated with early embryo mortality. World's Poultry Science Journal, 57: 359–372.

Cook, M. I., Beissinger, S. R., Toranzos, G. A., Rodriguez, R. A and Arendt, W. J. 2003. Trans-Shell infection by pathogenic micro- organism reduced the shelf life of non – incubated bird's eggs: a constrain on the onset of incubation? Proceedings of the Royal Society of London Series B- Biological Science. 270: 2230-2233.

Cook, M. I., Beissinger, S. R., Toranzos, G. A., Rodriguez R. A and Arendt, W. J. 2005a. Incubation reduces microbial growth on eggshells and the opportunity for trans-shell infection. Ecology Letters. 8: 532-537.

Cook, M. I., Beissinger, S. R., Toranzos, G. A., Rodriguez, R. A and Arendt , W. J. (2005b). Microbial infection affects egg viability and incubation behavior. Ecology. 16: 30-36.

Duncan, I. J. H., Hocking, P. M. and Seawright, E. 1990. Sexual behaviour and fertility in broiler breeder domestic fowl. Appl. Anim. Behav. Sci. 26:201–213.

England J. A, Salas, C., Ekmay, R. D. Coon, C. N. 2012. Dual Energy X-Ray Absorptiometry Analysis of Broiler Breeder Eggs for prediction of Egg Components and Education of Egg Shell Quality. In International Journal. of Poultry Science. 11(5) 316 – 325.

Etches, R. J. 1996. Reproduction in Poultry. Wallingford, Oxford: CAB International. ISBN: 0851 987 389.

Fathi, M. M. and El-Sahar, E. A. 1996. .Determining the strength ofeggshell by using an appropriate apparatus and an equation tocalculate egg surface depending on its dimensions. Egypt. Poultry. Science.16 (II): 285-303.

Islam, F.B., Ishishita,, S., Uno, M. d. Y., Mollah,, B. R., Srikulnath, K, and Matsuda, Y. 2013. Male Hybrid Sterility in the Mule Duck is Associated with Meiotic Arrest in Primary Spermatocytes. Japan. Poultry Science., 50: 311-320, 2013.

Ismoyowati, E. Tugiyanti, M. M and Purwantini. D. 2017. Sexual dimorphism and identification of single nucleotide polymorphism of growth hormone gene in Muscovy duck. J. Indonesian Tropical. Animal. jitaa42(3):167-174.

Kingori, A.M. 2011. Review of Factors the Influence egg fertility and hatchability in poultry. Int. J. Poultry Science, 10: 483-492.

Kirby, J. D., Tressler, C. J and Kirby. Y. K. 1998. Evaluation of the duration of sperm fertilizing ability in five lines of commercial broiler breeder and Delaware cross males. Poult. Sci. 77:1688–1694.

Li, X., Liang, D., Zhang, J and Liao. H. 2010. Study Progress of Intergeneric Hybridization between Chicken and Quail. International Journal of Biology. 2(1): 123-126.

Liptol, K and Hidas, A. 2006. Investigation of possible genetic background of early embryonic mortality in poultry. World's Poultry Science Journal 62(2):326-337.

Makram. A. 2016. Ducks world (Review Article). The 9th International Poultry Conference from 7-10 November.463-486.

Makram. A., and A. Abd El-Azzim. 2018. Study the Temperature of Fayoumi Duck (Cairina moschata) Eggs under Natural Incubation. The 10th International Poultry Conference from 26-29 November. Sharm Elsheikh., Cairo, Egypt. 218-225.

Makram. A., Abd El-Azzim, A. and EL-Attar. A.H. 2019. Natural incubation behavior of domestic Waterfowls as an approach to develop the artificial incubation (Review article) 9th International Conference for Sustainable Agricultural Development 4-6 March 2019 Fayoum J. Agric. Res,&Dev.,Vol.33 No. 1(B) March,161-168.

McGary, S., Estevez, I and Bakst. M. R. 2003. Potential relationships between physical traits and male broiler breeder fertility. Poultry. Science. 82:328–337.

Meijerhof, R. 1992. Pre- incubation holding of hatching eggs. World Poultry Science Journal. 38: 57-81.

Mignon-Grasteau, S., C. Beaumont, J. Paul Poivey, and Hubert de Rochambeau (1998). Estimation of the genetic parameters of sexual dimorphism of body weight in 'label' chickens and Muscovy ducks, genetic, sel, Evol . 30: 481 - 491.

