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STATISTICAL MODEL FOR STUDYING THE EFFECT OF AIR POLLUTION ON PRODUCTIVE EFFICIENCY OF CHICKEN FARMS

Fouda, M.M, Alabbasi,A.M[1],Abo El-fadl, E.A.and Badr, A. A

Department of Husbandry and Development of Animal Wealth, Faculty of Veterinary Medicine, Mansoura University.
[1]Department of Biostatistics and Demography, Institute of Statistical Studies and Research, Cairo University.

ABSTRACT

This study was carried out through field survey of 209 chicken farms records of 10 broiler farms and 25 layer farms in different regions of Dakahlia province and Damietta province during the period extended from 2008-2018 . (110) cycles of broiler farms and the other 99 cycles were from layer farms. Records included broiler breeds as Ross, Cobb, Hubbard, Arbor Acres, Sasso and Shaver. Several layer breeds were used in the study as Lohman, Bovans and Fayumi. Data were collected, arranged, Summarized and then statistically analyzed using the computer program SPSS/PC^{+} "Version 20".

This study was conducted to study the effect of air pollution on productive efficiency of broiler and layer farms. Regression analysis methods as stepwise , poisson and linear correlation were used to study the effect of chemical air pollution with ammonia and carbon dioxide on total production (total meat production / kg in broiler chicken and total egg production in layer chicken). The results showed that air pollution affect significantly ($P < 0.05$) on the total number of egg production by decreasing it about 19.7%. Meanwhile, air pollution had significant ($P < 0.05$) and negative correlation on total meat production.

INTRODUCTION

Chicken keeping has many advantages as chicken birds are good in converting the feed into protein in meat and eggs, production costs are low in comparison with other livestock with high benefits so, chicken production has a high productive efficiency **(Ojo, 2003)**. It has short payback period, which mean short production cycle in broiler chicken.

In many husbandry fields, the main aim in chicken breeding is to have high production level with low cost. In order for the chicken to give high production, it should kept in adequate environment. An adequate environment inside poultry house mean physical (heat, humidity and air movement) and chemical factors as ammonia and carbon dioxide in the air **(Kocaman et al., 2006)**.

Air pollution derived from the gaseous products of animal respiration and microbiological decomposition products of manure, together with airborne dust and associated disease agents derived from bedding, food and from the animals themselves as stated by **Harry, (1978)**. **WHO, (2015)** stated that pollution of the environment is caused by physical, chemical or biological substances that changed the characters of the air. Pollutants of major public health are ammonia, carbon dioxide, carbon monoxide, nitrogen dioxide and sulfur dioxide. Our study studied the effect of chemical air pollution with ammonia and carbon dioxide on productive efficiency of chicken farms. Ammonia results from breakdown of the urea that present in the urine by urease enzyme. Urease is excreted with uric acid wasted feed and undigested feed proteins are additional sources of ammonia in production systems **(Powers, 2004)**.

Gaseous NH_3 is the predominant pollutant in poultry houses. Higher levels have a negative effect on welfare and human health, bird performance and production of chicken **(Costa et al., 2012)**. Reduction in feed consumption, feed efficiency, live body weight, carcass condemnation and egg production that caused by hyperammonia level as reported by **(Charles and Payne, (1966); Kling and Quarles (1974); Reece, (1979); Wijaya, (2000); Deaton et al., 1984).**

Co_2 is produced as a waste product of human and animal respiration, combustion of natural gas for heating and cooking and decomposition of organic matter **(Knizatova et al., 2010)**. Increasing co_2 levels in broilers during early grow out leading to death as carbon dioxide complete with oxygen to bind with hemoglobin leading to hypoxia then death.Co_2 causes increase in the red blood cell production leading to increase the resistance to blood flow **(Owen et al., 1995).**

According to literatures, chemical air pollution with ammonia and carbon dioxide affect productive efficiency of broiler and layer farms via livability, morality rate, feed conversion ratio, growth rate, marketing age and marketing weight.

