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Effects of Some Environmental Factors on Milking Time Milk Yield in Red Holstein Cows

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A R T I C L E I N F O

Research Article

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A B S T R A C T

The purpose of this study is to investigate the environmental factors on the milking time milk yield of Red Holstein cows. For this aim, 172,826 morning milk yield (MMY) and 172,771 evening milk yield (EMY) data collected between 2001 and 2010 from a dairy farm in Aydin Province, Turkey were used. The THI is over 72 from June to August in the region. The effects of calving month, calving year, parity, lactation month and milking month on MMY and EMY were found to be statistically significant (P<0.01). For every month, year and parity, the MMY means were higher than those of the EMY. The peak daily milk yield was determined on the 46th day of lactation (31.7±0.013 kg). For parity, the highest milk yield means were detected for the third parity: 13.69±0.023 kg for MMY and 11.70±0.021 kg for EMY. In conclusion, taking precautions to protect the cows from heat stress especially for the cows calved in summer and keeping the milking interval equal for whole year would help increasing the milk yield.

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Introduction

The milk yield of a dairy cow is affected by genetic capacity of it and some environmental factors. Feeding programs, herd management, health and climatic factors are the main environmental factors affecting the milk yield. In a hot environment, climatic factors, temperature, humidity, wind velocity, solar radiation is the main factors that affect animal comfort.

Heat stress is one of the main factors affecting the comfort of the cow. It depends on the breed and body temperature regulation changes under heat stress in a hot environment (Hammond et al., 1998). When a dairy cow cannot maintain its body temperature within a physiological range, thermal stress occurs and thus respiration rate, body temperature, drinking frequency and water intake increases and also feed intake, milk yield, milk constituents, health condition, mobility and also fertility of it decreases. Under thermo-neutral environmental conditions, animals can maintain physiological parameters in equilibrium and keep their body temperature constant. Maintaining the physiologic parameters of animals in a narrow range can compromise thermoregulation (Banerjee and Ashutosh, 2011).

To determine heat stress in cattle, the temperature-humidity index (THI) is used and THI of 72 is accepted as a threshold for heat stress in dairy cows (Ravagnolo and Misztal, 2000; Gantner et al., 2011). However, some researchers indicated that heat stress starts below this level (Linvill and Pardue, 1992). Under heat stress conditions, production costs increase in dairy industry (Gantner et al., 2011), and the milk yield, fat and protein contents decrease (Ravagnolo and Misztal, 2000; Barash et al., 2001; Bernabucci et al., 2002; Gantner et al., 2011). Somatic cell count in milk of dairy cow can also be increased under heat stress conditions (Bouraoui et al., 2002; Bertocchi et al., 2014).

In hot summer months, there can be significant decreases in milk yield in Red Holstein (RH) (Koc, 2012; 2015), in fat content in Holstein and Montbeliarde cows (Koc, 2011), in protein content in RH (Koc, 2011; 2015), in non-fat dry matter content in bulk milk in Holstein, Montbeliarde and RH cows (Koc, 2008; 2011; 2015) as well as increases in somatic cell count in bulk milk in RH, Holstein and Montbeliarde cows (Koc, 2008; 2011, Yilmaz and Koc, 2013).

Some studies reported significant milking time effects on milk yield as well as milk constituents of dairy cows (Koc and Kizilkaya, 2009; Koc, 2007; 2015; Yilmaz and Koc, 2013). It was reported that morning milk yield in Holstein (Koc and Kizilkaya, 2009) and in Red-Holstein (Yimaz and Koc, 2013; Koc 2015) is higher than that of evening milk yield. Depending on the decrease in evening milk yield, solid component of milk would be increases and protein content in evening milk yield of Red-Holstein cows was reported higher than that of morning milk yield (Koc, 2015).

The objective of this study was to determine the effects of some environmental factors on milking time milk yield in Red Holstein cows raised under Mediterranean climatic conditions in Aydin Province, Turkey.

