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Hatchability of duck eggs as affected by types of incubators under varying relative humidity

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Abstract The mean percentage hatchability was not significantly affected by types of incubators, two levels (70% and 80%) of relative humidity, and the interaction effect of types of incubators and relative humidity. However, the percentage of egg hatching was significantly affected by types of incubators such that the means of the percentage hatch in Cabinet-Type Electric Incubator (M=43.95%) and in Bamboo or "Garong"-Type Incubator (M=41.88%) were significantly higher from "Lawanit" Board-Type Incubator (M=27.68%). There was no significant difference in the percentage hatch as affected by two different levels of relative humidity and the interactions of types of incubators and varying percent relative humidity. In this study, the use of Bamboo or "Garong"- Type Incubator indicated the lowest cost (₱0.83) to hatch a duckling, the cheapest (₱17.70) to produce a duckling, and highest ROI of 2.00%.Thus, the Bamboo or "Garong"-Type Incubator was the most economical to use among the three types of incubators.Among the three types of incubators under the two levels of relative humidity, it was observed that the cost to hatch and the cost to produce a duckling is lower under 80% relative humidity with an average cost of ₱1.89 and ₱20.00 respectively. Higher ROI (1.56%) was also observed when the eggs were incubated under 80% RH than 70% RH with an average ROI of 1.54%. Furtheremore, the Cabinet-Type Electric Incubator and Bamboo or "Garong"-Type Incubator were identified to be the most efficient types of incubators. All the hatching parameters were not significantly affected by two levels (70% and 80%) of relative humidity.

Keywords: Bamboo or "Garong" incubator, Duck egg incubation, Parched rice incubation, Rice husk incubation technique

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Introduction

Ducks are commonly raised by rural farmers in the Philippines mostly in Central Luzon and some part of Western Visayas. Around 429,700 families derive their livelihood from it (Santiago, 2018). These farmers, who have less than 100 heads of ducks, contribute to 70% of the ducks in the country (Philippine Statistics Authority [PSA], 2015) as reported by Arrosa (2018). Ducks are preferred by small-holders in the communities compared to other fowls because ducks can adapt and survive under a wide range of climatic conditions, can feed on a variety of feedstuffs, and are resistant to diseases. Raising Mallard Duck (*Anas platyrhynchos*), being known for egg production, provides a good source of income to farmers through its products such as *balut* (embryonated egg) and salted egg. These ducks can also be sold as cull after two years of egg production when their laying performance begins to decline. However, there are some issues and concerns about the duck industry. Results from a farm survey on duck egg production in the Philippines showed that duck farmers generally lack the technical know-how and extension services as well as insufficient supply and high cost of producing good quality ducklings (Chang *et al*., 2008). Most of these problems, particularly on technical and production and supply aspects, are brought about by the issues concerning the type of incubator used and the physical factors to which the eggs were subjected before and during the incubation period.

The duck industry has a promising future given the high demand for salted eggs and *balut* which accounts for 90% of the total egg production in the country (Beltran, 2015). The vast knowledge of local farmers in raising ducks, the availability of complete feeds at different stages of growth (from brooding to laying), and the government programs on strengthening mallard duck production (*Itik Pinas*) all over the country make the duck raising more encouraging. Furthermore, it is one of the special programs of the Bureau of Animal Industry under the Department of Agriculture that aims to contribute to attaining one of the goals of President Duterte on food sufficiency. However, there are other problems with the industry such as the fluctuating prices of eggs, limited space for free-range operations, and inadequate research studies being conducted on duck raising ("Native", 2016).

At present, commercial incubators of varying capacities are being used by *balut* and duck producers in the country. Most of these incubators are operating with electricity for heating and other mechanical functions. However, small-holders experience issues in the cost of procurement, maintenance, and operations. According to Boleli *et al.* (2016), the main focus of research at present is the manipulation of thermal incubation conditions and the integrated effect of factors that influence incubation. Commercial hatcheries use modern state-of-the-art incubators but one of the questions that need to be answered is how effective and cost-efficient the incubators are in terms of promoting greater hatchability and better chick quality.

Currently, artificial incubators made from locally available materials, using parched rice and rice husk, have been used by hatcheries in Central Luzon and National Capital Region. However, the technology was not widely adopted and little is known about the efficiency of using this type of incubator. Furthermore, literature and studies suggest a wide range of humidity levels inside the incubator and different egg turning frequencies to produce a good hatch. Therefore, it is important to find a method and technique of duck egg incubation that is efficient, less expensive, uses locally available resources, and can easily be adopted by both backyard and commercial raisers.