Norman, J.S. and Robert, P.R. 1984. Phenotypic variation of the Mexican duck (Anas platyrhnchos Diazi) in Mexico. The Condor, 86: 266-274

Ogah, D. M. 2011. Assessing size and conformation of the body of Nigerian indigenous turkey. Slovak Journal of Animal Science 44 (1): 21-27.

Ogbu, O. C and Oguike, M.A. 2019. Hatchability of fertile eggs in poultry industry. Journal of Agriculture and Sustainability. 12:107-123.

Oka A, Mita A, Takada Y, Koseki H and Shiroishi T. 2010. Reproductive isolation in hybrid mice due to spermatogenesis defects at three meiotic stages. Genetics, 186: 339-351. 2010.

Piersma, T. 1988. Morphological variation in a European population of great crested grebes Podiceps cristatus in relation to age, sex and season. J. Ornithol., 3: 299-316.

Rachid, M. A., Kawsar, M.H., Rachid, M.A., Miah, M.Y and Howlider. M.A.R. 2009. Fertility and Hatchability of Pekin and Muscovy Duck Eggs and Performance of Their ducklings. Progress. Agric. 20(1 & 2) : 93 – 98.

Raji, A. O., Igwebuike, J. U. and Usman M. T. 2009. Zoometrical body measurements and their relation with live weight in matured local Muscovy Ducks in Borno State Nigeria. ARPN J. Agr. Biol. Sci., Vol. 4: 3.

Romanov, M.N. 1999. Goose Production Efficiency as Influenced by Genotype, Nutrition and Production Systems. World Poult. Sci. J, 55: 281-294.

Saka,i C, Konno, F, Nakano, O, Iwai T, Yokota, T, Lee J, Nishida, U. C., Kuroiwa, A, Matsuda, Y and Yamashita, M. 2007. Chromosome elimination in the interspecific hybrid medaka between Oryzias latipes and O. hubbsi. Chromosome Research, 15: 697-709. 2007.

Salamon, A. 2019. Fertality and hatchabilty in Goose eggs: A review. International Journal Poultry Science, 10: 1-15.

SAS Institute (2001). SAS/STAT User's Guide Version 8.2 ed: Statistics. SAS Institute Inc., Cary, NC.

Sellier, N., Brun, J.M. Richard, M. M., Batellier, F., Dupuy, V and Brillard, J.P. 2005. Comparison of fertility and embryo mortality following artificial insemination of Common Duck females (Anas platyrhynchos) with semen from Common or Muscovey (Cairina moschata) Drakes. Theriogenology 64: 429–439.

Smith, R .J (1999). Statistics of sexual size dimorphism. Journal of Human Evolution 36: 423–459.

Sun, Y.Q., Zhao, Z.S and Meng, Q.M. 2007. Karyotype analysis of chicken-quail hybrids. Journal of Anhui Agriculture Sciences, 35(14):4152-4153.

Tai Liu, J.J and Tai, C. 1991.Mule duck production in taiwan. I. Artificial insemination of ducks. Food and Fertilizer Technology Center, extension bulletin, 328: 1-6.

Takahashi, H, Nagai, T and Goto, A. 2005. Hybrid male sterility between the fresh- and brackish-water types of ninespine stickleback Pungitius pungitius (Pisces, Gasterosteidae). Zoological Science, 22: 35-40. 2005.

Vander Sluis, W. 1993. Waterfowl production increasing slowly, World Poultry - Misset Volume 9: 89 93.

Webster, M.S. 1992. Sexual dimorphism, mating system and body size in new world black birds (Icterinae). Evolution, 46(6),1992, pp. 1621-1641.

Wolanski, N. J, Renema, R. A.,. Robinson, F. E. Varney, V. L and Fancher. B. I. 2007. Relationships and early characteristics, chick measurements and early growth traits in then broiler breeder strains. Poultry Science. 86: 1784 – 1792.

Yakubu, A. 2011. Disctiminant analysis of sexualdimorphism in morphological traits of African Muscovy ducks. Arch. Zootec. 60 (232): 1115-1123.

Yoshihiro, T. 1982. The sex ratio of chicken quail hybrids. Japanese Poultry Science, 19(1):53-54.

Zhao, Z.S., Li, D.Q and Jiao, L.P. 2005. Determination of body size and meat traits of poultry generic hybrid progeny and their parents. Chinese Journal of Animal Science, 41(2):22-23.

Zhao, Z.S., Li, D.Q and Yu, C.M. 2003. Studies on operating and survival time of sperm in other female interliner poultry genital tract. Heilongjiang Animal Science and Veterinary Medicine, 11:13-15under local breeder conditions. Kafkas .niversitesi Veteriner Fakültesi Dergisi, 18:663-672.