

# Factors Associated with the Onset of Ovarian Activity of Cattle Commonly Reared in the Huasteca Veracruzana, Mexico

Olivares-Sixto, Luciano<sup>1</sup>; Silva-Martínez, Karla L.<sup>1</sup>; Vite-Cristóbal, Claudio<sup>1</sup>; Del Ángel-Piña, Oscar<sup>1</sup>; Arrieta-González, Armando<sup>1\*</sup>

<sup>1</sup> Tecnológico Nacional de México/Instituto Tecnológico Superior de Tantoyuca. Tantoyuca, Veracruz, México. C. P. 92100

\* Corresponding author: armando.arrieta@itsta.edu.mx

## ABSTRACT

**Objective:** To identify the factors that affect the onset of ovarian activity in prepuberal heifers in the Huasteca Veracruzana of Mexico.

**Design/Methodology/Approach:** Samples were taken from animal production units of the municipality of Tantoyuca, Veracruz. The onset of ovarian activity was determined by the presence of ovarian follicles and corpus luteum by ultrasonography technique. Zoometric indices and body condition were calculated at the same time, and the zootechnical practices that were applied to the animals in the last six months before the sampling day were registered. A survey was applied to characterize the management of animal production units; the main topics in the survey were: health, reproduction, nutrition, and suckling. All animals available within selection criteria in the production units were sampled. A multiple linear regression (Statistical Analysis Software Version 9.4) and cluster analysis (R Studio Version 1.1.419) were used to identify the main categorical variables that affected the model.

**Results:** The onset of ovarian activity depends mainly on the anatomical development of the heifers. The biostimulation (male effect) on the heifers has an important effect on reducing the age at puberty.

**Study Limitations/Implications:** The study was developed during a long drought period in the region.

**Findings/Conclusions:** The genetic mosaic of the evaluated animals in the production units did not affect the onset of ovarian activity of the heifers; however crossbred heifers (*Bos taurus* × *Bos indicus*) begin the ovarian activity younger.

**Keywords:** Male effect, reproductive efficiency, zoometrics.

## INTRODUCTION

The dual purpose cattle production system (DPCPS) is developed in most of the tropical regions of Latin America, and in this system extensive grazing is the most widely used (Vilaboa and Díaz, 2009). Meat and milk production depends on this system in this region (Orantes *et al.*, 2010). The DPCPS in Veracruz contributes to the national total of around 739 thousand tons of standing livestock and carcass and 745.30 million liters of milk annually. Therefore, livestock production is one of the activities that contributes most to the economy in Veracruz; 53.70% of the surface of this state is devoted to livestock production (PSAV, 2019). The DPCPS is characterized by having low productive and reproductive indices compared to the specialized animal production systems (beef and dairy cattle). One of these indices is the age at puberty, which can be defined as the moment when females physiologically start the capacity to reproduce (Estill, 2014). The onset of puberty is determined by age, and this process also depends on an undefined order of physiological conditions that result from a specific critical weight (Kenny *et al.*, 2018), for others, body development and nutrition are more important (Grajales *et al.*, 2006). The beginning of ovarian activity is a parameter that

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affects the fertility of the herd and this in turn affects the productive level of a livestock system (Osorio-Arce and Segura-Correa, 2002; Teyer *et al.*, 2003; Parra-Bracamonte *et al.*, 2005). Given the importance of this physiological event, this study identifies some factors that affect the beginning of the ovarian activity in heifers bred in DPCPS in the Huasteca Veracruzana (HV).

## **MATERIALS AND METHODS**

The research work was carried out in the municipality of Tantoyuca, Veracruz, located in the mountainous zone of the HV, in coordinates 98° 14' Longitude West and 21° 21' Latitude North, at an average altitude of 140 meters above sea level. Its climate is warm-extreme with an annual average temperature of 23 °C; the mean annual rainfall fluctuates between 1,000 and 1,500 mm (INEGI, 2010).

