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Path Analysis for Milk Yield Characteristics in Jersey Dairy Cows

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ABSTRACT

This study was made to the direct and indirect influences of some important milk yield components on 305 days milk yield in breeding by adopting correlation and path coefficient analysis. Path analysis was used to determine the interrelationships between age (X_1), number of lactation (X_2), calving season (X_3), lactation period (X_4) and 305 days milk yield (Y) in jersey dairy cattle. For this purpose, milk production record of 898 Jersey cattle raised in 2005 and 2009 years in Koçaş State Farm was used. The results show that age and number of lactation were the most important factors affecting milk yield components. During 5 years, the correlations between age and 305 days milk yield and number of lactation and 305 days milk yield were positive with statistical significance. Age had the highest positive direct effect on 305 days milk yield when data evaluated of 5 years. Number of lactation had a positive and direct effect on 305 days milk yield. The correlation coefficients between calving season and 305 days milk yield were not significant between 2005 and 2009 years.

Key words: Path analysis, relationship, correlation, milk yield, calving season, lactation

INTRODUCTION

Path analysis is an interpretive analysis depending heavily upon the previous knowledge of the subject matter and the investigator's preference for a directional association between variables. Path analysis allows the decomposition of the correlations between two variables (X and Y) in a sum of the direct effect of X on Y and the effects of X on Y via other independent variables in a system of correlations. The goal of the path analysis is to identify possible causal explanations of the correlations observed between a variable response (dependent) and a series of predictor variables (independent) (Abbott *et al.*, 2007).

A path coefficient is a standardized partial regression coefficient that measures the direct impact of one variable on another. It also provides a means of partitioning both direct and indirect effects and effectively measuring the relative importance of casual factors (Ojo *et al.*, 2006).

The advantage of path analysis is that it allows the investigator to develop a conceptual model of causation (including temporal arrangement of variables) prior to the evaluation of relationships between variables (Etherington *et al.*, 1985). According to Sürek and Beşer (2003) path analysis allows the partitioning of the correlation coefficient into its components, one component being the path coefficient that measures the direct effect of a predictor variable upon its response variable; the second component being the indirect effect(s) of a predictor variable on the response variable through the another predictor variable.

Animal breeding methodology in dairy cattle requires an understanding of the responses and relationships between yield-determining traits under the conditions in which the races are to be deployed. Such relationships have been studied a lot using correlation coefficients. Correlation coefficients alone may still not be reliable in selection as they represent simple linear relationships between traits. Further studies have used non-linear connecting paths of influence between traits through further breaking down of correlation coefficients. These influences have been termed path coefficients attributable to direct and indirect causes. Path coefficients give the relative contribution of various yield-determining traits, enabling breeders to decide between direct and indirect selection. Therefore, correlation and general relationships studies between yield-determining traits give an indication of the responses due to selection based on individual traits (Makanda *et al.*, 2009).

Correlation studies have been enabling the breeder to know the strength of relationship between various characters as well as the magnitude and direction of changes expected during selection. Correlation and path coefficient analyses would help to determine the characters whose selection would result in the improvement of a complex character such as yield (Ariyo, 1995). Estimation of simple correlation between various milk yield characters may provide good information necessary for cattle breeders, when selection is based on two or more traits simultaneously. Path coefficient analysis helps to determine the direct effect of traits and their indirect effects on other traits (Yocel *et al.*, 2006).

The objectives for this study were (1) to estimate correlation coefficients for phenotypic characters between milk yield and milk yield components and (2) to evaluate the relative contribution of each component to milk yield using path coefficient analyses. In the current study, an attempt was made to study the direct and indirect influences of some important milk yield components on 305 days milk yield in breeding by adopting correlation and path coefficient analysis. The result might be used to adopt selection criteria in further studies. It may increase selection efficiency. Therefore breeders save time and expenses during selection.

MATERIALS AND METHODS

The main factors were the age, number of lactations, lactation period, calving season and 305 days milk yield in the analysis of data were obtained from Jersey Cattle in Koçaş State Farm Aksaray, Turkey. The data were collected during the period of on 10th January 2005 and 30th December 2009. SPSS (Windows version of SPSS, release 13.00) and AMOS programs was used for the application of path analysis and correlation analysis.

Path analysis is considered as an extension of the regression model. Path analysis is a multiple regression technique that allows a second dimension-time sequence-to enter into the analysis (Curtis *et al.*, 1985). Path analysis, as used in this study, utilizes standard multiple linear regression techniques to estimate the path coefficients (p_{yx}), that is, the effect of one variable on another. The standardized regression coefficients from these multiple regressions were the path coefficients (Erb *et al.*, 1981).

