BODY CONDITION DURING PREGNANCY AND LACTATION AND REPRODUCTIVE EFFICIENCY OF MARES[a]

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Received for publication: October 19, 1983
Accepted: April 19, 1984

ABSTRACT

In Experiment I, 32 mares were equally allotted to the following treatments: mares fed to A) high body condition from 90 days prepartum to foaling and maintained in high body condition to 90 days postpartum, B) high body condition from 90 days prepartum to foaling and allowed to lose body condition to 90 days postpartum, C) lose body condition from 90 days prepartum to foaling and maintained in low body condition to 90 days postpartum, and D) lose body condition from 90 days prepartum to foaling and allowed to gain weight after foaling to attain a high level of body condition by 90 days postpartum. After three cycles, pregnancy rate at 30 days postovulation was lower ($P<0.05$) in C mares (50%) than in those in the other three groups (100%). Maintenance of pregnancy to 90 days was also reduced ($P<0.05$) in C mares (25%) when compared with A, D (both 100%) and B mares (88%). Foal growth to 90 days of age was similar in all treatments. In Experiment II, 927 mares were evaluated for body condition and monitored for reproductive performance. Pregnancy rate was lower ($P<0.05$) and number of cycles/conception was higher ($P<0.05$) for barren and maiden mares entering the breeding season in thin condition and for pregnant mares foaling in thin condition (condition score less than 5.0) when compared with mares with a higher level of condition. Also, onset of estrus and ovulation appeared to be delayed in barren and maiden mares entering the breeding season in thin condition. Breeding efficiency was enhanced in mares entering the breeding season or foaling at a condition of 5.0 or above. Initial excess stores of body fat enhanced fertility. There were no detrimental effects of excess body fat stored in late gestation.

Key Words: Equine, Body Condition, Reproductive Efficiency, Lactation

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[a]Technical article 17363, Texas Agr. Exp. Sta.
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The authors express gratitude to the owners and staff of the following ranches for their cooperation in the study: Shelton Ranch, Kerrville, TX; Phillips Ranch, Frisco, TX; McDermott Ranch, Madisonville, TX: Wilson Ranch, Pattison, TX.

The authors gratefully acknowledge the assistance of Dr. C. E. Gates, Institute of Statistics, and Dr. R. W. Blake, Dept. of Animal Science, Texas A&M Univ., in the statistical analyses of the data.

INTRODUCTION

Body condition, i.e., the amount of stored fat in an animal's body, has a marked influence on reproductive performance in cows (1,2,3,4) and ewes (5). However, research concerning the relationship between body condition and reproductive performance in the equine is limited and vague. Early research indicated that mares should have a high degree of body condition at mating to achieve maximum reproductive efficiency and that a major management factor contributing to low fertility in horses was allowing mares to become too thin (6). In contrast, later reports suggest that maximum reproductive performance is achieved by bringing mares into the breeding season in thin condition and subsequently placing them on an increasing plane of nutrition (7,8). The study presented here was conducted to examine the relationships between body condition at the onset of the breeding season, subsequent postpartum nutrition levels and reproductive performance in mares.

MATERIALS AND METHODS

Experiment I. Thirty-two pregnant Quarter Horse mares were blocked by expected foaling dates, then randomly allotted to one of four dietary treatment groups, providing eight mares per group. Nutrition treatments, which began 90 days before expected foaling date,were as follows: mares were fed to A) attain high body condition from 90 days prepartum to foaling (4.5 kg gain/wk), then maintained at constant weight in high body condition to 90 days postpartum; B) attain high body condition from 90 days prepartum to foaling (4.5 kg gain/wk), then allowed to lose body condition (4.5 kg loss/wk) to 90 days postpartum; C) lose body condition from 90 days prepartum to foaling (4.5 kg loss/wk), then maintained in low body condition at constant weight to 90 days postpartum; and D) lose body condition from 90 days prepartum to foaling (4.5 kg loss/wk), then allowed to gain weight after foaling (4.5 kg gain/wk) to attain a high level of body condition by 90 days postpartum. Mares were weighed weekly and concentrate intake was adjusted to obtain the desired weight gain or loss.

