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Relationship of Longevity with Productive and Reproductive Variables in Nelore Cows of the Bolivian Tropic

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Abstract: The objective of this study was to evaluate the relationship between longevity with productive and reproductive efficiency variables of Nelore cows in grazing systems in the Bolivian tropics. Retrospective data corresponding to the period 1992-2019, belonging to the Cooperativa Agropecuaria Integral San Juan de Yapacaní and the Foundation Technology Center on Agriculture and Livestock, Santa Cruz-Bolivia were used. The data corresponding to 774 Nelore breed cows, primiparous and multiparous discarded with a total of 4050 calvings were evaluated. The following variables were analyzed: Number of calves, live weight of cow in kg, calf weight at birth in kg, calf weight at weaning in kg, total calf weight in kg, age at first calving in months, longevity in days and calving interval in days. Cows born in the year (1985-1995) are those that arrive later to have their first calving, have a greater calving interval, have greater longevity, similar weaning weight, lower birth weight, lower live weight and higher weight total calf. While cows born in the year (2005-2015) are those that arrive younger to have their first calving, they have a shorter calving interval; have shorter longevity, similar weaning weight, higher birth weight, live weight intermediate and lower total calf weight. For the three periods analyzed, the length of life increases between 0.66-0.95 days on average when the age at first calving increases by one unit, between 1.78-2.99 days on average when the calving-calving interval increases by one unit and between 1.77-1.83 days on average when total calf weight increases by one unit. It is concluded that it was possible to find a model that explained that the greater longevity of Nelore cows in a grazing system in the Bolivian tropics was related to the older age at first calving, the greater calving interval and the greater kg of weights total calves.

Keywords: Length of Life, Calving Interval, Age at First Calving, Birth Weight, Weaning Weight

Introduction

Age at first calving, survival and longevity are economically important characteristics in beef cattle (Dakay *et al*., 2006; Carvalho *et al*., 2015; Damiran *et al*., 2018). Longevity, includes from the first to the last calving, being an economically important trait. An extension of longevity, allows increasing the number of adult cows that have a higher accumulated production (Ikeda *et al*., 2020) and also reduces annual production costs, which are associated with replacement heifers and with the number of involuntary culls of cows (Rogers *et al*., 2004). This coincides with what was reported by (Ikeda *et al*., 2020) where adult Nelore cows older than five years were more productive in total kg of weaned calves and in reproduction than younger animals. Not achieving this distribution, the nutritional requirements are higher, because there would be more cows in a growing state (first and second calving cows), leaving the pregnancy relegated to the background; therefore they will be less efficient. Keeping the largest number of adult cows in the herd close to 80%, would make it possible from a zoo technical concept that the traits associated with biological efficiency such as longevity and reproduction of animals produce greater sustainability of the productive system (Ikeda *et al*., 2020). To obtain efficient productivity in beef cows, in addition to taking into account important factors of the system, such as health aspects, age at first calving, birth and weaning weight, nutritional, reproductive and genetic factors, it is necessary to control body weight and body condition of the animals (Carrizales Montealegre, 2005; Orozco *et al*., 2013; Diskin and Kenny, 2014). In addition, the production of beef cattle is influenced, among other factors, by the genotype of the animal associated with the environmental conditions to which it is subjected (Holgado and Rabasa, 1999). A previous work by (Ikeda *et al*., 2019), showed results on the relationship between the longevity of the productive variables, in this case the parturition-parturition interval is introduced as a reproductive variable and a greater number of years of information to be able to continue deepening the understanding of why some cows live longer than others.

For this reason, the objective of this study was to evaluate the relationship between longevity with productive and reproductive efficiency variables of Nelore cows in grazing systems in the Bolivian tropics.

Materials and Methods

Retrospective data corresponding to the period between 1992 and 2019 were used for the research work belonging to the Cooperativa Agropecuaria Integral San Juan de Yapacaní (CAISY) located in Japanese Community San Juan 16°59′0″ south latitude, 63°58′0″ west longitude and Technology Center on Agriculture and Livestock in Bolivia (FUNDACION CETABOL) in Japanese Community Okinawa (17°13′12″ south latitudes, 62°53′39″ west longitude) Santa Cruz, Bolivia. The communities are located at 286 m above sea level and they present a tropical climate, with significant rains in most months of the year and a short dry season with little effect on the general climate.

