Gaziosmanpaşa Üniversitesi Ziraat Fakültesi Dergisi
Journal of Agricultural Faculty of Gaziosmanpasa University
http://ziraatdergi.gop.edu.tr/

Araştırma Makalesi/*Research Article*

JAFAG
ISSN: 1300-2910
E-ISSN: 2147-8848
(2019) 36 (3), 171-176
doi:10.13002/jafag4622

A Path Analysis for Determination of Factors Affecting 305-Day Milk Yield in Jersey Cows

Yalçın TAHTALI[1*] Lütfi BAYYURT[1] Samet Hasan ABACI[2]
[1]Tokat Gaziosmanpasa University, Agriculture Faculty, Department of Animal Science, Tasliciftlik, Tokat,
(orcid.org/0000-0003-0012-0611), (orcid.org/0000-0003-2613-9302)
[2]Ondokuz Mayıs University, Agriculture Faculty, Department of Animal Science, Kurupelit, Samsun,
(orcid.org/0000-0002-1341-4056)
*e-mail: yalcin.tahtali@gop.edu.tr

Alındığı tarih (Received): 31.05.2019 Kabul tarihi (Accepted): 07.08.2019
Online Baskı tarihi (Printed Online): 17.09.2019 Yazılı baskı tarihi (Printed): 17.09.2019

Abstract: The purpose of this paper was to determine the direct, indirect and total effect of age of calving (AC), year of calving (YC), calving season (SC) and lactation length (LL) on 305-day milk yield (305-DMY) in Jersey cows using path analysis. The data used included 1717 lactation yield records of 617 Jersey cows calving from 2002 to 2012 on the Samsun Karakoy State Farm in Turkey. The results showed that AC, YC, SC and LL had statistically important effects on the 305-day milk yield f the Jersey cows. The results further indicated that the direct and total effects of LL on 305-day milk yield were higher than the effect of AC, YC and SC, although the indirect effect of AC on 305-day milk yield was the highest. As a consequence, to facilitate increasing milk yield per cow, the use of the lactation length provides some useful knowledge for management and the genetic evaluation of Jersey cows.

Keywords: Correlation, Jersey cows, Path coefficient

Jersey İneklerinde 305 Günlük Süt Verimini Etkileyen Faktörlerin Belirlenmesi için Bir Path Analizi

Öz: Bu çalışmanın amacı path analizi kullanarak Jersey ineklerinin 305 günlük süt verimleri üzerine buzağılama yaşının(BYaş) buzağılama yılının(BY), buzağılama mevsiminin(BM) ve laktasyon uzunluğunun(LU) doğrudan, dolaylı ve toplam etkilerini belirlemektir. Kullanılan veriler, Türkiye'de Samsun Karaköy Devlet Çiftliği'nde 2002'den 2012'ye kadar buzağılayan 617 Jersey ineğinin 1717 laktasyon verim kayıtlarını içermektedir. Sonuçlar BYaş, BY, BM ve LU' nun Jersey ineklerinin 305 günlük süt verimi üzerinde istatistiksel olarak önemli etkileri olduğunu göstermiştir. Sonuçlar ayrıca LU' nun 305 günlük süt verimi üzerindeki doğrudan ve toplam etkilerinin BYaş' nin, BY ve BM' nin etkisinden daha yüksek olduğunu, ancak BYaş' ın 305 günlük süt verimi üzerindeki dolaylı etkisinin en yüksek olduğunu göstermiştir. Sonuç olarak, inek başına süt verimini arttırılmasını kolaylaştırmak için, laktasyon uzunluğunun kullanılması, Jersey ineklerinin yönetimi ve genetik değerlendirilmesi için bazı yararlı bilgiler sağlamaktadır.

Anahtar kelimeler: Korelasyon, Jersey ineği, Path katsayısı

1. Introduction

The most important aspect of livestock production is to increase the yield achieved and to increase milk yield in dairy cattle. Milk yield is influenced directly or indirectly by various factors such as the age of calving, the year of calving, the season of calving and the length of lactation. Therefore, statistical analyses involving more than one feature can be used for purposes related to reproductive strategies (Unalan and Cebeci 2004; Choi et al. 2005).