Thus, this study was conducted to determine the hatchability of duck eggs using different types of incubators under two levels of relative humidity. Also, this study aimed to determine which among the three types of incubators is the most efficient and most economical to be used and be recommended for small-hold, backyard duck raisers, or commercial hatcheries. The results of this study could contribute to the determination of optimum relative humidity which would be needed to attain better hatchability of duck eggs using different types of incubators. Moreover, the results may lead to finding better techniques for hatching duck eggs through the use of locally available resources that would reduce the production cost of quality hatchlings. Through the adoption of technology to be generated, more duck raisers especially the small-hold raisers would be benefited and be able to produce their own ducklings instead of buying them from commercial hatcheries or other suppliers. Furtheremore, the results of this study may be used as a basis for further researches about duck egg incubation.

Materials and methods

Time and place of research

The experiment was conducted at the duck egg hatchery and "balutan" of Mr. Renato C. Ramos in Brgy. Carmen, Zaragosa, Nueva Ecija from June 2020 to July 2020.

Research design

The study was laid out into treatment combinations using a Completely Randomized Design following the 3 x 2 factorial arrangements using three types of incubators under varying relative humidity. Factor A served as the three types of incubators (Cabinet-Type Electric Incubator, Bamboo or “Garong”-Type Incubator, and “Lawanit” Board-Type Incubator) while the Factor B served as the two levels of relative humidity (70% RH and 80%RH).

Experimental treatments and layout

Five thousand and four hundred duck eggs were used in the study. These were randomly divided into six treatment combinations based on the experimental factor. Each composed of 900 eggs. Each treatment combination was further subdivided into three replications with 300 eggs per replicate.

Setting-up of cabinet-type incubator

Six cabinet-type forced-air electric incubators were used. These were prepared by cleaning especially in the interior area. Thermometers and hygrometers were checked and ensured that these were functioning. The experimental eggs were incubated at a temperature ranging from 37.22-37.78^{o}C.

Setting-up of bamboo or “Garong” and “Lawanit” board incubator

Six “Garong” and six “Lawanit” Board Incubators were also used to complete the types of incubators needed in the study. Each incubator had a diameter of 45-50 cm and a height of 85-90 cm. Nylon net with a size of 75 cm x 70 cm was used to contain 100 eggs and also to contain 1.5 kg of unpolished rice/parched rice as a source of heat.

The rice was heated twice a day to about 42^{0}C to 43^{0}C using a vat or cauldron or “kawa” following the procedures in making *balut* (ATBP.PH, 2016). A pan of water was placed at the bottom of the incubator. Bamboo slats were placed on top of the pan before making a pile of heated rice and duck eggs. Five bags of heated unpolished rice (1.5 kg per bag) and three bags of preheated eggs (100 eggs per bag) were piled in an alternating position having the rice at the bottom and on top when the pile was completed.

The incubators were arranged at a distance of at least four inches from each other. Rice hull was used to fill up spaces between incubators. It served as an insulator and to conserve heat energy.

Egg collection

Large-sized eggs, 65-70 grams, were collected from mated flocks in a selected house on the farm. Eggs laid not later than three days were selected as experimental materials.

Egg setting

The 300 eggs were set in each replication of the three types of incubators. Before setting, eggs were pre-heated under the sun for two to three hours with a temperature ranging from 23.9-26.1^{o}C following the procedures stated in Hatchery Tips (2017).

Incubation duration

Experimental eggs were incubated (with a source of heat) for 15 days. On the 16th day after setting, eggs were transferred onto a table in a closed room (no window) until they were hatched.

Egg turning

Eggs in “Garong” and “Lawanit” board were manually turned two times a day following the procedures in making *balut* by ATBP.PH (2016). On the other hand, eggs in electric incubators were turned by switching on the “turn” button. The eggs were turned twice a day until the 15th day of incubation. From 16 days to hatching, eggs were turned four times within 24 hours.

Candling

The first candling was done on the 10th day after egg setting to determine the number of fertile eggs and infertile eggs. The second candling was done on the 15th day of incubation to select fertile eggs but would fail to hatch due to the following reasons: (1) dead embryo, (2) presence of a red ring or blood around the embryo, (3) enlarged blood vessels, and (4) presence of oozing substance (Smith, 2018).

