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Determination of Effect of Placental Characteristics on Lamb Birth Weight in Bafra Sheep by Path Analysis

Bafra Koyunlarında Kuzu Doğum Ağırlığı Üzerine Plasental Özelliklerin etkisinin Path Analizi ile Belirlenmesi

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DETERMINATION OF EFFECT OF PLACENTAL CHARACTERISTICS ON LAMB BIRTH WEIGHT IN BAFRA SHEEP BY PATH ANALYSIS

ABSTRACT

Path analysis is applied to identify directed dependencies between a set of variables and used in animal breeding to improve breeding practices. Therefore, the aim of this study was to examine the direct and indirect effect of some placental traits on lamb birth weight born to Bafra sheep breed using path analysis. For this aim, the relationship between lamb birth weight and seven placental traits (placental weight; PW, total cotyledon numbers; TCN, total cotyledon surface area; TCSA, cotyledon efficiency; CE, total cotyledon volume; TCV, volumetric cotyledon efficiency; VCE, placenta efficiency; PE) were studied in 40 singleton - bearing Bafra ewe with same live weight and parity. Birth weight (BW), lamb sex, and placental measurements were recorded within 12 h after parturition. The direct effects of PE on birth weight were found statistically significant ($p<0.05$). Additionally, the indirect effects of PW on birth weight were found statistically significant ($p<0.05$). While the PE variable was found with the highest direct effect (0.602) on BW, the highest total indirect effect (-0,468) on BW was found in the PW variable. The direct effect (-0.046) of the TCN variable was lowest on BW. Also, the indirect effect (0.093) of the PE variable was lowest on BW. The results showed that PW and PE were the most explanatory variable for the birth weight of Bafra lambs.

Keywords: Path Analysis, Lamb Birth Weight, Placental Traits, Direct Effect, Indirect Effect, Bafra Breed.

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BAFRA KOYUNLARINDA KUZU DOĞUM AĞIRLIĞI ÜZERİNE PLASENTAL ÖZELLİKLERİN ETKİSİNİN PATH ANALİZİ İLE BELİRLENMESİ

ÖZ:

Path analizi, bir dizi değişken arasındaki yönlendirilmiş bağımlılıkları tanımlamak ve ıslah uygulamalarını iyileştirmek için hayvan yetiştiriciliğinde uygulanmaktadır. Dolayısıyla bu çalışmanın amacı, Bafra koyun ırkında bazı plasental özelliklerin, kuzu doğum ağırlığına doğrudan ve dolaylı etkisini path analizi kullanarak incelemektir. Bu amaçla kuzu doğum ağırlığı ile yedi plasental özellik (plasenta ağırlığı; PA, toplam kotiledon sayısı; TKS, toplam kotiledon yüzey alanı; TKYA, kotiledon verimliliği; KV, toplam kotiledon hacmi; TKH, hacimsel kotiledon verimliliği; HKV, plasenta etkinliği; PE) arasındaki ilişki 40 baş tekiz doğum yapmış, benzer canlı ağırlığa ve doğum sayısına sahip Bafra ırkı koyunda incelenmiştir. Kuzu doğum ağırlığı (DA), kuzu cinsiyeti ve plasental ölçümler doğumdan sonraki 12 saat içinde kaydedilmiştir. Çalışmada PE'nin doğum ağırlığına direkt etkisi istatistiksel olarak anlamlı bulundu ($p<0.05$). Ayrıca PA'nın doğum ağırlığı üzerindeki dolaylı etkileri istatistiksel olarak önemli olduğu tespit edilmiştir ($p<0.05$). DA üzerinde en yüksek doğrudan etki (0,602) PE değişkeninde bulunurken, DA üzerinde en yüksek toplam dolaylı etki (-0,468) PA değişkeninde tespit edilmiştir. DA üzerine doğrudan en düşük etki TKS (-0.046) değişkeninde, dolaylı en düşük etki ise PE (0.093) değişkeninde tespit edilmiştir. Çalışmanın sonuçları, Bafra kuzularının doğum ağırlığı için en açıklayıcı değişkenin PA ve PE olduğunu göstermiştir.