Materials and Methods

The Red Holstein data was collected between 2001 and 2010 from the farmer's records. The farm is located in Aydin Province, Turkey and has Mediterranean climate. The geographic coordinates of the farm are 37° 45' 48.15" N and 27° 17' 34.45" E. In order to evaluate the climate in the region and monitor the heat stress in cows on the farm, the long term monthly averages of temperature (°C) and relative humidity (%) of Aydin province obtained from the Turkish State Meteorological Services (2012) were used to calculate THI from the formula developed by Kibler (1964). As seen in Figure 1a, the long-term monthly average highest temperature and THI for the region are 33.5°C and 72.97 in June, 36.1°C and 76.15 in July, 35.4°C and 75.49 in August and 32.0°C and 70.26 in September, respectively. The average calving interval, lactation length, lactation milk yield, and 305-d milk yield of this RH herd were 443±4.9 d, 349±4.0 d, 8.509±120.1 kg, and 7.679±87.5 kg, respectively (Koc, 2012).

The cows in this herd milked twice in a day, roughly 12 hours apart, but the milking interval could be 11-13 hours depending on the length of the day. The cows were kept in an open stall barn and were cooled with fans in summer. For statistical analysis, 172.826 morning milk yield (MMY) data and 172.771 evening milk yield (EMY) data belonging to 431 lactations of 169 cows were used. The MMY and EMY data were analyzed separately. Lactations were defined as starting one day after calving, and due to colostrum production at the first few days, the milk yield of these days were estimated with the averages of the first three days records of the cows for that lactation. During lactation, missing records were estimated as the averages from the last three and the next three days records. If the number of missing records were more than 15 days, then interpolation was not done and that lactation was not included in the analysis. For the long lasting lactation, only the records of the first 550 days were used.

Before the statistical analysis, twelve calving months (1,2, and 12), ten calving years (from 2001 to 2010), five parity classes (1, 2, 3, 4, and 5 or more), twelve lactation months (1,2,… and 12 or more) and twelve milking months (1,2,… and 12) were assumed. Data were analyzed using the GLM procedure in SAS (1999). The differences between the least squares means of fixed factor levels were considered to be statistically significant at P<0.05 (2-tailed) based on Tukey's adjustment type-I error rate. The statistical model used for the analysis was as follows:

$$y_{ijklmn}= \mu + a_i+ b_j+ c_k+ d_l+ f_m +(ad)_{il}+ (df)_{lm} + e_{ijklmn}$$

Where, y_{ijklmn} is morning or evening daily milk yield, μ is overall mean, a_i is the calving month effects (i = 1, 2, 3, … and 12), b_j is the calving year effects (j = 2001, 2002, … and 2010), c_k is the parity effects (k = 1, 2, 3, 4 and 5+), d_l is the lactation month effects (l = 1, 2, 3, … and 12), f_m is the milking month effects (m = 1, 2, 3, …and 12), $(ad)_{il}$ is the calving month x the lactation month interaction effects, $(df)_{lm}$ is the lactation month x the milking month interaction effects, and e_{ijklmn} is normally distributed random error with mean zero and unknown variance σ^2.

Results and Discussion

MMY and EMY LS means in RH cows are given in Table 1. Monthly changes of THI, MMY and EMY for calving months are given in Figure 1a. The averages of MMY and EMY were 12.79±0.011 kg and 11.14±0.010 kg, respectively. Figure 1a shows that for every calving month, the MMY is higher than the EMY. In both milking times, the highest mean was determined for the April calving month (Table 1, Figure 1a) and MMY average (14.16±0.057 kg) was 2.14 kg higher than the EMY (12.02±0.051 kg) for this month. The lowest milk yield was seen in July for both milkings, and the means for July were 11.86±0.057 kg and 10.04±0.049 kg for MMY and EMY, respectively.