Diets were based on a commercially available pelleted concentrate[a] containing 13% crude protein, 2% fat and 10% fiber, and Coastal Bermudagrass hay. A commercially available 33% protein supplement[b] fortified with vitamins and minerals was included in the diets of the C and D mares during gestation and in the B and C mare diets during lactation to meet or exceed the NRC recommended protein intake (9). No attempt was made to keep diets isonitrogenous across treatments. Concentrates were fed to each mare in individual stalls twice daily and hay was fed in dirt lots where mares were maintained by experimental group. Except during digestion trials, hay was fed on the ground in eight separate locations in each paddock to facilitate approximately equal hay consumption by each mare. Mares were constantly monitored by a technician during hay feeding time to prevent dramatically unequal hay consumption.

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[a] Fat-Kaf, Kimbell Feed Co., Bryan, TX.
[b] Horse Charge, Ralston Purina Co., Fort Worth, TX.

A digestion trial was conducted on each mare at 30 days before parturition and at day 30 of lactation to determine energy and protein digestibility. During the digestion trial, each mare was fed concentrate and hay in individual stalls at 12-h intervals. Intakes were recorded and samples of concentrate and hay were taken for subsequent analyses for energy, nitrogen and lignin. Following a 6-day preliminary period, fecal grab samples were taken over 6 days to represent each 2-h interval after feeding, then compounded into one sample for each mare. Gross energy of concentrates, hay and fecal samples was determined by oxygen bomb calorimetry, and nitrogen content was determined by standard Kjeldahl procedures. Lignin content of feed and fecal samples was determined using H_2SO_4 digestion procedures (10). Digestibility of energy and nitrogen was calculated from changes in nutrient:lignin ratios in the rations and feces.

Mare weights, percentages of body fat and condition scores were determined 90 days before parturition, after parturition (within 12 h) and after 90 days of lactation. Foals were weighed and measured for height and heart girth circumference within 12 h following birth and at 30, 60 and 90 days of age. Ultrasonic scans of rump-fat thickness were taken on each mare and percentage of body fat was calculated as described by Westervelt et al. (11). Body condition was evaluated using a scoring system that is based on visual appraisal and palpable fat cover over the horse's body (12). In this system, scores ranged from 1 to 9, with 1 representing extremely emaciated and 9 representing extremely fat animals.

Mares were not bred during foal heat but were palpated to verify ovarian follicular activity. Beginning with the second postpartum estrus and during each subsequent estrus, mares were inseminated with 500×10^6 motile spermatozoa when a 20-mm or larger follicle was detected and every other day thereafter until ovulation. Mares were palpated per rectum at 30, 60 and 90 days postovulation to confirm establishment of pregnancy.

Data on mare weight, percentage of body fat and condition score in Experiment I were analyzed by general linear models procedures (GLM) as a split plot in time. A highly significant treatment by time interaction necessitated comparisons of treatments within times and times within treatments (13). Postpartum interval data were also subjected to GLM analysis of variance. Tukey's W-procedure was used to evaluate differences between means of variables shown by GLM analyses of variance to be significant sources of variation. Pregnancy data in Experiment I were examined by chi-square analysis using the herd averages over the previous five years as the expected values.

Experiment II. Nine hundred twenty-seven mares were evaluated for body condition and monitored for reproductive efficiency at four commercial horse breeding operations. Technicians at each ranch were instructed and trained in the application of the condition score system. Barren and maiden mares were evaluated for body condition on February 1 or when they arrived at the ranch, while foaling mares were scored at parturition (initial condition score). All mares that were considered too thin upon arrival or at foaling were fed to gain weight, and the fatter mares were not forced to lose weight during the study. Mares were evaluated for body condition at pregnancy determination or when they left the ranch (final condition score). For statistical evaluation, mares were grouped according to initial condition score, and final condition scores were expressed as the mean final score in each initial condition score group. Pregnancy rates and number of cycles/conception were calculated for mares in each initial condition score group. These calculations facilitated measuring effects of body condition at the onset of breeding on reproductive performance. Barren and maiden mares across all initial score groups that were maintained under normal day length were monitored for onset of estrus and ovulation.

The data for pregnancy rate and cycles per conception were plotted by initial condition score group, and resulting slopes between condition score groups 3 to 4.5 appeared different than those between 5 to 8. Therefore, the data were separated into two groups (3 to 4.5 and 5 to 8) and then subjected to linear regression analyses to confirm the relationship between initial condition score and the reproductive performance variables.