It is known that the relationship between statistical variables is determined by the degree and direction of the correlation coefficients, and the mathematical structure of the relationship is determined by regression analysis. However, these approaches are often insufficient to fully account for the relationship between variables. The relationship between the two variables also depends on a third variable. In such a multivariate data structure, any dependent variable may depend on one or more other dependent variables and on independent variables. In this case, correlation and regression analysis may be insufficient to establish the cause–effect relationships. For this reason, this analysis is used to more accurately define the relationships between variables. Path analysis is very closely related to multiple regression analysis and is used to explain dependencies between variables (Anonymous 2015).

Path analysis is the creation of a path diagram to show the relationship between variables, and it is used to determine the strength and direction of the linear relationship. It also includes an investigation of the effects (direct and indirect) on the relationships and the stages of interpretation of these relationships. The creation of the path diagram, which is the most important stage in the development of the path model, is a gradual step-by-step process. By using path analysis, each dependent variable is analyzed with each independent variable and more than one regression analysis is performed. In other words, path analysis is an expanded form of multiple regression analysis. For this reason, linear regression assumptions were applied for the path analysis (Anonymous 2015).

In animal breeding applications, studies using path analysis have begun to increase with the development and accessibility of statistical software (Curtis et al. 1985; Guneri et al. 2015). As we know, few researchers have used this method to estimate the correlation between some environmental factors and the milk yield traits of Jersey cows (Gorgulu 2011). This study aimed to describe the factors affecting 305-DMY and to research the direct, indirect and total effects between the following factors/variables: age of calving (AC), year of calving (YC), calving season (SC) and lactation length (LL), on the 305-DMY of Jersey cows by means of path analysis.

2. Materials and Methods

In this study we used the data from Jersey cattle on the Samsun Karakoy State Farm in Turkey. Three lactation official milk yield records containing monthly recordings of 1717 lactations between May 2002 and June 2012 were used. In addition to this data, the 305-DMY considered to be affected by the AC, YC, SC and LL of the Jersey cows were used.

An analysis by Orhan and Kasıkcı 2002; Gorgulu 2011; Guneri et al. 2015 established the direct and indirect effects of some environmental factors on milk yields in animal breeding. Thus, we used that analysis in this paper to explore the direct, indirect and total effects of AC, YC, SC and LL on the 305-DMY of Jersey cows. Path coefficients were used to define the relative importance of the different direct and indirect causal paths on the dependent variables Korkut et al. 1993; Garson 2008). The coefficients are standardized models of linear regression weights. If taken into consideration in a path diagram, the figure can be used to illustrate the relationship between response variables and independent variables (Figure 1).

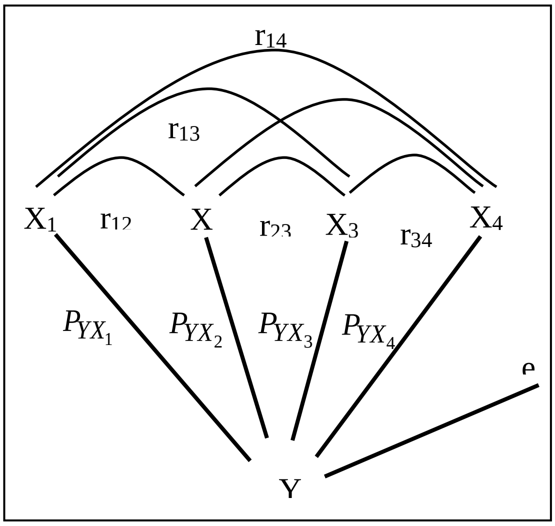

Figure 1. The path diagram for independent variables, X_1 to X_4, and response variable Y. r_{ij} is the correlation coefficient, P_{YXi} is the path coefficient (direct effect), e is the residual effect

Şekil 1. *Bağımsız değişkenler, yanıt değişkeni, korelasyon katsayısı, Path katsayısı ve hata etkisi için Path diyagramı*