This study was carried out to study the effect of chemical air pollution with ammonia and carbon dioxide on total meat production / kg in broiler farms and on total number of egg production of layer farms. Also, studying the effect of starter ration / kg, grower ration / kg , total feed consumption / kg, drugs cost/ L.E, vaccines cost/ L.E, disinfectant cost/ L.E, veterinary supervision cost/ L.E, labor cost/L.E, litter cost/L.E, electricity cost/ L.E, marketing age / day, marketing weight / kg and mortality % on productive efficiency of chicken farms.

MATERIALS AND METHODS

Duration and area of the study:

This investigation was carried out during the period of 2008 – 2018 on cycles of broiler and layer farms in two different provinces including Dakahlia and Damietta.

Methods of data collection:

The data were collected from records of the broiler and layer farms, during which there was an intimate contact with the chicken farms. The data were collected from accurate records in the farms or by research questionnaire methods that were conducted when there are no records in the farms **(Attallah, 2000; Ahmed, 2007)**.

Data collection about chicken farms:

Data were collected from six different broiler breeds (Cobb (1), Ross (2), Hubbard (3), Arbor acres (4), sasso (5) and Shaver (6)) according to the methods done by **Omar (2003).** Moreover, Data were collected from three different layer breeds (Lohman (1), Bovans (2) and Fayumi(3)). Also ,data collected about chemical air pollution with ammonia and carbon dioxide(Air polluted broiler and layer farms were taken the code (1) and non-air polluted broiler and layer farms were taken the code (0)),starter ration/ kg, grower ration /kg , total feed consumption / kg, drugs cost/L.E, vaccines cost/L.E, disinfectant cost/L.E, veterinary supervision cost/L.E, labor cost/L.E, litter cost/L.E, electricity cost/L.E, marketing age /day, marketing weight/ kg and mortality % .

Statistical analysis:

Data were collected, arranged, summarized and statistically analyzed using the computer program **SPSS/PC$^+$ "Version 20"(SPSS, 2010).**

Different statistical methods were used in this study as stepwise and poisson regression.

Stepwise regression:

Stepwise regression is a combination of forward and backward selection techniques, so it requires two significant levels one for adding variables and one for removing variables .Starting the stepwise regression model with backward method by which deleting one variable at a time when you have small number of predictor variables as the regression model progresses then going to forward method by adding one variable at a time when you have large number of predictor variables **(Steyerberg et al., 1999).** The main assumptions for stepwise regression analysis include the sample should be representative of the population, the independent variables should be error free and if the errors are present, model techniques may be done using error invariables, the errors are uncorrelated thus the variance covariance matrix of the errors is diagonal and each non-zero element is the variance of the error, The predictors must be linearly independent or absence of multicorrelation that means it mustn't be possible to express any predictor as a linear combination of the others and absence of autocorrelation that occurs when variable value in specific place and time is correlated with its value in other places and time.

If we imagine that for each value of X, there is a population of Y values, the stepwise regression equation world be:

Model (1) $Y = \alpha + \beta_1 X_1$

Y: Total meat production / kg.

α: Intercept or Constant.

β_1:Regression coefficient for mortality %.

X_1 : Mortality %.

Model (2) $Y = \alpha + \beta_1 X_1 + \beta_2 X_2$

Y: Total meat production / kg.

α: Intercept or Constant.

β_1:Regression coefficient for mortality %.

X_1 : Mortality %.

β_2 : Regression coefficient for drugs cost.

X_2 : Drugs cost / L.E.

The stepwise regression equation deals with the following variables:

X are the independent variables which include chemical air pollution with ammonia and carbon dioxide, breed type, flock size, season of the year, starter ration/kg, grower ration/kg, total feed consumption /kg, drugs cost/L.E, vaccines cost/L.E, disinfectant cost/L.E, veterinary supervision cost/L.E, labor cost/L.E, litter cost/L.E, electricity cost/L.E, marketing age /day and mortality % .

$\hat{Y}$ is the dependent variable, which includes total meat production/kg in broiler farms.

α is the constant term which represents the intercept of the line. It is the value of X when X is equal to zero.

β is the slope of the line and represents the mean change in X for a unit change in X. It describes by how much Y changes on average when X increases by one unit.

Linear correlation:

Refers to how close two variables are to having a linear relationship with each other. Correlations are useful because they can indicate a predictive relationship that can be exploited in practice.