As seen in Figure 1a, for both milkings, the milk yield means dropped from April to June and then increased through October. Cows giving birth in April had 2.3 kg and 1.98 kg higher milk yield in morning and evening milkings than those who gave birth in July, respectively. These differences between the means for both milkings were also found to be statistically significant (P<0.01). The increases from July to October are 1.92 kg and 1.76 kg for morning and evening milkings, respectively. The decreases in milk yields in the summer calving cows might be due to the hot weather. Because the beginning of the lactations of these cows coincides with hot summer months, and seen in Figure 1a the THI of the region is over 72 at this time of the year and due to possible heat stress cows produced less milk. This has been also shown in the literature (Gurses and Bayraktar, 2012; M'hamdi et al., 2012; Sahin and Ulutas, 2011).

The mean MMY is higher than that of EMY for Holstein (Koc and Kizilkaya, 2009), Holstein and Montbeliarde (Koc, 2011) and RH (Koc, 2015; Yilmaz and Koc, 2013). For EMY, the mean found in this study is higher than the findings of Koc and Kizilkaya (2009). In this study, higher milk yield found in MMY than EMY—especially in winter—might be attributed to unequal milking interval. During the visit to the farm, the longer winter nights implied that cows were often milked late in the morning and early in the evening. However, in the summer, the interval was nearly equal. In the winter, cows produce more milk in the morning milking due to longer intervals from evening milking to morning milking. Similar to this study, Holsteins (Koc and Kizilkaya, 2009) and RH (Yilmaz and Koc, 2013; Koc, 2015) were shown to have higher milk yield in the morning milking than the evening milking.

Table 1 LS MEANS and standard errors of morning and evening milk yield in Red Holstein cows