In path analysis, each correlation can be decomposed into four types of effects; by definition, the Direct Effect (DE) of a variable is that effect which is not mediated by an intervening variable (p_{21}, Fig. 1a) and also equals to correlation coefficient between two variables. The Indirect Effect (IE) is that effect mediated by one or more independent variables (p_{21}* p_{32}, Fig. 1b). The Unanalyzed Effect (UE) is that effect occurs as a result of the relationships between two causes (p_{21}* p_{32}, Fig. 1c). The Spurious Effect (SE) is the paths connecting with two variables but affected by two causes (p_{21}* p_{31}, Fig. 1d).

In path analysis, 305 days milk yield was the dependent variable and the other characteristics were considered as independent variables in path diagram (Fig. 2).

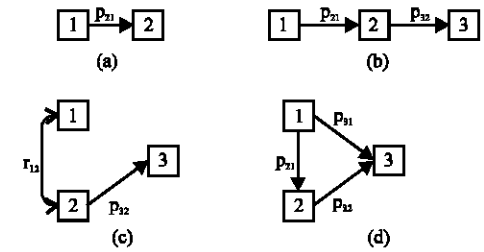

Fig. 1: (a) Direct effect, (b) indirect effect, (c) unanalyzed effect and (d) spurious effect

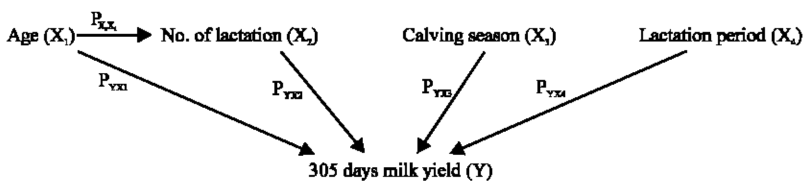

Fig. 2: The path diagram

Data was analyzed in SPSS and AMOS package programs. Correlation coefficients (r) were computed among all the measured traits and path coefficients (p_{yx}) calculated using the simultaneous solutions of the equation below:

$$r_{x_1y} = DE + IE = p_{yx_1} + p_{x_2x_1} * p_{yx_2} \tag{1}$$

$$r_{x_2y} = DE + SE = p_{yx_2} + p_{yx_1} * p_{x_2x_1} \tag{2}$$

$$r_{x_3y} = DE = p_{yx_3} \tag{3}$$

$$r_{x_4y} = DE = p_{yx_4} \tag{4}$$

RESULTS

According to Table 1, the numbers of cattle were higher in the 2007 than other years of this study; the highest average of the age was for 2005 years (1648.70 days). In 5 years of collected data, the numbers of lactation were ranged from 1 to 10. The average of 305 days milk yield was the highest in 2009 (7762.83 kg). The lowest average of 305 days milk yield was in 2008 (5820.07 kg). The longest lactation period was in 2005 (357.05 days). Whereas, the shortest lactation period was in 2008 (299.54 days).

Correlation coefficients: Table 2 presents the correlation matrix between 305 days milk yield and milk yield characters, all the correlation coefficients between age and 305 days milk yield ($r_{2009} = 0.874$, $r_{2008} = 0.634$, $r_{2007} = 0.767$, $r_{2006} = 0.896$, $r_{2005} = 0.783$) were positive and significant ($p<0.01$). When 5 years data were evaluated, the correlations between number of lactation and the 305 days milk yield ($r_{2009} = 0.503$, $r_{2008} = 0.488$, $r_{2007} = 0.546$, $r_{2006} = 0.605$, $r_{2005} = 0.465$, respectively) were positive and quite higher value ($p<0.01$).

