Body Measurements, Metritis, and Postpartum Performance of First Lactation Cows

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ABSTRACT

Effects of herd, sire, season, body height, BW, age at calving, and metritis on future performance of first lactation cows were evaluated in eight commercial Israeli Holstein herds. Short, heavy first lactation cows had an odds ratio of 3.1 of incidence of metritis at calving compared with all others; 648 first lactation cows were measured at wk 1 postpartum. Sire, herd, age, height, season, and BW contributed to peak milk yield. Metritis did not affect peak yield. Herd, sire, height, and age contributed to mature equivalent corrected 305-d milk yield. No effect was found for BW, season, or metritis. Herd was the only variable contributing to month of peak yield and rate of monthly drop in yield. Interactions between BW, height, and incidence of metritis were significant. Tall, heavy first lactation cows with metritis peaked higher and yielded more than those without metritis. Short, light first lactation cows with metritis yielded less and peaked lower than their healthy counterparts. Metritis did not affect future fertility, but season and the interaction between BW and height did. Tall, heavy first lactation cows had a lower pregnancy rate from first AI, independent of milk yield. The relative importance of height as a predictor of future milk yield is underestimated. The interaction between height and BW may have an antagonistic effect on yield and fertility.
(**Key words**: first lactation cow measurements, metritis, yield, fertility)

Abbreviation key: **AFC** = age at first calving, **H** = height, **ME** = mature equivalent 305-d milk, **MTR** = metritis, **PY** = peak milk yield, **YS** = year-season.

INTRODUCTION

Genetic and phenotypic associations between milk yield and age at first calving (**AFC**), BW, and height (**H**) of first lactation cows at calving are now well established. Few studies dealt with the combined effects of those factors on yield and fertility, and most of those were carried out under experimental conditions (13, 22), compared groups with extreme AFC or feeding regimens (8), or dealt with low yielding cows (13, 22, 27). Some researchers maintain (7, 19) that large cows give more milk than small ones. Effects of BW and H were confined to yields of the entire lactation without regard for the shape of the lactation curves.

Yield and fertility following incidence of metritis (**MTR**) were lower than in cows without MTR (6, 16, 28). The combined effects of MTR and body measurements at calving on these traits have not been reported previously.

The objectives of this study were to evaluate 1) the separate and combined effects of H and BW at calving on the incidence of postparturient MTR, 2) the combined effects of H and BW, AFC, and MTR on lactation curves, and 3) the relative effects of body dimensions, milk yield, and MTR status on conception in high yielding, first lactation cows kept in commercial herds.

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MATERIALS AND METHODS

Data were collected from the senior author's routine practice on eight Israeli Holstein herds from all first lactation cows calving from July 1991 to April 1992. These herds are characterized by high annual milk yield (9000 to 11,000 kg). Replacements were raised on the farms. Rations conformed to NRC (23) recommendations. Broiler manure silage was the main source of protein in the diet. The silage was made with orange peels and usually contributed 50 to 70% of the CP in the ration of heifers aged 8 mo to calving. The estimated respective metabolic energy concentration and CP contents of the silage were 2.2 Mcal/kg of DM and 25%.

Clinical Examination, Body Measurements, and Milk Recordings

Heart girth was used to estimate BW according to standard conversion tables (2). Heart girth measurements have a correlation of 80% with the actual fasting BW of the cow (8), are accurate to 7% (25), and thus fall within the range of normal variation. Height at withers was measured with a vertical standard calibrated to 1 cm and equipped with a crossbar.

All calving first lactation cows were presented for routine examination 5 to 12 d postpartum. At that time, cows were examined for postparturient uterine diseases and measured for heart girth and height of withers. The procedure of that examination and the definitions of the postparturient diseases were described in detail (18).

Yield data were taken from the *Israeli Herd Book* (Israeli Cattle Breeder's Association, Tel Aviv, Israel). All cows included in the study were registered; the milk yield was recorded monthly. Mature equivalent (**ME**) 305-d milk yield was corrected to AFC, month of calving, and days open. The rate of monthly drop in milk was calculated from month of peak yield (**PY**) to that of the sixth milk recording, respectively.

Scope and Methods of Statistical Analysis

Two data sets were used in the study. A group of 191 heifers measured in the last 14 d before calving were used to evaluate the effects of BW and H before calving on the risk of MTR. Of those heifers, 155 had six monthly milk recordings, which were used to evaluate the effects of BW and H before calving on future yield. A group of 648 cows measured after calving were used for the evaluation of the effects of herd, sire, year-season (**YS**), MTR, AFC, BW, and H on yield variables. A total of 621 cows were bred and included to evaluate the effects of those variables on fertility.