The study was performed in the last six months of the year 2019, and 73 prepuberal heifers (12-24 months of age) were included, from nine livestock production units devoted to DPCPS in the municipality of Tantoyuca, Ver. The genetic groups of the animals sampled were: I. *Bos indicus*, II. *Bos taurus*, III. *B. indicus* × *B. Taurus* Cross, IV. Predominance of *B. indicus*, and V. Predominance of *B. taurus*. The dependent variables evaluated were: right ovary follicular activity (ROFA), left ovary follicular activity (LOFA), right ovary size (ROS), left ovary size (LOS), right ovary shape (ROSh) and shape of the left ovary (LOSh). The ROFA and LOFA were determined with the presence of follicles and *corpus luteum*. Three categories were established for ROS and LOS: I. (<1 cm), II. (1-2 cm), and III. (>2 cm). These variables were measured with ultrasound techniques (Mindray DP 10-VET). The ROSh and LOSh were determined through the rectal palpation technique, establishing three categories: I. Amorphous, II. Oval plane, and III. Oval cylindrical. In addition, the following values were found: body condition (Edmonson *et al.*, 1989), biometric measurements of the heifer's trunk (Fernandes *et al.*, 2010; Dubuc, 1991; Contreras *et al.*, 2011), proximity to the male (males and females together or separate), number of technological-productive practices implemented in herd management (nutrition-health index), and zoometric indices of anatomical development (Contreras *et al.*, 2011).

## **Data analysis**

The systematization of information was digitalized in the Microsoft Excel 2016 software. The data were processed through a multiple linear regression analysis with the statistical package SAS version 9.4 and the REG procedure, in order to explain the possible relationships between independent and dependent variables. The independent or categorical variables were: ranch ( $X_1$ ), race ( $X_2$ ), age ( $X_3$ ), body condition ( $X_4$ ), proximity of male ( $X_5$ ), nutrition-health index ( $X_6$ ), thoracic index ( $X_7$ ), body index ( $X_8$ ), lateral body index ( $X_9$ ), and transverse-pelvic index ( $X_{10}$ ). Meanwhile, the dependent variables corresponded to: ROSh, ROS, ROFA, LOSh, LOS, and LOFA. A cluster analysis was carried out, which allowed identifying the management differences between the livestock production systems studied, and which in turn

impacted the beginning of the ovarian activity; this was done through the statistical package R Studio Version 1.1.419.

## **RESULTS AND DISCUSSION**

The regression equations that showed significant impact ( $p < 0.0001$ ), of the categorical variables (ranch, race, age, bodily condition, proximity to the male, nutrition-health index, thoracic index, bodily index, lateral body index, transverse-pelvic index) on the response variables were: LOS, LOFA, ROFA and ROS. Multiple determination coefficients were obtained with these equations, with values higher than 42%. The equations related to the response variables LOFA and ROFA showed a value of  $R^2$  of 47%, which indicates a moderate adjustment of the data of the model designed for these equations only under LOS, which for these same models was significant ( $p < 0.0001$ ). This result could be consequence of the genetic mosaic found in the bovines studied and the variability in the nutritional and sanitary management that is given to the animals in the different livestock production units where the study was performed; in this regard, Heslin *et al.* (2020) found that heifers who had daily weight gains of 1 kg during 150 days began puberty at a younger age, and this is because a better diet allows a greater anatomical development and favors the physiological maturation as a result of higher contribution of energy and protein in the diet.

The model for the variable LOS<sub>h</sub> obtained an  $R^2$  of 17% ( $p = 0.24$ ), and these results are the ones of lowest value of all the equations developed. The data related to this equation are not adjusted to the model and therefore lack practical importance in the conditions under which this study was carried out. For the case of ROS<sub>h</sub>, the model was significant with an  $R^2$  of 30% ( $p = 0.0081$ ). This indicates that data adjustment regarding the model is not conclusive (Table 1).

