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Multidimensional scaling analysis for investigating relations between milk yield and fertility parameters

[*Análise multidimensional de escala para investigar as relações entre o rendimento do leite e os parâmetros de fertilidade*]

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ABSTRACT

Milk yield and fertility traits in dairy cattle and their relationship with the influencing factors were investigated using multidimensional scaling analysis (MDS) in this study. The study focused on the relationship between lactation length, 305-day milk yield, actual milk yield and peak remaining days from milk yield characteristics, and service period, dry period, insemination per conception and calving interval from fertility traits, as well as the influencing factors such as calving age, lactation number, birth season, and birth year. When the MDS results were examined, it was discovered that all the traits had close Euclidean distances from each other, save for the birth season and birth year. As a result of MDS analysis, R^2 and Stress Coefficient were calculated as 88.4% and 0.099, respectively. Consequently, the selection direction was tried to be identified by determining the milk yield and fertility traits and the relationship between these traits and the influencing factors through the MDS analysis and it was concluded that the MDS method could be employed in this field.

Keywords: 305-day milk yield, multidimensional scaling analysis, prediction, dairy cows

RESUMO

As características de produção de leite e fertilidade do gado leiteiro e sua relação com os fatores de influência foram investigadas utilizando a análise de escala multidimensional (MDS) neste estudo. O estudo concentrou-se na relação entre o tempo de lactação, produção de leite de 305 dias, produção real de leite e pico de dias restantes das características de produção de leite, e período de serviço, período seco, inseminação por concepção e intervalo de partos dos traços de fertilidade, bem como os fatores influenciadores como idade de parição, número de lactação, época de nascimento e ano de nascimento. Quando os resultados do MDS foram examinados, descobriu-se que todos os traços tinham distâncias Euclidianas próximas umas das outras, exceto para a época de nascimento e ano de nascimento. Como resultado da análise do MDS, o R2 e o Coeficiente de Estresse foram calculados como 88,4% e 0,099, respectivamente. Consequentemente, tentou-se identificar a direção da seleção determinando os traços de produção e fertilidade do leite e a relação entre estes traços e os fatores de influência através da análise MDS e concluiu-se que o método MDS poderia ser empregado neste campo.

Palavras-chave: 305 dias de produção de leite, análise multidimensional de escala, previsão, vacas leiteiras

INTRODUCTION

The milk yield and fertility traits are the most significant topics that researchers studying on animal improvement have focused on in recent years (Berry *et al*., 2007; Khalid *et al.*, 2007; Kuthu *et al.*, 2007; Genç and Soysal, 2018, 2019; Öztürk *et al.*, 2021). Therefore, the studies in the literature have aimed to improve milk and fertility parameters in future generations and to identify the influencing factors and to identify the environmental and genetic factors that affect milk yield and fertility traits in livestock (dairy

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cattle, sheep, goat, buffalo, etc.), particularly dairy cattle, and to determine the relationship between them (Van Vleck and Henderson, 1961; Ashmawy *et al.*, 1985; Mendes and Akkartal, 2009; Genç and Mendeş, 2021). The proper implementation of these works depends on keeping the yield records and pedigree regularly. Many environmental factors affect milk yield and fertility traits. The factors, such as age, lactation number, birth season, calving year, calving month, calving age, and farm size are the most significant ones. The preceding environmental factors directly or indirectly affect the milk yield traits, such as overall milk yield, 305-day milk yield, peak milk yield, and lactation length, as well as fertility traits, such as service period, dry period, and insemination per conception (Olori *et al*., 1999; De'ath and Katharina, 2000; David and Paul, 2004; Kocak *et al*., 2007; Zheng *et al*., 2009; Genç and Mendeş, 2021). In recent years, several mathematical and statistical methods have been frequently utilized to identify these effects. The identification of the milk yield and fertility traits, as well as the influencing factors with these methods, will improve the efficiency in breeding improvement, and it will be utilized in later studies. Therefore, the Multidimensional Scaling Method (MDS) has been used frequently in recent years (Kruskal and Wish, 1978; Başpınar *et al*., 2000; Borg and Groenen, 2005).