The annual average temperature is 24.3°C with average rainfall of 1805 mm in Japanese Community San Juan and 986 mm in Japanese Community Okinawa, Santa Cruz. Rainfall is minimal in the month of July, with average values of 50 mm. The wettest month in January with an average rainfall of 330 mm. The highest average temperatures correspond to the month of January, with values of 26.5°C and the lowest to the month of July with records of 20.7°C.

Animals

The data corresponding to 774 Nelore breed cows, primiparous and multiparous discarded with a total of 4050 calvings were used. The primiparous cows calve between the months of May and July of each year, while the rest do so between the months of July and September. Weaning occurs between seven and eight months in two or three stages depending on the body condition and general state. Gynecological control is performed routinely at weaning, by a technical advisor, as well as health. Natural conceptions were used in the years analyzed.

Feeding and Management

The herd was fed grazing managed in intensive conditions, on 311 hectares with cultivated pastures *Brachiaria brizantha* (10 to 18 t/ha/year of DM) *Brachiaria decumbens* (8 to 12 t/ha/year of DM), *Brachiaria humidicola* (8 to 10 t/ha/year of DM), *Brachiaria dictyoneura* (8 to 10 t/ha/year of DM), *Cynodon dactylon* (10 to 20 t/ha/year of DM) and *Panicum maximum cv mombaza* (20 to 28 t/ha/year of DM) (ESCASAN, 2020).

Body Weight Record

The cows had at least two individual weight controls every year. The weighing of the animals was always carried out at the same time (8:00 am). The calves were weighed with a brand manual scale (POCKET BALANCE; Made in Germany) on the same day of birth. From two months of age, calves and dams were weighed with a brand electronic scale (ICONIX New Zealand Ltd.).

Variables Used

Variables productive
Date of Birth (DB)
First Calving Date (FCD)
Number of Calvings (NC): Sum of deliveries in their productive life
Cow Live Weight (LW) in kg: Average weight of cow of all weights of her lactation.
Calf weight at Birth (CWB) in kg: Average calf weight at birth for all calvings
Calf Weight at Weaning (CWW) in kg: Average calf weight at weaning of all calvings
Total Calf Weight (TCW) in kg: Sum of calf weights at weaning of all calvings
Age at First Calving (AFC) in months: The age at first calving (date of birth - date of first calving)
Longevity (L) in days: Date of discard or death - date of birth in days
Variable reproductive
Calving Interval (CI) in days: Average calving interval of all calvings.

Statistic Analysis

The cows were grouped by date of birth, where they were ordered in three decades [(1985-1995; 1995-2005; 2005-2015)]. A multiple regression model was applied that describes longevity as a function of the other variables. To select the best predictors, the stepwise method is used based on the bidirectional approach, which in each step tests which variables are excluded or included in the model. The quality of the model will be evaluated using the Akaike criteria. The interpretation of the model was carried out based on the estimated regression coefficients. The statistical analyzes were carried out with the R 4.0.0

Results

Descriptive Analysis

Table 1 shows the descriptive results of the variables studied, showing that cows born in the year (1985-1995) are those that arrive later to have their first calving, have greater calving intervals, have greater longevity, similar weaning weight of calves, lower birth weight of calves, lower live weight and higher total calf weight. While cows born in the year (2005-2015) are those that arrive younger to have their first calving, they have shorter calving intervals, have shorter longevity, similar wearing weight of calves, greater birth weight of calves, intermediate live weight and lower total calf weight.

Table 1: Descriptive measures of position and dispersion for variables considered in the study