Relative humidity and temperature control

Relative humidity in the “Garong”-Type and “Lawanit” Board-Type Incubators was controlled by placing a moisture pan inside. Rice was heated two times a day until the 15th day of hatching. After 15 days, rice or palay bags were not heated anymore since the embryos could generate enough heat to keep them warm. However, the humidity in Cabinet-Type Electric Incubator was controlled by placing also moisture pan inside. The temperature was set into 37.5 ^{0}C until 15 days of hatching.

Data analysis

The data from the experiment were subjected to analysis of variance in 3x2 factorial in Completely Randomized Design (Gomez and Gomez, 1984). When significant differences were obtained, means were compared using the Least Significant Difference (LSD) at 5% probability. To facilitate calculations and analysis of experimental data, the computer program Statistical Tool for Agricultural Research was used.

Results

Percentage hatchability

The mean of the percentage hatchability of duck eggs as affected by types of incubators under varying relative humidity is shown in Table 1. The results of the study revealed that percent hatchability of duck eggs was not affected by the types of incubators as indicated by their means (M=48.42%, M=50.40%, and M=37.17%) having no significant difference, $F(2,12) = 2.78$, $p = 0.1020$ when analyzed for variance. The percentage hatchability was not affected also by the two levels (70% and 80%) of relative humidity wherein their means (M=44.98% and M=45.68%) were comparable. As for the effect of the interactions of types of incubators and varying percent relative humidity, it was found out that these interactions did not affect the percent hatchability of duck eggs, $F(2,12) = 1.81$, $p = 0.2057$.

Table 1. Mean of the percentage hatchability of duck eggs as affected by types of incubators under varying relative humidity

Factor A – Types of Incubators	**Factor B – Relative Humidity**		**Factor A Mean**
	70% RH	**80% RH**	
Cabinet-Type Electric Incubator	44.83	52.00	**48.42**
Bamboo or “Garong”-Type Incubator	56.70	44.10	**50.40**
“Lawanit” Board-Type Incubator	33.40	40.93	**37.17**
Factor B Mean	**44.98**	**45.68**	

Percentage hatch

The mean of the percentage hatch of duck eggs as affected by types of incubators under varying relative humidity is presented in Table 2. In this study, the percentage hatch of duck eggs was significantly affected by the types of incubators, F(2,12) = 5.73, p = 0.0179.The mean percentage hatch in Cabinet-Type Electric Incubators (M=43.95%) and Bamboo or “Garong”-Type Incubators (M=41.88%) was significantly higher than the mean percentage hatch in “Lawanit”Board-Type Incubator (M=27.68%).

However, the percentage hatch was not affected by the two levels (70% and 80%) of relative humidity with which their means (M=38.03% and M=37.65%) were not significantly different, F(1,12) = 0.01, p = 0.9290. As for the effect of the interaction of types of incubators and varying percent relative humidity, it was revealed that these interactions did not affect the percent hatch of duck eggs.

Table 2. Mean of the percentage hatch of duck eggs as affected by types of incubators under varying relative humidity

Factor A – Types of Incubators	**Factor B – Relative Humidity**		**Factor A Mean**
	70% RH	**80% RH**	
Cabinet-Type Electric Incubator	39.00	48.90	**43.95 a**
Bamboo or “Garong”-Type Incubator	48.00	35.77	**41.88 a**
“Lawanit” Board-Type Incubator	27.10	28.27	**27.68 b**
Factor B Mean	**38.03**	**37.65**	

Note: Means followed by the same letter are not significantly different at 5% level of significance by LSD

The most economical type of incubator

The mean of the average cost to hatch a duckling among three types of incubators for 70% and 80% relative humidity is shown in Table 3. In this study, the lowest average cost (₱0.83) to hatch a duckling was determined when using the Bamboo or “Garong”-Type Incubator. It was lower than the cost of using the “Lawanit” Board-Type Incubator and Cabinet-Type Electric Incubator with the average costs of ₱1.12 and ₱4.11, respectively.

Among the three types of incubators under the two levels of relative humidity, it was observed that the lowest average cost (₱0.75) to hatch a duckling was with the use of Bamboo or “Garong”-Type Incubator under 70% while the highest average cost (₱4.47) was by using Cabinet-Type Electric Incubator also under 70% relative humidity. Furthermore, the cost to hatch a ducking was lower (₱1.89) under 80% relative humidity than 70% relative humidity with an average of ₱2.59.