Anahtar Kelimeler: Path Analizi, Kuzu Doğum Ağırlığı, Plasental Özellikler, Doğrudan Etki, Dolaylı Etki, Bafra Irkı.

1. INTRODUCTION

Placental traits are one of the main causes of the postnatal death of offspring in goats and sheep (Dwyer et al., 2005). A past study reported that postnatal viability of newborns was highly correlated with placental growth and development during pregnancy (Mellor and Stafford, 2004). The exchange capacity of the placenta between the maternal and fetal tracts in small ruminants depends on the size of the placenta and the number of cotyledons. (Ocak et al., 2013; Sen and Onder, 2016). Therefore, placental size has a crucial role in determining the prenatal growth trend of the offspring, and consequently birth weight and postnatal survival (Sen et al., 2013). In sheep, the placenta completes most of its growth and development until mid-pregnancy (about the 90th day), and after this period it begins to effectively support fetal growth and development until birth. (Redmer et al., 2004; Igwebuike, 2010; Sen et al., 2013). Previous studies have shown a high level of correlation between placental weight and the birth weight of the offspring (Osgerby et al., 2003; Dwyer et al., 2005; Sen et al., 2013; Sen and Onder, 2016).

One of the main goals of animal breeding is to genetically improve livestock populations so that they can produce higher yields under expected future production conditions (Önder and Abacı, 2015). Genetic improvement in terms of economic characteristics is achieved by selecting the highest performing animals on farms and using them as sires or dams for the generation next (Dekkers et al., 2004). In many cases, the offspring with higher birth weight are selected as future breeding material or these criteria are used to valorize the animals. Placental traits have important effect on birth weight of the newborn (Osgerby et al., 2003; Dwyer et al., 2005; Sen et al., 2013; Sen and Onder, 2016). Generally, to evaluate relationship between placental characteristics and birth-related traits data relational statistics such as regression and correlation are used (Ocak et al., 2013; Sen et al., 2013;

Sen and Onder, 2016). Birth weight of the newborn is selected as response variable and placental characteristics are selected as explanatory variables. Therefore, it is aimed to explain the desired response variable by using explanatory variables. Nevertheless, besides the direct effects, the indirect effects of explanatory variables on the response variable should not be ignored (Arı and Önder, 2013).

The Path analysis is applied to detect directed dependencies between a set of variables (Önder and Abacı, 2015). For this reason, the use of path analysis has begun to increase in animal husbandry to determine the related traits (Önder and Abacı, 2015). In addition, there is lack of studies that examined the direct and indirect effects of placental characteristics on birth weight of the newborn. The aim of the current study was therefore to investigate direct, indirect and total effects of placental characteristics ((placental weight; PW, total cotyledon numbers; TCN, total cotyledon surface area; TCSA, cotyledon efficiency; CE, total cotyledon volume; TCV, volumetric cotyledon efficiency; VCE, placenta efficiency; PE) on lamb birth weight in Bafra ewes.

2. MATERIAL AND METHODS

The experimental procedures were approved by the Local Animal Care and Ethics Committee of Ondokuz Mayis University, Samsun, Turkey, ensuring compliance with EC Directive 86/609/EEC for animal experiments. Experimental animals were of the Bafra sheep breed, 3–5 years of age, and maintained at the Sheep Farm of Ondokuz Mayis University, Samsun, Turkey. The study was conducted on 40 singleton-bearing Bafra ewes with same live weight (46.93 ± 0.68 kg) and parity (at least second) in the normal breeding season. All ewes were housed and cared for under the same conditions in the stockyard and were allowed to graze for 5 h daily during gestation. Birth weight (BW) and the sex of lambs were recorded within 12 h after parturition. Each Bafra ewe was left to deliver the placenta naturally and placentas were collected immediately after delivery. Placental weight (PW) was measured and recorded after removing placental fluid. The total cotyledon numbers (TCN) and total cotyledon weights (TCW) of placental cotyledons dissected from the chorioallantois were also counted and determined. Cotyledon length (CL), depth (CDe), and width (CWi) were measured with a digital compass and 30 cotyledons of the same size were selected (small, <10 mm diameter; medium, 10–30 mm diameter; large, >30 mm diameter). Placental efficiency (PE) was calculated for each Bafra ewe, as the ratio of lamb birth weight to placental weight (PW). Cotyledon density (CD) was calculated as the number of cotyledons per gram PW. Cotyledon efficiency (CE) was defined as the ratio of kid BW in grams to the total cotyledon surface area (TCSA). TCSA was calculated after the measurements of all the cotyledons in individual placenta as cm^2 with the following formula: radius