Variable	Year of birth	N	Mean	S.D.	CV	Mín.	Máx.	Median	Q1	Q3	I.Q.R
Age first calving (days)	(1985, 1995)	146	1383	338	24	777	2757	1319	1163	1597	434
	(1995; 2005)	330	1066	157	15	695	1848	1056	949	1124	175
	(2005; 2015)	298	1030	128	12	757	1511	1026	927	1098	171
Calving interval (days)	(1985, 1995)	146	460	80	17	324	827	443	415	486	71
	(1995; 2005)	330	455	99	22	321	1092	429	390	487	97
	(2005; 2015)	298	437	87	20	293	836	414	374	469	94
Longevity (days)	(1985, 1995)	146	4174	1058	25	1983	6335	4167	3266	5161	1895
	(1995; 2005)	330	3275	1268	39	1475	6852	2995	2173	4356	2183
	(2005; 2015)	298	2535	832	33	1305	4813	2329	1895	3041	1146
Calf weight at weaning (kg)	(1985, 1995)	146	214	22	10	147	284	216	202	227	25
	(1995; 2005)	330	218	23	11	102	286	221	205	234	29
	(2005; 2015)	298	216	25	11	138	367	218	201	232	30
Calf weight at birth (kg)	(1985, 1995)	146	32	3	8	26	40	33	31	34	3
	(1995; 2005)	330	35	4	11	24	47	35	32	37	5
	(2005; 2015)	298	36	4	10	28	50	36	34	38	4
Live weight of cow (kg)	(1985, 1995)	146	499	59	12	384	647	493	452	537	84
	(1995; 2005)	330	520	55	11	325	653	524	480	558	78
	(2005; 2015)	298	503	54	11	342	651	502	464	537	73
Total calf weight (kg)	(1985, 1995)	146	1450	609	42	362	3480	1445	944	1926	982
	(1995; 2005)	330	1227	729	59	238	3315	1074	593	1760	1166
	(2005; 2015)	298	862	458	53	300	2331	733	485	1074	588

Mean: Arithmetic mean, S.D.: Standard deviation, CV: Coefficient of variation, Min.: Minimum
Max: Maximum, Median: Median value, Q1: Quartile one, Q3: quartile three, I.Q.R: INTERQUARTILE range.

Table 2: Analysis of variance of year of birth, year at first calving, calving interval and total weight

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Year of birth	2	272333432	136166716	2035.0752	< 2.2e-16 ***
AFC (days)	1	312	312	0.0047	0.945598
CI (days)	1	1463545	1463545	21.8734	3.448e-06 ***
Total weight (kg)	1	829466733	829466733	12396.7677	< 2.2e-16 ***
YB*AFC	2	522340	261170	3.9033	0.020582 *
YB*CI	2	687548	343774	5.1379	0.006076 **
YB*Total weight(kg)	2	200319	100159	1.4969	0.224477
Error	758	50717719	66910		

Significant codes ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
AFC: Year at First Calving
CI: Calving Interval
YB: Year of Birth
YB*AFC: Year of Birth *Age of First Calving
YB*CI: Year of Birth *Calving Interval
YB*Total Weight: Year of Birth *Total Weight

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Model Results

Table 2 shows that there is a significant interaction between the year of birth and the age at the first calving and the year of birth and the variable calving interval. That is, the relationship between age at first birth and life length is not the same for all birth year intervals. The same happens with the relationship length of life and the calving interval. Regarding the variable total weight (kg), it is significant by itself but its interaction with year of birth is not significant.

In Table 4 the results of the equations can be interpreted as follows.

For the Year (1985-1995) the Length of Life

- It increases 0.95 days on average when the Age at First Birth increases by one unit, leaving the values of the other variables fixed
- Increases 2.99 days on average per unit increase in the Calving Interval, setting the values of the other variables
- Increases 1.83 days on average per unit increase in total calf weight, leaving the values of the other variables fixed

For the Year (1995-2005) the Length of Life

- It increases 0.66 days on average when the Age at first birth increases by one unit, leaving the values of the other variables fixed
- Increases 1.85 days on average per unit increase in the Calving Interval, setting the values of the other variables
- Increases 1.75 days on average per unit increase in total calf weight, leaving the values of the other variables fixed

For the Year (2005-2015): The Length of Life

- It increases 0.68 days on average when the age at first birth increases by one unit, leaving the values of the other variables fixed
- Increases 1.78 days on average per unit increase in the calving interval, setting the values of the other variables
- Increases 1.77 days on average per unit increase in Total Calf Weight, leaving the values of the other variables fixed

In Fig. 2 it is observed that the predicted values of the length of life as a function of the calving interval behave in a similar way as for the previous case (Fig. 1). The relationship between the calving interval and the length of life is positive in the three intervals of year of birth. However, the slope or increase in the average life length for each unit increase in the calving interval is greater for cows born between 1985-1995 than for those born between 1995-2005 and 2005-2015 (p-value = 0.006076).