Pearson's product-moment coefficient:

The most familiar measure of dependence between two quantities is the Pearson product-moment correlation coefficient, or "Pearson's correlation coefficient", commonly called simply "the correlation coefficient "of the two variables by the product of their standard deviations. Coefficient from a similar but slightly different idea.

The population correlation coefficient $\rho_{X,Y}$ between two random variables *X* and *Y* with expected values μ_X and μ_Y and standard deviations σ_X and σ_Y is defined as:

$$\rho_{X,Y} = \text{corr}(X,Y) = \frac{cov(X,Y)}{\sigma X \sigma Y} = \frac{E(X-\mu x)(Y-\mu y)}{\sigma X \sigma Y}$$

Where E is the expected value operator, cov means covariance, and corr is a widely used alternative notation for the correlation coefficient.

The Pearson correlation is +1 in the case of a perfect direct (increasing) linear relationship (correlation), −1 in the case of a perfect decreasing (inverse) linear relationship (anticorrelation), and some value in the open interval (−1, 1) in all other cases, indicating the degree of linear dependence between the variables. As it approaches zero there is less of a relationship (closer to uncorrelated). The closer the coefficient is to either −1 or 1, the stronger the correlation between the variables.

If we have a series of n measurements of X and Y written as x_i and y_i for I = 1, 2... n, then the sample correlation coefficient can be used to estimate the population Pearson correlation r between X and Y. The sample correlation coefficient is written as:

$$r_{xy} = \frac{\sum_{i=1}^{n}(x_i - x^-)(y_i - y^-)}{(n-1)s_x s_y} = \frac{\sum_{i=1}^{n}(x_i - x^-)(y_i - y^-)}{\sqrt{\sum_{i=1}^{n}(x_i - x^-)^2 \sum_{i=1}^{n}(y_i - y^-)^2}}$$

Where x and y are the sample means of X and Y, and s_x and s_y are the corrected sample standard deviations of X and Y.

The uncorrected form of ***r*** (not standard) can be written as:

$$r_{xy} = \frac{\sum x_i y_i - n x^- y^-}{n s_x s_y}$$

$$r_{xy} = \frac{n\sum x_i y_i - \sum x_i \sum y_i}{\sqrt{n\sum x_i^2 - (\sum x_i)^2}\sqrt{n\sum y_i^2 - (\sum y_i)^2}}$$

Where s_x and s_y are now the uncorrected sample standard deviations of X and Y.

The Pearson correlation ranged from 0 to 0.3 is weak, from o.3 to 0.5 is moderate, from 0.5 to 0.7 strong and from 0.7 to 0.9 very strong **(Boddy and Smith, 2009).**

Detection of air pollution:

Three different air samples were collected from 10 broiler farms at 7, 14 and 30 days from the broiler cycle. Another three air samples were collected from25 layer farms at 1, 6 and 15 month of layer cycle for detection of chemical air pollution by ammonia and carbon dioxide

Detection of ammonia:

Sampling:

A large flask of 1 liter capacity was filled with distilled water and emptying inside the farm at which required air displaced the water. The flask is then stoppered with a cork and paraffin.

Technique:

10 ml H_2SO_4 (N/10) are poured in the flask and shake well for 15 minutes.

Then take 5ml of H_2SO_4 in small beaker and titrate against ammonium Hydroxide using methyl orange as indicator. When the color become yellow estimate the amount of ammonium hydroxide consumed which is noted (X_1).

Repeat the test again by the same manner by using stock solution of H_2SO_4 and notice the amount of ammonium hydroxide consumed(X_2) **(Yimit, 2003)**.

CALCULATION

Ammonia content mg/l = $X_2 - X_1 \times 2 \times 2$

Co₂ detection:

Sampling:

A large flask of 1 liter capacity was filled with distilled water and emptying inside the farm at which required air displaced the water. The flask is then stoppered with a cork and paraffin.

Technique:

10 ml of barium hydroxide solution are poured in the flask shake well for 15 minutes.

CO_2 Combine with barium hydroxide form insoluble $BrCo_3$, which cause turbidity.

Take 1ml of supernatant clear fluid with pipette in small beaker and titrate against oxalic acid using ph.ph as indicator.

When the color disappear estimate the amount of oxalic acid consumed which is noted (X_1).