Table 3. Mean average cost (₱) to hatch a duckling using three types of incubators under 70% and 80% relative humidity

Incubator type	Cost to hatch a duckling (₱)		Mean
	70% RH	80% RH	
Cabinet-Type Electric Incubator	4.47	3.75	**4.11**
Bamboo or "Garong"-Type Incubator	0.75	0.91	**0.83**
"Lawanit" Board-Type Incubator	1.22	1.01	**1.12**
Mean	**2.15**	**1.89**	

The mean of the average cost to produce a duckling among three types of incubators for 70% and 80% relative humidity is shown in Table 4. The study revealed that the Bamboo or "Garong"-Type Incubator was the cheapest to use among the three types of incubators to produce a duckling with an average cost of ₱17.70. However, a higher average cost to produce a duckling was realized with the use ofCabinet-Type Electric Incubator and "Lawanit" Board-Type Incubator with the average costs of ₱21.04 and ₱23.72, respectively.

Among the three types of incubators under the two levels of relative humidity, it was observed that the lowest average cost (₱16.02) to produce a duckling was by using Bamboo or "Garong"-Type Incubator under 70% while the highest average cost (₱26.02) was by using the "Lawanit" Board-Type Incubator also under 70% relative humidity. Moreover, it was determined that it was cheaper ((₱20.00) to produce a duckling under 80% relative humidity than under 70% relative humidity with an average cost of ₱21.64.

Table 4. Mean of the average cost (₱) to produce a duckling among three types of incubators for 70% and 80% relative humidity

Incubator type	Cost to hatch a duckling (₱)		Mean
	70% RH	80% RH	
Cabinet-Type Electric Incubator	22.87	19.21	**21.04**
Bamboo or "Garong"-Type Incubator	16.02	19.37	**17.70**
"Lawanit" Board-Type Incubator	26.02	21.42	**23.72**
Mean	**21.64**	**20.00**	

The mean of the average percentage ROI among the three types of incubators for 70% and 80% relative humidity is illustrated in Table 5. Among the three types of incubators, the Bamboo or "Garong"-Type Incubator obtained the highest average percentage return on investment (2.00%) while the "Lawanit" Board-Type Incubator obtained the lowest average ROI (1.21%).

Among the three types of incubators under the two levels of relative humidity, the highest average percentage ROI (2.37%) was obtained when Bamboo or "Garong"-Type Incubator was used under 70%. However, the lowest average percentage ROI (0.99%) was attained when “Lawanit” Board-Type Incubator was used under 70% relative humidity. On the other hand, higher ROI (1.56%) was realized under 80% relative humidity than under 70% relative humidity with an average ROI of 1.54%.

Table 5. Mean of the average percentage (%) return on investment among three types of incubators for 70% and 80% Relative Humidity

Incubator type	% ROI		Mean
	70% RH	80% RH	
Cabinet-Type Electric Incubator	1.25	1.62	**1.44**
Bamboo or “Garong”-Type Incubator	2.37	1.62	**2.00**
“Lawanit” Board-Type Incubator	0.99	1.43	**1.21**
Mean	**1.54**	**1.56**	

The most efficient type of incubator

Based on the results of the study, only the percentage hatch was affected by a certain factor - the types of the incubators. The analysis of variance yielded a main effect for the type of incubator, $F(2,12) = 5.73$, $p < .05$, such that the average percentage hatch was significantly higher inCabinet-Type Electric Incubator (M=43.95%) and Bamboo or “Garong”-Type Incubator (M=41.88%) than in“Lawanit”Board-Type Incubator (M=27.68%) (see Table 2). The main effects of humidity and interaction were non-significant, $F(1,12) = 0.01$, $p > .05$ and $F(2,12) = 2.27$, $p > .05$, respectively. Therefore, the most efficient types of incubators are the Cabinet-Type Electric Incubator and the Bamboo or “Garong”-Type Incubator.

Discussion

Commercial incubators of varying capacities are being used by *balut* and duck producers. However, the cost of procurement and operation, and the effectiveness and cost-efficiency in terms of promoting greater hatchability of these incubators are the major concerns needed to be answered. Artificial incubators made from locally available materials are being used by hatcheries in Central Luzon and National Capital Region. However, the technology was not widely adopted and little is known about the efficiency of using this type of incubator. The study was conducted to determine the effect of types of incubators under varying relative humidity on the different hatching parameters.

