decreased utero-cervical weight, myometrial and endometrial cross-sectional areas, density of endometrial glands, and the amount of uterine luminal total protein at 15 months of age. The alterations in uterine tissues demonstrated in this study are associated with age at implanting. The commercial implant used in this study (Synovex® C) is approved for use in heifers intended for breeding at no earlier than 45 days of age. The results of this study emphasize the importance of following label recommendations.

Pelvic Growth and Dystocia in Holstein X Hereford Heifers

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Abstract

Growth of the pelvic area and relationship to external pelvic measurements was monitored in 129 Holstein X Hereford heifers fed an all forage diet. Pelvic area increased at a rate of .27 ± .20 cm²/day from 10 to 16 months and a rate of .13± .13 cm²/day from 16 to 22 months ($p < .01$). A moderate correlation between pelvic area and external pelvic measures (body weight, height at hooks or pins, distance between hooks and hooks to pins) was noted ($R^2 \leq .15$ - .38, $p < .01$) and the relationship did not change with age. In 76 of these heifers, pelvic area was measured within 24 hours of calving. From 22 months to calving, pelvic area increased at the rate of 1.15± .88 cm²/day. This was 7 times greater than the rate observed from 16 to 22 months (.13± .13 cm²/day). While pelvic area at calving had a significant correlation to pelvic area measured prior to calving ($p < .01$) correlations were low to moderate (R=.29-.52).

The influence of pelvic area and calf birth weight on incidence of dystocia were modeled with both logistic regression and discriminant analysis techniques. Neither was superior, both correctly predicting 72% of cases. While ratio of pelvic area at calving to calf birth weight significantly ($p < .01$) influenced the incidence of dystocia, pelvic area measured at any time other than calving was not associated with dystocia ($p > .05$). The low correlation between pelvic area at calving and precalving measurement was due to the high degree of variation noted in pelvic growth. As a result, we were unable to predict dystocia by measuring pelvic area prior to calving.

Introduction

The two most important variables influencing dystocia are pelvic area and calf birth weight.[1-7] Many early studies used multiple regression to model dystocia. Dystocia is a categorical trait which violates many of the assumptions of multiple regression.[6] Discriminant analysis techniques are superior to multiple regression for categorical traits such as dystocia, and can accurately predict as high as 85% of cases.[6] It has been suggested that the size of calf a heifer can deliver can be determined at breeding,[8] yet in a clinical trial, pelvic area at breeding had no predictive value for dystocia.[9] Furthermore, not all trials have shown pelvic area to have a significant influence on dystocia.[10,11]

Few have studied the growth of the pelvic area in first calf heifers, in particular the change immediately prior to calving. The objectives of this study were to monitor the growth of the pelvis in heifers and determine the relationship between pelvic area, calf birth weight, and dystocia. Our hypothesis was that variation in growth among and within heifers will reduce the correlation of pelvic area at calving to pelvic area measured at other times. As a result, pelvic area measured prior to calving may not be a significant determinant of dystocia, whereas pelvic area at calving is a determinant of dystocia.

Materials and Methods

Data were collected on 129 Holstein x Hereford heifers beginning at 10 months of age until calving at 23 months of age. The heifers were maintained at the Lancaster Agricultural Research Station. No grain supplements (only forages) were fed to the heifers from 12 months of age until calving. All heifers were in good body condition throughout the study. The heifers were bred by artificial insemination with semen from a single Angus sire for the first two services of the breeding season. This sire was selected for artificial insemination due to the low expected weight of his calves (expected progeny difference was -1.3 Kg for calf birth weight). Another Angus sire was then exposed to the heifers for a third natural service.