Data analysis for yield variables was by the general linear models procedure of SAS (26). Effects were estimated by the following model:

$$Y_{ijklm} = \mu + H_i + S_j + YS_k + MTR_l + BW + H + AFC + e_{ijklm} \quad [1]$$

where Y = the trait, PY, ME, rate of decline in yield, or month of PY on cow m; μ = the overall mean of the population; H_i = the mean effect of the herd i; S_j = the mean effect of the sire j; YS_k = the mean effect of season k (k = 1 if the month of calving was between May and October, or, otherwise, k = 2); MTR_l is the mean effect of MTR 1, 1 = 0, 1; BW, H, and AFC = continuous effects; and other class effect, e, = the unexplained residual.

The combined effects of AFC, BW, H, and MTR on PY and ME were estimated by the following model:

$$Y_{ijklmno} = \mu + H_i + S_j + YS_k + BWH(MTR \times D1 \times D2)_{lmn} + AFC + e_{ijklmno} \quad [2]$$

where D1 = 1 if the heifer H is above the median, or, otherwise, D1 = 2; D2 = 1 if the heifer BW is above the median, or, otherwise, D2 = 2; BWH = BW × H; $BWH(MTR \times D1 \times D2))_{lmn}$ = the interaction between MTR_l and $D1_m$, and $D2_n$ with BWH; AFC and BWH are continuous effects.

The models permitted the estimation of combined and separate effects of the predictor variables on pertinent dependent variables (20). Quadratic models, in agreement with a previous study (27), proved to be of no advantage in our data.

The associations of MTR with body measurements before calving and that of conception with various factors were established by the modified Mantel-Haenszel method (15). Cows were divided into four groups by the four combinations of BW and H related to the medians. The odds ratio of a cow in one group having a trait was compared with that of all other groups pooled together and calculated in subcategories of various control factors.

RESULTS AND DISCUSSION

AFC, BW, H, and Milk Yield

Means and standard deviations were 485.0 ± 47.2 kg for BW, 129.2 ± 3.4 cm for H, and 24.0 ± 1.3 mo for AFC, respectively, measured for 648 cows 5 to 12 d postpartum. Detailed data are in Table 1. The respective means for 191 heifers measured before calving were 532.0 ± 65.9 kg, 128.6 ± 3.4 cm, and 23.9 ± 1.2 mo. The correlation coefficient measured between BW before and after calving was .76 ($P < .0001$) and that between the BW before calving and the rate of BW loss at calving was .47 ($P < .001$).

Although BW in the present study was similar, H (129 cm) was lower than that cited (132.8 cm) for American Holsteins (10). Heifers fed a ration that was high in energy but low in protein may have a normal BW but a short H (5). Energy concentration and CP content of the ration fed to the heifers in our study were according to the NRC (23) recommendations. The nature of the protein can affect H, but not BW, as in a trial in which two different diets were compared. Heifers fed alfalfa silage with corn grain were of equal BW but 3.2 cm taller than those fed corn silage with urea (22). In the present study, the main source of protein in the ration was poultry manure silage. The quality of the protein fed may have been responsible for the somewhat low H. In the present study, as in previous studies (13, 21, 27), cows were measured after calving. Changes associated with parturition had already taken place; the loss in BW was estimated to be 36 kg (3). Correlations established between first lactation performance and BW measured after calving might therefore be misleading because of an incorrect interpretation of cause and effect. Estimates of regression for the traits measured before and after calving were similar on yield variables (Table 2). That similarity, with the high correlation coefficient between BW before and after calving ($r = .76$), justifies the use of the larger data set of measurements taken after calving.

The regression coefficients for yield traits measured after calving (Model [1]) are presented in Table 2. The F values of PY were significant on all measured variables except MTR ($R^2 = .352$, partial $R^2 = .106$, .142, .027, .030, .018, and .030 for herd, sire, YS, H, BW, and AFC, respectively). The F values of projected ME were significant on all measured variables except YS, MTR, and BW ($R^2 = .323$; partial $R^2 = .180$, .096, .024, and .013 for herd, sire, H, and AFC, respectively). The F

TABLE 1. Means, standard deviations, and range of traits among farms.