MDS is one of the statistical methods that is used to determine the correlation between the variables by utilizing the distances in cases where the correlation between the traits is not known exactly but the distances between them can be calculated (Özdamar, 2004). MDS can help to determine the relationship between variables represented in a k-dimensional space by displaying them very close to their original positions in a less dimensional (two, three, …) conceptual space. When these features of MDS are evaluated, identifying the distances of the milk yield and fertility traits, as well as the influencing factors, will constitute the framework of the study (Kruskal and Wish, 1978; Başpınar *et al*., 2000; Yiğit and Mendeş, 2018; Genç and Mendeş, 2021).

The identification of the milk yield and fertility traits, as well as the influencing factors is used at every stage of selection in animal improvement. MDS analysis makes it easier to determine relationship between all these variables than other known methods (correlation and regression), and it addresses all observation values. In general, phenotypic and genotypic selection takes precedence in selection treatments. However, the number of variables used in these methods is limited. Therefore, phenotypic or genotypic selection by these methods involves long processes (Yiğit and Mendeş, 2016; Genç and Soysal, 2019; Öztürk *et al.,* 2021). For some non-parametric traits (insemination number, fertility rate, etc.), the selection is delayed or cannot be applied. The MDS method assesses all variables and the factors affecting them, regardless of being parametric or not. The selection direction may be identified at every stage of improvement using this method, by revealing the correlations between the variables. With the MDS method, the effect and direction of each variable are known. With this analysis, it will be possible to graphically determine which selection will be easier, faster, in which direction and which variables will be used in selected herds. This analysis enables to graphically determine which selection will be easier, faster, which direction will be taken, and which variables will be utilized in selected herds (Kruskal and Wish, 1978, Başpınar *et al*., 2000, Yiğit and Mendeş, 2018; Genç and Mendeş, 2021; Mendes, 2021).

The relationship between lactation length, 305-day milk yield, actual milk yield, peak milk yield and peak remaining days from milk yield characteristics, and service period, drying period, insemination per conception, and calving interval from fertility traits, as well as the influencing factors such as calving age, lactation number, birth season, and birth year were determined through MDS method. The main purpose of this study is to investigate the relationships among the milk yield and fertility parameters by using multidimensional scaling technique"

MATERIALS AND METHODS

The material of the study contained data from 2936 lactation records of Holstein dairy cattle raised between 2011 and 2019 on a private enterprise, a member of the Cattle Breeders' Association of Turkey. These records consisted of the variables of lactation length, 305-day milk yield, actual milk yield, peak milk yield and peak remaining days from milk yield characteristics, service period, drying period, insemination per conception and calving interval from fertility traits, as well as the variables of calving age, lactation number, birth season and birth year.

While preparing the data, animals whose numbers were less than 100 in the groups of year and lactation number, as well as animals that were separated from the herd due to the reasons such as stillbirth, abortion, disease, or disability were excluded from the evaluation. Animals with unknown maternal and paternal ear tags were also excluded. Animals with a lactation length longer than 550 days and less than 220 days, as well as those with a calving age less than 20 months for the first lactation and greater than 40 months, as well as those remaining outside by adding 12 months to the previous lower limit and 14 months to the upper limit in successive lactations were excluded from the analysis. However, those with calving intervals less than 310 days and more than 550 days were not utilized as an observation value (Kumlu and Akman, 1999).

Holstein dairy cattle with an average body weight of 500 kg, whose milk and progeny parameters were started to be monitored during the lactation period, were fed with NRC (Nutrint…, 2001) TMR ration with 20% crude protein and 33.7 Mcal NEL energy content.

Many methods are utilized in the literature to identify the factors that affect the milk yield and fertility traits of farm animals. Therefore, the Multidimensional Scaling Method (MDS) was used in the study.

The MDS aims to obtain a graphical result by analyzing the distances and differences between n points in a p-dimensional (p=2, 3, …) space, as well as their proximity to each other and positions in Euclidean space. This is utilized to gain a better understanding of the dimensions of the conceptual space and data, as well as to generate new knowledge. The MDS method may analyze data without requiring the relevant distribution assumption. It enables the determination of the configuration distances (configuration distances, map distances, d_{ij}) that would represent the distance between the variables (data distances, δ_{ij}) with the least error through one of the regression methods (linear, polynomial, monotonic). The original and geometric display distances between N objects are calculated. These distances are processed as configuration (configuration coordinate system) and original distances and are displayed in the coordinate system. The stress measure refers to the metric between the original and configuration distances (Kruskal and Wish, 1978; Breiman *et al*., 1984; Başpınar *et al*., 2000; Bevilacqua *et al*., 2003; David and Paul, 2004; Özdamar, 2004; Camdeviren *et al*., 2005; Mendes and Akkartal, 2009; Karabag *et al*., 2010; Yiğit and Mendeş, 2018). The distances are calculated as follows:

$$d_{ij} = a + b\delta_{ij} + e$$

The SPSS software was utilized in the study to identify the factors that affect the milk yield and fertility traits by the MDS method (Statistical…, 2008).