Table 3: Estimation of the model parameters for the regressor variables

	Estimate	Std. Error	t value	Pr(>|t|)	Signif
Intercept	-1.162e+03	2.010e+02	-5.783	1.07e-08	***
Year of Birth (1995; 2005)	7.368e+02	2.364e+02	3.116	0.001900	**
Year of Birth (2005; 2015)	6.925e+02	2.560e+02	2.705	0.006992	**
Age at First Calving	9.532e-01	6.672e-02	14.285	< 2e-16	***
Calving Interval	2.985e+00	3.126e-01	9.549	< 2e-16	***
Total Calf Weight	1.834e+00	4.109e-02	44.638	< 2e-16	***
Year of Birth (1995; 2005): Age at First Calving	-2.896e-01	1.132e-01	-2.558	0.010731	*
Year of Birth (2005; 2015): Age at First Calving	-2.743e-01	1.370e-01	-2.002	0.045650	*
Year of Birth (1995; 2005): Calving Interval	-1.140e+00	3.463e-01	-3.293	0.001039	**
Year of Birth (2005; 2015): Calving Interval	-1.207e+00	3.575e-01	-3.377	0.000771	***
Year of Birth (2005; 2015): Total Calf Weight	-7.928e-02	4.586e-02	-1.729	0.084277	.
Year of Birth `[2005; 2015): Total Calf Weight	-6.080e-02	5.296e-02	-1.148	0.251321	

Significant Codes: *** 0.001; ** 0.01; * 0.05; . 0.1; ‘ ’ 1
Residual standard error: 258.7 on 758 degrees of freedom
Multiple R-squared: 0.9561, Adjusted R-squared: 0.9555
F-statistic: 1501 on 11 and 758 DF, p-value: < 2.2e-16

Table 4: Intercept and estimated slopes for each birth year interval according to the model used

	Year (1985-1995)	Year (1995-2005)	Year (2005-2015)
Intercept	-1162,000000	-425,200000	-469,500000
Age at first calving	0,953200	0,663600	0,678900
Calving interval	2,985000	1,845000	1,778000
Total calf weight	1,834000	1,754720	1,773200

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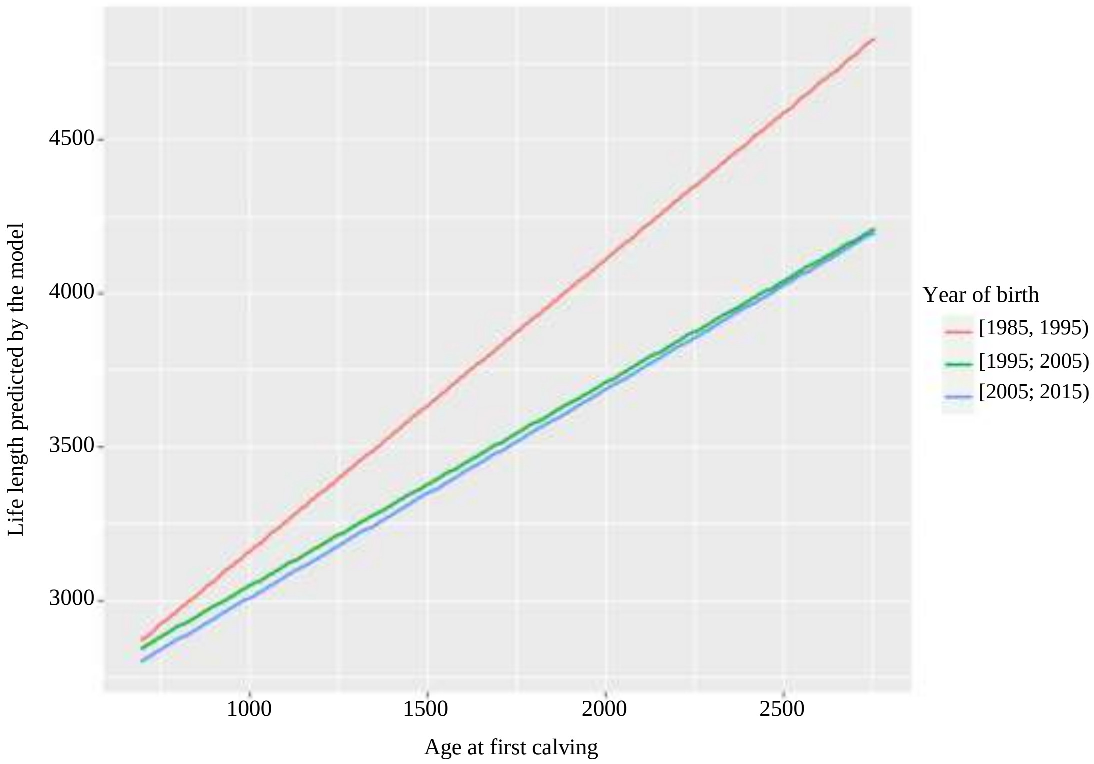