Trait[1]	$\overline{X}$	SD	Range
Number	80.2		70.0–93.0
ACF, mo	23.9	.5	23.5–25.0
BW, kg	484.8	15.6	465.6–513.5
H, cm	129.2	.6	128.3–130.3
PY, kg/d	34.5	1.7	31.2–37.5
Month of PY, mo	3.3	.2	2.8–3.7
Rate of monthly drop in yield, %	5.7	1.9	3.8–9.9
ME, kg	10,045.0	602.0	9177.0–10,916.0
MTR, %	48.6	7.9	35.5–60.9
Not pregnant from first AI, %	54.7	5.8	43.3–62.7
Open >150 d from calving, %	28.8	2.3	23.9–31.6

[1]AFC = Age at first calving, H = height, PY = peak yield, ME = mature equivalent corrected 305-d milk yield, MTR = postparturient metritis.

TABLE 2. Estimated coefficients for regression equations for yield variables.

Dependent variable	Variable[1]											
	Model						H		BW		AFC	
	R^2	F	Herd F	Sire F	YS F	MTR F	F	Estimate	F	Estimate	F	Estimate
Cows measured after calving (n = 621)												
PY	.352	4.94****	12.70****	1.88***	3.87*	.13	9.73**	.190**	6.52*	.013*	26.65****	.942****
305-d ME yield	.323	4.30****	20.28****	1.36	0	1.63	11.01***	56.200***	1.34	1.580	11.19***	168.900***
Month of PY	.145	1.54**	3.39**	1.29	.29	1.89	.13	.006	.44	−.001	.15	−.020
Drop in yield	.232	2.45****	8.89****	1.11	1.38	.38	1.25	.0009	.72	0	.89	.002
Cows measured before calving (n = 155)												
PY	.275	4.49****	5.54****		1.11	.03	3.24†	.209†	1.17	.008	4.07*	.743*
305-d ME yield	.297	5.00****	7.45****		.05	0	2.83†	52.060†	.43	1.250	1.44	117.980

[1]YS = Year-season, MTR = postparturient metritis, H = height, AFC = age at first calving, PY = peak milk yield, ME = mature equivalent corrected 305-d milk yield.

†$P < .10$.

*$P < .05$.

**$P < .01$.

***$P < .001$.

****$P < .0001$.

values for month of PY and rate of decline in yield were significant only on herd (R^2 = .145 and .232).

Effects of AFC, BW, and H at calving on future performance are debatable. Both AFC and BW gain have a minor influence on yield compared with that of environmental and nutritional factors (13). In the present study, AFC and H were more important than BW at calving as determinants of future milk yield. These results contrast with a previous study (11) in which *F* was more significant for BW than for AFC. The effects of AFC, BW, and H on yield are through PY, not through other components of the lactation curve. Neither month of PY nor rate of decline in yield were affected. Each additional month in AFC raised PY by .942 kg and ME 305-d milk yield by 168.9 kg. The increase in yield with AFC agrees with results of most studies (3, 9, 11) but should be weighed against a lower life time yield (12).

In the present study, BW had minor influence on future yield. Each additional kilogram of BW at calving raised PY by .013 kg; the effects on 305-d ME milk yield were small and nonsignificant. These results agree with those of a previous study (27) but contrast with others (8, 10, 13, 21).

In the present study, H had a significant influence on future yield. Each additional centimeter of H at calving raised PY by .190 kg and 305-d ME milk yield by 56.2 kg. Results were similar in a few previous studies (8, 10, 27) dealing with the effect of H on yield. We suggest that, in previous studies in which H was not included in the model, additional yield was related to BW, which was overestimated.

Body Measurements and Conception

The combination of BW and H and the season of calving affected the rate of pregnancy from first AI (Table 3). The odds ratio that a cow calving in summer would not conceive was 1.6 compared with winter calving. The odds ratio that a tall, heavy first lactation cow would not become pregnant from first AI was 1.6 compared with all other cows pooled. The effects of herd, YS, MTR, and PY were controlled. No effect of body measurements on conception was evident 150 d from calving. The correlation between BW before calving and the rate of BW loss at calving (r = .47) indicated that larger cows lost more BW than smaller ones. A similar greater loss of body reserves was described in high yielding, larger cows (13). Lower conception rate was attributed to loss of BW and high milk yield before AI. Cows with greater daily milk yield in the first 42 d of lactation had first ovulation later than those with lower yields (29). The lower conception rate in high yielding, heavy cows was attributed to the combination of overconditioning and negative energy balance (30). Reduced accuracy of timing of AI relative to ovulation was suggested to be the direct cause of lower fertility. In contrast to some results of previous studies (24), the lower fertility of heavy cows in the present study was independent of the effect of milk yield.

