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Effect of Environmental Factors from Birth to the Onset of Reproductive Function and Management in Indo-Brazilian Heifers

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Abstract: In order to evaluate factors that affect growth, age at first breeding (AFB) and age at conception (AC) 246 records of Indo-Brazilian heifers were used. An analysis of variance was performed with a model including the fixed effects of season of birth (SB), year of birth (YB), dam's parity number (DPN) and breeding season (BS). Birth weight (BW), weaning weight (WW) and weight at first breeding (WFB) were included as covariates. The following interactions were also included, SBxYB, YBxDPN and BSxYB. The association of WFB with AFB and AC was analyzed by regression. The growth was described from birth to first calving with the Gompertz equation. AFB and AC were affected by SBxYB and BSxYB ($p<0.01$). Differences in SBxYB for AFB of 16.56 and in BSxYB for AC of 17.24 months were detected. In average, heifers were bred at 32 months of age and became pregnant at 33, because some of them required two breedings. Variation in AFB and AC was due to SBxYB, BSrxYB and WFB ($p<0.01$). Indo-Brazilian heifers with a higher WFB which are born and bred in spring will be the first ones to get pregnant. The most important sources of variation for WFB and AC were the interactions SBxYB, YBxDPN and BSxYB. Sire and mating year had a significant effect on the three parameters of the growth curve ($p<0.05$). It is concluded that Gompertz equation is useful to describe the growth of Indo-Brazilian heifers because it allows adjustments during growth involving daily weight gain.

Keywords: Age at conception, age at first breeding, beef production, Gompertz equation, puberty, tropical regions, Zebu cattle

INTRODUCTION

Beef production largely depends on the area where it takes place, since environmental conditions favor or limit production, conditioning the expression of productive and reproductive parameters in cattle. For instance, Zebu bovine breeds for beef production in the tropics are characterized by starting puberty at an older age than European breeds (Villagómez *et al*., 2000). Post and Reich (1980) defined puberty as a gradual process that appears in the stage of somatic development (growth) of an individual, which becomes capable for reproduction and ends when sexual maturity is reached. This process, which can be spontaneous or induced, is characterized by the presence of a marked increase in the frequency of pulses of gonadotropic secretion (LH and FSH), the development of genitals and secondary sexual traits.

Information on age at first breeding in beef cattle in tropical areas is limited, although it is considered a parameter of economic importance and essential to maintain an optimal age at first calving and to extend overall herd life (Gonzalez-Stagnaro *et al*., 2006). In the tropics, Zebu breeds (*Bos indicus*) show a lower productive performance than European breeds (*Bos taurus*) in parameters such as age at first calving (Magaña and Segura, 2001) and growth rate (Magaña and Segura, 2006), even under good management conditions (Lunstra and Cundiff, 2003). However, due to its adaptation to the conditions of solar radiation, temperature, humidity and fluctuating nutrition, Zebu breeds dominate the Mexican tropics. In this region, farmers often ignore age at first breeding, age at conception, birth weight, weaning weight and conception weight for immediate decision making and future animal production because they neglect record analysis to allow implementing new programs aimed to improve overall performance of the beef producing herd.

Studying the importance and magnitude of environmental factors on Indo-Brazilian replacement females will allow distinguishing the most influential

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factors affecting these animals at the start of their reproductive lives. Such information is necessary to help livestock producers making better decisions for replacement heifer selection and make adjustments to the reproductive management of their herds, so the aim of this study was to assess the effect of environmental factors on growth and the onset of reproductive behavior of Indo-Brazilian heifers.

MATERIALS AND METHODS

Location: The study was conducted at the Playa Vicente Experimental Site of the Mexican National Institute for Forestry, Agriculture and Livestock Research (INIFAP). The experimental site is located in the municipality of Playa Vicente, Veracruz, Mexico, at 17°19' north latitude, 95°41' west longitude and an altitude of 95 m above sea level. The region climate is humid tropical with abundant rains in summer and a dry season from March to May. Average annual temperature is 26.8°C, accumulated annual rainfall is 2124 mm and average relative humidity is 77.4%.