Fig. 1: Age at first birth Vs life length values predicted by the model, leaving the values of the other variables fixed

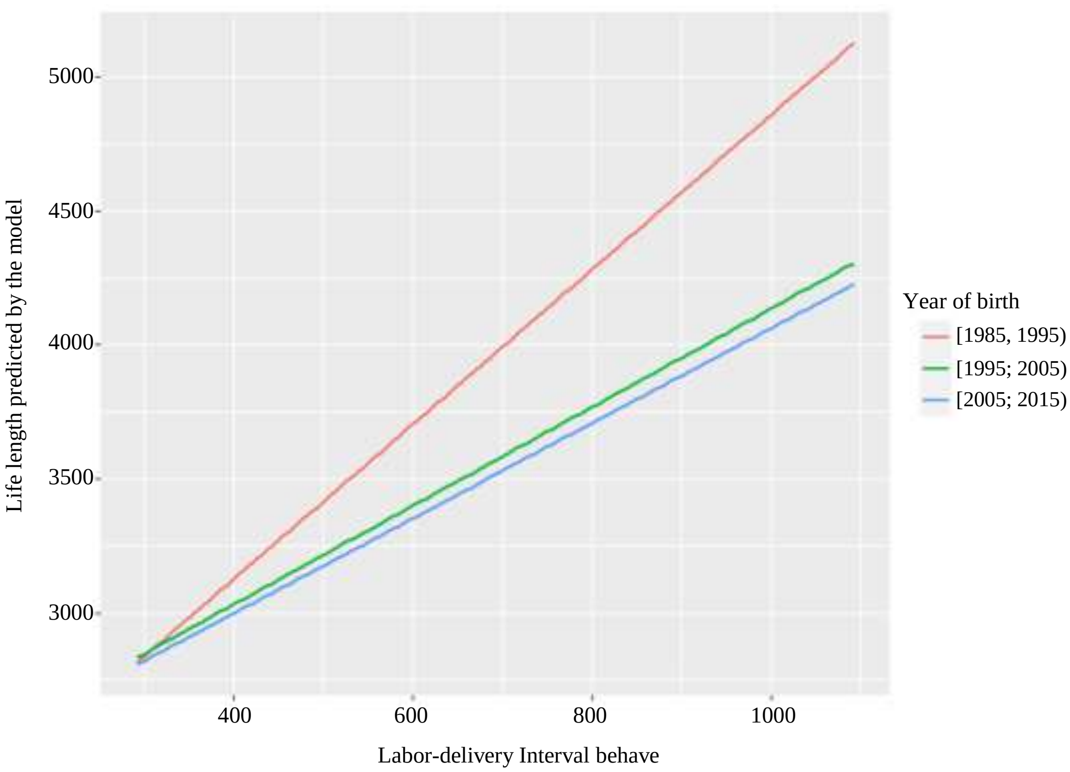

Fig. 2: Labor-delivery interval Vs life length values predicted by the model, leaving the values of the other variables fixed