The modelled variables ROFA and LOFA were affected primarily by the categorical variables, body index (BI) ( $p = 0.0002$ ), lateral body index (LBI) ( $p = 0.0009$ ), thoracic index (TI) ( $p = 0.001$ ) and age (A) ( $p = 0.01$ ). These two models were affected moderately by the categorical variable PM ( $p = 0.13$ ). The rest of the categorical variables showed a non-significant impact toward the models.

The onset of the ovarian activity of the heifers raised in the dual-purpose system in the Huasteca Veracruzana is influenced by the anatomical development and chronological age, and concerning this Cardoso *et al.* (2021) mention that body weight and physical development are the main factors that determine the age at puberty, and they also indicate that they are closely related with the weight at birth, which can be compromised by nutritional deficiencies of the mother during gestation. Maternal nutrition is directly related to the functioning of the neuroendocrine system so that it can modulate the hypothalamus routes that control the secretion of the gonadotropin liberating factor.

**Table 1.** Multiple regression equations of ROFA, LOFA, ROS, LOS, ROSh and LOSh, R<sup>2</sup> and significance level.

Variable	Equation	R <sup>2</sup>	Significance
ROSh	$y=5.43-0.004x_1-0.19x_2+0.05x_3-0.11x_4+0.93x_5+3.39x_6-0.007x_7-0.03x_8-0.02x_9-0.07x_{10}$	0.30	0.0081
ROS	$y=16.84+0.11x_1-0.009x_2+0.03x_3+0.33x_4+0.24x_5-1.91x_6-0.05x_7-0.08x_8-0.03x_9+0.02x_{10}$	0.42	0.0001
ROFA	$y=28.68+0.003x_1-0.001x_2+0.02x_3+0.01x_4-0.16x_5-0.46x_6-0.06x_7-0.13x_8-0.07x_9-0.009x_{10}$	0.47	0.0001
LOSh	$y=16.72+0.001x_1-0.11x_2+0.004x_3-0.25x_4+0.76x_5+1.95x_6-0.04x_7-0.07x_8-0.04x_9-0.02x_{10}$	0.17	0.2412
LOS	$y=40.12+0.13x_1-0.07x_2+0.02x_3+0.28x_4+0.47x_5-2.08x_6-0.11x_7-0.17x_8-0.09x_9-0.02x_{10}$	0.52	0.0001
LOFA	$y=28.68+0.003x_1-0.001x_2+0.02x_3+0.01x_4-0.16x_5-0.46x_6-0.06x_7-0.13x_8-0.07x_9-0.009x_{10}$	0.47	0.0001

Dependent variables: ROFA=right ovary follicular activity, LOFA=left ovary follicular activity, ROS=right ovary size, LOS=left ovary size, ROSh=right ovary shape and LOSh=left ovary shape. Independent variables: X<sub>1</sub>=ranch, X<sub>2</sub>=racial group, X<sub>3</sub>=age, X<sub>4</sub>=Body condition score, X<sub>5</sub>=Proximity of male, X<sub>6</sub>=nutrition-health index, X<sub>7</sub>=thoracic index, X<sub>8</sub>=body index, X<sub>9</sub>=lateral body index, X<sub>10</sub>=transverse-pelvic index.

The stimulating effect of the males' presence in the females' lots (Male effect) showed a positive impact on the onset of the ovarian activity. The fact of keeping females and males in the same lot of animals proved that the onset of the ovarian activity can be stimulated (p=0.13), in the bovines bred under the dual purpose system in the Huasteca Veracruzana (Table 2). In this regard, Diskin and Kenny (2014) reported that prepuberal heifers exposed to bulls advanced puberty; although the physiological mechanism is not well defined, the possibility has been proposed that the reduction in sensitivity to estradiol caused by masculine pheromones increases the secretion of the gonadotropin liberating factor and the luteinizing hormone.

**Table 2.** Significance of the parameters of the multiple regression equations of the categorical variables for the modeled variables ROFA, LOFA, ROS, LOS, ROSh and LOSh in bovines older than 12 months raised in the dual-purpose system in the Huasteca Veracruzana.

