

## ***Bos indicus* and *Bos indicus* x *Bos taurus* heifers performance under two grazing systems in the Arid Chaco of Argentina**

**R Ayerza**

*Office of Arid Lands Studies The University of Arizona, Tucson, AZ 85705, (USA).  
Current address: Barrientos 1584, (1115) Buenos Aires, Argentina, Phone: (54-11) 48062370  
[rayerza@ag.arizona.edu](mailto:rayerza@ag.arizona.edu)*

### **Abstract**

The objective of this study was to assess the beef cattle production potential of the Arid Chaco ecosystem through a silvopastoral system with two different breeds Nelore (*Bos Indicus*) and Braford (*Bos indicus* x *Bos taurus*), and two grazing managements (rotative and alternative) on a Buffel Grass (*Cenchrus ciliaris* L.) var. Nueces pasture. Twenty-eight growing heifers (365-385 days of age), 14 Nelore (*Bos indicus*) and 14 Braford (*Bos indicus* x *Bos taurus*), were randomly assigned into two groups containing seven heifers of each breed. Stocking rates of two heifers/ha were assigned.

The most significant finding in this study was the capacity of the silvopastoral system to support two growing heifers/ha, up to 270 kg live weight gain/ha/year, without any feed supplementation. The kg/ha yield in the silvopastoral system means a great improvement compared to the present yields (4 to 10 kg beef/ha/year) obtained at the Arid Chaco with traditional beef cattle production systems. Results indicate the great potential of the silvopastoral system to produce beef cattle on the Arid Chaco, without performing a complete elimination of the natural tree stratus.

**Keywords:** Braford, Buffel Grass, *Cenchrus ciliaris* L., Nelore, silvopastoral

### **Introduction**

Argentina is one of the world wide largest food producer and exporter. It is the fifth larger producer of beef cattle, contributing in 2006 with 2.98 million tons (4.9% of world production) (FAO 2008). The 61% of the beef cattle are produced in the humid and sub-humid flat Pampas. The 65% of the farms dedicated to breed and fattening the beef cattle are located there (Rotolo et al 2007).

Last years, due to the high revenue of the food crops, the beef cattle production started to move to the arid and semiarid lands where these crops cannot be produced economically. This fast substitution process could affect beef cattle's industry, as well as the stability of the fragile dry lands environment (Morello and Saravia Toledo 1959; SECYT 1986; Ayerza 1992).

This region is the driest part of the Great South American Chaco plains, with more than 100

millions hectares. It is the second largest South American ecosystem, following the Amazon. Although it shares some characteristics with neighboring phytogeographic regions (Monte Desert and Semi-Arid Chaco), it has features of its own, on account of which it can be treated as a unique ecosystem (Ayerza et al 1988).

The Dry Chaco climate is characterized by having high temperatures in summer and moderate temperatures in winter, with 5 to 15 days/year of frosts. Rainfall is concentrated in the warm season, and 80% of the total occur between November and April. Mean annual rainfall ranges from 500mm in the East to 300mm in the West (SECYT 1986).

The Arid Chaco climax vegetation has been strongly modified by overgrazing and deforestation (SECYT 1986; Ayerza et al 1988). Only traces of the climax plant cover reconstructed by observing the no so altered areas, remain. The predominant vegetation was as follows: A xerophytic tree layer: low (7 to 12m high) and not dense; made up mostly of *Aspidosperma quebracho blanco* Schltdl, and *Prosopis* spp. There is no abundant tree species, such as *Ziziphus pistol* Grisea and *Celtis tala* Gill, ex Planch and *Scutia*. Herbaceous vegetation is dominated by C<sub>4</sub> grasses, mostly species of genus *Chloris*, *Digitaria*, *Setaria*, and *Trichloris* (Díaz and Karlin 1984).

The original vegetation changed to a continuous shrub land with isolated trees and small spots dominated by grasses. Most of the new structure is formed by shrubs from the genus *Larrea*, *Cercidium*, *Cassia*, and Cactaceae as *Opuntia* spp., and *Cereus* spp., and annual grasses of the genus *Aristida*, and *Bouteloua* (Ayerza et al 1988). This bush cover competes strongly with the herbaceous stratus and with second-growth trees, precluding rapid recovery (Karlin and Díaz 1984). Therefore, forage and consequently animal production have decreased dramatically. The present and basic production system are extensive livestock farming (cattle and, to a lesser extent, goats and sheeps), with sporadic extraction of forest products. The real output of the region is low, with 4 to 10kg of live weight gain/ha/year, at stocking rates of 15 to 20ha/cattle head, 40% to 50% calves of 120kg at weaning (Calella 1986; Bocco et al 2007; Blanco et al 2008).