Factors	Morning Milking Milk Yield, Kg		Evening Milking Milk Yield, Kg	
	n	X±Sx	n	X±Sx
Calving Month		**		**
1	21050	12.822±0.0519^{Ada}	21021	11.234±0.0456^{Aab}
2	27275	12.759±0.0516^{Aa}	27267	11.245±0.0454^{AFag}
3	19414	13.200±0.0522^{Bbg}	19403	11.370±0.0462^{AFbh}
4	9067	14.156±0.0566^{Cc}	9074	12.017±0.0509^{Bc}
5	12183	13.108±0.0537^{BDbg}	12294	11.286±0.0489^{AFabh}
6	8891	11.977±0.0586^{Ede}	8860	10.334±0.0528^{Cd}
7	14972	11.862±0.0566^{Ed}	14614	10.040±0.0488^{De}
8	12892	12.043±0.0569^{Ee}	12907	10.099±0.0480^{De}
9	18032	12.821±0.0564^{Ada}	18041	10.872±0.0513^{Ef}
10	6836	13.783±0.0635^{Ff}	7107	11.798±0.058^{Bc}
11	6919	13.086±0.0615^{BDb}	6899	10.769±0.0554^{Ef}
12	15295	13.312±0.0534^{Bg}	15284	11.412±0.0476^{Fgh}
Calving Year		**		**
2001	28477	11.154±0.0278^{Aa}	28438	10.392±0.0251^{Aa}
2002	18029	11.730±0.0312^{Bb}	18018	11.002±0.0284^{Bb}
2003	18986	12.686±0.0280^{Cc}	18981	11.422±0.0251^{Cc}
2004	15011	13.130±0.0293^{Dd}	15005	11.445±0.0264^{Cc}
2005	15989	14.571±0.0278^{Ee}	15986	12.300±0.0251^{Dd}
2006	24456	14.135±0.0227^{Ff}	24449	12.568±0.0205^{Ee}
2007	16963	13.521±0.0271^{Gg}	16978	11.147±0.0244^{Ff}
2008	15743	12.775±0.0278^{Cc}	15740	10.151±0.0250^{Gg}
2009	13756	13.277±0.0307^{Dh}	13756	10.342±0.0278^{Aa}
2010	5416	12.128±0.0478^{Hi}	5420	9.629±0.0431^{Hh}
Parity		**		**
1	57053	12.545±0.0183^{Aa}	57015	10.564±0.0165^{Aa}
2	46462	13.111±0.0192^{Bb}	46462	11.105±0.0173^{Bb}
3	29584	13.694±0.0231^{Cc}	29577	11.701±0.0208^{Cc}
4	15418	12.842±0.0308^{Dd}	15409	10.996±0.0278^{Dd}
5	24309	12.360±0.0234^{Ee}	24308	10.834±0.0211^{Ee}
Lactation Month		**		**
1	15092	15.407±0.0303^{Aa}	15092	13.720±0.0273^{Aa}
2	15128	16.754±0.0303^{Bb}	15129	14.732±0.0273^{Bb}
3	15175	16.290±0.0302^{Cc}	15176	14.175±0.0272^{Cc}
4	15022	15.485±0.0305^{Aa}	15026	13.310±0.0274^{Dd}
5	14664	14.656±0.0310^{Dd}	14660	12.403±0.0278^{Ee}
6	14390	13.651±0.0314^{Ee}	14383	11.470±0.0283^{Ff}
7	14023	12.770±0.0319^{Ff}	14021	10.770±0.0287^{Gg}
8	13628	11.834±0.0322^{Gg}	13628	9.959±0.0290^{Hh}
9	12808	10.754±0.0332^{Hh}	12805	9.055±0.0299^{Ii}
10	10828	9.900±0.0352^{Ii}	10834	8.388±0.0318^{Jj}
11	8974	9.283±0.0385^{Jj}	8963	7.782±0.0348^{Kk}
12	23094	8.143±0.0251^{Kk}	23054	6.713±0.0226^{Ll}
Milking month		**		**
1	13354	13.292±0.0500^{AEa}	13315	10.757±0.0493^{ACEabi}
2	12999	13.138±0.0569^{AEa}	12989	10.816±0.0508^{ACEabi}
3	15515	12.858±0.0558^{Bb}	15457	10.648±0.0496^{AEai}
4	15176	12.612±0.0551^{Cc}	15128	10.813±0.0492^{ACEbj}
5	15402	12.663±0.0549^{BCbc}	15369	11.269±0.0489^{BDcefg}
6	14323	12.623±0.0558^{BCbc}	14304	11.453±0.0497^{Bdh}
7	14798	12.457±0.0559^{Cc}	14758	11.482±0.0501^{Bcdh}
8	15158	12.203±0.0554^{Dd}	15120	11.046±0.0492^{CDbe}
9	14824	13.017±0.0549^{ABab}	15176	11.470±0.0469^{Bdf}
10	15430	13.092±0.0535^{ABab}	15399	11.302±0.0477^{Bgh}
11	13007	13.382±0.0550^{EFa}	12946	10.812±0.0496^{ACab}
12	12840	13.590±0.0551^{Fe}	12810	10.610±0.0498^{Eij}
Calving Month x Lactation Month		**		**
Lactation Month x Milking Month		**		**
Overall	172826	12.79±0.011	172771	11.14±0.010

**: $P < 0.01$. A, B, C, D, E, F, G, H, I, J, K, L show significance at $P<0.01$; a, b, c, d, e, f, g, h, i, j, k, l show significance at ($P<0.05$).