RESULTS AND DISCUSSION

Experiment I. Average daily feed, digestible energy and digestible protein intakes during the last 90 days of gestation and the first 90 days of lactation are shown in Table 1. Variations in energy intake of

TABLE 1. AVERAGE DAILY FEED, DIGESTIBLE ENERGY AND DIGESTIBLE PROTEIN INTAKE DURING THE LAST 90 DAYS OF GESTATION AND THE FIRST 90 DAYS OF LACTATION (EXPERIMENT I)

Treatment	Gestation[1]			Lactation[2]		
	Concentrate, kg	DE,[3] Mcal	DP,[3] kg	Concentrate, kg	DE, Mcal	DP, kg
A	10.03	32.40	1.29	10.03	37.98	1.74
B	10.00	32.34	1.29	4.90	27.01	1.40
C	2.47	15.68	0.78	7.00	32.20	1.74
D	2.40	15.52	0.78	15.23	50.02	2.28
NRC (1978)		21.04	0.46		28.27	0.84

[1]Mares received 4.5 kg hay/head/day.

[2]Mares received 7.0 kg hay/head/day.

[3]DE = Digestible energy. DP = Digestible protein.

mares in different treatment groups were accomplished as intended. Also, all mares consumed protein in excess of 1978 NRC requirements. Mares in group C, which were fed during lactation to sustain body weight, consumed approximately 4 Mcal more digestible energy per day than the 1978 NRC estimated requirement.

Mare weights, body fat percentages and condition scores are shown in Table 2. Initial weights, percentages of body fat and condition scores were similar for mares in all four dietary treatment groups. After parturition, A and B mares were higher in body fat percentage and had higher condition scores than C and D mares ($P<0.05$). Also, A, B, and C mares were heavier ($P<0.05$) than D mares. During the first 90 days of lactation, mare weight, percentage body fat and condition score decreased ($P<0.05$) in B mares, while these characteristics increased ($P<0.05$) in D mares. Mares in group C maintained stable weight, body fat content and condition score from foaling to day 90 of lactation. Average weight loss during lactation was 38 kg in B mares, while D mares gained 34 kg during lactation. At day 90 of lactation, percentage of body fat was similar between A and D mares, and these mares had more ($P<0.05$) body fat than B and C mares.

During the 90 days of lactation, percentage of body fat decreased ($P<0.05$) in A mares even though weight at day 90 was not significantly lower than postfoaling weight. This observation agrees with reports in dairy cattle (15) and rats (16), which showed a decrease in body fat during early lactation even when a high-energy diet was fed ad libitum. These data support the theory that stored body fat serves as a primary source of energy during the initiation of lactation (15).

Gestation length was similar for mares fed to a low body condition at foaling (345 days for C and D mares) to that of mares with a high body condition (342 days for A and B mares). Also, average birth weight of foals from high-condition mares was similar (51 kg) to foals from low-condition mares (48 kg), which supports the theory that the fetus has priority on nutrients in the maternal bloodstream (17) and that the dam will mobilize stored body nutrients to insure adequate growth and development of the fetus when dietary intake is limited (18). Mean foal weights at 90 days of age were similar for foals of A, B, C, and D mares (158, 149, 147 and 146 kg, respectively). There were no significant treatment effects on foal height or heart girth measurements. Therefore, since all foals grow at similar rates, dietary energy intake of C mares during lactation was apparently adequate for lactation. Furthermore, B mares apparently used stored body energy for milk production, since they were fed less energy than the NRC recommendation (9) and lost body fat during lactation.

Rebreeding data were not collected from three D mares because of two accidental foal deaths and one emergency abdominal surgery not related to diet treatments. Also, one B mare suffered a rectal tear during palpation and was excluded from the rebreeding data.