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squared of cotyledon [((CWi + CL) / 4)²] × 3.14 (π) × TCN. PE was calculated as the ratio of kid BW to PW for each Bafra ewe.

SPSS (2004) statistical software was used to analyze the data with the license of Ondokuz Mayıs University. Every linear model has a direct effect and amount of indirect effect which is number of explanatory variables minus one". The general expression of multiple regression model formed for the measurements (one response and p explanatory variables) is given in Equation 1.

$$y_k = \beta_0 x_{k_1}^{\beta_1} x_{k_2}^{\beta_2} x_{k_3}^{\beta_3} \ldots x_{k_p}^{\beta_p} e_i; \quad i = 1,2,\ldots,n \qquad (1)$$

The multiple linear regression model adopted was as follows (equation 2);

$$\hat{y}_k = b_0 + b_1 x_{k1} + b_2 x_{k2} + b_3 x_{k3} \qquad (2)$$

where:

$\hat{y}_k$ = response variable (BW),

b_0 = intercept,

b_i = standardized regression coefficients,

x_{kp} = explanatory variables (CG, BL, HS)

A path coefficient (P) is a standardized regression coefficient (b) showing the direct effect of an independent variable on a dependent variable in the path model (Garson, 2008; Önder and Abacı, 2015). Path coefficient, which indicates the effect of one standard deviation change of any explanatory variable X versus on response variable Y, can be calculated as (Mendes et al., 2005) (equation 3).

$$Pyx_k = b\frac{Sx_k}{S_y} \qquad (3)$$

Here; P_{yx} is the path coefficient which indicates the direct effect of X explanatory variable on response variable Y, S_x indicates the standard deviation of X, S_y indicates the standard deviation of Y and b indicates the partial regression coefficient. Path coefficients can be shown with path diagrams. One way and two way arrows are used in path diagrams. One way arrows which named as direct effects are drawn from explanatory variable to response variable and two way arrows which showed correlations are drawn between explanatory variables (Tahtali et al., 2011).

To obtain the path coefficients should be replaced in linear equation system as given in Equation 4.

$$\begin{bmatrix} P_{YX_1} \\ P_{YX_2} \\ P_{YX_3} \end{bmatrix} = \begin{bmatrix} 1 & r_{X_1X_2} & r_{X_1X_3} \\ r_{X_2X_1} & 1 & r_{X_2X_3} \\ r_{X_3X_1} & r_{X_3X_2} & 1 \end{bmatrix}^{-1} * \begin{bmatrix} r_{YX_1} \\ r_{YX_2} \\ r_{YX_3} \end{bmatrix} \quad (4)$$

In the Equation 4, coefficients given by P_{YXi} were path coefficients (direct effects) between explanatory variable and response variable and $r_{xixj}P_{YXi}$ represented indirect effects of explanatory variable ith on response variable via explanatory variable j^{th}, r_{xixj} represented pearson correlation coefficients between i^{th} an j^{th} traits (Topal et al., 2008).

3. RESULTS AND DISCUSSION

Direct and indirect effects of explanatory variables on birth weight in Bafra ewes are present Table 1. The direct effects of PE on birth weight were found statistically significant ($p<0.05$). Additionally, direct effects of PW, TCN, TCSA, CE, TCV and VCE on birth weight were not found statistically significant. The indirect effects of PW on birth weight were found statistically significant ($p<0.05$). Moreover, direct effects of TCN, TCSA, CE, TCV, VCE and PE on birth weight were not found statistically significant in the present study. While PE was found with highest direct effect (0.602) on BW, the highest total indirect effect (-0,468) on BW was found PW variable. The direct effect (0.046) of TCN was lowest on BW. Also, the indirect effect (0.093) of PE was lowest on BW.