Animals and management: Records of two-hundred and forty-six Indo-Brazilian heifers that reached puberty during the years 1983-2003 were included in this study. Cattle remained in an intensive rotational grazing system, in an area of approximately 60 ha divided in paddocks of 1-2 ha each and made up of African Star (*Cynodon plectostachyus*), Insurgent (*Brachiaria brizantha*), Chontalpo (*B. decumbens*) and Elephant grass (*Pennisetum purpureum*), as well as German grass (*Echynochloa polystachya*) in the lowlands and floodplains. Stocking handled on average 1.4 to 1.8 AU/ha/year over the study period. Calves were handled in pens with free access to water and mineral salts. Calves were kept separated from their mothers until weaning and under controlled lactation (one hour in the morning and 1 h in the afternoon). Animals were treated against external and internal parasites and vaccinated against paralytic rabies, blackleg, malignant edema, and Pasteurellosis; females between 3 and 6 months of age were also vaccinated against Brucellosis. These operations were carried out according to a health management calendar.

Calves were identified and weighed within the first 24 h after birth and during each month including weights at weaning, 12 and 24 months, weight at conception and at calving. Reproduction was performed by artificial insemination in two breeding seasons (spring and fall). Estrus was detected twice daily by direct visual observation and with the help of a chin ball bull. Pregnancy diagnosis was performed routinely by rectal palpation at the end of the breeding season.

Data: The information was obtained from field sheets from 1983 to 2003, which were emptied into individual cards for each of the heifers. Record cards were divided into different sections including calf identification number, sire and dam ID, birth date, monthly weights, reproductive management records such as age and weight at the beginning of breeding, year of breeding, date of first breeding, age and weight at first breeding, number of mating, age and weight at conception, number of services per conception, month and year of birth, calving season and length of gestation among others.

Statistical analyses: A database in Microsoft Excel ® was developed and the data was exported to SAS (Version 9.0) (2002), to KaleidaGraph ® 3.5 (2000) and to Scientist ® 2.01 (1995) to be analyzed and graphed.

To estimate environmental effects, variables such as age at first breeding (AFB) and age at conception (AC) were analyzed by general linear models (GLM). Fixed effects were: season of birth (SB), year of birth (YB), parity of the dam (DPN) and breeding season (BS). Covariates were birth weight (BW), weaning weight (WW), weight at first breeding (WFB) and the interactions SBxYB, YBxDPN and BSxYB.

To analyze the importance of weight at first mating (WFB) with BS and AC, correlation and simple regression analyses were applied. The data were analyzed by time until 1995, since from 1996 on there was only one breeding season as a result of the economic benefit derived from concentrating the sale of calves in one short period.

Growth modeling: To analyze the growth of Indo-Brazilian heifers from birth to first calving, Gompertz equation, a mathematical model for graphic description, was used. This model quantifies the biomass increase per unit of time (Arlinghaus, 1994). Time was used as the independent variable and weight as dependent variable. For the analysis of variance, year of mating was considered as a fixed effect and sire of the heifer as a random effect. Response variables were the parameters generated by the Gompertz equation: growth rate (C), inflection point (B) and weight at first calving (A).

RESULTS AND DISCUSSION

Age at first breeding and AC were 32.1 (SME = ±0.20) and 32.8 (SME = ±0.25) months, respectively and were affected by interactions BSxYB and SBxYB ($p<0.01$) interactions. There were differences in SBxYB (January-March vs April-May) up to 16.56 months for AFB and BSxYB (January-March vs April-May) up to 17.24 months for AC. Weight at first breeding was 401.02 kg (SME = 0.66). Differences in each factor may vary due to the interaction SBxYB.