Heifers were measured for pelvic area and other body measurements at 10 months of age (prebreeding), 16 months of age (pregnancy diagnosis), and 22 months of age (1 month prior to calving). A Krautmann Bovine Pelvic Meter (E. J. Krautmann, 1706 Jennings Place, Chillicothe, MO) was used for the internal pelvic measures. The internal pelvic width was the longest horizontal distance between the ilial shafts. The internal pelvic height was the shortest distance between the sacral vertebrae and the symphysis pubis. The pelvic area was the product of the pelvic height and width. External body measurements included height at hooks, height at pins, distance between hooks, distance from hooks to pins and weight. All external measurements were taken by 1 technician; internal pelvic measurements were taken by 2 technicians. The external measurements were determined just prior to restraining the heifer in a chute for internal pelvic measurements. A caliper was used to measure the maximum distance between the lateral aspects of the tuber coxae (distance between hooks) and maximum distance from the cranial aspect of the tuber coxae and caudal aspect of the tuber ischii (distance from hooks to pin). Heights at hooks and pins were determined with a measuring stick (HCR Box 188A RFD2 Wright City, MO 63390).

Dystocia scores were assigned at calving: 1=no assistance, 2= slight pulling, 3= difficult pulling but no use of fetal extractor, 4=fetal extractor required, 5= caesarian section, 6= caudal presentation. Heifers were observed at least every 4 hours. If fetal membranes or extremities were observed and significant progress did not occur within 45 minutes an examination was performed, and assistance was provided as necessary. Twins and caudal presentations were excluded from analysis. Calf birth weights were determined within 24 hours of parturition, but after the calf had dried off and was ambulatory. The internal pelvic measurements were determined within 24 hours of calving of the first 76 heifers to calve. A shortage of technicians limited the number of heifers measured after calving.

Regression analysis and analysis of covariance were used to study the growth of the pelvis and relation to external body measurements. Discriminant analysis and logistic regression techniques were used to study the relationship of calf birth weight and pelvic area to dystocia score.[12,13] Dystocia score was collapsed into two scores (1=no assistance, 2=assistance) to facilitate analysis and to aid comparison to other studies. Stepwise techniques were not used due to the high degree of correlation noted between external and internal pelvic measurements and also between calf sex gestation length and calf birth weight. The effect of pelvic area determined at 10, 16, and 22 months of age and at calving on dystocia were modeled and compared.

Results

Summary statistics of external and internal measurements of 129 heifers are in Table 1. Pelvic area increased at the rate of .27 ± .20 cm^2/days (x ± S.D.) from 10 to 16 months and increased .13 ± .13 cm^2/day from 16 to 22 months of age. The relationship of pelvic area to external measurements was not influenced by time of measurement (Table 2).

Summary statistics of pelvic area and growth of pelvic area of the 76 heifers in which pelvic area was measured within 24 hours of calving are in Table 3. Pearson's R of pelvic areas of these 76 heifers at 10 months, 16 months, 22 months, and calving are in Table 4. Growth of pelvic area of these 76 heifers was similar to the pelvic growth of all 129 heifers. Growth of the pelvic area in cm^2/day in these heifers increased dramatically (from .14 cm^2/day to 1.15 cm^2/day) in the month just prior to calving ($p < .01$). The rate of increase was highly variable between individuals (S.D. = 0.88 cm^2/day) just prior to calving. Correlations of pelvic area at 10 months, 16 months, and 22 months to pelvic area at calving while significant ($p < .01$) were low (Table 4).

Dystocia was observed in 33 (43%) of 76 calvings, no dystocia score's of 3 or 5 were observed. The results of discriminant analysis and logistic regression models of pelvic area, calf birth weights and dystocia of the heifers in which pelvic area was measured at parturition are in Table 5. Pelvic area at the time of calving and calf birth weight accurately classified 73% of cases. Pelvic area measured at times other than calving were not significantly associated with dystocia ($p > .34$). Ratio of pelvic area at calving to calf birth weight was as efficient at classifying cases of dystocia as including both as independent variables within a model.

Table 1. Body weight, external body measures, and internal pelvic measures.

