



NIGERIAN JOURNAL OF GENETICS

VOLUME 31, 2017



TETFUND-SUPPORTED PRODUCTION

Published by The Genetics Society of Nigeria

University of Ife
Business Manager:
Dr. O.F. Owolade
L.A.R. & T.,
Obafemi Awolowo University,
P.M.B. 5029,
Moor Plantation, Ibadan
ofowolade@softhome.net

EDITORIAL ADVISORY COUNCIL

Professor Kayode Adetugbo
(Medical Genetics)
Department of Chemical Pathology,
Hematology and Immunology
Obafemi Awolowo University
Ile-Ife, Nigeria

Professor I.U. Obi
(Plant Breeding)
Department of Crop Science
University of Nigeria
Nsukka, Nigeria

Professor N.I. Dim
(Animal Breeding)
Department of Animal Science
Ahmadu Bello University,
Samaru, Zaria, Nigeria

Professor J.A. Adegoke
(Molecular Genetics)
Department of Zoology
Obafemi Awolowo University
Ile-Ife, Nigeria

Professor Omotoye Olorode
(Plant Genetics)
Department of Botany
Obafemi Awolowo University
Ile-Ife, Nigeria

Professor M.E. Aken 'Ova
(Plant Breeding)
Department of Agronomy
University of Ibadan
Ibadan, Nigeria

Professor (Mrs.) O.A. Adebambo
(Animal Breeding)
Department of Animal Breeding and
Genetics
University of Agriculture,
P.M.B. 2240, Abeokuta, Nigeria

STATISTICAL MODELING OF CLIMATIC AND INCUBATOR CONDITIONS FOR HATCHABILITY OF JAPANESE QUAIL (*COTURNIX COTURNIX JAPONICA*) EGGS

¹I.I Adedibu*, ¹H.Y. Abbaya, ¹A.O. Yusuf and ²F.E. Sola-Ojo

¹Department of Animal Science, Ahmadu Bello University, Zaria, Nigeria. ²Department of Animal Production, University of Ilorin, ilipinyomi@yahoo.com +2348036001668

ABSTRACT

The study was undertaken to verify the relationship between hatchability of quail eggs and environmental temperature and humidity (ET; EH) as well as incubator temperature and humidity (IT, IH), and to predict the hatchability of the eggs using ET, EH, IT, IH. A total number of 1421 and 2393 quail eggs were set in the late rainy and dry cold season respectively. Artificial Neural Network (ANN) and Multiple Linear Regression (MLR) were used to predict hatchability while correlation studies were computed for the relationship. There were moderate negative relationships between hatchability of quail eggs and ET and EH. The four factors ET, EH, IT and IH could account for 95 and 30 percent of hatchability of the eggs using the ANN and MLR in the rainy season but 21 percent using ANN and MLR in dry season.

INTRODUCTION

The knowledge of the environmental conditions in which fertile eggs are kept before setting in the incubator is essential for optimum hatchability in tropical climes. According to Naas (2008), the environmental conditions in which eggs are kept before incubation influence fungi and carbon dioxide concentrations, which in turn affect their hatchability. Egg quality of the fertile eggs could also be negatively influenced when ambient temperature is very high (Tona *et al.*, 2007) and this will affect hatchability. Humidity and temperature have significant influence on the duration of incubation and an indirect effect on embryonic viability and hatch weight of chick (Morita *et al.*, 2010). The rate of metabolism of egg yolk, consumption and mobilization of egg albumen including the development of the embryo during incubation is highly subjected to the incubation temperature (Deeming and Ferguson, 1991). Previous studies have standardized the optimal incubator temperature and relative humidity for eggs from several species of

livestock including: duck (Cheng *et al.*, 2005), turkey (Applegate *et al.*, 1999), broiler chicken (Van Brecht *et al.*, 2003) and quails (Dudusola, 2013). However, these studies have not taken cognizance of the influence of ambient temperature and relative humidity in the locations where the fertile eggs were kept prior to incubation. There was no previous work known to the authors on the prediction of hatchability of quail eggs using the incubator temperature and humidity. The objectives of the study are

1. To model the hatchability of quail eggs from environmental and incubator temperatures and humidity.
2. To estimate the relationship between hatchability of quail eggs and environmental temperatures and humidity.