The correlation between the number of lactation and age was also positive and high value when 5 years data were analyzed ($r_{2009} = 0.979$, $r_{2008} = 0.935$, $r_{2007} = 0.973$, $r_{2006} = 0.983$, $r_{2005} = 0.956$ and

Table 1: A Summary description for different characters used in the path analysis

Year	Characters	N	Mean	Min.	Max.
2009	Age (days)	120	1433.86	723.00	3142.00
	No. of lactation	120	2.55	1.00	6.00
	Lactation period (days)	120	339.40	283.00	395.00
	305 days milk yield (kg)	120	7762.83	5348.00	9725.00
2008	Age (days)	217	1491.97	710.00	4411.00
	No. of Lactation	217	4.33	1.00	8.00
	Lactation period (days)	217	299.54	229.00	397.00
	305 days milk yield (kg)	217	5820.07	2241.00	9788.00
2007	Age (days)	257	1441.29	714.00	4251.00
	No. of lactation	257	2.60	1.00	10.00
	Lactation period (days)	257	325.98	139.00	408.00
	305 days milk yield (kg)	257	6403.32	1631.00	9986.00
2006	Age (days)	145	1617.40	785.00	4191.00
	No. of lactation	145	3.00	1.00	10.00
	Lactation period (days)	145	341.46	150.00	425.00
	305 days milk yield (kg)	145	7126.71	2342.00	11693.00
2005	Age (days)	159	1648.70	791.00	3663.00
	No. of lactation	159	3.22	1.00	8.00
	Lactation period (days)	159	357.05	209.00	439.00
	305 days milk yield (kg)	159	7544.55	3184.00	11476.00

Table 2: Correlation coefficients between milk yield components in the jersey cattle

Years		Characters	X_2	X_3	X_4	Total correlation to 305 days milk yield (Y)
2009	X_1	Age (days)	0.979**	-0.062	-0.049	0.874**
	X_2	No. of lactation	1.000	0.054	-0.085	0.503**
	X_3	Calving season		1.000	0.106	-0.023
	X_4	Lactation period (days)			1.000	0.020
2008	X_1	Age (days)	0.935**	-0.029	-0.058	0.634**
	X_2	No. of lactation	1.000	-0.071	0.017	0.488**
	X_3	Calving season		1.000	-0.071	-0.050
	X_4	Lactation period (days)			1.000	0.169*
2007	X_1	Age (days)	0.973**	0.098	0.003	0.767**
	X_2	No. of lactation	1.000	0.056	-0.009	0.546**
	X_3	Calving season		1.000	0.095	0.065
	X_4	Lactation period (days)			1.000	0.260**
2006	X_1	Age (days)	0.983**	-0.051	-0.015	0.896**
	X_2	No. of lactation	1.000	-0.086	-0.027	0.605**
	X_3	Calving season		1.000	0.129	-0.094
	X_4	Lactation period (days)			1.000	0.133
2005	X_1	Age (days)	0.956**	-0.060	0.087	0.783**
	X_2	No. of lactation	1.000	-0.046	0.068	0.465**
	X_3	Calving season		1.000	-0.008	-0.042
	X_4	Lactation period (days)			1.000	0.039

* and **Significant 5 and 1% level, respectively

r_{2005} = 0.935, respectively). The lactation period had a moderate and positive correlation with 305 days milk yield in 2007 (r = 0.260) and 2008 (r = 0.169). These correlations were significant at alpha 1 and 5%, respectively.

With respect to the correlations between different traits, the calving season had a moderate positive correlation with the lactation period in 2006 and 2009 years (r_{2009} = 0.106, r_{2006} = 0.129, p>0.05). There was not significantly correlation between 305 days milk yield and calving season in all years.

The distribution of the calving season of 898 jersey cattle in the study was presented in Fig. 3, according to Fig. 3, births were occurred more in Spring and Winter season between 2005 and 2009. Minimum births were occurred in Autumn and Summer in 2005-2009.

Figure 3 tells about the birth occurrence during years, these were significant difference between seasons with respect to birth occurrence, most likely to attributing the husbandry methods and management conditions in Koçaş Dairy Cattle Farm.

The path coefficient analysis: In order to determine the relationships between 305 days milk yield and the other milk yield traits, correlation coefficients were calculated. Path coefficient analysis was used to partition the correlations between 305 days milk yield and milk yield traits related to milk yield into direct, indirect and S effects by using 305 days milk yield as a dependent variable. The pathways through which the four milk yield traits operate to produce their relationships with 305 days milk yield reveal direct, indirect and S effects (Table 3) and are shown in Fig. 2. Correlation and path coefficient analysis indicated that age and number of lactation were the major contributors to 305 days milk yield.

Path coefficient analysis revealed that age had the highest positive direct effect on 305 days milk yield in 5 years. The indirect effect of the age was positive and moderate in all years. Number of lactation had a positive and high direct effect on 305 days milk yield in 2006, 2008 and 2009. The path coefficient value of number of lactation was found to be the result strong positive S effect of number of lactation via age in 2005 and 2007.