TABLE 2. MEAN MARE WEIGHT, PERCENTAGE OF BODY FAT AND CONDITION SCORE AT 90 DAYS BEFORE PARTURITION, AFTER PARTURITION AND AT DAY 90 OF LACTATION (EXPERIMENT I)

Treatment Group	Parturition Minus 90 Days			After Parturition			Day 90 of Lactation		
	Weight, kg	Body fat, %	Condition score	Weight, kg	Body fat, %	Condition score	Weight, kg	Body fat, %	Condition score
A	562	14.5	6.6	537^{a1}	16.8^{a1}	7.7^{a1}	541^{a1}	14.1^{a}	7.1^{a1}
B	566	13.8	6.7	528^{a1}	15.7^{a1}	7.5^{a1}	490^{b2}	11.2^{b2}	4.7^{b2}
C	549	13.4	6.1	502^{a1}	11.4^{b1}	3.4^{b1}	505^{c1}	11.1^{b1}	3.7^{c1}
D	530	13.2	6.0	478^{b1}	11.4^{b1}	3.8^{b1}	512^{c}	13.7^{a}	6.8^{a2}
Period Mean	522.8	13.8	6.1	514.6	13.9	5.6	517.9	12.5	5.5
Standard Error	7.4	0.3	0.2	8.2	0.5	0.4	7.1	0.3	0.3

[a,b,c]Different superscripts within columns differ ($P<0.05$).

[1,2]Different superscripts within each row for each characteristic differ ($P<0.05$).

As shown in Table 3, the mean intervals from parturition to first ovulation were not significantly different ($P<0.05$) between dietary energy treatments but tended to be longer ($P<0.15$) in C mares. However, the interval to second ovulation was longer ($P<0.05$) in C mares than in A, B, and D mares. When the data were pooled by prefoaling energy intake, the interval from parturition to first ovulation was slightly delayed and the interval to second ovulation was significantly delayed by restricting calorie intake during the last 90 days of pregnancy. These findings agree with data on cattle (19,20) which showed that precalving energy levels exerted the greatest influence on the occurrence of estrus during the early postpartum period.

TABLE 3. INTERVALS FROM PARTURITION TO FIRST AND SECOND OVULATIONS (EXPERIMENT I)

Treatment	First Ovulation	Second Ovulation
A	12.7	32.8
B	13.2	37.2
C	16.8	45.8*
D	13.2	37.3
Mean	14.1	38.5
Standard Error	0.8	0.2

*($P<0.05$).

Pregnancy rates are shown in Table 4. Although there was a trend, pregnancy rates were not significantly different between treatments for the first cycle bred. However, pregnancy rate was reduced ($P<0.05$) in the second and third cycles for C mares. Total pregnancy rate over three cycles was lower ($P<0.05$) in C mares (50%) than in the other groups (100%). These data agree with a previous study in beef cattle indicating calorie restriction during gestation reduced pregnancy rate (19). The improved pregnancy rate observed in D mares when compared with C mares is consistent with the observation that feeding higher levels of energy during lactation exerted a favorable influence on conception rates of cows subjected to restricted energy intake during gestation (21). However, the tremendous increase in feed consumption (Table 1) required to produce the gains in weight and body fat in D mares during lactation may increase the risk of colic and founder. During lactation, this group of mares was monitored closely and fed three times per day at 8-h intervals to prevent digestive disorders. This management system is not practical on most breeding farms.

TABLE 4. PREGNANCY RATES OVER THREE CYCLES AND MAINTENANCE OF PREGNANCY (EXPERIMENT I)

	Treatment			
	A	B	C	D
Pregnancy rates				
1st cycle	63(5/8)[1]	57(4/7)	33(3/9)	60(3/5)
2nd cycle	67(2/3)	75(3/4)	20(1/5)*	100(2/2)
3rd cycle	100(1/1)	100(1/1)	0(0/4)*	
Total	100(8/8)	100(8/8)	50(4/8)*	100(5/5)
Maintenance of pregnancy				
60 days	100(8/8)[2]	88(7/8)	75(3/4)	100(5/5)
90 days	100(8/8)	88(7/8)	25(1/4)*	100(5/5)

[1]Numbers in parentheses indicate number of mares pregnant/number of mares bred.

[2]Numbers in parentheses indicate number of mares pregnant/number of mares conceived.

*($P<0.05$).

Maintenance of pregnancy to 60 days after ovulation was not significantly different between treatment groups (Table 4). Only one B and one C mare was open at day 60 postbreeding. However, three of the four C mares diagnosed pregnant at day 30 were open at day 90, while no pregnancy losses were detected in the other groups between days 60 and 90 after conception. Restricting energy intake during gestation and maintaining mares in a low body condition during lactation resulted not only in lower conception rates but also in increased incidence of embryonic mortality compared with mares fed excess energy during lactation or with mares restricted in energy intake during gestation and fed excess energy during lactation. Mares foaling in high body condition apparently used stored body energy to offset adverse effects on embryo survivability of restricted energy during lactation.