It is known that path analysis is based on a multiple regression model. The equation for a multiple regression model is shown below:

$$Y_i=\beta_0+\beta_1X_{i1}+\beta_2X_{i2}+\ldots+\beta pX_{ip}+e_i \quad i=1, 2, 3,\ldots,n \quad (1)$$

In this study, the standardized linear regression equations were used

$$\hat{y}_i = b_0 + b_1 x_{i1} + b_2 x_{i2} + b_3 x_{i3} + b_4 x_{i4} \quad (2)$$

where:

$\hat{y}_i$ = the predicted response variable,

b_i = standardized regression coefficients,

x_{ip} = independent variables (AC, YC, SC and LL)

$$b_i = P_{yx_i} = \hat{b}_i \frac{S_{x_i}}{S_y} \quad (3)$$

where:

b_i = P_{yx_i} = Path coefficient,

$\hat{b}_i$ = Non standardized regression coefficient,

S_{x_i} = Standard deviation of X_i

$$S_{xi} = \sqrt{\sum(x_{ij}-\bar{x}_i)^2}.\frac{1}{n} = \sqrt{\left(\sum x_{ij}^2 - \frac{\left(\sum x_{ij}\right)^2}{n}\right)}.\frac{1}{n} = \sqrt{s_{xx_i}} \quad (4)$$

S_y = Standard deviation of Y

$$S_y = \sqrt{\sum(Y-\bar{Y})^2}.\frac{1}{n} = \sqrt{\left(\sum Y^2 - \frac{\left(\sum Y\right)^2}{n}\right)}.\frac{1}{n} = \sqrt{s_{yy}} \quad (5)$$

The b_i term in equation (3) is the same as the standardized coefficient estimates (Bring 1994).

The data for year of calving, age of calving, lactation length and season of calving were standardized. Thus, the estimated partial regression coefficients from the above equation are called path coefficients. The coefficients or standardized partial regression coefficients can be easily calculated with the following matrix system:

$$\begin{bmatrix} P_{YX_1} \\ P_{YX_2} \\ P_{YX_3} \\ P_{YX_4} \end{bmatrix} = \begin{bmatrix} 1 & r_{X_1X_2} & r_{X_1X_3} & r_{X_1X_4} \\ r_{X_2X_1} & 1 & r_{X_2X_3} & r_{X_2X_4} \\ r_{X_3X_1} & r_{X_3X_2} & 1 & r_{X_3X_4} \\ r_{X_4X_1} & r_{X_4X_2} & r_{X_4X_3} & 1 \end{bmatrix}^{-1} x \begin{bmatrix} r_{YX_1} \\ r_{YX_2} \\ r_{YX_3} \\ r_{YX_4} \end{bmatrix} \quad (6)$$

In Equation (3), the coefficients given by P_{YX_i} were path coefficients (the direct effects) between the independent variable and responsible variable, and $r_{X_iX_j} P_{YX_i}$ symbolizes the indirect effects of the i^th^ independent variable on the responsible variable via the j^th^ independent variable; the term $r_{X_iX_j}$ symbolizes the Pearson correlation coefficients between the i^th^ and j^th^ traits (Topal and Esenboga 2001)

3.Results and Discussion

Descriptive statistics for the properties of Jersey cows (AC, YC, SC, LL and 305-DMY) are presented as sample size (n), mean ± standard deviation, minimum and maximum values that are given in Table 1.

.

Table 1. Descriptive statistics for the examined traits of the Jersey cows
Çizelge 1. Jersey ineklerinin incelenen özellikleri için tanımlayıcı istatistikler

Traits	n	Mean	SD	Min	Max
305-day milk production	1717	4015.8	945.7	867	6988
Age of calving (Monthly)	1717	52.8	20.9	21.9	110.6
Year of calving	1717	2004*	-	2002	2012
Season of calving	1717	2.3	1.0	1	4
Lactation length	1717	299.2	44.9	153	400

n: Number of lactation
**: Mode value instead of mean, SD: Standard Deviation, Season of calving(1: Winter 2: Spring 3: Summer 4:Autumn)*

Table 2 shows the bivariate correlations that relate to the properties of the Jersey cows. All the correlations between 305-DMY and AC, YC, SC and LL were found to be positive and statistically significant (P<0.01). The relationships between LL and YC and SC were insignificant.