Repeat the test again by the same manner by using stock solution of barium hydroxide and notice the amount of oxalic acid consumed(X_2) **(Keeling, 1960)**.

Calculation:

CO_2 % = $X_2 - X_1 \times 0.25$

Carbon dioxide level shouldn't exceed 0.1%. If it exceeds 0.1% cause health and environmental problems.

Table (1): ANOVA table.

Model		Sum of Squares	D.F	Mean Square	F	Sig.
1	Regression	65928.637	1	65928.637	535.415	0.000
	Residual	13298.634	108	123.135		
	Total	79227.271	109			
2	Regression	66589.013	2	33294.506	281.883	0.000
	Residual	12638.258	107	118.115		
	Total	79227.271	109			

D.F: Degree of freedom.

Table (2): Variables entered stepwise regression.

Variables Entered	Method
Mortality %	Stepwise (Criteria: Probability of F to enter ≤ 0.05 , Probability of F to remove ≥ 0.1).
Drugs cost / L.E	Stepwise (Criteria: Probability of F to enter ≤ 0.05, Probability of F to remove ≥ 0.1).

Table (3): Model fit measures.

Model	R	R Square	Adjusted R Square	S.E of the Estimate	Durbin-Watson
1	0.912[a]	0.832	0.831	11.0966435	1.55
2	0.917[b]	0.840	0.837	10.8680522	

a. Predictors: (Constant), mortality percent %.
b. Predictors: (Constant), mortality percent %, drugs cost/L.E.
S.E: Standard error .

Table (4): Coefficients of regression.

Model		Unstandardized Coefficients		Standardized Coefficients	T-value	Sig.
		B	S.D	Beta		
1	Constant	194.633	3.050		63.822	0.000
	Mortality %	-2.028	0.088	-0.912	23.139	0.000
2	Constant	183.211	5.679		32.259	0.000
	Mortality %	-2.128	0.096	-0.958	22.214	0.000
	Drugs cost/L.E	0.078	0.033	0.102	2.365	0.020

S.D: Standard deviation

Table(5): Correlation matrix between air pollution and different factors affecting broiler production.

	Parameters	Total meat production/kg	Air pollution
Pearson Correlation	Total meat production/kg		-0.552
	Starter ration/ kg	-0.064	0.180
	Grower ration/kg	0.085	-0.171
	Total ration/kg	0.033	-0.080
	Drugs cost/L.E	-0.324	0.410
	Disinfectant cost/L.E	-0.361	0.336
	Veterinary Supervision/L.E	-0.413	0.431
	Labor cost/L.E	-0.137	-0.005
	Litter cost/L.E	-0.290	0.238
	Electricity cost/L.E	0.031	-0.097
	Age of marketing/days	0.538	-0.530
	Mortality %	-0.912	0.637
	Air pollution	-0.552	1.000
Sig. (1-tailed)	Total meat production/kg		0.000
	Starter ration/ kg	0.254	0.030
	Grower ration/kg	0.189	0.037
	Total ration/kg	0.367	0.202
	Drugs cost/L.E	0.000	0.000
	Disinfectant cost/L.E	0.000	0.000
	Veterinary Supervision/L.E	0.000	0.000
	Labor cost/L.E	0.076	0.481
	Litter cost/L.E	0.001	0.006
	Electricity cost/L.E	0.374	0.157
	Age of marketing/days	0.000	0.000
	Mortality %	0.000	0.000
	Air pollution	0.000	

RESULTS AND DISCUSSION

The first statistical model of broiler farms:

Stepwise regression

ANOVA test:

The results observed in table (1) showed that that was a significant effect ($P < 0.05$) of model 1 that contain mortality % as an independent factor affecting dependent variable(total meat production /100 broilers).Also there was significant effect of model(2)which contain both mortality percent% /100 broilers and drugs cost/100 broilers as an independent factor affecting dependent variable(total meat production /kg/100 broiler .So, we accept the alternative hypothesis(H_A) which said that independent variables(mortality % and drugs cost/L.E) had a significant effect ($P<0.05$) on dependent variable(total meat production/kg).