MATERIALS AND METHODS

Experimental site

The study was conducted in the Poultry unit of the Department of Animal Science Teaching and Research farm, Ahmadu

Bello University, Zaria. Zaria is located in the Northern Guinea Savannah ecological zone of Nigeria. The area lies between Latitude 11°11'N and Longitude 7°38'E, at an altitude of 686 m above sea level. The climate is relatively dry, with a mean annual rainfall of 700-1400 mm, occurring between the month of April and September (Akpa *et al.*, 2002; Ovimaps, 2015).

Experimental birds and incubation condition

The experimental animals consisted of adult (4 weeks old) 150 males and 250 females. They were fed a breeder diet. Water was served *ad libitum* throughout the duration of the experiment. A mating ratio of 1:2 was used to ensure high fertility (Dogan *et al.*, 2013). Mating took place for the first time at seven weeks of age; however collection of eggs for hatching was done at nine weeks of age (Daikwo, 2011). The eggs were collected twice daily for a 7-day period. These eggs were stored under an electric fan in a room (room temperature was about 25 °C) away from direct sun rays. (At the end of the 7th day, the eggs were screen to ensure suitability for incubation, fumigated and placed in an incubator (Chick Master®, Model 2002) maintained at a temperature of 37.8°C and 65-75% relative humidity. On the 15th day of incubation, the eggs were candled and those that were fertile were transferred to the hatcher (37.8°C; 90% humidity) for the last three days of incubation. The hatched chicks were collected on the 18th day of incubation

Data collection

The data collected include the following; The total number of eggs set: these were the total number of eggs which had been screened after collection from the hens and found suitable for incubation.

The number of fertile eggs: these were the eggs that had growing embryos on candling on the 15th day of incubation.

The number of hatched eggs was those fertile eggs from which live chicks emerged on the 18th day of incubation.

Daily average ambient temperature and relative humidity (RH) were sourced from the Institute of Agricultural Research (IAR), Ahmadu Bello University, Zaria meteorological station situated within the same premises as the experiment.

The incubator temperature and relative humidity were set at 37.8°C and 65-75% respectively in the first 15 days of incubation and 37.8°C; 90% respectively in the last three days of incubation.

Hatchability was calculated as:

$$\text{Hatchability \%} = \frac{\text{Number of eggs hatched}}{\text{Number of fertile eggs}} \times 100$$

Data analysis

Artificial Neural Network (ANN) computation

The whole data set for environmental parameters were separated at random into two subsets (training and testing) using a supervised neural network. The training set consisted of 75 percent (experimental) and testing subset comprising of 25 percent (control). The training sets were used to train the neural network models and the testing sets were used to validate the models. The network was tested with seven hidden layers with 3 - 25 neurons in each hidden layer to optimize the environmental parameters. Initial weights of the matrix and bias matrix were randomly initialized between minus one and one. A nonlinear transformation (or activation) function tangent sigmoid (eq. 1) were used to compute the output from summation of weighted inputs of neurons in each hidden layer. A pure linear transformation function was used as output layer for getting network response.

$$f(x) = \frac{1}{1 + e^{-x}}$$

Where, x is weighted sum of inputs and α = constant

The modeled network were trained in supervisory mode with Bayesian regularization back propagation algorithm available in ANN tool box of R 3.0.3 interface to evaluate the performance of ANN models.

The accuracy of the model was calculated using the coefficient of determination (R^2). The R^2 is a predictive strength of the hatchability of the quail eggs that was captured by the model.

$$R^2 = 1 - \left[\frac{\sum_{i=1}^N \left(\frac{Q_{exp} - Q_{cal}}{Q_{exp}} \right)^2}{\sum_{i=1}^N \left(\frac{Q_{exp}}{Q_{exp}} \right)^2} \right]$$

$$R^2 \text{ value} = \frac{\text{Total sum of squares} - \text{Error sum of squares}}{\text{Total sum of squares}} \times 100$$

