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Regression Tree Approach for Assessing the Effects of Non-Genetic Factors on Birth Weight of Hemşin Lamb

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Abstract: This study examined effects of birth year, herd type, age of dam, lamb sex, birth type and lamb color on birth weight in Hemsin lambs using the regression tree method. The study used the data obtained from 9113 Hemsin lambs born between 2007-2010. The average birth weight of Hemsin lambs was found to be 3.55 kg and the standard deviation was 0.727 kg. Significant differences were found in birth weights of Hemsin lambs according to birth year ($P<0.001$), birth type ($P<0.001$) and lamb sec ($P<0.01$), whereas no statistically significant difference was found according to herd type, age of dam and lamb color ($P>0.05$). According to the regression tree diagram, the most important factors affecting birth weight of Hemsin lambs were birth year, birth type, sex, herd type and age of dam. The absence of lamb color in the regression tree diagram indicates its insignificant effect on birth weight. The low risk value (0.456) and high R-Squared value (0.862) of the regression tree model shows that the model is sufficient to explain birth weight. Variables of birth year, birth type, sex, herd type and age of dam explained 86.2% of the variation in birth weight.

Keywords: Hemşin lamb, birth weight, regression tree.

Hemşin Kuzularının Doğum Ağırlığına Genetik Olmayan Faktörlerin Etkilerinin Belirlenmesinde Regresyon Ağacı Yaklaşımı

Öz: Bu çalışmada, Hemşin kuzularında doğum ağırlığına yıl, sürü tipi, anayaşı, kuzu cinsiyeti, doğum tipi ve kuzu renginin etkileri Regresyon ağacı analiz yöntemi ile incelenmiştir. Çalışmada, 2007-2010 yılları arasında doğan 9113 baş Hemşin kuzusuna ait veriler kullanılmıştır. Hemşin kuzularının doğum ağırlığı ortalaması 3.55 ve standart sapması 0.727 kg bulunmuştur. Hemşin kuzularının doğum ağırlığında yıllar ($P<0.001$), doğum tipleri ($P<0.001$) ve cinsiyetler ($P<0.01$) arasında önemli farklılıklar bulunurken sürü tipleri, ana yaşları ve kuzu renklerinde istatistiksel olarak farklılık bulunamamıştır ($P>0.05$). Regresyon ağacı diagramına göre Hemşin kuzularının doğum ağırlığına etkide bulunan en önemli değişkenler sırasıyla yıl, doğum tipi, cinsiyet, sürü tipi ve anayaşıdır. Kuzu renginin Regresyon ağaç diagramında olmaması doğum ağırlığı üzerinde önemli bir etkide bulunmadığını göstermektedir. Regresyon ağaç modelinin risk (0,456) değerinin düşük ve R^2 (0,862) değerinin yüksek olması uydurulan modelin doğum ağırlığını açıklamada yeterli olduğunu göstermektedir. Doğum ağırlığındaki varyasyonun 86,2%'nin doğum yılı, doğum tipi, cinsiyet, sürü tipi ve anayaşı değişkenleri tarafından açıklandığı ifade edilir.

Anahtar kelimeler: Hemşin kuzusu, Doğum ağırlığı, Regresyon ağacı.

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1. INTRODUCTION

The primary objectives in sheep businesses are milk yield, live weight, wool yield, number of lambs born per dam and lamb viability, since these provide important economic gains. The viability of lambs born in businesses leads to an increase in other yield characteristics. Therefore, it is necessary to accurately identify number of lambs born per dam and factors affecting lamb viability and rank these factors according to their importance in selection studies. Yield characteristics are affected by various factors such as genotype, environment, breeding conditions and diseases. Effects of these factors may be determined with linear and non-linear models and classified with regression tree analysis. It is reported in various studies that non-genetic factors such as low birth weight, breed, age of dam, parity, lamb sex, injury, poisoning, birth type, season and month of birth, birth year and mothering ability affect lamb viability (Susic *et al*., 2005; Khan *et al*., 2006; Morris *et al*., 2000; Mandal *et al*., 2007; Sawalha *et al*., 2007; Vatankhah and Talebi, 2009).