Table 2. Bivariate correlations for the traits of the Jersey cows
Çizelge 2. Jersey ineklerinin özellikleri için iki değişkenli korelasyonlar

Traits	305-DMY	AC	YC	SC
AC	0.148**			
YC	0.279**	-0.050*		
SC	-0.089**	0.048*	-0.067**	
LL	0.596**	0.082**	0.034	-0.010

*** (P<0.01) *(P<0.05)*

Regression analysis results are given in Table 3. These results show partial regression coefficients, P values, VIF (Variance Inflation Factor) and tolerance values to explain the relationship between the other properties and the 305-day milk yield of the Jersey cows. The effect of all the selected properties had a significant effect on the 305-day milk yield (P<0.001). Furthermore, multicollinearity problems were not seen because the VIF values for the independent variables were smaller than 10 in Table 3. So, according to F statistics, the regression model is statistically significant at the 1% level (F=337.17).

Table 3. The partial regression coefficients
Çizelge 3. Kısmi regresyon katsayıları

Parameters	AC	YC	SC	LL
Coefficient (b_i)	0.117	0.261	-0.071	0.577
Significant Level (P)	<0.001	<0.001	<0.001	<0.001
VIF values	1.012	1.008	1.007	1.008
Tolerance	0.988	0.992	0.993	0.992

Dependent variable: 305-day milk yield

The path coefficients of the independent variables for 305-DMY in Jersey cows are shown in Table 4. The direct effect of LL on 305-DMY was significant and higher than the other traits. In addition, the direct effect (0.577) in 305-day milk yield was found to be higher than the total indirect effect (0.019). However, the direct effect of SC on 305-DMY was negative and statistically significant. The highest indirect effect was the LL in AC, while the LL in SC had the lowest indirect effect.

Table 4. The correlation coefficients and effects of some properties on the 305-day milk yield in Jersey cows
Çizelge 4. Jersey ineklerinde korelasyon katsayıları ve bazı özelliklerin 305 günlük süt verimi üzerine etkileri

Trait	Correlation coefficient with 305-DMY	Direct effect	Indirect effect				
			AC	YC	SC	LL	Total
AC	0.148**	0.117**		-0.013	-0.003	0.047	0.031
YC	0.279**	0.261**	-0.006		0.005	0.019	0.018
SC	-0.089**	-0.071**	0.006	-0.017	-	-0.006	-0.018
LL	0.596**	0.577**	0.010	0.008	0.001	-	0.019

*** (P<0.01)*

The essential aim of this analysis as regards the selection plan was to get information on indirect variable (Cankaya and Abaci, 2012). AC, YC, SC and LL, which are recorded variables in dairy research,

are important indicators for 305-day milk yield in cows.

The highest correlation was estimated between YC and the 305-DMY of Jersey cows (0.279, P<0.01), and the lowest correlation was between SC and LL (−0.010, P>0.05). Additionally, the correlations between the investigated traits and the 305-DMY are similar to the results of previous papers in Table 2 (Choi et al. 2005; Cankaya et al 2011; Gorgulu 2011; Guneri 2015).

It is clear that LL had the highest effect on the 305-DMY of Jersey cows, while SC had the lowest effect on the model. Multicollinearity problems were not seen between the environmental factors since initial analysis showed that the VIF values (from 1.007 to 1.012) were smaller than 10 and the tolerance values (from 0.988 to 0.993) were greater than 0.1 in all the data in Table 3.

According to the path analysis results in this paper, the selection of LL can be used as an estimation index for the 305-DMY of Jersey cows. The results are similar to the findings of Orhan and Kasıkcı 2002; Mendes et al 2005; Tahtali et al. 2010; Güneri et al. 2015, and also similar to the results of Gorgulu 2011, and Bakır and Cetin 2003.