Variable	Categorical variables									
	R	RG	Ag	BCS	PM	NHI	TI	BI	LBI	TPI
ROSh	0.84	0.005	0.02	0.43	0.0009	0.0005	0.87	0.71	0.68	0.002
ROS	0.0002	0.9149	0.33	0.07	0.48	0.11	0.35	0.45	0.62	0.42
ROFA	0.68	0.95	0.01	0.75	0.13	0.22	0.001	0.0002	0.0009	0.36
LOSh	0.95	0.07	0.85	0.05	0.002	0.02	0.28	0.34	0.36	0.23
LOS	0.0001	0.38	0.41	0.10	0.15	0.07	0.05	0.09	0.12	0.46
LOFA	0.68	0.95	0.01	0.75	0.13	0.22	0.001	0.0002	0.0009	0.36

Modeled variables: ROFA=right ovary follicular activity, LOFA=left ovary follicular activity, ROS=right ovary size, LOS=left ovary size, ROSh=right ovary shape and LOSh=left ovary shape. Categorical variables: R=ranch, RG=racial group, Ag=age, BCS=Body condition score, PM=Proximity of male, NHI=nutrition-health index, TI=thoracic index, BI=body index, LBI=lateral body index, TPI=transverse-pelvic index.

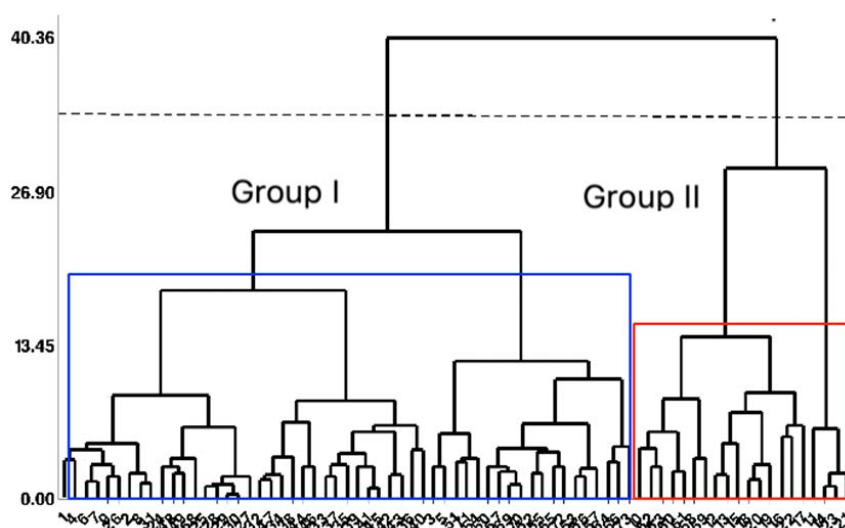
Choudhary *et al.* (2020) researched the biostimulating effect of the presence of the male in Sahiwal heifers of 14 months of age in confining conditions, and they found that biostimulated females began ovarian activity five months before those that were not

biostimulated ( $p < 0.05$ ). In addition, they reported that the contact with males affected positively the serum concentrations of progesterone ( $2.0 \text{ ng/mL}^{-1}$ ), in comparison to the control group with concentrations lower than  $1 \text{ ng/mL}$  ( $p < 0.05$ ). Rekwot *et al.* (2000) showed that biostimulation (exposure to vasectomized males) reduced the age at puberty in Bunaji and Friesian  $\times$  Bunaji heifers managed in grazing; they found that biostimulated heifers began puberty at an age of  $23.10 \pm 0.4$  months, while the females that did not receive biostimulation began puberty at  $26.40 \pm 0.4$  months of age ( $p < .05$ ). Fiol *et al.* (2010) found a higher proportion of cyclic animals at the end of the exposure period in Aberdeen Angus  $\times$  Hereford crossed heifers (Age 11 months, under grazing conditions), exposed to androgenized steers, in comparison to females that were kept isolated from the males; they also determined that the age at puberty of females exposed to males was lower compared to those not exposed (428 vs 441 days) ( $p = 0.06$ ). Therefore, biostimulation would be efficient to reduce the age at puberty in heifers of different genetic characteristics and under different management conditions.