The method used to determine functional relationship between dependent and independent variables for farm animals and examine effects of independent variables on the dependent variable according to this functional

relationship is usually the least squares method of the regression analysis. The dependent variable must have a normal distribution in the least squares method. If the dependent variable is a nominal variable, the logistic regression analysis may be used. In order to determine factors affecting yield characteristics in various studies on small ruminants, Çankaya and Abaci (2012) and Önder and Abaci (2015) used multiple linear regression method and path analysis, Cam *et al*. (2010) used multiple linear regression method, Tariq *et al.* (2012) used multiple linear regression method and factor analysis and Younas *et al*. (2013) and Iqbal *et al*. (2014) used multiple linear regression method. The regression tree method is a non-parametric method alternative to the least squares method and logistic regression method and does not involve assumptions necessary for the regression analysis. Dependent and independent variables may be continuous, nominal and ordinal in the regression tree analysis. The regression tree is a non-parametric partitioning method that identifies dependent variables and the interaction between variables. The classification tree method may be used in order to determine and classify effects of genetic and non-genetic factors affecting variables such as mortality, birth weight and live weight in lambs. The following are some studies in which this method was used: Eyduran *et al*. (2008) used the regression tree method to determine effects of genotype, sex, birth type and age of dam on birth weight in Noduz and Karakas lambs. Khan *et al*. (2014) and Mohammad *et al*. (2012) used the regression tree method to estimate live weight of sheep with some body measurements. Topal *et al*. (2010) used regression tree analysis to determine factors affecting birth weight and actual milk yield in Swedissh Red cattle using regression tree analysis. Topal *et al*. (2017) used to Chaid and Logistic Regression for assessing the effects of non-genetic factors on lamb mortality. Piwczyński (2009) established factors responsible for the number of lambs reared from fertilized mother using classification tree. Classification trees and logistic regression were used to obtain mortality of Polish Merino lambs between their birth and weaning time (Piwczyński *et al*. 2012). Classification trees and logistic regression were used to obtain relation between PrP genotypes and litter size in Polish Merino, Black-headed, Ile de France and Berrichon du Cher breeds (Grochowska *et al*. 2014). Regression tree was used to detect relationship between body weight and morphometric traits of Uda sheep (Yakubu, 2012).

This study aimed to identify effects of birth year, herd type, age of dam, lamb sex, birth type and lamb color on birth weight in Hemsin lambs using the regression tree method.

2. MATERIAL AND METHODS

Material

The study used the data obtained from 9111 Hemsin lambs bred in the province of Artvinbetween 2007-2010. The Hemsin race is bred primarily in Ardahan and also in provinces of Artvin, Rize, Giresun and Trabzon, which are located in the Black Sea Region, Turkey. This region has a pretty rough terrain and pasture fields are limited. In terms of body structure, Hemsin lambs are usually medium-sized. The bottom part of the tail is large and thins out toward the end. Females do not have horns, whereas males may have horns. They can feed on weak pastures and have an advanced instinct of motherhood. The average live weight of adult Hemsin lambs is about 60 kg, the average lactation period is 150 days, the average milk yield is 120 kg, wool yield is approximately 1.5 kg and the sperm yield is approximately 100%.

Methods

This study examined effects of birth year, herd type, age of dam, lamb sex, birth type and lamb color on birth weight in Hemsin lambs using the regression tree method. The regression tree analysis was performed using SPSS 17.0 for Windows. There are several studies that theoretically explain the regression tree analysis method (De'ath and Fabricius, 2000; Larsen and Speckman, 2004; Questier *et al*., 2004; Moisen, 2008; Zheng *et al*., 2009) and advantages of this method (Yohannes and Hoddinott, 1999; Timofeev, 2004; Topal *et al*., 2010; Cak *et al*., 2013). The compatibility of the regression tree model was tested using the R-Squared value and the risk value. The R-Squared value of the regression tree model is calculated using $R-Squared=\sum\left(Y_i-\hat{Y}_i\right)^2/\sum(Y_i-\bar{Y})^2$ of $R-Squared=1-\sum\left(\hat{Y}_i-\bar{Y}_i\right)^2/\sum(Y_i-\bar{Y})^2$ equations.Where Y_i : observed value, $\hat{Y}_i$; estimated value according to the model and $\bar{Y}$; mean. A R-Squared value closer to 1 indicates a high compatibility. The risk value is found by dividing the sum of the squares of the differences between observed values (Y_i) and estimated values according to the model by the total data number. Namely, it is calculated according to $Risk=\sum\left(Y_i-\hat{Y}_i\right)^2/n$ equation. The lower the risk value is, the more compatible the model to explain the dependent variable. Our regression tree model was planned so that values belonging to at least 300 individuals in the parent node and 100 individuals in the child nodes be found in order to identify the random effects of ewe breeds, year of birth, month of birth, birth type, lamb sex and lamb birth weight on lamb mortality.