Under the conditions of this study, heifers were bred for the first time at 32 months of age and got

Table 1: Least squares means of weights from birth to calving of replacement Indo-Brazilian heifers

	Live weight		
	----------------------------		Difference
Variables	kg	(SEM)	(kg)
Weight at birth, kg	31.27	0.35	
Weight at 7 months, kg	180.80	0.85	149.5
Weight at 12 months, kg	217.50	0.94	36.7
Weight at 24 months, kg	341.40	1.18	123.9
Weight at start of breeding, kg	390.30	1.26	48.9
Weight at first mating, kg	401.00	1.27	10.6
Weight at conception, kg	414.10	1.30	13.0
Weight at calving, kg	458.60	1.36	44.5

SEM: Standard error of the mean

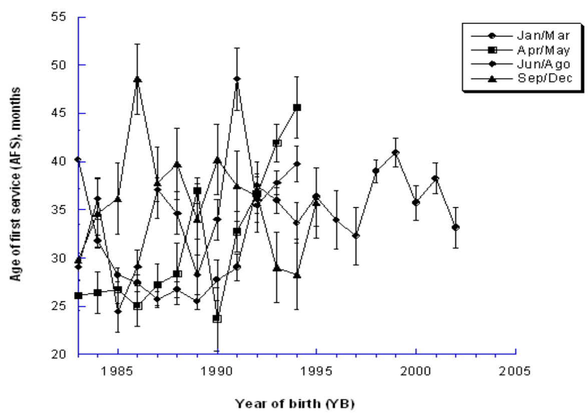

Fig. 1: Effect of the interaction of season of birth by year of birth (BSxYB) on age at first breeding (AFB) of Indo-Brazilian heifers

pregnant at 33 months because heifers required two services and the number of matings per conception was 2.34 (SEM = 0.07). Gestation length was 288 days (SEM = 0.72) and age at first calving was at 42.4 months-old (SEM = 0.28). Differences in AFB and AC resulted from SBxYB and BSxYB interactions ($p<0.01$) and from the effect of WFB ($p<0.01$). Details on weights considered important from birth to calving are summarized in Table 1.

The interaction of birth season and year of birth had an effect ($p<0.01$) on age at first service in both the magnitude of the differences as well as its distribution in each season during the period of the study.

The years 1986 and 1991 showed the highest values of AFB for season 3 (June to August) and 4 (September to December). In general, heifers had the lowest performance in AFB every year. Values of AFB were: 33.6 (SEM = 2.13) for season 1 (January-March), 32.7 (SEM = 2.13) for season 2 (April-May), 34.6 (SEM = 2.21) for season 3 (June-August) and 35.7 months (SEM = 1.76) for season 4 (September-December; Fig. 1). However, Figure 1 only depicts season values observed until 1995, as from year 1996 on, management changed and only one breeding season was used, taking advantage of the fact that getting pregnant heifers during this season provides a better

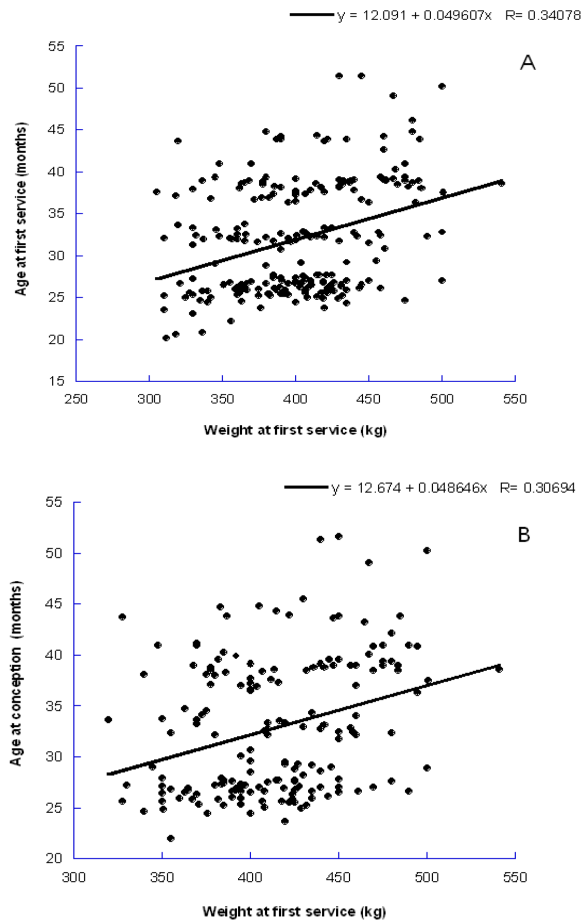

Fig. 2: Relationship between weight at first breeding and age at first breeding (A) and weight at first breeding and age at conception (B) of Indo-Brazilian heifers

price for calves at sale. Moreover, in the study period a greater number of heifers conceived during season 1 than at other seasons.