Variables entered stepwise regression:

The results showed in table (2) indicated that only mortality % and drugs cost / L.E from the independent factors have a significant ($P < 0.05$) effect on total meat production/kg (dependent factor).So, air pollution hadn't any significant ($P < 0.05$) effect on total meat production /kg.

Model fit measures:

The table (3) showed that the value of R^2 for model (1) is 0.831withR=0.912 which mean that mortality % was responsible for 83.1 % changes in total meat production /100 broilers. This explains that mortality % was a major determined factor to total meat production /100 broilers. Meanwhile, the value of R^2 for model (2)was 0.840 with R=0.917 mean that 84% changes in total meat production /100 broilers was occurred due to changes in both mortality % and drugs cost. In comparison between model (1) and model (2), model (2) was better than model (1).This was due to the high value of R^2 and adjusted R^2 in model (2). Adjusted R^2 in model (1) was 0.831, meanwhile in model(2) adjusted R^2 = 0.837. The higher value of R^2 and adjusted R^2, the better the model fit to the data.

Coefficients of regression:

The results observed in table (4) showed that standardized coefficient of model (1) for mortality %($\beta = - 0.912$, $p<0.05$) is significant. This explained that only mortality % is controlled variable on total meat production /100broilers.While in model (2), the standardized coefficient for mortality % ($\beta = - 0.958$, $P < 0.05$) and drugs cost ($\beta = - 0.102$, $P < 0.05$) were significant. This explained that mortality % and drugs cost were independent factors affecting total meat production. As concluded that model (2) was better than model (1). So, air pollution didn't affect significantly ($P < 0.05$) on total meat production.

Stepwise regression equation for model (1) $Y= \alpha + \beta_1 X_1$

Also, stepwise regression equation for model (2) $Y= \alpha + \beta_1 X_1 + \beta_2 X_2$

Specifying this MLR equation in our study can be written from table (5) as the following:

Model (1)Y=194.633-2.028× mortality %

Model (2)Y=183.211-2.128× mortality% + 0.078 × drugs cost

The second statistical model of broiler farms:

Correlation matrix of broiler farms:

Effect of air pollution on total meat production (kg) / 100 broilers:

The results observed in table (5) indicated that, there is a significant (P < 0.05) and negative correlation of air pollution on total meat production /kg. Which means the higher the level of air pollution with ammonia and carbon dioxide, the total meat production decreased.

The results agreed with **Charles and Payne, (1966)** who indicated that air pollution has a significant effect (P<0.05) on total meat production of broilers/kg.

Effect of air pollution on the amount of starter, grower and total rations (kg) /100 broilers:

The results indicated that the air pollution had a significant (P < 0.05) and positive effect on starter ration. Which means the higher the air pollution production, the higher the amount of starter ration consumed.

The results showed that air pollution had a significant (P < 0.05) and negative effect on grower ration. Which means the higher the level of air pollution with ammonia and carbon dioxide, the lower the amount of grower ration consumed.

Air pollution had a significant (P < 0.05) and negative effect on total ration. Which means the higher the level of air pollution with ammonia and carbon dioxide, the lower the amount of total ration consumed.

The results disagreed **Charles and Payne, (1966)** who indicated that air pollution decrease the amount of total feed consumption.

Effect of air pollution on the cost of drugs, disinfectants and veterinary supervision (L.E) / 100 broilers:

The results indicated high significant (P < 0.05) and positive effect of air pollution on drugs cost. Which means the higher the level of air pollution with ammonia and carbon dioxide, the higher the drugs cost.

The air pollution had a significant (P < 0.05) and positive effect on disinfectant cost. Which means the higher the level of air pollution with ammonia and carbon dioxide, the higher the disinfectant cost.

The air pollution had a significant (P < 0.05) and positive effect on veterinary supervision cost. Which means the higher the level of air pollution with ammonia and carbon dioxide, the higher the veterinary supervision cost.

Effect of air pollution on labor, litter and electricity costs (L.E) /100 broilers:

The results showed in table (5) that there was not significance (P < 0.05) between air pollution and labor cost.

Furthermore, the air pollution had a significant (P < 0.05) and positive effect on litter cost. Which means the higher the level of air pollution with ammonia and carbon dioxide, the higher the litter cost.

Moreover, the air pollution didn't have a significant ($P < 0.05$) effect on electricity cost.