3. RESULTS AND DISCUSSION

Descriptive statistical values and significance levels of non-genetic factors affecting birth weight of Hemşin lambs are given in Table 1.

Table 1. Descriptive statistical values of birth weight in Hemsin lambs

Factors	N	$\bar{X} \pm S_{\bar{X}}$	CV (%)
OVERAL	9111	3,5500 ± 0,0076	20,49
SEX		**	
Female	4370	3,4353 ± 0,0109	20,99
Male	4741	3,6554 ± 0,0104	19,61
BIRTH TYPE		***	
Singleton	8049	$3,5985^{a}$ ± 0,0081	20,24
Twin	988	$3,1832^{b}$ ± 0,0189	18,70
Triplet	74	$3,1480^{b}$ ± 0,0786	21,48
HERD TYPE		NS	
Base	7627	3,5210 ± 0,0084	20,74
Multiplyres Elite	1484	3,6982 ± 0,0180	18,72
AGE of DAM		NS	
2	1115	3,5419 ± 0,0206	19,46
3	600	3,7066 ± 0,0240	18,84
4	1171	3,6763 ± 0,0238	22,18
5	2133	3,6253 ± 0,0164	20,94
6	4092	3,4535 ± 0,0109	20,20
COLOR		NS	
White	4692	3,5280 ± 0,0104	20,15
Black	3675	3,5284 ± 0,0121	20,73
Pied	744	3,7934 ± 0,0279	20,08
YEARS		***	
2007	3642	$3,6696^{a}$ ± 0,0167	23,34
2008	1936	$3,5306^{b}$ ± 0,0142	17,69
2009	2125	$3,2688^{c}$ ± 0,0151	21,30
2010	2408	$3,6819^{a}$ ± 0,0121	16,11

^{a,b,c}: The difference between groups in the same columns with different letters is significant,
***:P<0,001, **:P<0,01, NS: Non Significant, $\bar{X}$: Mean, $S_{\bar{X}}$: Standart error of mean, CV: Coefficient of variation

According to Table 1, the average birth weight of Hemsin lambs was 3.550 kg. The average birth weight of male lambs (3.6554) was higher compared to female lambs (3.4353) and the difference was statistically significant (P<0,01). Considering birth weights according to birth type, it was found that average birth weights in singleton, twin and triplet birth types were 3.5985, 3.1832 and 3.1480 respectively. The average birth weight in singleton birth type was found to be significantly different than twin and triplet birth types (P<0.001), whereas no significant difference was found between average birth weights in twin and triplet birth types (P>0.05). Although the average birth weight in the multipliers elite herd (3.6982) was higher than the average birth weight in the base herd (3.5210), the difference was not statistically significant. Considering average birth weights according to age of dam, it was found that average birth weights of lambs born by dams aged 2, 3, 4, 5 and 6 years were 3.5419, 3.7066, 3.6763, 3.6253 and 3.4535 respectively. The differences between birth weights according to age of dam were not statistically significant (P>0.05).It was observed that lamb color had no significant effect on birth weight (P>0.05). It was found that the birth weight of lambs varied according to birth year and average weights of lambs born in 2007, 2008, 2009 and 2010 were 3.6696, 3.5306, 3.2688 and 3.6819 respectively. While there was no difference between birth weights in 2007 and 2010, a very significant difference was found between other years (P>0.001).

Table 2. Significance levels of independent variables affecting birth weight according to the regression tree diagram

Independent Variable	Importance	Relative Importance (%)
Birth year	0,029	100,0
Birth type	0,028	97,9
Sex of Lamb	0,013	44,8
Herd type	0,013	43,8
Age of dam	0,004	12,3
Color	0,001	2,9
R-Squared=0,862	Risk:0.456	Standart Error of Risk: 0.007

As seen in Table 2, the most effective variables on birth weight of Hemsin lambs were birth year, birth type, sex, herd type, age of dam and lamb color respectively. The least effective variable on birth weight was observed to be lamb color and the absence of lamb color in the regression tree diagram indicates its insignificant effect on birth weight. The R-Squared and risk values of the model were used to test its compatibility (Table 2). The low risk value (0.456) and high R-Squared value (0.862) of the regression tree model shows that the model is sufficient to explain birth weight. Variables of birth year, birth type, sex, herd type and age of dam explained 86.2% of the variation in birth weight.