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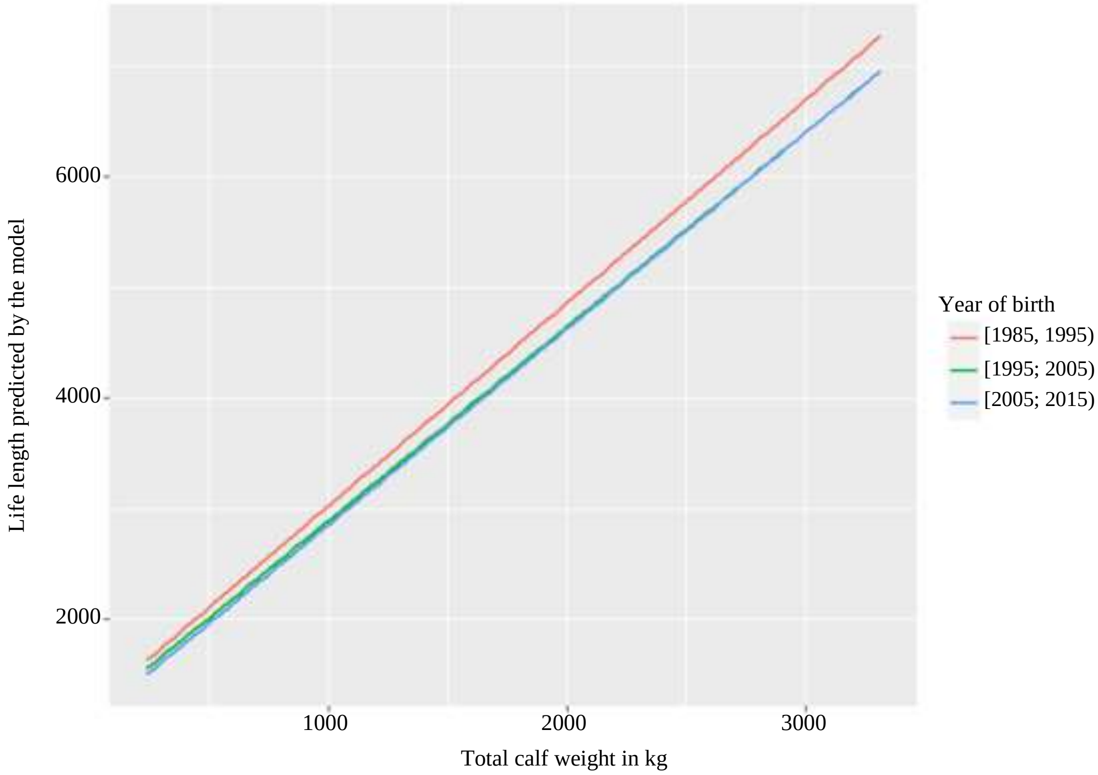

Fig. 3: Total calf weight (kg) Vs life length values predicted by the model, leaving the values of the other variables fixed

In Fig. 3 it can be seen that as the total calf weight in kg increases, the average life length also increases. However, since there is no significant interaction between total weight and year of birth (p-value = 0.224477), the increase in average life length for each unit increase in total weight is similar in the three intervals of year of birth. That is, there is a linear relationship between total weight and life length (p-value < 2e-16).

Discussion

The period in which the cows remain productive is an important factor in the profitability of the systems, because their permanence and productivity affect production costs. Therefore, the profitability of beef cattle production is directly related to productive efficiency and costs (Bernardes *et al*., 2018). It is logical to expect that there are differences in the longevity of cows between different production systems, which may be associated with environmental factors, herd size and management (Segura-Correa *et al*., 2013). The results found in this study with respect to the ages at the first calving were different and significant with respect to the year of birth.

Where cows born in the decade 1985-1995 reached their first calving at 45 months, while in the other two decades (1995-2005; 2005-2015) it was 34.9 and 33.7 months respectively. Observing a decrease in the age at first calving in the last two decades studied. The results for the decades 1995-2005 and 2005-2015 are below the 38.7 months found by (García *et al*., 2003) and are similar to the 35.6 months presented by (Flores and Ortiz, 2010) both in Nelore cattle. The age at first calving can influence the number of calvings of a cow during its useful life in the herd, because the greater sexual precocity of the cows would lead to a longer productive life (Nunez-Dominguez *et al*., 1991, Vukasinovic *et al*., 2001; Rogers *et al*., 2004; Aranda-Avila *et al*., 2010). In this study, the results do not coincide with the aforementioned authors, since in the model estimates for the three periods studied, an increase in the age at first calving by one unit increases the longevity of the cows. The greater probability of a greater longevity of Nelore cows occurs when they arrive at an older age at the first calving.

