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Pelvimetry in Farm Animals: An Anatomical Approach for Reproductive Management

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Abstract:

Dystocia is a major reproductive problem in cattle and is associated with calf mortality, reduced reproductive efficiency, postpartum complications, and economic losses. Fetopelvic disproportion, particularly resulting from inadequate maternal pelvic dimensions, is an important cause of calving difficulty. Pelvimetry, which involves the measurement of pelvic dimensions either externally or internally, is therefore an important tool for assessing pelvic capacity and identifying animals at risk of dystocia. Internal pelvimetry using instruments such as the Rice pelvimeter enables direct measurement of the vertical and transverse diameters of the pelvic inlet, from which the pelvic area can be estimated. Pelvic measurements are particularly useful in replacement heifers for breeding selection and culling decisions. Heifers with adequate pelvic areas may be selected for normal breeding, whereas animals with smaller pelvic dimensions may be bred to low-birth-weight or calving-ease sires or considered for culling. Pelvic size may also be influenced by sire selection and is related to several growth and body traits. As pelvic area generally increases with age, measurements can be adjusted to a standard age to improve comparison among animals. The combined use of pelvimetry, appropriate sire selection, and calving-ease genetic evaluations can help reduce the incidence and severity of dystocia at the herd level. However, pelvimetry should not be used as an isolated predictor because fetal characteristics, fetal posture, soft tissue resistance, and other maternal factors also influence calving outcome. Future developments, including digital pelvimeters, three-dimensional pelvic modelling, ultrasonographic techniques, and artificial intelligence-based prediction tools, may further improve the accuracy and practical application of pelvic assessment in cattle breeding and herd management.

Keywords: Reproductive Management

1. Introduction

Dystocia is a frequent problem in bovine breeding and remains one of the leading causes of perinatal calf mortality (Dematawena & Berger, 1997). A narrow or inadequately shaped maternal pelvis can restrict the passage of the fetus, resulting in difficulties during parturition. In livestock production systems, dystocia is associated with neonatal mortality, reduced reproductive efficiency, increased postpartum complications and substantial economic losses. A considerable proportion of dystocia cases result from fetopelvic disproportion, in which the size or shape of the maternal pelvis is inadequate for the fetus to pass through the birth canal. Therefore, assessment of pelvic dimensions before breeding can provide valuable information for predicting and preventing dystocia (Silva *et al.*, 2019).

The occurrence of dystocia can be reduced by evaluating important pelvic measurements, particularly the true conjugate (sacropubic) diameter and median bi-iliac width, as successful vaginal delivery depends on the compatibility

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between the fetal size and the dimensions of the maternal pelvic canal (Oliveira *et al.*, 2003). When the size of the fetus is disproportionate to the pelvic canal, dystocia may result in increased expenses associated with surgical intervention, medication, delayed postpartum recovery, prolonged calving intervals, and, in severe cases, loss of the calf or dam during parturition (Hafez & Hafez, 2013).

2. Pelvimetry and its types:

Pelvimetry

Pelvimetry is the measurement of the capacity and dimensions of the pelvis, either internally, externally, or by both methods, using the hands or a pelvimeter (Blood *et al.*, 2007). Based on the method used to obtain pelvic measurements, pelvimetry can be broadly classified as external pelvimetry and internal pelvimetry.

External Pelvimetry

External pelvimetry involves the assessment of pelvic dimensions using measurements obtained from external anatomical landmarks. These measurements include the distance between the two tuber ischii (pin width), the two tuber coxae (hip or hook width), the anterior surface of the wing of the ilium and the posterior surface of the ischium (rump length), the wing of the ilium to the hip joint, and the distance between the iliac crest and ischial tuberosity (hook-to-pin length) (Bellows *et al.*, 1971). Initially, these distances were measured using straight pieces of wood and a measuring tape, whereas sliding calipers were later introduced to improve the accuracy and convenience of measurement (Coopman *et al.*, 2003).

The pelvic area is commonly estimated by multiplying pelvic height by pelvic width, resulting in a rectangular estimation of the pelvic opening area (Kolkman *et al.*, 2009). However, observations of the actual pelvic inlet indicate that its shape more closely resembles an ellipse than a rectangle. Accordingly, the pelvic area may also be estimated using an ellipsoidal equation.