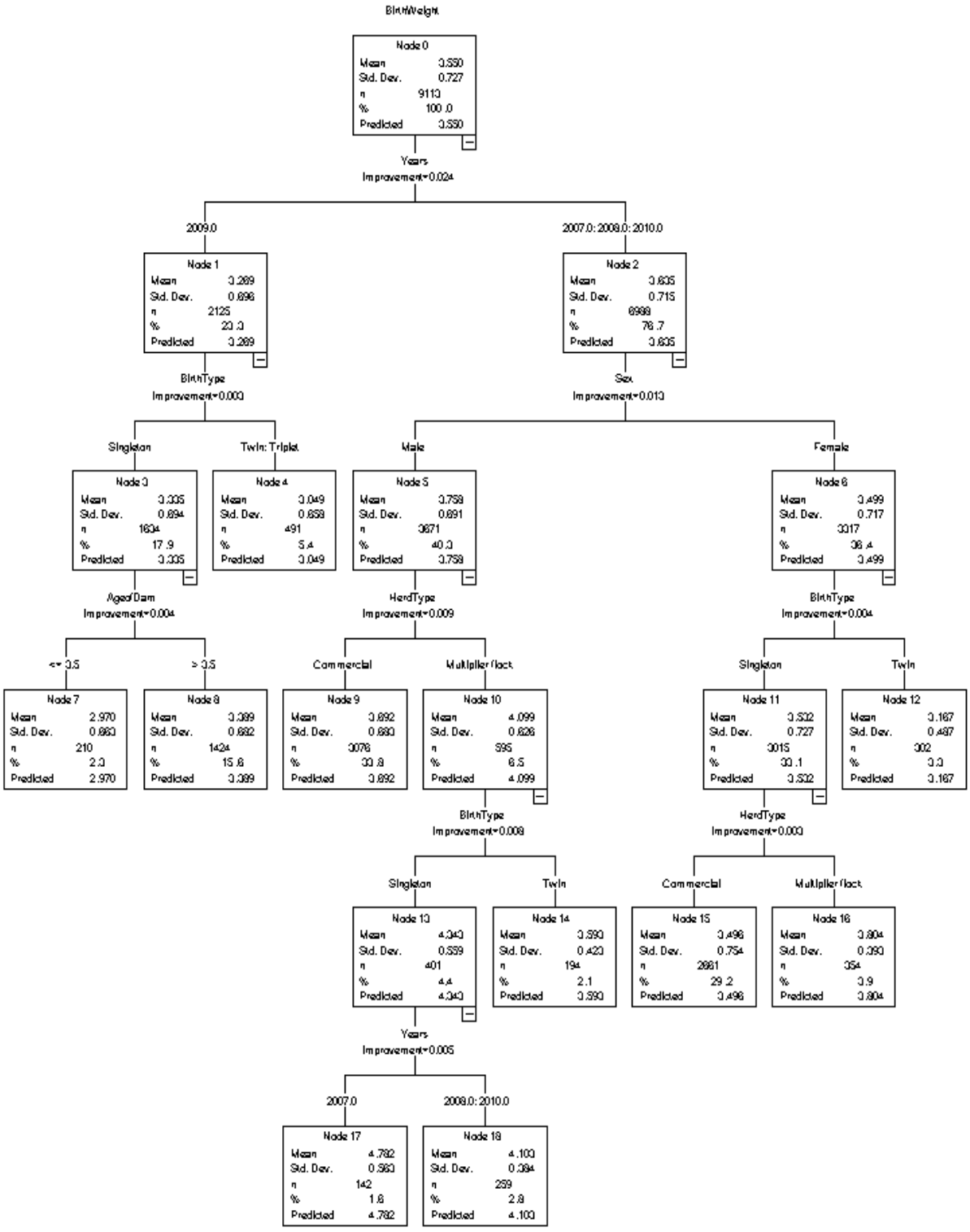

Figure 1. Tree diagram of combined categories and subset obtained from Regression tree analysis

The average value (3.550 kg) of the birth weight of Hemsin lambs and the standard deviation (0.727 kg) are given in the parent node of the regression tree (Figure 1). Parent node was split into two child nodes (Node 1 and Node 2) according to birth year, which was the most important predictor variable determining lamb birth weight in the regression tree model. The average birth weight of lambs born in 2009 (Node 1) and the standard deviation were