Table 1. Direct and indirect effects of explanatory variables on birth weight in Bafra ewes

Tablo 1. *Bafra koyunlarında açıklayıcı değişkenlerin doğum ağırlığına doğrudan ve dolaylı etkileri*

Trait	Direct effects	Indirect Effect	Correlation Coefficient
PW	0.371	-0.468*	-0.097
TCN	0.046	0.303	0.349
TCSA	0.115	0.178	0.293
CE	0.068	0.197	0.265
TCV	-0.088	0.188	0.100
VCE	-0.089	0.428	0.339
PE	0.602*	0.093	0.695

PW= placental weight, TCN= total cotyledon numbers, TCSA= total cotyledon surface area, CE= cotyledon efficiency, TCV= total cotyledon volume, VCE= volumetric cotyledon efficiency, PE= plancenta efficiency. * $p<0.05$

The highest Pearson correlation coefficient (CC) between BW was observed with PE which was as expected because calculation of PE includes BW. The other correlation coefficients were too small to interpret that was there is no relation with BW. While PW was found with positive direct effect (0.371), it was statistically significant indirect negative effect (-0.468) on BW. Only correlation coefficient between PW and BW was found negative but it was statistically meaningless. This finding should be considered carefully that the Pearson correlation was nominal near zero but direct effect was positive about four times of CC and indirect effect of PW was negative about four times of CC. It means that CC between PW and BW is not a reliable statistics to evaluate. For TCN, the indirect effect was found 6.5 times higher than its direct effect. It may be caused by the relation of TCN with TCSA and VCE. Another interesting finding recognized that indirect effect of VCE on BW was 5.8 times higher than its direct effect and when the direct effect was negative the indirect effect was obtained positive. The CC between VCE and BW was close to indirect effect. It can be interpreted that the effect behavior of VCE came from many of the placental characteristics include cotyledonal traits. Direct effect value of PE on BW was found so close to correlation coefficient between PE and BW. It means that the most reliable explanatory variable was PE for BW.

Placental traits, such as placental weight, cotyledon numbers, cotyledon efficiency, plancenta efficiency etc., are important indicators of the postnatal survive of lambs in sheep (Dwyer et al., 2005; Sen et al., 2013). Therefore, some factors affecting lambs birth weight should be determined. Owing to this, the path analysis is very important for determining factors affecting lamb birth weight (Önder and

Abacı, 2015). In this study, this aimed to investigate the direct, indirect and total effects of placental characteristics on birth weight in Bafra lambs. Mostly, evaluation of relationship between placental characteristics and birth-related traits data relational statistics such as regression and correlation are used (Ocak et al., 2013; Sen et al., 2013; Sen and Onder, 2016). Birth weight of the lambs was selected as response variable and placental characteristics were selected as explanatory variables in the present study. Therefore, path analysis was used to describe the directed dependencies among a set of variables in the present study. Onder et al. (2017) direct and total effects on lamb birth weight were supported by studies in Akkaraman lambs. Some direct and total effects of placental traits on lamb birth weight were similar with results of Onder et al. (2017).

4. CONCLUSIONS

As a result, it has been concluded that PW and VCE can be used as indirect selection criteria in the flock for management and breeding decisions according to lamb birth weight since PW has the highest direct effect and PE has the lowest indirect effect of lamb birth weight in Bafra sheep breed.

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Conflict of Interest

The authors declared that there is no conflict of interest.

Ethical Approval

The experimental procedures were approved by the Local Animal Care and Ethics Committee of Ondokuz Mayıs University, Samsun, Turkey, ensuring compliance with EC Directive 86/609/EEC for animal experiments (Date: July 10, 2018, Approve number: 68489742-604-E.15277).

Author Contribution Rates

Design of study: UŞ (60 %), HÖ (40 %)

Data acquisition : UŞ (80 %), HÖ (20 %)

Data analysis: UŞ (20 %), HÖ (80 %)

Writing up: UŞ (70 %), HÖ (30%)

Submission and revision: UŞ (80 %), HÖ (20 %)

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