(mean ±s.d.) of 129 Holstein X Hereford heifers

Age (months)	10	16	22
Number	129	129	129
Weight (kg)	358 ± 32	393 ± 30	490 ± 38
Height Hooks (cm)	119 ± 3.8	121 ± 17	126 ± 4
Height Pins (cm)	107 ± 4.2	116 ± 14	118 ± 5
Distance Hooks (cm)	43.3 ± 2.0	44.6 ± 1.9	48.6 ± 2
Hooks/pins (cm)	45.2 ± 1.9	47.2 ± 1.8	48.9 ± 1.0
Pelvic Height (cm)	13.5 ± .7	15.2 ± .8	15.8 ± 1.0
Pelvic Width (cm)	12.6 ± .7	14.6 ± .7	15.3 ± .8
Pelvic Area (cm^2)	170 ± 16	221 ± 16	242 ± 21

Table 2. Linear and quadratic growth rates of pelvic area, body weight and external body measures (mean ±s.d.) in 129 Holstein X Hereford heifers.

Period	10-16 Mn	16-22 Mn	10-22 Mn Linear	10-22 Mn Quadratic
Weight (kg)	.97/.46	2.93/.22	1.89/.35	-1.96/.64
Height Hooks (cm)	.012/.10[a]	.032/.110	.022/.100	-.020/.205[a]
Height Pins (cm)	.060/.057	.003/.057[a]	.032/.015	.055/.112
Distance Hooks (cm)	.008/.011	.003/.057[a]	.016/.006	-.000/.019[a]
Hooks/Pins (cm)	.011/.011	.011/.011	.011/.006	-.000/.019[a]
Pelvic Height (cm)	.008/.015	.004/.005	.006/.008	.004/.016[a]
Pelvic Width (cm)	.012/.004	.004/.005	.008/.002	.007/.008
Pelvic Area (cm^2)	.272/.203	.127/.125	.203/.114	.145/.254

[a] not significant P>.05

Table 3. Summary statistics of pelvic area of 76 Holstein X Hereford heifers in which pelvic area was measured at calving.

Age (months)	10	16	22	Calving
Pelvic Area cm^2 (Mean ± S.D.)	169 ± 16.5	219 ± 14.5	241 ± 24.0	274 ± 24.5

Table 4. Correlations (Pearson's R) of Pelvic Area at 10, 16, and 22 Months and Calving in 76 Holstein X Hereford heifers.

Age (months)	10	16	22	Calving
10	1.00			
16	.53	1.00		
22	.56	.53	1.00	
Calving	.29	.43	.52	1.00

* All correlations were significant (p < .01)

Table 5. Discriminant and logistic regression analysis of pelvic area at calving, calf birth weight, and ratio on prediction of dystocia in 76 Holstein X Hereford heifers.

	Discriminant Analysis		Logistic Regression	
Model	Percent Correct	p < of Variable	Percent Correct	p < of Variable
Ratio PA/Calfwt	73	.000	73	.000
Pelvic Area, Calfwt	73	.002 .024	73	.002 .009
Pelvic Area	59	.002	58	.003
Calfwt	57	.013	58	.012

Discussion

The growth of the pelvis was not linear. The pelvis averaged a .27 cm^2 increase per day from 10 to 16 months and then slowed to an increase of .13 cm^2/day from 16-22 months (Table 2). Growth of the pelvis has been shown to be affected by breed and also management conditions.[11] We noticed a high degree of variation in growth of the pelvis. The standard deviation of growth from 10-16 months was .2 cm^2/day indicating the individual also has a significant effect. We noted a strong relationship between external measurements and pelvic area that did not change with age (i.e., no interaction was noted between time of measurement of pelvic area and relationship to external measures). Therefore, it appears that pelvic growth is less a function of age than a function of increase in frame size or weight. This is similar to other research findings.[1,7,11]

The rate of pelvic growth in the month prior to calving increased dramatically to 1.15 cm^2/day. A high degree of individual variation was observed, some heifers did not increase at all while one heifer increased her pelvic area by almost 2 cm^2/day prior to calving. Others have noted an increase in rate of growth of pelvic area prior to calving.[2] The high degree of variation in rate of pelvic growth and the dramatic increase in rate of growth just prior to calving is the most likely explanation for the low correlation observed in pelvic area measured at different ages. We were unable to predict pelvic area at calving with measurements taken prior to calving.