3.269 and 0.696 kg respectively, whereas the average birth weight of lambs born in 2007, 2008 and 2010 (Node 2) and the standard deviation were 3.635 and 0.715 kg. Accordingly, it can be said that birth weights of lambs born in 2009 were lower compared to lambs born in other years. Node 1 was split into two child nodes (Node 3 and Node 4) according to birth type, which was found to be the second most important variable determining birth weight of Hemsin lambs. The average birth weight of singleton lambs born in 2009 (Node 3) and the standard deviation were 3.335 and 0.694 kg respectively, whereas the average birth weight of twin and triplet lambs born in 2009 (Node 4) and the standard deviation were 3.049 and 0.658 kg. Also, Node 3 and 4 show that out of 2125 lambs born in 2009, 1643 were singleton and 491 lambs were twin or triplet, which indicates that singleton birth is much more common in Hemsin lambs compared to twin and triplet births. Node 2 was split into two child nodes according to lamb sex as Node 5 (male) and Node 6 (female), which was found to be the third most important variable determining birth weight of Hemsin lambs. The average birth weight of male Hemsin lambs born in 2007, 2008 and 2010 and the standard deviation were 3.758 and 0.691 kg respectively, whereas the average birth weight of female lambs born in 2007, 2008 and 2010 and the standard deviation were 3.499 and 0.717 kg. The average birth weight of male lambs was found to be higher compared to female lambs. Node 3 was split into two child nodes (Node 7 and Node 8) according to age of dam, which was found to be the fourth most important variable determining birth weight of Hemsin lambs. It was seen that the average birth weight of lambs born by dams aged 3.5 and below (Node 7; 2.970 ± 0.663) was lower than the average birth weight of lambs born by dams aged above 3.5 (Node 8; 3.389 ± 0.682). Accordingly, there was a linear relationship between age of dam and birth weight in Hemsin lambs, i.e. birth weight increased as age of dam increased. Node 5 was split into two child nodes according to herd type (Node 9 and Node 10), which can be said to have an important effect on birth weight of Hemsinlambs. It was found that the average birth weight of lambs born by dams in the base herd (Node 9; 3.692 ± 0.683) was lower than the average birth weight of lambs born by dams in the multipliers elite (Node 10; 4.099 ± 0.626). Also, Node 11 containing female singleton lambs was split into two child nodes according to herd type as base herd (Node 15) and multipliers elite herd (Node 16) and the average birth weight of female singleton lambs born by dams in the base herd (3.496 ± 0.754) was found to be lower compared to female singleton lambs born by dams in the multipliers elite herd (3.804 ± 0.393) (Figure 1). Herd type had a significant effect on birth weight for both sexes and the average birth weight of lambs born by dams in the multipliers elite herd was higher. Node 6 containing female lambs born in 2007, 2008 and 2010 was split into two child nodes according to birth type (Node 11 and Node 12) and the average birth weight of female singleton lambs (Node 11; 3.532 ± 0.727) was found to be higher compared to female twin lambs (Node 12; 3.167 ± 0.487). Node 10 containing female lambs born by dams in the multipliers elite herd was split into two child nodes according to birth type (Node 13 and Node 14) and the average birth weight of singleton lambs (Node 13; 4.343 ± 0.559) was found to be higher compared to twin lambs (Node 14; 3.593 ± 0.423). It was found that birth type had a significant effect on birth weight of both sexes and the average weight of singleton lambs was higher compared to the average birth weight of twin and triplet lambs.

The average birth weight of Hemsin lambs was found to be 3.550 kg in this study, which is similar to the finding of the study conducted by Sezgin *et al.* (2012) on Hemsin lambs. The average birth weight of Hemsin lambs in this study was found to be lower compared to Morkaraman (4.03) (Esenbuga and Dayioglu, 2002), Ivesi (4.31) (Jawasreh *et al*., 2009), Akkaraman (4.037) (Gökçe *et al*., 2013), Rambouillet (3.67) (Hussain *et al*., 2000), Lohi (3.59) (Babar *et al*., 2004), Suffolk (5.04), Texel (4.93) and Charallais (4.88) (Yaqoob *et al*., 2004) and higher compared to West African (2.3), Persian Black Head (2.4), West African cross (2.5), Dorset Horn cross (2,9) (Combellas*et al*., 1980).