Body condition at calving has been shown to influence postpartum reproductive performance of cattle markedly (3,4). When compared across treatments, mares in this study which foaled in low body condition (condition score less than 5.0) had significantly lower pregnancy rates and maintenance of pregnancies when body condition was maintained at a low level (Table 5). None of the mares that foaled at a condition score of less than 5 and that was maintained in that condition during lactation was pregnant 90 days after conception.

Experiment II. In the second experiment, there were 497 foaling mares, 378 barren mares and 52 maiden mares which were evaluated for

TABLE 5. CONDITION AT FOALING, CONDITION CHANGE DURING LACTATION, PREGNANCY RATE AND MAINTENANCE OF PREGNANCY AT DAY 90 OF GESTATION (EXPERIMENT I)

Condition at Foaling	Condition Change	Pregnancy	Maintenance
		------------%	------------
> 7.0	None (6)[1]	100	100
	Decrease (8)	100	88
5.0 to 6.5	Increase (2)	100	100
	Decrease (2)	100	100
< 5.0	Increase (4)	100	100
	None (7)	43**	0**

[1]Number of mares in parentheses.
**(P<0.01).

body condition and reproductive performance. Initial condition scores ranged from 3 to 8. There were no mares that were extremely emaciated (score 1 or 2) nor were there any mares that were obese (score of 9).

Pregnancy rates and cycles per conception for mares in each initial condition score group are shown in Table 6. Pregnancy rates were obviously lower in mares entering the breeding season or foaling at a condition score of less than 5.0 when compared with mares with higher initial condition scores. Also, the average number of cycles/conception was higher in mares with initial condition scores of less than 5.0 when compared with mares in higher condition. Plots of pregnancy rate (percent) and cycles per conception versus initial condition scores indicated distinctly different slopes for mares with condition scores < 4.5 and those 5.0 and above. Therefore, the data were partitioned accordingly and subjected to simple linear regression analyses. Results are shown in Figures 1 and 2. Regression of pregnancy rate on initial condition scores resulted in a slope of 15.2 (P<0.05) for mares with an average condition score < 4.5 compared with 2.9 (P<.0.05) for those 5.0 and above (Figure 1). This relationship suggests that the greatest detrimental effects of low body condition occurred when condition scores were below 5.0. However, the significant positive slope above condition score 5.0 indicates a possible beneficial effect of increasing fat stores above condition score 5.0, but the effect is smaller than in thin mares. Corresponding regression slopes for cycles per conception were -0.72 (P<0.05) and -0.04 for mares with condition scores of $\leq$ 4.5 and 5.0 and above, respectively (Figure 2). The negative effects of low body condition in this case were apparently confined to mares with condition scores below 5.0.

TABLE 6. PREGNANCY RATES AND MEAN CYCLES PER CONCEPTION FOR MARES (EXPERIMENT II)

Initial Condition Score Group	No. Mares	Mean Final Condition Score	Pregnancy Rate (%)	Cycles/ Conception
3.0	16	5.0	56	3.66
3.5	36	6.0	55	3.40
4.0	39	6.0	79	2.77
4.5	67	6.0	74	2.58
5.0	175	6.0	89	1.52
5.5	167	6.0	96	1.38
6.0	222	6.5	92	1.48
6.5	103	6.5	97	1.24
7.0	63	7.0	94	1.43
7.5	26	7.5	100	1.61
8.0	13	8.0	100	1.38
Mean			89.3	1.64
Standard Error			0.28	0.02

Increases in condition score while at the breeding farm were highest for mares with lowest initial condition scores, and changes in condition score became smaller as initial condition score increased. Therefore, the lower reproductive efficiency observed in mares entering the breeding season or foaling in low body condition apparently was due not to inadequate nutrition during the breeding season but to the low body condition at the onset of the breeding season. Excess body fat at parturition or at the onset of the breeding season did not adversely affect reproductive performance in this experiment.

In nonfoaling mares with condition scores of less than 5.0 (barren or maiden), the average intervals from February 1 to first estrus and first ovulation were 39 days and 63 days, respectively. Corresponding intervals for nonfoaling mares with condition scores above 5.0 were 26 days and 37 days ($P<0.05$).