This study demonstrated that the hatchability of fertile duck eggs was not affected by types of incubators ($p = 0.1020$), by the two levels (70% and 80%)

of relative humidity, and the interactions of types of incubators and varying percent relative humidity (p = 0.2057) when analyzed for variance.This result is parallel with the study of Indarsih *et al.* (2019) which revealed that the sawdust incubator gave similar fertility, hatchability, and embryonic mortality values as the electric incubator. Also, this result is associated with the findings of the study Bruzual *et al.* (2000), whichpointed out that fertile hatchability was optimum when incubated at 53% relative humidity. The findings of Bruzual *et al.* (2000), is supported by Hitchener (2017) and Daniels (2020) who recommended that the ideal relative humidity is at 55%.

The percentage hatch of duck eggs was significantly affected by the types of incubators (p = 0.0179). In this experiment, the mean percentage hatch in Cabinet-Type Electric incubators (M=43.95%) and Bamboo or "Garong"-Type Incubators (M=41.88%) was significantly higher than the mean percentage hatch in "Lawanit" Board-Type Incubator (M=27.68%). Boleli *et al*. (2016) explained that this is because the latter provides better incubation physical conditions such as ventilation, egg turning, and egg position, which may affect hatchability. However, the percentage hatch was not affected by the two levels (70% and 80%) of relative humidity and the interaction of types of incubators and varying percent relative humidity. These results could be correlated to the statement of Paniago (2005) as specified by Boleli *et al.* (2016) that despite the technological advances of modern incubation machines, still, the quality of labor both inside and outside the hatcheries determines the success of incubation.

The most economical type of incubator was determined based on the following aspects: (1) cost to hatch a duckling; (2) cost to produce a duckling; and (3) percentage ROI.In this study, the use of Bamboo or "Garong"-Type Incubator indicated the lowest cost (₱0.83) to hatch a duckling, the cheapest (₱17.70) to produce a duckling, and has the highest ROI of 2.00%.

Among the three types of incubators under the two levels of relative humidity, it was observed that the cost to hatch and the cost to produce a duckling was lower under 80% relative humiditywith an average cost of ₱1.89 and ₱20.00 respectively against ₱2.15 and ₱21.64 under 70% relative humidity. Higher ROI (1.56%) was also observed when the eggs were incubated under 80% RH than 70% RH with an average ROI of 1.54%. Moreover, the determination of most economical type of incubator is greatly affected by the hatchability of fertile duck eggs from the specific incubator. This means that the higher the hatchability of an egg from a certain incubator, the lower the cost that may incur to hatch or to produce a duckling. These results are supported by the results of the experiments conducted by El-Hanoun and Mossad (2008) pointing out that the hatchability of fertile Pekin Duck eggs could be improved by raising the relative humidity (RH) to 80% during the period of 14-28 days of incubation. Their experiments are related to the study of Onbasilar *et al*. (2014) which revealed that hatchability of set and fertile eggs of Pekin Ducks were higher when incubated at 37.5^0C and sprayed with warm water (25-28^0C) from day 4 to day 25 of incubation.

The most efficient type of incubator was determined only when the types of incubators, relative humidity, and the interaction effect of incubator and humidity have a significant effect on the hatching parameters. These conditions were discussed by Boleli *et al.* (2016) in their article regarding optimizing production efficiency that includes manipulation of thermal incubation conditions and the integrated effect of factors that influence incubation. In this present study, only the percentage hatch was affected by a certain factor, the types of the incubators, which revealed that a significantly higher percentage hatch was obtained in Cabinet-Type Electric Incubator and Bamboo or “Garong”-Type Incubator than in “Lawanit” Board-Type Incubator. In addition, all the hatching parameters were not significantly affected by two levels of relative humidity. Therefore, the effects of 70% and 80% relative humiditiesare comparative.

In summary, the study showed that the Cabinet-Type Electric Incubator and Bamboo or “Garong”-Type Incubator yield a significantly higher number of hatch eggs than “Lawanit” Board-Type Incubator. Also, the Cabinet-Type Electric Incubator and Bamboo or “Garong”-Type Incubators were the most efficient types of incubators. Bamboo or “Garong”-Type Incubator was the most economical (lowest cost to hatch and to produce duckling and highest % ROI) type of incubator to use.

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