4. Conclusions

Correlation between 305-DMY and some environmental factors might be misleading if this analysis is not taken into consideration. For this reason, the analysis is very important for determining the factors affecting 305-DMY in Jersey cows. The result showed that the LL can be used as a forecast index for the 305-DMY of Jersey cows, because the direct effect of the LL on 305-DMP of Jersey cows was both positive and higher than AC, YC and SC. So, based on that data a decision can be made on whether a cow can be kept in the herd in terms of its 305-DMY. In conclusion, it can be said that the LL can be used as a selection criteria for both management decisions and the milk yield in Jersey cows.

References

Anonymous 2015. Path analysis (statistics). http://en.wikipedia.org/wiki/Path_analysis_(statistics), Accessed: 03.11.2015.

Bakır G, Çetin M. 2003. Breeding characteristics and milk yield traits of Holstein cattle in Reyhanlı agricultural facility. *Turk J Vet Anim Sci,* 27 (1): 173-180.Bring J: How to standardize regression coefficients, *Am Stat*, 48 (3): 209-213, 1994.

Cankaya S, Kayaalp GT. 2007. Estimation of relationship between live weights and some body measurements in German Farm×Hair crossbred by canonical correlation analysis. *J Anim Prod,* 48, 27-32.

Cankaya S, Unalan A, Soydan E. 2011. Selection of a mathematical model to describe the lactation curves of Jersey cattle. *Arc Tierz,* 54 (1): 27-35.

Cankaya S. Abaci SH. 2012. Path analysis for determination of relationships between some body measurements and live weight of German fawn× hair crossbred kids. *Kafkas Univ Vet Fak Derg,* 18(5): 769-773.

Choi SB, Lee JW, Choy KH, Na KJ, Kim NS. 2005. Estimates of parameters for genetics relationship between reproductive performances and body condition score of Hanwoo cows. *Asian-Aust. J Anim Sci,* 18 (7): 909 (Abstract).

Curtis CR, Erb HN, Sniffen CJ, Smith, RD, Kronfeld DS. 1985. Path analysis of dry period nutrition, postpartum metabolic and reproductive disorders and mastitis in Holstein cows. *J Dairy Sci*, 68, 2347-2360.

Garson GD. 2015. Path analysis from Lecturenotes, 2008. http://hbanaszak.mjr.uw.edu.pl/TempTxt/Garson_2008_PathAnalysis.pdf Accessed:10.07.2015.

Gorgulu O. 2011. Path analysis for milk yield characteristics in Jersey dairy cows. *Asian J Anim Vet Adv,* 6 (2): 182-188.

Guler M, Adak MS, Ulukan H. 2001. Determining relationships among yield and some yield components using path coefficient analysis in chickpea (Cicer arietinum L.). *Eur J Agron,* 14(2): 161-166.

Guneri O, Takma C, Akbaş Y. 2015. Determination of factors affecting 305-day milk production via path analysis on Holstein Friesians. *Kafkas Univ Vet Fak Derg*, 21(2): 219-224.

Korkut ZK, Başer İ, Bilir S. 1993. The studies path coefficient and correlation of drum wheat's. *Symposium of Drum Wheat and Its Products,* Ankara, 183-87.

Mendes M, Karabayır A, Pala A. 2005. Path analysis of the relationships between various body measures and live weight of American Bronze Turkeys under the three different lighting programs. *J Agric Sci*, 11 (2): 184-188.

Orhan H, Kaşıkçı D. 2002. A study on comparison of the correlation, path and partial regression coefficients. *J Anim Prod*, 43(2), 68-78.

Tahtali Y, Şahin A, Ulutaş Z, Şirin E, Abacı SH. 2011. Determination of effective factors for milk yield of Brown Swiss Cattle using by path analysis. *Kafkas Univ Vet Fak Derg,* 17 (5): 859-864.

Topal M, Esenboga N:. 2001. A Study on direct and indirect effects of some factors on weaning weight of a Awassi lambs. *Turk J Vet Anim Sci,* 25, 377-382.

Unalan A, Cebeci Z. 2004. Estimation of Genetic parameters and correlations for the first three lactation milk yields in Holstein Friesian cattle by the REML method. *Turk J Vet Sci*, 28, 1043-1049.