Studies utilizing multiple linear regression techniques have identified calf weight and pelvic area as the major factors influencing dystocia.[1,2,3,4] Yet, 50% of variation in dystocia was unaccounted for by these models leading to the conclusion that other unidentified factors influence dystocia. Discriminant analysis and logistic regression are superior methods of statistical analysis of a categorical trait such as dystocia.[12,13] Use of discriminant analysis has resulted in accurate classification of as many as 86% of cases.[6,7,8] However, not all studies utilizing discriminant analysis or logistic regression have corroborated these results.[9,10] Use of these techniques in this data set showed that both calf weight, and pelvic area at time of calving, were important determinants of dystocia (Table 5). Inclusion of both of these variables increased the percent of cases correctly classified to 73% versus 57-59% when only calf weight or pelvic area were studied. However, pelvic area measured at any other time (10, 16 and 22 months) was not significantly associated with dystocia (p < .34). The studies that have utilized discriminant analysis or logistic regression techniques and not demonstrated pelvic area to be an important factor influencing dystocia have not measured pelvic area at or close to calving.[9,10] Pelvic area was measured at the time of pregnancy diagnosis, prebreeding, or four to five months after calving in studies not showing an influence of pelvic area on dystocia.[4,10] Studies that have shown pelvic area to have a significant influence on dystocia measured pelvic area within one month or less prior to calving.[6,7,8] Considering the fact that pelvic area at calving has low correlation to pelvic area measured at other time it can not be concluded from the former studies that pelvic area does not influence dystocia.

Yet, only 73% of cases of dystocia were accurately classified by pelvic area at calving and calf birth weight (Table 5). Often a holdout sample is used to validate a model developed with discriminant analysis techniques. When such an approach is used, the model is developed from a random sample of the initial data set. The model is then tested for accuracy of prediction in the rest of the data set. We did not use this approach because we had a limited number of animals (76) with which to develop our models. This may result in some upward bias in percent accurate classification. Therefore, factors other than calf birth weight and pelvic area which were not identified in this study may influence dystocia.

Development of strategies to control dystocia should focus on methods of reducing calf size and increasing pelvic area at calving. Calf size is significantly influenced by sire.[4] Measurement of pelvic area, however, at any time other than calving does not accurately represent pelvic area at parturition. The high degree of variation in pelvic growth and dilation prior to calving indicate factors inherent to the individual determine pelvic area at calving and dystocia. Research efforts should be focused on identification and control of these factors.

Conclusion

The ratio of pelvic area at the time of calving to calf birth weight is a major determinant of dystocia. The high degree of variation in pelvic growth and dilation, however, results in low correlation of pelvic area at calving to pelvic area measured prior to calving. Prediction of dystocia utilizing pelvic area measured prior to calving is difficult and not highly accurate.

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Variable Efficacy of Benzimidazole Anthelmintics Against Inhibited Larvae of *Ostertagia Ostertagi*

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Abstract

Variable efficacy of benzimidazole anthelmintics (albendazole, fenbendazole, and oxfendazole) against inhibited *Ostertagia ostertagi* larvae has been reported in the literature. Efficacies at manufacturer's recomended dosages for the three anthelmintics, respectively, were 18.6%-84.9%, 61.5%-97.5%, and 33.5%-93.6%. Respective efficacies for dosages lower than recommended were 30.8%-86.6%, 0.0%-97.5%, and 0.0%-85.8%. Respective efficacies for dosages higher than recommended were 84.9%, 92.0%-99.0%, and 78.8%-95.0%.

One of the hypotheses for variable efficacy is a difference in larval metabolic activity during the inhibition season (i.e. when metabolic activity is high efficacy is high and vice versa). This hypothesis was tested in a critical evaluation using oxfendazole. Forty-eight steer calves commenced grazing 10 acres of pasture in November. In the months of March,