Body Measurements, MTR, Milk Yield, and Fertility

The associations of MTR with the body measurements before calving are presented in Table 4. The odds ratio that cows in the group with BW above the median and H below the median would suffer from MTR was 3.1 com-

TABLE 3. The association of rate of no pregnancy from first AI with various factors (n = 621).[1]

Factor[2]	Cows	Rate	Odds ratio
	(n)	(%)	
Group			
BW and H above median	164	61.0	1.6*
BW below and H below median	136	54.0	1.0
BW below and H above median	124	49.7	1.0
BW and H below median	197	49.7	.7
MTR			
With MTR	295	54.9	1.1
Without MTR	326	54.3	
PY			
Above mean	319	55.2	.9
Below mean	302	54.0	
YS			
Summer	206	60.7	1.6*
Winter	415	51.6	

[1]YS = Year-season, MTR = postparturient metritis, H = height, PY = peak milk milk.

[2]Variables selected as control factors were herd, MTR, PY, and YS for group; herd, BW, H, PY, and YS for MTR; herd, BW, H, MTR, and YS for PY; and herd, BW, H, MTR, and PY for YS.

*$P < .05$.

TABLE 4. The effects of cow BW and height (H) before calving on rate of metritis (MTR) (n = 191).

Group	Cows	Rate	Odds ratio[1]
	(n)	(%)	
BW and H above median	61	29.5	.9
BW above and H below median	30	53.3	3.1**
BW below and H above median	49	30.6	.9
BW and H below median	51	23.5	.5

[1]The odds ratio that a cow would belong to the group suffering from metritis compared with all other cows pooled, adjusted to the effects of the various farms.

**$P < .01$.

pared with that of the three other groups pooled ($P < .01$).

Little information on the relationships between MTR and BW or H at calving is available. No difference in MTR could be detected between two groups of cows with similar BW except different H at calving (22). The combined effect of short H with heavy BW on the incidence of MTR supports previously published results (17). Damage inflicted to the uterine wall during parturition because of an oversized fetus or an overconditioned mother may be a major factor in the etiology of the disease.

The effect of MTR on yield was equivocal. A distinct effect of MTR on future yield occurred, which was related to the interaction of BW and H (Model [2]). The effect of the model was statistically significant, and effect of each interaction was significantly different from all others (Table 5). Large cows with MTR peaked higher and yielded more than those without MTR, in contrast to the opposite effect in small cows.

The effects of MTR on yield and reproduction are debatable. Although no main effects of MTR on yield occurred in one study (1), losses of up to 9% of milk yield in cows were related to MTR in other studies (4, 14, 28). Our findings offer a possible explanation for these contrasting results; the effect of MTR on yield depends on its interaction with the cow's BW and H.

First lactation cows with MTR had a pregnancy rate from first AI similar to that of healthy cows (Table 3). These results are in contrast to previous studies (1, 6, 24, 28) in which MTR lowered fertility. This contrast could be because only primiparous cows were included in our study. The findings are consistent with previous studies (16) in which no

TABLE 5. Partial linear regression coefficients of yield variables on interactions of BW and height (H) for metritis (MTR).

Dependent variable	Estimate		R	F
	With MTR	Without MTR		
Peak yield			.364	4.80****
Group				
Heavy and tall	.0001463***	.0001218**		
Heavy and short	.0001131*	.0001149*		
Light and tall	.0001128*	.0001288*		
Light and short	.0001165****	.0001369*		
305-d ME Yield[1]			.327	4.03****
Group				
Heavy and tall	.030383*	.026426*		
Heavy and short	.024236	.025054		
Light and tall	.022981	.031072*		
Light and short	.025554	.031196*		

[1]ME = Mature equivalent corrected 305-d milk yield.

*$P < .05$.

**$P < .01$.

***$P < .001$.

****$P < .0001$.

effects on fertility were evident in primiparous cows in contrast to multiparous cows with MTR.

CONCLUSIONS

The relative importance of H as a predictor of future milk yield is underestimated and should be stressed more in replacement heifers. The interaction between H and BW may have an antagonistic effect on yield and fertility. Contrasting results as to the effects of MTR on future yield could be explained by the interaction between H, BW, and MTR.

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