This could be explained by a set of factors, including the environment in which they develop (nutritional and climatic). This means that those cows that manage to reach their first calving going through the difficulties that they had to overcome in the breeding and rearing stage, acquire a level of adaptation that allows them to face the different future calvings, in addition to being attributed to the greater rusticity and adaptability of the race analyzed to the tropical climate. Marulanda (1996), reported that the ideal is that the age at first calving coincides when the heifer is mature enough to withstand the stress of lactation, making it clear that there would not be a target time to meet since it could be subject to the factors previously cited.

To be efficient in the production of cows for meat, it is necessary to identify profitable females and for that, reproductive traits should be included when the objective of selection is the highest economic profitability for the breeder (Oyama *et al*., 2004; Laske *et al*., 2012; de Lima Silva *et al*., 2019). Brumatti *et al*. (2011) showed the need to readjust the current selection indices, thus giving greater emphasis to reproductive traits, since they are economically more relevant. The results found in this study regarding the calving interval were different and significant regarding the year of birth.

Where cows born in the decade 1985-1995 had a greater calving interval than in the other two decades (1995-2005; 2005-2015). The calving interval values found are below to those reported by (*Perotto et al*., 2006), where they reported that the calving interval in Nelore herds is 492 days and 483 days found by (McManus *et al*., 2002), also equivalent to the 465 days reported by (Silveira *et al*., 2004). In this study, the model estimates for the three periods studied (Table 3) showed that an increase of one unit in the calving interval increases the longevity of the cows.

The interpretation of this result may be that the cows go through traumatic nutritional and environmental situations (few or excessive rains, high temperatures) that do not allow them to carry out a gestation that allows a shorter calving interval, although this does not affect their longevity of the themselves, showing that in this environment the cows the longest intervals are part of their adaptation.

The variable total calf weight in kg is the third variable that explains the model, being the most important from the productive point of view and that in general this type of aggregate indicator is not used for the analysis of the systems. It is necessary for the cows to achieve the highest amount of kg of total calf weight at the end of their productive life, being within the model the one with the greatest economic impact and also, having the need for the cows to meet the highest life expectancy possible.

The results found in this study regarding the total calf weight were different and significant with respect to the year of birth. Where cows born in the decade of 1985-1995 had a higher total calf weight, than in the other two decades (1995-2005; 2005-2015), the latter being the one with the lowest value. The model estimates for the three periods studied showed that an increase in one unit in the calving interval increases the longevity of the cows. These results reinforce what was expressed by (Parish, 2010) where the herds made up of a higher proportion of mature cows tend to have a higher percentage of weaned calves (kg of total calf), reduce production costs and increase the sale of kilograms of calf total.

In addition, a greater number of adult cows in the herd close to 80%, would allow from a zootechnical concept that the traits associated with biological efficiency such as longevity and reproduction of the animals contribute to greater sustainability to the productive system (Ikeda *et al*., 2020). Nunez-Dominguez *et al*. (1990) suggested that the cumulative production of weaned calves per replacement female is an appropriate statistic that takes into account the fertility, maternal instinct and longevity of the cow to measure the reproductive behavior of the evaluated herd.

The results found in this study allow us to reflect that in livestock production and specifically in breeding in systems with very little environmental control, care would have to be taken just by thinking of maximizing weaning weight as the only objective, instead, it should be more comprehensive vision and think about the inclusion of the entire life of the cow (longevity), which would imply including reproductive success and rearing efficiency in the analysis.

Conclusion

It is concluded that it was possible to find a model that explained that the greater longevity of Nelore cows in a grazing system in the Bolivian tropics and it was related to the older age at first calving, the greater calving interval and the greater kg of weights of calves.

This will imply in the future replicating the model found to be able to explain the longevity of the cows in the systems that are required.

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Author’s Contributions

Atsuko Ikeda: Corresponding author and coordination of the study.

Ivana Barbona: Participated in all experiments, coordinated the data-analysis.

Yoichiro Hayashi: Designed the research plan and organized the study.

Juan Antonio Pereira: Organized and reviewed the article.

Pablo Roberto Marini: Contributed in planning the strategy and reviewing the article.

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Ethics

The authors confirm that the present article is original and no ethical issues related to this study.

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