However, the beef cattle production potential can be strongly increased in the Arid Chaco through the implementation of systems including species adapted to arid lands, such as Zebu cattle (*Bos indicus*), and Buffel Grass (*Cenchrus ciliaris* L.), as it was reported in a number of papers (Ayerza 1981a, 1982, 1988, 1991; Ferrando et al 1985; Seia 1985). In addition, the use of silvopastoral systems have been reported as an effective means of improving the overall forage quality in a number of arid and semiarid ecosystems (Saravia Toledo 1984, 1989; Le Houérou 1987; Ainalis et al 2006; Tefera et al 2007), maintaining its sustainability (Le Houérou 1993). An abundant tree cover dominates the environment, by modifying sunlight intensity and quality, changing the water balance and the nutrient cycle. Its influence is evidenced by changes in the soil, and in the amount, composition and quality of the species under tree canopies. In a fragile region such as the Dry Chaco, these features, if well managed, can have great relevance in increasing and sustaining productivity (Ayerza et al 1988; Saravia Toledo 1989; Diaz 2003). However, the productivity of Buffel Grass and native trees association system, for animal production in the Arid Chaco, has not been reported. Although this study was carried out in 1993,

it was neither published nor presented at any conference. This study could help to understand the potential of this ecosystem for beef cattle production and avoid the indiscriminate deforestation practice as a normal methodology to sow pastures for the former Humid Pampa's cattle, arriving to this region.

The objective of this study was to assess the beef cattle production potential of the Arid Chaco ecosystem with a Buffel Grass and native trees mixed pasture system, two different breeds, and two grazing managements.

## Materials and methods

### Study site

The research was carried out in the southern portion of the Arid Chaco region, 15km south of Villa Dolores town, Cordoba Province, Argentina. The farm was located at 31° 57' south latitude, and 65° 08' west longitude, and 470m above sea level. Soils are light sandy loam, pH: 7.6, poor in organic matter and nitrogen, and rich in calcium and phosphorus (Ayerza, 1988). Climatic conditions are typical of the Arid Chaco; main climatic characteristics throughout the experimental period are shown in Table 1.

**Table 1.** Weather conditions at the farm site during the experiment

Variable °C	Months											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Max T	31.5	29.3	29.3	25.9	21.6	16.5	16.9	20.5	22.9	28.7	29.6	33.7
Min T	18.4	17.3	15.8	13.5	8.5	3.1	3.6	5.7	8.5	14.5	15.3	19.9
Mean T	25.6	23.8	23.5	20.4	15.4	10.0	10.2	13.7	16.8	22.4	23.5	28.5
Max ext T	37.7	38.0	34.0	32.7	27.9	23.3	23.2	29.1	34.7	37.7	38.5	38.4
Min ext T	14.6	12.4	9.6	8.6	-1.8	-3.6	-3.1	-0.6	-2.2	5.6	8.0	13.1
Frost (days)	0	0	0	0	1 <sup>1</sup>	6	3	1	2 <sup>2</sup>	0	0	0
Rainfall mm	131.1	119.4	30.7	22.4	5.6	1.0	50.3	24.7	17.0	0.1	52.3	48.3

<sup>1</sup> May 5 (first frost); <sup>2</sup> September 8 (last frost)

Lands used were the typical Arid Chaco woodlands, highly eroded due to overgrazing and deforestation practices. In winter time, two years before the trial starts, the lands were shrubs cleaned. About 90% of them were creosote brush (*Larrea divaricata* Cav.). All the trees were kept being the Algarrobo Negro (*Prosopis nigra* Griseb) the largest component, followed by Quebracho Blanco (*Aspidosperma quebracho-blanco* Schltdl), Chañar (*Geoffroea decorticans* Gill ex Hook), and Brea (*Cercidium praecox* Ruiz and Pav), with 85.3, 13.9, 0.6, and 0.2% of the total tree density, respectively. Total tree density was 60 trees/ha, aged 15-30 years old, surviving from the last deforestation due to their young stage at that time.

### Pasture and grazing system

Following the shrubs cleaning process, and twelve months before the trial starts, a pasture of

Buffel Grass (*Cenchrus ciliaris* L.) cv. Nueces was established, sowing 3 kg of certificated seed by hectare. Afterwards, the 28 hectares were divided in two same size fields using a conventional fence. North side division was subdivided in seven equally sized fields, and the south side division was subdivided in two equally sized fields using electric fence system inside of both divisions' subplots. The north and south fields were denominated rotational grazing system (RGS) and alternative grazing system (AGS), respectively.

The pasture grazing pressure was 8 and 2 animals/ha, for rotational and alternative grazing system, respectively. Stocking rates of two heifers/ha were assigned, and the minimum stubble height of 10cm of Buffel Grass used to move forward animals in the rotational system, based in previous experiences of trials achieved in adjacent fields of Buffel Grass pastures, but without keeping the natural trees on it (Ayerza 1981a, 1982). Animals were placed into the experimental fields from January 17 until December 28, the same year.

Forage production estimation was done on the original 28 hectares field, three days before the trial started. Thirty samples of one square meter each, selected at random, were cut by hand at 10cm of height. On June 14, analysis for crude protein content was done from an enclosure, ea. 20m x 30m in size. Samples from under tree canopies and samples from the open range were analyzed by separated. The forage samples were transferred in cool packages to the laboratory where fresh weight was determined. Afterwards the samples were chopped and dried at 70°C for 48 hours, and then dry weight was determined (Table 2). Protein determination was done by AOAC method (AOAC 1980).