Q_{exp} = Observed value

Q_{cal} = Predicted value

N = Number of observation

Multiple Linear Regressions

This was used to calculate the best linear combination of environmental parameters that could best explain the expected hatchability. The model used was;

$$Y = a + b_1x_1 + b_2x_2 + b_3x_3 + \dots + b_nx_n$$

Where:

Y = the dependent variable (hatchability)

a = the intercept of regression curve on y -axis

b_i = the partial regression coefficient associated with respective independent variable x_i .

x_i = the independent variables (environmental temperature, incubator temperature incubator humidity, relative humidity)

Correlation study

The degree of association between all pairs of metric variables was computed for hatchability and environmental parameters using Correlation procedure of the SAS 9.2 (2003) package.

$$\text{Phenotypic correlation } r = \frac{\text{COV}_{xy}}{\sqrt{\sigma^2_x \sigma^2_y}}$$

Where:

σ^2_x = variance of x

σ^2_y = variance of y

σ^2_{xy} = covariance between x and y

Variables x and y are assumed to be random normal variables jointly distributed with a bivariate normal distribution.

RESULTS AND DISCUSSION

The temperature of the quail breeders' pen used for this experiment (Table 1) is above the optimum (Tona *et al.*, 2007) poultry house temperature in the rainy season. Ideally, the poultry house temperature should be kept constant at 25°C in the summer (Tona *et al.*, 2007).

The storage temperature is the most crucial factor for fertile egg (Tona *et al.*, 2003, 2004). Fertile eggs should be stored at physiological zero temperature which is between 13-17°C for chicken (Tona *et al.*, 2007). Decupere and Michels (1992) put the physiological zero or holding temperature for stored chicken eggs as 19-28°C. This condition will help the eggs cool to below physiological zero as this prevents cell multiplication and abnormal embryos (Tona *et al.*, 2007).

Hatchability of the quail eggs had a negative correlation with environmental temperature (Figure 1). This indicates that any increase in ambient temperature in the rainy season would be associated with a lower hatchability of the eggs (Table 2). This is in line with the report of Tona *et al.* (2007) that hatchability of eggs is lower during the summer months which is characterized with high ambient temperature. Tona *et al.* (2007) suggested

the installation of cooling systems in egg storage rooms and incubator rooms to reduce the impact of high ambient temperature. The incubator temperature and incubator humidity had a highly significant and positive relationship. Clauer (2007) indicated that although incubator temperature, humidity, turning of the eggs and ventilation are essential in hatchery operation, but the first two (*i.e.* incubator temperature and humidity) are the most critical. This indicated that the incubator conditions (temperature and humidity) were optimal for the quail eggs incubation which was why there were significantly high positive correlation. An optimal incubator temperature and humidity such as this would prevent moisture loss from the quail eggs and enhance high hatchability (Nakage, 2003). Evaporative loss from the eggs could have informed the environmental humidity having a very low and insignificant correlation with hatchability in the rainy season (Figure 1).

Prediction of hatchability using environmental variables

The four predictors of hatchability; environmental temperature, incubator temperature, incubator humidity, relative humidity; in the rainy season (Table 3) using the artificial neural network (ANN) model could predict with 95 percent accuracy. The 95 percent accuracy using the ANN model has shown that hatchability of fertile eggs in the rainy season depends not only on genetic factor but also non-genetic factors such as environmental influence as well as incubator conditions as has also been reported by Tona *et al.*, (2007). The four predictors using the multiple linear regression (MLR) model could predict with only 30 percent accuracy (Table 2).

The four parameters were useful in the prediction of hatchability with up to 21 percent accuracy for the two models (Table 4) in the dry season. This could be that prediction of hatchability in the cold dry season is not influenced by ambient temperature and humidity as is the norm in the summer/ rainy season (Tona *et al.* 2007).

CONCLUSION

The four factors (ET, EH, IT and IH) could account for 95 and 30 percent of hatchability of the eggs using the ANN and MLR in the rainy season but only 21 percent in dry season thus quail breeders and farmers could consider installing apparatus which could optimize environmental temperature and humidity in breeder pens so as to maximize for better hatchability.