RESULTS AND DISCUSSION

Table 1 shows descriptive statistics. According to these findings, 305-day milk yield and Actual milk yield were found above the average herds when milk yield traits were considered. When the fertility traits were reviewed, they are found to be in accord with the average herd fertility parameters. When these results are examined, it appears that MDS, one of the graphical methods to be utilized on these data, can operate with sufficient reliability.

The descriptive statistics of independent and dependent variables are given in Table 1. The mean and standard error of lactation length, 305-day milk yield, actual milk yield, peak remaining day, peak milk yield and drying period of the cows were obtained as 357.6±1.33, 9317.6±35.10, 10450±51.70, 81.8±0.85, 40.5±0.14 and 55.4±0.50 respectively. And also, insemination per conp., service period, calving age and calving interval were calculated as 2.6±0.026, 147.8±1.3, 37.6±0.26 and 385.4±2.22 respectively.

Table 1. Descriptive statistics for fertility and milk yield parameters

		n	$\bar{X} \pm S_{\bar{X}}$	CV (%)	Minimum	Maximum
Mil yield parameters	Lactation length (day)	2936	357.6±1.33	20.1	220	550
	305-day milk yield (kg)	2936	9317.6±35.10	20.4	2394	15176
	Actual milk yield (kg)	2936	10450±51.70	26.8	2209	21679
	Peak remaining day	2879	81.8±0.85	55.9	2.00	240.0
	Peak milk yield (kg)	2924	40.5±0.14	18.7	20.60	66.62
	Drying period (day)	2225	55.4±0.50	41.8	20.00	101.0
Fertility yield parameters	Insemination per conp.	2498	2.6±0.026	50.6	1.00	5.0
	Service period (day)	2787	147.8±1.3	47.8	33.00	120.0
	Calving age (month)	2936	37.6±0.26	37.8	20.40	39.6
	Calving interval (day)	475	385.4±2.22	12.5	310.00	550.0

$\bar{X} \pm S_{\bar{X}}$:Mean±SE Mean; CV% :coefficient of variation

MDS analysis was performed to investigate the relations between milk yield parameters and some fertility parameters (Figure 1. and Table 2.). Two different goodness-of-fit criteria namely: R^2 and stress coefficient have been used to determine the suitability of MDS technique for investigating the relations investigate the relations between milk yield parameters and some fertility parameters (Kruskal and Wish, 1978; Başpınar *et al*., 2000; Yiğit and Mendeş, 2018). R^2 and stress coefficient values (88.4% and 0.099) indicated that MDS technique was one of a good choice in evaluating interested relations (Berry *et al*., 2007; Mendes and Akkartal, 2009).