These data agree with research conducted on cattle (1,2,3,4) suggesting that increasing the condition score of cattle at mating improved reproductive performance. These results are also consistent with early observations which indicated that mares should be in good condition at mating to achieve maximum reproductive efficiency (6). A condition score of 5.0 as used in this study may represent a minimal level of

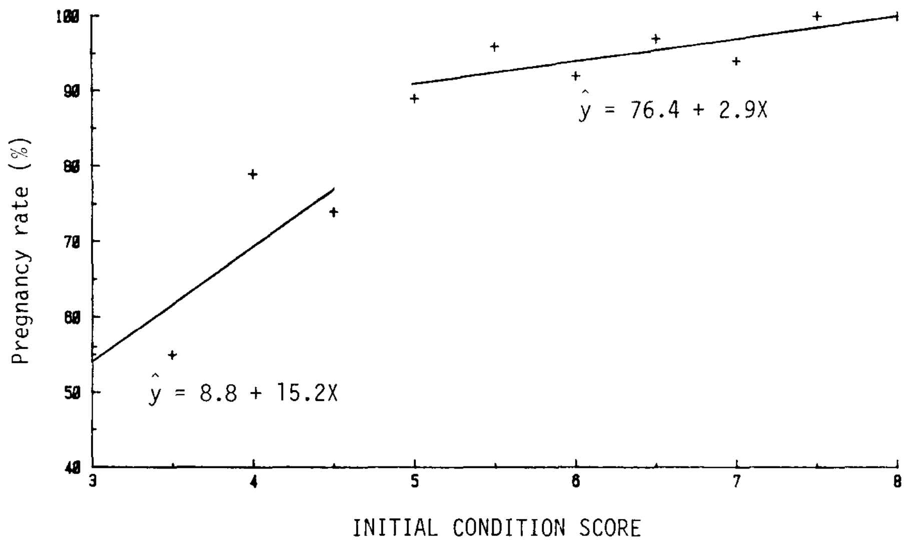

Figure 1. Regression of pregnancy rate on initial condition score for mares with initial condition score ≤ 4 and 5 and above.

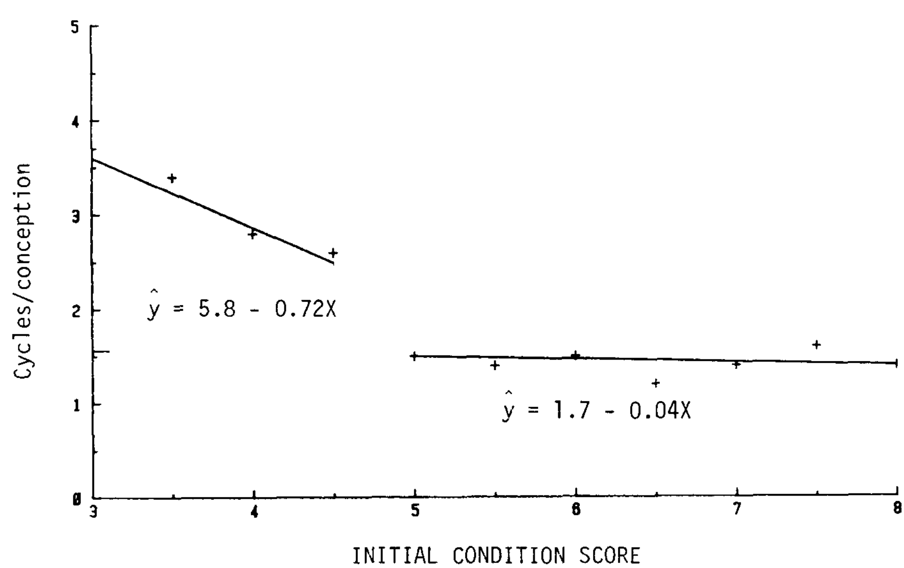

Figure 2. Regression of cycles/conception on initial condition score for mares with initial condition scores ≤ 4.5 and 5 and above.

stored energy required by the mare for maximum reproductive performance. Results of this study point to the conclusion that the often recommended practice of bringing mares into the breeding season in thin condition and placing them on an increasing plane of nutrition is not likely to improve reproductive performance above that of mares which are brought into the breeding season in moderate to high body condition.

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