A higher average birth weight for male lambs compared to female lambs and a higher average birth weight for singleton lambs compared to twin and triplet lambs on a statistically significant level were expected results of the study. Sezgin *et al*. (2012) found that male Hemsin lambs had a significantly higher birth weight compared to female lambs. Similar results were found in studies performed with different races as well. A higher average birth weight for male lambs compared to female lambs and a higher average birth weight for singleton lambs compared to twin lambs were found by Gökçe *et al*. (2013) in Akkaraman lambs, by Kopuzlu *et al*. (2014) in Morkaraman lambs, by Oldham *et al*. (2011) in Merinos lambs and by Combellas *et al*. (1980) in West African and Black-Headed Persian lambs.

In this study, the average birth weight of lambs born by dams in the multipliers elite herd was found to be higher compared to lambs born by dams in the base herd, however the difference between average birth weights was not statistically significant. Sezgin *et al*. (2012) found that the average birth weight of Hemsin lambs born by dams in the multipliers elite herd was higher compared to lambs born by dams in the multipliers elite herd and base herd and the difference was significant. In their study performed with MorKaraman lambs, Kopuzlu *et al*. (2014) reported a difference in average birth weight betweenlambs born by dams in elite, multipliers and base herds. Although the average birth weight of lambs born by dams aged 3,4 and 5 years was found to be higher than the average birth weight of lambs born by dams aged 2 and 6 years, the difference was not statistically significant

(P>0.05). Sezgin *et al*. (2012) reported that birth weight of Hemsin lambs increased as age of dam increased. Babar *et al.* (2004) reported a higher average birth weight for Lohi lambs born by older dams. In this study, average weights of lambs born in 2007, 2008, 2009 and 2010 were 3.6696, 3.5306, 3.2688 and 3.6819 respectively. While there was no difference between birth weights in 2007 and 2010, a very significant difference was found between other years (P>0.001). Babar *et al.*(2004) found no significant different in birth weight for Lohi lambs according to birth year. Although no significance difference was observed in this study in average birth weight according to lamb color (P>0.05), Sezgin *et al*. (2012) reported a difference in birth weight of Hemsin lambs according to lamb color.

In this study, according to the regression tree diagram, the most important factors affecting birth weight of Hemsin lambs were birth year, birth type, sex, herd type and age of dam. While birth year, birth type, sex, herd type and age of dam are present in the regression tree diagram, lamb color is not. The absence of lamb color in the regression tree diagram indicates its insignificant effect on birth weight. Similar results were found in various studies as well. Gökçe *et al*. (2013) reported that type of birth, parity and gender had significant effect on birth weight of Akkaraman lamb. Eyduran *et al*. (2008) reported that birth type and lamb sex were the most significant variables affecting birth weight according to the regression tree model. Babar *et al*. (2004) observed that the birth weight in Lohi lambs was affected by the year, season of birth, type of birth and the sex. One of the most important reasons behind the effect of birth year on birth weight is that environmental conditions vary between years. Environmental conditions have an important impact especially in pasture areas. Good weather conditions have a positive effect on animals fed in pastures. Especially dry air has negative effects on farm animals. Negative effects of environmental conditions may be minimized by improved care and feeding during the pregnancy period of sheep. In parallel, an increase in both birth weight and viability of lambs may be achieved. The low risk value (0.456) and high R-Squared value (0.862) of the regression tree model shows that the model is sufficient to explain birth weight. According to the regression tree model, variables of birth year, birth type, sex, herd type and age of dam explained 86.2% of the variation in birth weight. The risk value of the regression tree model (0,456) is also the error mean square of the model and a low error mean square indicates a low deviation between observed values and estimated values according to the model, in other words, that the model has a minimum error value in explaining actual values.

4. CONCLUSION

In conclusion, the regression tree analysis may be used when examining effects of any variable on other variables in farm animals. The average birth weight of Hemsin lambs was found to be 3.55 kg and the standard deviation was 0.727 kg. According to the regression tree diagram, the most important factors affecting birth weight of Hemsin lambs were birth year, birth type, sex, herd type and age of dam. The absence of lamb color in the regression tree diagram indicates its insignificant effect on birth weight. The low risk value (0.862) and high R-Squared value (0,456) of the regression tree model shows that the model is sufficient to explain birth weight. According to the regression tree model, variables of birth year, birth type, sex, herd type and age of dam explained 86.2% of the variation in birth weight. Significance levels of factors affecting birth weight of Hemsin lambs were revealed using the regression tree analysis and a good guide was created to be used in studies aiming to improve this feature.

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