Ellipsoidal pelvic area = $\pi \times (\text{Width}/2) \times (\text{Height}/2)$

When these two methods of calculating the pelvic area were compared, the ellipsoidal equation provided a more accurate representation of the actual pelvic opening. However, it showed no advantage over the rectangular equation in predicting dystocia or ranking animals according to pelvic size. Furthermore, the use of the ellipsoidal equation did not influence the variance components and essentially converted the rectangular area by a constant factor of $\pi/4$, resulting in an average ellipsoidal area approximately 21% lower than the rectangular estimate (Morrison *et al.*, 1986).

Internal Pelvimetry

Internal pelvimetry is the gold standard for assessing the pelvic dimensions in cattle. In this method, a pelvimeter, such as the Rice pelvimeter, is introduced through the rectum to directly measure the internal dimensions of the pelvic inlet. The Rice pelvimeter is one of the earliest and most commonly used instruments for evaluating internal pelvic dimensions, particularly in heifers, and is useful for assessing the potential risk of dystocia.

The instrument consists of long, curved arms with a measuring scale that enables the examiner to obtain pelvic measurements through rectal palpation. The two principal measurements obtained are as follows:

- **Vertical diameter (pelvic height):** distance from the sacrum to the pubis.
- **Transverse diameter (pelvic width):** the widest horizontal distance across the pelvic inlet.

These measurements are used to estimate the pelvic area, usually expressed in cm^2, by multiplying pelvic height and pelvic width. Pelvic area provides an important indication of pelvic capacity and can assist in identifying animals that may be at an increased risk of dystocia. Internal pelvimetry is particularly valuable in heifers, as inadequate pelvic development and fetopelvic disproportion are important contributors to calving difficulty. Although the procedure requires proper skill and careful handling to minimize animal discomfort and prevent rectal injury, the Rice pelvimeter remains a practical and useful instrument because of its simplicity, durability, and ability to provide direct and reliable pelvic measurements for selection and breeding decisions (Kalyan *et al.*, 2021).

Use of Pelvic Measurements to Estimate Deliverable Calf Size (Birth Weight) (*Deutscher, 1987*)

Time of Measurement	Heifer Age (months)	Heifer Weight (lb)	Pelvic Area (cm^2)	Pelvic Area / Birth Weight Ratio	Estimated Calf Birth Weight (lb)
Before Breeding	12-13	600	155	2.1	67
			160	2.1	76
			180	2.1	86
Pregnancy Examination	18-19	800	180	2.7	67
			200	2.7	74
			220	2.7	82

Breeding Strategy and Heifer Replacement

A group of replacement heifers can be classified into three categories based on pelvimetry results: heifers with sufficiently large pelvic areas can be bred to bulls with average calving performance in the herd; heifers with smaller pelvic areas may be unsuitable for breeding with regular herd bulls; and heifers with very small pelvic dimensions may be considered for culling. Alternatively, heifers meeting a minimum pelvic area requirement can be selected for breeding with bulls known to produce calves with low birth weights. Such selection strategies can help reduce the incidence of calving difficulties at the herd level (Kalyan *et al.*, 2021).

Bull Pelvic Measurements

Pelvic size can be inherited from the sire by its progeny. Therefore, the selection of bulls with larger pelvic dimensions may contribute to increased pelvic size in their daughters. The pelvic area in bulls is significantly influenced by their age and body weight (Table 1). Other traits, such as hip height, frame score, and scrotal circumference, are positively correlated with pelvic area, whereas body weight shows a relatively weak correlation. Therefore, these parameters should be considered collectively during sire selection to achieve an optimum pelvic size in female progeny. The most appropriate time for pelvic measurement in bulls is during the yearling stage or at the completion of a performance feeding test. These measurements can be performed by a veterinarian as part of a breeding soundness examination or fertility evaluation (Kalyan *et al.*, 2021).