REFERENCES

- Akpa, G. N., Asirbo, O. E, N., Oni, O. O., Alawa, J. P., Dim, N. I., Asinwo, O. A. AND Abubakar, B. Y. (2002). Milk production by Agropastoral Red Sokoto Goats in Nigeria. *Tropical Animal Health and Production*. 34(6):525-533.
- Applegate, T.J., Dibner, J. J., Kitchell, M. L., Uni, Z and Lilburn, M. S. (1999). Effect of turkey (*meleagrisgallopavo*) breeder hen age and egg size on poult development.2 intestinal villus growth, enterocyte migration and proliferation of the turkey poult. *Comp. Biochem. and Physiol. Pt. B*124: 381-389.
- Cheng, Y. S., Rouvier, R. and Poivvey, J. P. (2005). Selection responses in duration of fertility and its consequences on hatchability in the

intergeneric crossbreeding of ducks. *British Poultry Science*. 46(5): 565-571.

Clauer, P.J. (2007). Incubating Eggs. Virginia Cooperative Extension. <https://pub.ext.vt.edu/20102/2902-1090-pdf.pdf> 2.45pm 14/02/2017

Daikwo, I.S. (2011). *Genetic Studies on Japanese quail (Coturnixcoturnix japonica) in a tropical environment*. Ph.D. Thesis submitted to College of Animal Science, University of Agriculture, Makurdi, Nigeria, Pp 167.

Decuypere, E. and Mitchels, H. (1992). Incubation temperature as a management tool: A review. *World's Poultry Science Journal*. 48: 28-38

Deeming, D.C. and Ferguson, M.W.F. (1991). Physiological effects of incubation temperature on embryonic development in reptiles and birds. Chapter 10. Pages 147-172 in *Egg Incubation*. Deeming, D. C. and Ferguson, M. W. F. ED. Cambridge University Press, Cambridge, UK.

Dogan, N., Ali, A. and Tolga, S. (2013). Effect of cage type and mating ratio on Fertility of Japanese quails (*CoturnixCoturnix japonica*) eggs. *Agricultural Science Development*. 2(1): 4-7.

Dudusola, I.O. (2013). The effect of parental age and egg weight on fertility, hatchability and day-old chick weight of Japanese quail (*Cortunixcortunix japonica*). *Standard Research Journal of Agricultural Sciences*. 2: 13-16.

Morita, V.S., Boleli, I.C. and Oliveira, J.A. (2010). Hematological and incubation parameters of chicks from young breeder eggs: variation with sex and incubation temperature. *International Journal of Poultry Science*. 9: 606-612.

Naas, I.A., Gigli, A.C.S., Baracho, M.S., Almeida-Paz, I.C.L. and Salgado, D.O. (2008). Estimating the impact of environmental condition on hatching results using multivariable analysis. *Brazilian Journal of Poultry Science*. 10(4): 215 – 222.

Nakage, E.S., Cardozo, J.P., Pereira, G.T., Queiroz, S.A. and Boleli, I.C. (2003). Effect of temperature on incubation period, embryonic mortality, hatch rate, egg water loss and partridge chick weight (*Rhynchotus rufescens*). *Revista Brasileira Cientica Avicola*. Vol.5 no.2 Campinas May /Aug. 2003
<http://dx.doi.org/10.1590/S1516-635X2003000200007>

OVIMAPS. (2015). Ovimap location: ovi earth imagery date 23th October, 2014.

SAS. (2002). Statistical users guide. SAS. Int., Cary, NC. USA.

Tona, K., Bamelis, F., De Ketelaere, B., Bruggeman, V., Moraes, V.M.B., Buyse, J., Onagbesan, O. and Decuypere, E. (2003). Effects of Egg Storage Time on Spread of Hatch, Chick Quality and Chick Juvenile Growth. *Poultry Science*. 82: 736-741.

Tona, K., Onagbesan, O., De Ketelaere, B., Decuypere, E. and Bruggeman, V. (2004): Effects of Age of Broiler Breeders and Egg Storage on Egg Quality, Hatchability, Chick Quality, Chick Weight and Chick Post-Hatch Growth to 42 Days. *Journal of Applied Poultry Research*. 13: 10-18.