The interaction of birth season by year of birth had an effect on age at conception ($p<0.01$). The years 1989 and 1999 reported the lowest and the highest value in season 1 with 25.6 (SEM = 0.79) and 42.2 (SEM = 1.47) months, respectively.

Weight at first breeding was significantly associated with AFB and AC ($p<0.01$) with an average of 401.17 kg (SEM = 1.32), a minimum weight of 305.0 kg (SEM = 1.15) and a maximum value of 541.0 kg (SEM = 1.53). AFB mean, minimum and maximum were 32.11 (SEM = 0.36), 20.10 (SEM = 0.28) and 51.40 (SEM = 0.46) months. Minimum and maximum values for AC were 22.0 (SEM = 0.35) and 55.6 (SEM = 0.56) months, respectively. For each 1 kg increase in WFB, AFB was reduced by 0.043 months. EPS in Fig. 2A and B show the trend estimated by linear regression equation.

Estimates of correlation coefficients for WFB with AFB and AC were: 0.34 ($p<0.001$) and 0.26 (p 0.004). Correlation between WFB and AC could decrease by

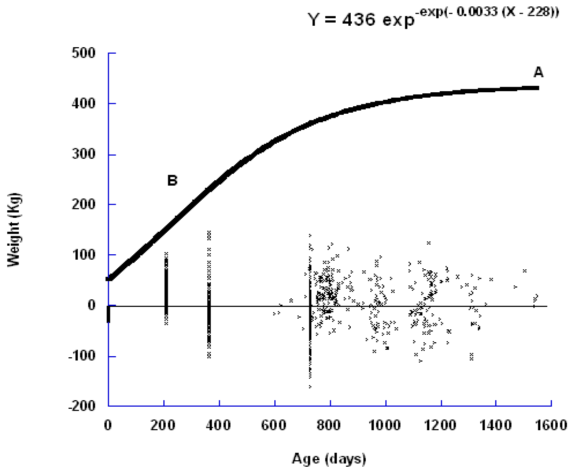

Fig. 3: Growth curve (from weight at birth to weight at first calving) and residual coefficients generated by Gompertz model in Indo-Brazilian heifers

factors other than daily weight gain, such as reproductive management, number of mating to conception and estrus detection efficiency, which also affect conception rate. Because a great deal of the onset of estrus in Zebu cattle is nocturnal, the possibility of heifers to become pregnant by the first AI service is reduced (Galina *et al*., 1996). Moreover, growth curve parameters such as growth rate (C = 0.0033±9.23 kg), inflection point (B = 227.85±4.87 kg), which represents the turning point, i.e., where growth ascending process decreases, is related to weight at puberty and the maximum weight at first calving (a = 436.34±4.25 kg), with a R^2 = 0.97 (Fig. 3).

In this regard, the NRC (National Research Council) (2001) mentions that the weight at puberty of females in these tropical systems corresponds to 55% of the mature body weight (A) (NRC, 2001); in this case, 55% of A = 436.34 would be 240 kg, so the weight estimated in this study with the Gompertz equation is very close to the information generated by the NRC for cattle in the tropics.