Oliveira *et al.* (2009) showed a reduction in age at puberty, age at first season of mounting, age at pregnancy, and higher rate of pregnancy in Nelore heifers supplemented and not supplemented exposed to the bull at prepuberal phase. Thus, the degree of development, the nutritional status, and the rates of gain have a direct relationship with the age at puberty in meat heifers (Diskin and Kenny, 2014). The significance value of the categorical variable racial group (RG) was  $p = 0.95$  (Table 2), which indicates that in this study the genetic characteristics did not have an impact on the onset of the ovarian activity. These results are set against what was reported by Rekwot *et al.* (2000), who found that the F1 Friesian  $\times$  Bunaji heifers bred in grazing began puberty at 23.6 months of age, while the lot of pure breed Bunaji females began puberty at an age of 26.1 months ( $p < 0.05$ ).

The modelled variables ROSh and LOSh were influenced significantly by the categorical variables, nutrition-health index (NHI) ( $p = 0.0005$ ), proximity to the male (PM) ( $p = 0.0009$ ), transverse-pelvic index (TPI) ( $p = 0.002$ ), GR ( $p = 0.005$ ) and A ( $p = 0.02$ ). The rest of the categorical variables showed low relevance on the modelled variables. This could indicate that the shape of the ovaries depends on the nutritional and health management that they receive since their breeding stage, until the beginning of their reproductive stage, and that this is all directly related with its anatomical development and physiological maturity. The modelled variable LOS was affected significantly by the categorical variable TI ( $p = 0.05$ ), followed by the effect of the categorical variable NHI ( $p = 0.07$ ) and with lower effect the categorical variable BI ( $p = 0.09$ ); however, it was found that the size of the ovary was not significantly affected by the PM variable ( $p = 0.15$ ). These results are contrary to those reported by Choudhary *et al.* (2020) who mention that biostimulation affects the number of small follicles present in Sahiwal heifers of 14 months of age under confinement conditions. These authors found that the groups of females not exposed to males produced a lower number of small follicles in comparison to the groups of biostimulated females with the presence of the male ( $p < 0.05$ ).

The cluster analysis formed two main groups (I and II). Group II showed the best behavior of the modelled variables while group I presented a low behavior for these same variables (Figure 1). Within group II, the best behavior corresponded to livestock production with animals of the racial group *Bos taurus* × *Bos indicus*, 14 months of age, body condition of 2.75, and the females with ovarian activity were concentrated in this group. Meanwhile, in group I livestock of low behavior was for individuals with amorphous ovaries, of smaller size and absence of ovarian activity (Figure 1).



**Figure 1.** Dendrogram of dependent variables (shape, size and follicular activity of right and left ovary) and categorical variables (ranch, racial group, age, body condition score, proximity of male, nutrition-health index, thoracic index, body index, lateral body index, transverse-pelvic index) for the dual-purpose bovine system in the Huasteca Veracruzana.

## CONCLUSIONS

The heifers reared in the dual-purpose system in the Huasteca Veracruzana could begin the ovarian activity at a younger age when their anatomical development, expressed in zoometric indexes, are of higher value and when the chronological age is over 14 months. The biometric measurements of heifers are a useful tool as parameter for the selection of replacements when the intent is to improve the sexual precocity of the herd. The husbandry practices designed to reduce the age at puberty should be directed at improving the quality of the diet. There is a need to research alternatives and practices of viable nutritional management (ecologically and economically) for replacement females in the DPCPS, and with this to guarantee an anatomical development in agreement with their genetic potential. The genetic improvement programs designed to reduce the age of puberty could lack effectiveness if the breeds or racial groups evaluated in this research are used. Biostimulation (presence of the male) is a useful tool to reduce the age at which the ovarian activity of heifers begins.



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