Tona, K., Onagbesan, O., Ketelaere, B. D., Bruggeman, V. and Decuypere, E. (2007). A model for predicting

hatchability as a function of flock age, reference hatchability, storage time and season. *Archiv Fur Geflugelkunde*. 17(1) S: 30-34

Van-Brecht, A., Aerts, J. M., Degraeve, P. and Berckmans, D. (2003). Quantification and control of the spatiotemporal gradients of air speed and air temperature in an incubator. *Poultry Sciences*. 82(11): 1677-1687.

Table
breeder
Season
Rainy

Table 1: Environment Temperature and Environment relative humidity of the quail breeders' pen

Season	Number of observations	Parameter	Mean $\pm$ S.D
Rainy Season	July	Minimum relative humidity	79 $\pm$ 6.44
		Maximum relative humidity	68.27 $\pm$ 12.80
		Mean Relative humidity	73.63 $\pm$ 7.06
		Maximum Temperature	30.63 $\pm$ 1.90
		Minimum Temperature	20.07 $\pm$ 1.26
		Mean daily Temperature	25.35 $\pm$ 1.25
	August	Minimum relative humidity	82 $\pm$ 4.33
		Maximum relative humidity	72 $\pm$ 10.59
		MeanRelative humidity	77 $\pm$ 5.98
		Maximum Temperature	30 $\pm$ 1.42
		Minimum Temperature	20 $\pm$ 1.01
		Mean daily Temperature	25 $\pm$ 0.85
Dry Season	September	Minimum relative humidity	77 $\pm$ 4.51
		Maximum relative humidity	65 $\pm$ 9.07
		MeanRelative humidity	71 $\pm$ 5.24
		Maximum Temperature	32 $\pm$ 1.47
		Minimum Temperature	25 $\pm$ 1.64
		Mean daily Temperature	29 $\pm$ 1.46
	October	Minimum relative humidity	58 $\pm$ 21.65
		Maximum relative humidity	53 $\pm$ 21.35
		Relative humidity	56 $\pm$ 18.87
		Maximum Temperature	33 $\pm$ 1.38
		Minimum Temperature	18 $\pm$ 2.84
		Mean daily Temperature	26 $\pm$ 1.28
	November	Minimum relative humidity	21 $\pm$ 5.53
		Maximum relative humidity	23 $\pm$ 4.69
		MeanRelative humidity	22 $\pm$ 4.48
		Maximum Temperature	34 $\pm$ 1.66
		Minimum Temperature	13 $\pm$ 1.58
		Mean daily Temperature	23 $\pm$ 1.03
December		Minimum relative humidity	21 $\pm$ 11.03
		Maximum relative humidity	18 $\pm$ 7.32
		MeanRelative humidity	19 $\pm$ 7.96
		Maximum Temperature	32 $\pm$ 3.18
		Minimum Temperature	15 $\pm$ 3.29
		Mean daily Temperature	25 $\pm$ 2.12

Source: Institute of Agricultural Research (IAR), Ahmadu Bello University

Table 2: Reproductive performance of Japanese quail eggs in the late rainy and dry cold season

Traits	Late rainy	Dry cold
The total number of eggs set	1421.00	2393
The number of fertile eggs	1246.00	1842
The number of hatched eggs	737.0	1466
The number of un-hatched eggs	509.00	376.0