Average Daily Gain (ADG) from the first service to conception was 0.290 and 0.200 kg at calving. These gains are comparable to results obtained by Martin *et al*. (1992) who reported a minimal gain of 0.262 kg for 164 days-old Brahman cattle grazing in the state of Tamaulipas, Mexico. There was no effect of dam's parity number or mother's age over weight at first mating (p>0.05) as reported by other authors for early stages of young Brahman growth, such as weight at calving (Segura, 1988) and at weaning (Torner *et al*., 1984). However, information it is not very clear since some authors have reported similar results to those from this study, because no differences were found for weights at 12, 16 and 24 months of age in Brahman calves (Plasse and Green, 1980). Other studies with commercial Zebu reported higher weights at birth, weaning and average daily weight gain (ADWG), which were 34.8±0.09 kg, 230.4 kg±0.66 and 727±2.56 g, respectively (Segura-Correa, 1990). In this study, significant sources of variation on birth weight were birth year and sex; unlike the present study, where cow age and the interaction of year by birth season were significant. For ADWG and weight at weaning significance was found for year, birth season, sex, weight at birth, age at weaning and the interaction of year by season (Segura-Correa, 1990).

The interactions of BSxYB and SBxYB are relevant in the early onset of puberty and reproductive life in connection to determine what is the weight and the minimum age in which a particular cow breed is likely to reach puberty. In *Bos indicus* breeds, heifers reach puberty at 65% of mature weight, so weight and age are important in the determination of puberty (Yelich *et al*., 1995). According to Clanton (1983), the time in which heifers reach puberty is determined by the total amount of growth obtained during the post weaning period, rather than by breed. For these reasons, in this study it was found that season influences the onset of reproductive age in heifers as well as its birth season; this seems to be conditioned by a number of mechanisms and control interrelationships among the environment, the nervous system and the reproductive activity (Kinder *et al*., 1987).

González-Stagnaro *et al*. (2007) noted that any risk that affects growth or daily weight gain modify the age at first breeding. Also, birth at weight, age at weaning and weight at weaning and its variations have been associated with risk factors such as production system, farm location and season of the year. Moreover, management practices that influence the quantity, quality and continuity of food supply, especially in the pre and post-weaning might also cause a delay in body growth at the time of heifer´s first service.

The weight at first calving found in this study was 458.6 kg (SEM = 1.36); the growth curve shows that Indo-Brazilian heifers reached this weight at about 1000 days-old, which agrees with the 1091.7±137.9 days-old at first calving found by Mejía *et al*. (2010) for Brahman cows and their crosses with *Bos taurus*.

Sire (S) and year of breeding (AE) had a significant effect for the three growth curve parameters (p<0.05). Inflection point (B = 227.85±4.87 kg), which represents the point where growth slows its increasing process, is related to weight at puberty and maximum weight at first calving (A = 436.34±4.25 kg) with a R^2 = 0.97 (Fig. 3). Growth rate (C) was 0.0033±0.00029 kg.

Among breeding years, the largest weight at calving occurred in 1999 (598.10±53.24 kg) and the lowest in 2001 (450±71.31). For the inflection point parameter, which represents the weight at puberty, the largest weight at puberty took place in 1999 (473.81±55.37) and the lowest in 2003 (250.30±30.11 kg). For the growth rate parameter, animals bred in 1999 exhibited the lowest growth rate (0.001785) and the largest was for heifers bred in 1992 (0.00444).

The fact that the highest growth rate in a year occurred long before years 2001 and 2003, when the highest weight at first calving and weight at puberty were observed, may be due to the fact that in 1992 such information still was not routinely collected, so the reproductive management of heifers was poor allowing more time than necessary to carry them to their first mating. This confirms that growth curve modeling is a valuable tool to identify factors that support decision making and helps extend the productive life of Indo-Brazilian heifers.

CONCLUSION

The most important sources of variation for weight at first service and age to conception were the interactions of season of birth by year of birth, season of breeding by year of birth and the effect of weight at first mating. Heavier Indo-Brazilian heifers at first service being born in spring will become pregnant before the others.

The Gompertz equation can be used as a tool to describe growth of Indo-Brazilian heifers and make adjustments during growth at moments where average daily weight gain could be affected by different environmental factors, thus compromising an appropriate weight at first breeding.

Growth curves for body weight are useful for examining the consequences of selection for increased biomass and to establish future strategies. Comparison of curves is simple when the parameters generated by the models describing the process of growth are known.

The results of this study may help improve growth management systems, allowing to reach Indo-Brazilian heifers´s their target weight (onset of reproductive age) and be more efficient in grazing under tropical conditions.

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