Effect of air pollution on mortality %/100 broilers:

The results showed high significant ($P < 0.05$) effect and positive effect of air pollution on mortality percent %. Which means the higher the level of air pollution with ammonia and carbon dioxide, the higher the mortality %.

Effect of air pollution on average marketing age (day) / 100 broilers:

The results showed high significant ($P < 0.05$) effect and negative effect of air pollution on average marketing age. Which means the higher the level of air pollution with ammonia and carbon dioxide, the lower the average marketing age day.

Also, the correlation matrix illustrated the relationship between independent factors(season, breed, starter ration/kg, grower ration/kg, total ration/kg, drugs cost/L.E, disinfectant cost /L.E, veterinary supervision cost/L.E, labor cost/L.E, litter cost/L.E, electricity cost/L.E, age of marketing/day, mortality %, air pollution and dependent variable(total meat production /kg).

From table (5) we can concluded that:

1. **Medium positive correlation ($P < 0.05$) between:**
   1.1. Age of marketing/ day and total meat production/kg (0.538).
2. **Strong (High) negative correlation ($P < 0.05$) between:**
   2.1. Mortality % and total meat production / kg (-0.912).
3. **Medium negative correlation ($P < 0.05$) between:**
   3.1. Air pollution and total meat production / kg (-0.552).
   3.2. Veterinary supervision cost/L.E and total meat production /kg (-0.413).
4. **Weak negative correlation ($P < 0.05$) between:**
   4.1. Drugs cost/L.E and total meat production /kg (-0.324).
5. **Very weak correlation ($P < 0.05$) between:**
   5.1. Disinfectant cost /L.E and total meat production / kg (-0.361).
   5.2. Labor cost/L.E and total meat production /kg (-0.37)
   5.3. Litter cost/L.E and total meat production /kg (-0.290).

CONCLUSION

This study concluded that adequate environment inside chicken house should be kept at optimum level to obtain good profits from chicken farming and to reach to efficient production. Also, air pollution has a significant ($P < 0.05$) and negative correlation on total meat production of broiler farms.

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الملخص العربي

نموذج إحصائي لدراسة تأثير تلوث الهواء على الكفاءة الانتاجية لمزارع الدواجن

محمد محمد فودة- عبد الحميد محمد العباسى[١]- ايمان احمد ابو الفضل- أسماء احمد بدر

قسم الرعاية وتنمية الثروة الحيوانية - كلية الطب البيطري - جامعة المنصورة
قسم الاحصاء الحيوي والسكاني – معهد الدراسات والبحوث الاحصائية – جامعة القاهرة[١]

لقد اجريت هذه الدراسة عن طريق المسح الحقلى على ٢٠٩ دورة دجاج تخص ١٠ مزارع تسمين و٢٥ مزرعة بياض من مزارع في محافظتي الدقهلية ودمياط. ولقد تم تجميع بيانات ١١٠ دورة من مزارع التسمين و٩٩ دورة من مزارع البياض. واشتملت البيانات علي سلالات التسمين التي تضم الروس والكاب والهبرد والاربورايكر والساسو وسلالات البياض التي تضم اللوهمان والبوفانز والفيومي. لقد تم ترتيب البيانات وتلخيصها ثم تحليلها احصائيا واقتصاديا باستخدام برنامج التحليل الإحصائي (SPSS, version 20).

لقد أجريت هذه الدراسة لمعرفة تأثير تلوث الهواء الكيميائي بالأمونيا وغاز ثاني أكسيد الكربون على الكفاءة الإنتاجية لمزارع التسمين والبياض. ولقد تم استخدام نموذج الانحدار المرحلى وانحدار بواسون ومعامل الارتباط والتلازم لدراسة ذلك التاثير على الإنتاج اللحم الكلي في مزارع التسمين وعدد البيض الكلى لمزارع البياض. ولقد أوضحت النتائج ان تلوث الهواء الكيميائى بالامونيا وغاز ثاني أكسيد الكربون أدى الى نقص في عدد البيض الكلي لمزارع البياض بنسبة ١٩,٧% بينما هناك ارتباط عكسي سالب بين تلوث الهواء وإنتاج اللحم الكلى لمزارع التسمين.