The direct effects of the calving season and lactation period on the 305 days milk yield were equal to their correlation coefficients. Because calving season and lactation period had only direct effect on the 305 days milk yield (Fig. 2). Calving season had a negative and low direct effect on 305 days milk yield in 2005, 2006, 2008 and 2009. Whereas calving season had a positive and low direct effect on 305 days milk yield in 2007. These effects were not significant (p>0.05).

Lactation period had a positive and moderate direct effect on 305 days milk yield in 2007 and 2008. These effects were significant at alpha 1 and 5%, respectively.

The result obtained in this study demonstrated the inconvenience of using only simple correlations to study the degree of association and interaction between milk yield trait components

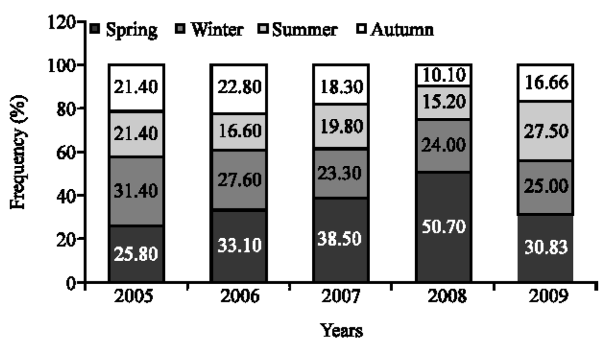

Fig. 3: The distribution by year of calving season

Table 3: Path coefficients between milk yield components in the jersey cattle

Pathways	2005 Effect	2006 Effect	2007 Effect	2008 Effect	2009 Effect
Age vs. 305-days milk yield					
Direct effect	0.402	0.522	0.433	0.319	0.504
Indirect effect via No. of lactation	0.381	0.347	0.334	0.315	0.370
Total correlation	0.783**	0.896**	0.767**	0.634**	0.874**
No. of lactation vs. 305-days milk yield					
Direct effect	0.191	0.312	0.255	0.256	0.285
S effect via age	0.274	0.293	0.291	0.232	0.218
Total correlation	0.465**	0.605**	0.546**	0.488**	0.503**
Calving season vs. 305-days milk yield					
Direct effect	-0.042	-0.094	0.065	-0.050	-0.023
Total correlation	-0.042	-0.094	0.065	-0.050	-0.023
Lactation period vs. 305-days milk yield					
Direct effect	0.039	0.133	0.260	0.169	-0.023
Total correlation	0.039	0.133	0.260**	0.169*	0.020

* and **Significant 5% and 1% level, respectively

in Jersey Cattle. The path coefficient analysis had higher usefulness, allowing us to know the real contribution of a group of independent variables on a dependent variable through their direct and indirect effects compared to convenient statistical methods.

Correlations showed that age and number of lactation were the most important factors affecting milk yield components. Overall, the study indicated that age was the most important factor on milk yield component in jersey cattle because of its significant and positive correlation and positive high direct effects to 305 days milk yield in are all the 5 years. This was followed by the number of lactation which also displayed a significant and positive correlation and positive direct effect on 305 days milk yield in three years (2006, 2008 and 2009).

DISCUSSION

According to the result obtained, we may observe that four traits studied as milk yield components had direct, indirect and S effects on 305 days milk yield. Age and number of lactation had high and positive effects on 305 days milk yield. The direct effect of calving season and lactation period were low, positive and negative, respectively. Similar results were reported by Bakir and Cetin (2003). The effect of lactation number on milk yield was found to be statistically significant by Ozçelik and Arpacik (2000), Şeker *et al.* (2009). Correlations between lactation period and lactation milk yield have been reported as non-significantly and negative in Mundan *et al.* (2009). According to (Bakir and Cetin, 2003; Tilki *et al.*, 2003) calving season has not significantly effect on milk yield in Holstein cattle. In contrast to these results Şeker *et al.* (2009), Çilek and Bakir (2010) reported effects of calving season on lactation milk yield and 305 days milk yield were significant in Brown Swiss. Similarly Kocak *et al.* (2007) reported effects of calving season on lactation milk yield were non-significant in Holstein Cows.

The results obtained in this study demonstrated the path coefficient analysis had higher usefulness, allowing us to know the real contribution of group independent variables on a dependent variable through their direct, indirect and S effects compared to simple correlations to study the degree of association and interrelationship between the milk yield components in Jersey cattle. At the same time, the path coefficient analysis showed that the age and number of lactation were the main factors affecting 305 days milk yield in Jersey cattle.

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