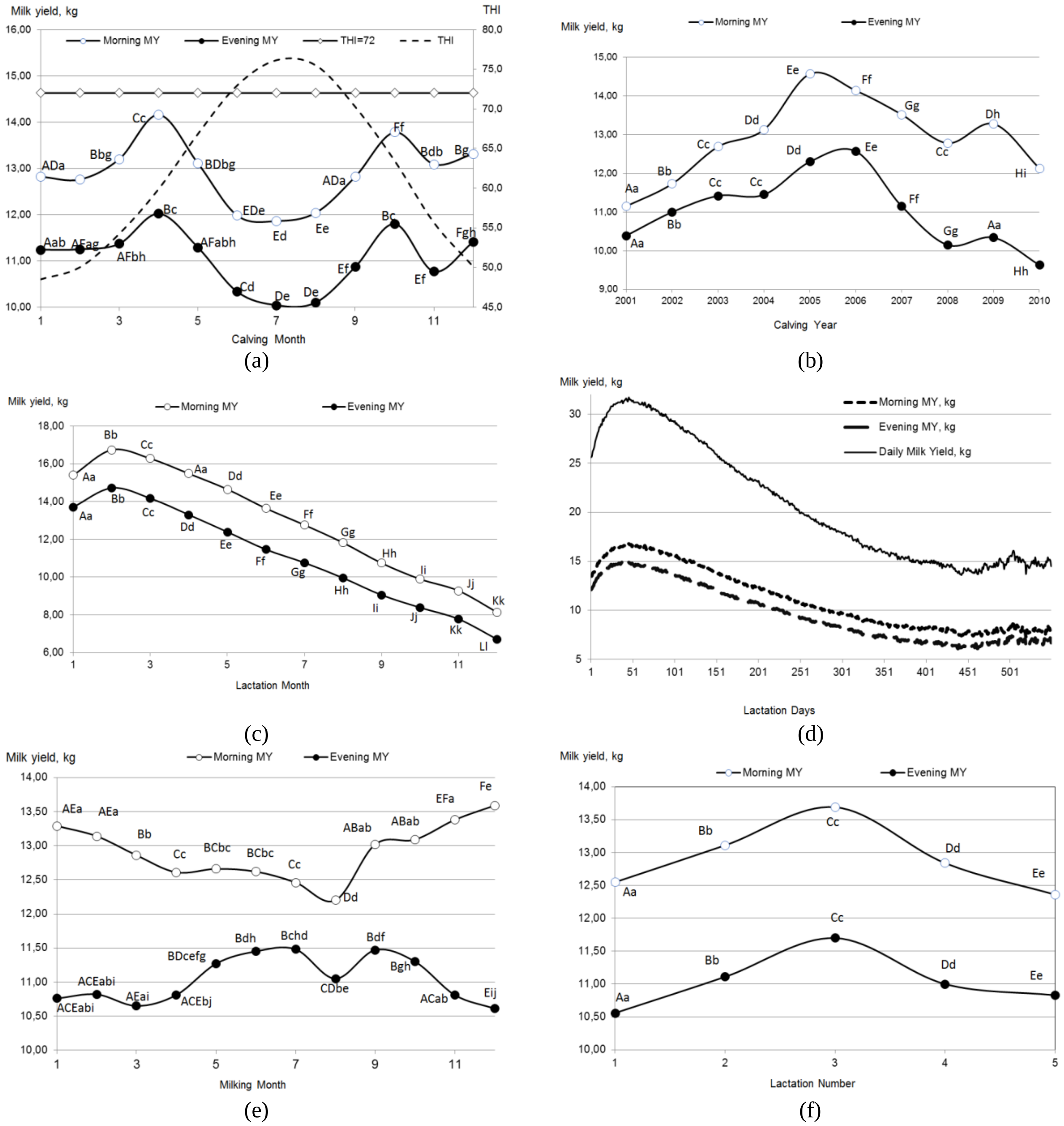

Figure 1 Morning and evening milk yield, a) monthly averages (P<0.01) and Temperature Humidity Index (THI), b) calving year averages (P<0.01), c) lactation month averages (P<0.01), d) lactation days averages (P<0.01), e) milking month averages (P<0.01) and f) parity averages (P<0.01).

For calving year, the highest milk yield mean was determined for 2005 (14.57±0.028 kg) and the lowest mean for 2001 (11.15±0.028 kg) for MMY (Figure 1b). For EMY, the highest and the lowest means were determined for 2006 (12.57±0.021 kg) and for 2010 (9.63±0.043 kg), respectively. The differences between the milk yield means for all years were also found to be statistically significant for MMY (P<0.01). For EMY, except for the differences between 2003 and 2004 and between 2001 and 2009, all other differences were statistically significant (P<0.01).