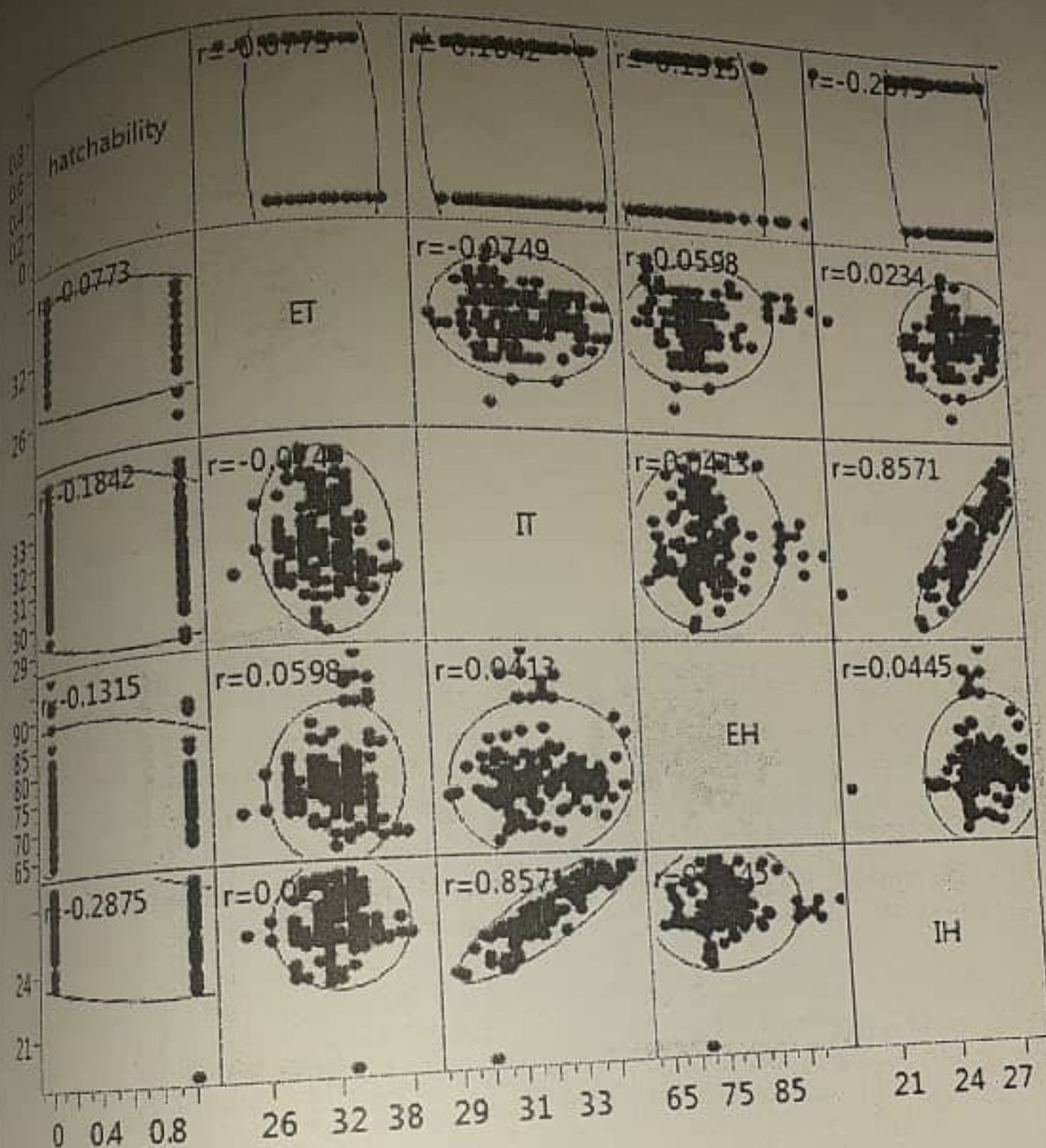
Table 3: Prediction of hatchability of quail eggs using two statistical models in the rainy season

Models	Model equation	R ²	SE	RMSE
ANN	Hatchability=83.22-18.27*ET+40.66*IT+2.24*IH+0.08*RH	0.95	0.04	1.50
MLR	Hatchability=79.89+3.45*ET+10.26*IT+0.12*IH+1.86*RH	0.30	0.09	1.78