Average Pelvic Areas and Growth Estimates for Yearling and Two-Year-Old Bulls (*Daly and Riese., 1992*) (1)		
Bull Age (Months)	Bull Weight (lb)	Average Pelvic Area (cm^2)
12-15	900-1200	150-170
23-25	1300-1500	190-210

Pelvimetry and Dystocia

Larger pelvic areas are generally associated with a lower incidence of calving difficulty (Murray *et al.*, 1999). Therefore, pelvic area is considered a useful indicator for predicting the risk of dystocia and identifying heifers with relatively small pelvic dimensions that may be more prone to calving problems (Micke *et al.*, 2010). Pelvic measurements can be performed during pregnancy examinations in multiparous cows and at the time of breeding or pregnancy diagnosis in heifers. Between one and two years of age, the pelvic area increases at an average rate of approximately 0.27 cm^2 per day. Therefore, the measured pelvic area of heifers can be adjusted to a standard age of 365 days using a fixed linear correction factor as follows:

365 day pelvic area = Actual pelvic area (cm^2) + [0.27 x (365 – age in days)]

3. Pelvic measurements

Obtaining Pelvic Measurements

Pelvimetry is a useful management and culling tool for reducing the incidence of dystocia (Holm *et al.*, 2014). Several instruments can be used to measure pelvic dimensions in cattle, including the Rice Pelvimeter, Krautmann-Litton Bovine Pelvic Meter, and Equibov Bovine Pelvimeter. Among these, the Rice pelvimeter is commonly preferred because it is easy to use, provides highly reproducible measurements, can measure pelvic dimensions up to at least 20 cm, and is relatively less expensive than other types of pelvimeters. Veterinarians can obtain accurate and consistent pelvic area measurements using the Rice pelvimeter (Van Donkersgoed *et al.*, 1993).

Accurate pelvic measurements require a thorough understanding of the anatomy of the pelvic canal, birth canal, and reproductive tract. Proper training and practical experience are essential for obtaining reliable measurement. The vertical pelvic measurement is taken from the symphysis pubis on the pelvic floor to the sacral vertebrae dorsally, whereas the horizontal measurement represents the maximum distance between the left and right ilial shafts. Both measurements are recorded in centimeters, and their product provides the pelvic area in square centimeters. Generally, the vertical pelvic dimension is greater than the horizontal dimension, as illustrated in Figure 2 (Poock and Payne, 2013).

Application and Use

Pre-breeding examinations should ideally be conducted four to six weeks before the start of the breeding season. During this evaluation, a pelvic area of 150 cm^2 or greater is generally considered acceptable, and such heifers may not require further pelvic measurement. Heifers with a pelvic area of less than 150 cm^2 should be re-evaluated during the first pregnancy examination, preferably within 90 days after the beginning of the breeding season. At this second assessment, a pelvic area of at least 180 cm^2 is expected. Between the yearling stage and two years of age, the pelvic area increases at an average rate of approximately 0.27 cm^2 per day. This relatively consistent linear growth rate can be used to adjust the pelvic area according to the age of the heifer at the time of measurement. When pelvimetry is used to identify heifers with unusually small or unfavorably shaped pelvises, together with the selection of service sires based on Calving Ease Direct Expected Progeny Difference (CED-EPD) values, both the incidence and severity of dystocia at the herd level can be effectively reduced

4. Limitations of Pelvimetry

- Manual pelvic measurements may vary according to the skill and experience of the operator, which can affect the accuracy and consistency of results.
- Pelvic measurements alone do not account for other important factors that influence parturition, such as fetal posture, presentation, and soft tissue resistance. These factors may also contribute significantly to the ease or difficulty of delivery.
- Breed-specific standards for pelvic dimensions are still under development, and further research is needed to establish reliable reference values for different breeds.
- Pelvic measurements should not be considered a standalone criterion for predicting dystocia or selecting breeding animals. They should be interpreted along with other factors, including body condition, body weight, fetal characteristics, and sire evaluation, to achieve a more comprehensive assessment.

5. Future Prospects:

Future developments in pelvimetry may include:

- **Digital pelvimeters with automated recording:** These devices may improve the accuracy and consistency of pelvic measurements while reducing errors associated with manual recording and facilitating better data management.
- **Three-dimensional pelvic modelling:** Three-dimensional models may provide a more detailed assessment of the shape and dimensions of the pelvic canal. This approach can improve the evaluation of pelvic capacity and help identify anatomical variations associated with dystocia.

- **Ultrasound-based internal pelvimetry:** Ultrasonographic techniques may enable the noninvasive assessment of internal pelvic structures and dimensions, providing additional information that may not be obtained through conventional pelvimetry.
- **AI-assisted prediction tools:** Artificial intelligence-based approaches may integrate pelvic measurements with fetal characteristics and heifer development indices to improve the prediction of dystocia risk. Such tools could support more effective breeding decisions and herd management strategies.

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