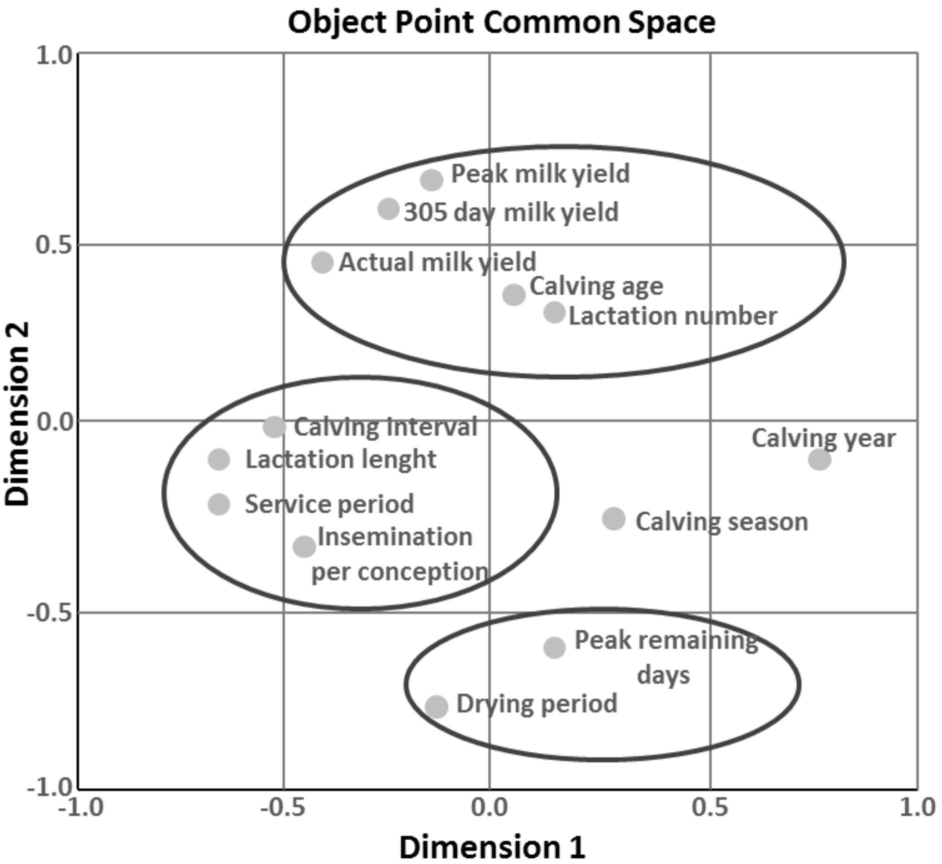

Figure 1. MDS map for investigating the relation between some milk yield and fertility parameters.

MDS results are presented in Figure 1. According to the MDS results, these parameters have been divided into three groups. As it can be seen from the Figure 1, peak milk yield, 305-day milk yield, actual milk yield, calving age and lactation number are placed in the same group that means these parameters are related each other. And there is a positive relationship between these parameters. Likewise, the calving interval, lactation length, service period and insemination per conception are in the same group. Therefore, these parameters are related or correlated. The peak remaining day and drying period have been placed in another group. On the other hand, the calving year and calving season are in different places (Kruskal and Wish, 1978; Başpınar *et al*., 2000; Yiğit and Mendeş, 2018).

Table 2. MDS final coordinates for milk and fertility yield

Final Coordinates		
	Dimension	
	1	2
Lactation length	-0.580	-0.139
305-day milk yield	0.583	-0.195
Actual milk yield	0.437	-0.312
Peak remaining days	0.527	**-0.659**
Peak milk yield	0.642	-0.121
Service period	-0.583	-0.198
Dry period	-0.071	**-0.764**
Insemination per conception	-0.481	-0.395
Calving interval	-0.486	0.069
Calving age (month)	0.516	0.422
Lactation number	0.603	0.413
Calving season	0.306	-0.284
Calving year	0.877	-0.127

MDS final coordinates for milk and fertility yield were given in Table 2. As it can be seen from the Table 2, dimensions 1 for milk yield parameters were obtained as 305-day milk yield and peak milk yield; 0.583 and 0.642 respectively. And also, fertility yield parameters were calculated as lactation number and calving year; 0.603 and 0.877 respectively.

The results obtained by MDS analysis have shown us which milk or fertility yield parameters can be used primarily in zootechnical practice. According to these results, peak remaining days for from milk yield parameters and the dry period from the fertility parameters should be used first.

CONCLUSION

Consequently, it was tried to be put forth which milk yield and fertility traits may be used in studies to be carried out to identify the parents of future generations with MDS analysis. Stress and R^2 values calculated by MDS analysis were sufficient. Thus, when milk yield traits were evaluated in selection works, it was observed that 305-day milk yield, actual milk yield, peak milk yield, lactation number, and calving age were all close to each other. When the fertility traits were evaluated, it was found that the calving interval, service period, insemination per conception, and lactation time were all closely correlated. It is believed that the MDS method, along with all these results, would contribute to improvement and selection studies. Future studies should take these findings into account. In other words, it is seen that the MDS method may be utilized in future studies. As a result, MDS method could be used as selection criteria and to increase the success of the selection in breeding studies for Holstein cattle population in Turkey.

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