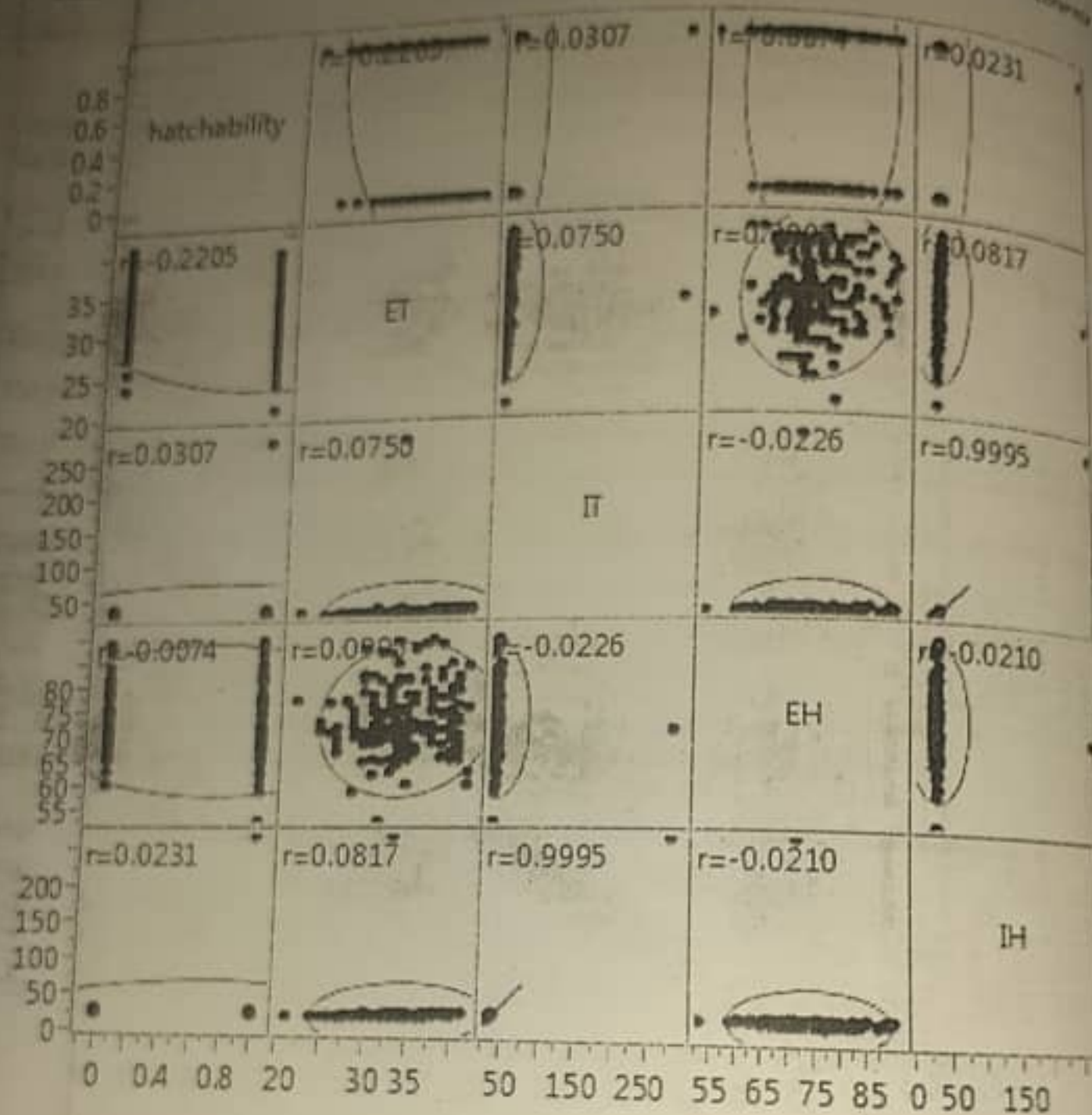
ET: Environmental temperature, IT: Incubator temperature, IH: Incubator humidity, RH: relative humidity, SE: standard error R²: RMSE: root mean square error

Table 4: Prediction of hatchability of quail eggs using two statistical models in the dry season

Models	Model equation	R ²	SE	RMSE
ANN	Hatchability=77.02-0.11*AT+0.45*IT+0.06*IH+0.03*RH	0.21	0.13	1.65
MLR	Hatchability=75.45+0.14*AT+0.18*IT+0.003*IH+0.01*RH	0.21	0.07	1.50



IT: incubator temperature; IH: incubator humidity; ET: environmental temperature; EH: environmental humidity
 Figure 1: The correlation estimates between hatchability and environmental measures in rainy season



IT: incubator temperature; IH: incubator humidity; ET: environmental temperature; EH: environmental humidity
 Figure 2: The correlation estimates between hatchability and environmental measures in dry season