As seen in Figure 1b, the milk yield means increased until 2005 for MMY and 2006 for EMY and then decreased. Increases in milk yield seen in the first few years could be attributed to the parities of the cows. This herd was established in 2001, and milk yield increased gradually in the following years depending on the increases in cow's parities. The older cows were then replaced with heifers, which might cause a reduction in milk yield in this herd. In addition, the reduction seen after 2005 in daily milk yield in this herd could be due to the reduction in the conditions of management and nutrition in this herd depending on the price instability of raw milk and increasing sources of Turkish dairy.

As seen in Table 1 and Figure 1c, with the 1.34 kg and 1.01 kg increases, the highest milk yield means were determined for the second lactation month in the morning (16.75±0.030 kg) and evening milkings (14.73±0.027 kg), respectively. The second month MMY was 2.02 kg higher than that of EMY. For every lactation month, the MMY means were higher than the EMY. Figure 1c shows that after the second month of lactation, the milk yield monthly means decreased gradually to the 12 month of lactation for both morning and evening milkings. The lowest means were detected at the 12^{th} month of lactation for both morning (8.14±0.025 kg) and evening (6.71±0.023 kg) milkings.

As seen in Figure 1d, the peak milk yield was determined on the 46th day of lactation (16.8±0.019 kg) for morning milking and at 14.9 kg for the 38th, 42th, 43th and 46th days for evening milking. For total daily milk yield, the highest mean was found on the 46th day of lactation (31.7±0.013 kg). For every lactation day, the MMY was also determined to be higher than those of the EMY (Figure 1d).

The peak day determined in this study is shorter than two other studies (Tekerli et al., 2000; Rekik et al., 2003), but longer than the result reported by Hansen et al. (2006). Similar peak days (range: 25-47 days) were also reported by Silvestre et al. (2009). The peak yield found in this study (31.7 ±0.013 kg) is higher than the results of two studies (Tekerli et al., 2000; Hansen et al., 2006), but lower than the results of two studies (Rekik et al., 2003; Silvestre et al., 2009).

As seen in Figure 1e, the MMY mean decreased from January to April and then very similar milk yield means were measured in April to July. After a small decrease in August, the MMY increased gradually from July to December. A nearly opposite pattern for EMY was noted. Milk yield mean increased from April to July, after a small decrease in August, the mean then decreased gradually from September to December. Between morning and evening milkings, higher milk yield differences were noted in the winter months, but the differences were small for summer months (Figure 1e). The seasonal differences detected in milk yield between milkings were mainly due to different milking intervals. Cows were milked late in the morning and early in the evening because of the longer night in the winter. Thus, the interval between morning and evening milking increased in the winter months. Figure 1e shows that for the morning milkings in August, the milk yield was 10.2% lower than in December. However, the evening milking yield in August was 7.6% higher than in December.

For parity, the highest means for both milkings were determined for the 3^{rd} parity (13.69±0.023 kg vs. 11.70±0.021 kg) for this herd; the lowest mean was for the 5^{th} parity (12.36±0.023 kg) for MMY and the first parity (10.56±0.017 kg) for EMY. For both milkings, all parity differences were statistically significant for MMY and EMY (P<0.01; Figure 1f).

Conclusions

In this study, some important findings about the factors having effects on milking time milk yield in RH cows were determined. In summer, because of high THI seen in the region, the weather conditions become one of the significant factors reducing the milk yield of cows. The reduction is very obvious in cows calved in summer. Some significant findings also determined between the morning and evening milkings milk yield. Between the milkings, the milk yield differences were much higher in winter time because of longer interval at night depending on the daylight. For this herd and the herds in the region, taking precautions to protect the cows from heat stress especially for the cows who calved in summer and keeping the milking interval equal for whole year would help increasing the milk yield. In addition, it is advised that as an environmental factor, milking time needs to be put in to the statistical model especially evaluating the data from the herds in which unequal milking time is operated.

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