**Table 2.** Buffel Grass var. Nueces: dry matter yields, and crude protein content.

Treatment	Dry matter <sup>x</sup>		Crude protein <sup>y</sup>
	kg/ha	%	% <sup>3</sup>
Under tree canopy	2,830 <sup>a1</sup>	24.4 <sup>a</sup>	8 <sup>a</sup>
In the open range	1,325 <sup>b</sup>	26.4 <sup>a</sup>	5.1 <sup>b</sup>
LSD <sup>2</sup>	810.173	3.947	0.817

<sup>x</sup> January 14<sup>th</sup>; <sup>y</sup> June 14<sup>th</sup>; <sup>1</sup> means in a line within a group with the same letter are not statistically different ( $P < 0.05$ ); <sup>2</sup> least significant difference for  $P < 0.05$ ; <sup>3</sup> percent of dry matter

## Experimental animals

Twenty-eight growing heifers (365-385 days of age), 14 Nelore (*Bos indicus*) and 14 Braford (*Bos indicus* x *Bos taurus*), were randomly assigned into two groups containing seven heifers of each breed, in January 17. Before the experiment started, the Nelore and Braford heifers were inspected and accepted by the Heard Book of the Argentine Nelore Association and Argentina Braford Association, respectively. Both, Nelore and Braford animals were conceived, gestated, born and breed in the same farm, grazing Buffel Grass pastures. Braford heifers were F<sub>1</sub> as a result of a cross between Hereford cows and Nelore bulls. Live weights were recorded initially (January 17), and at day 28 of each month until December 28, included. At the end of the experiment, each cow was palpated to determine sexual maturity by Dr. Vet. Carlos Taboada Candiotti (College of Veterinary, National University of Northeast). The daily gain was

calculated by dividing the change in live weight by the number of days between monthly weights. Each grazing system yield was calculated by dividing the total live weight gain/year by the number of hectares of each treatment.

### **Statistical analysis**

The trial was set up as a completely randomized design, with the experimental unit being one heifer. Each variable was compared by analysis of variance. When the F-value was significant ( $P < 0.05$ ), means were separated using the Least Significant Difference Test. The statistical program used in the present study was Cohort Stat 6.311 (Cohort Stat 2006).

## **Results and discussion**

### **Pasture production characteristics**

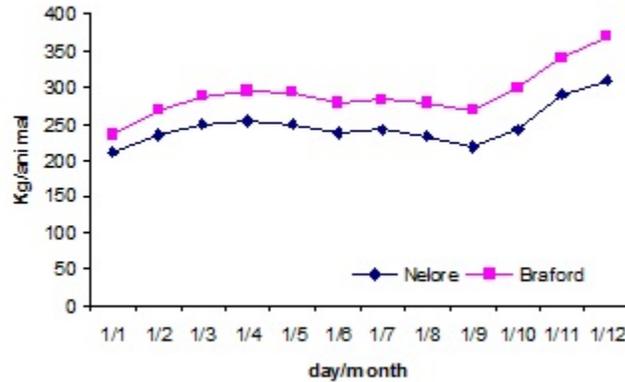
As the Buffel Grass is a non frost resistant plant, its growing season length is a frost free period dependent (Pandeya et al 1977). As it was reported, its vegetative growth starts after the last frost occurs; however, growth rates are minimum until rains and high temperatures fulfill species requirements, which in the Arid Chaco in general are set up at the end of January lasting up April or May, depending on the first frost date. Although the Buffel Grass does not have an aggressive growing rate until the rainy season starts, immediately after the frost season ends and an increase in temperatures is evident, Buffel Grass starts to produce new vegetation (Pandeya et al 1977; Ayerza 1981b).

Buffel Grass dry matter production at starting date, and crude protein content on June 14, under and out of a tree canopy, are presented in Table 2. Significantly ( $P < 0.05$ ) higher dry matter yields and protein content under trees' canopy than that on the open range, agree with early results reported by Diaz and Karlin (1984) for Buffel Grass var. Texas 4464, under and out canopies of Algarrobo Negro (*Prosopis nigra* Griseb) tree, at the same location. However, dry matter yields found in this study were lower than those reported by Diaz and Karlin (1984). Disagreement between experiments could be related to the fact that the Buffel Grass forage quality and quantity of these two growing conditions (under and out of a tree canopy) are affected by the period of time since the grass has been sown, by the climatic conditions of the year, by the Buffel Grass variety, and/or by its interactions (Ayerza and Ortubia 1986; Ayerza et al 1988). Starting forage's dry matter yield availability was coincident with that used by Ferrando et al (1985), as indicator to graze a Buffel Grass pasture in the Arid Chaco.

Protein content obtained herein (Table 2) was in agreement with values reported by Diaz and Karlin (1984), for the Buffel Grass collected in winter, and confirmed the higher protein content of the Buffel Grass forage growing under the Algarrobo Negro canopy, compared with that growing in the open range. The open range value for crude protein was in agreement with that reported for the Buffel Grass var. Nueces, growing in the Arid Chaco in an open range also (Ayerza and Ortubia 1986).

### Body live weights: results between breeds

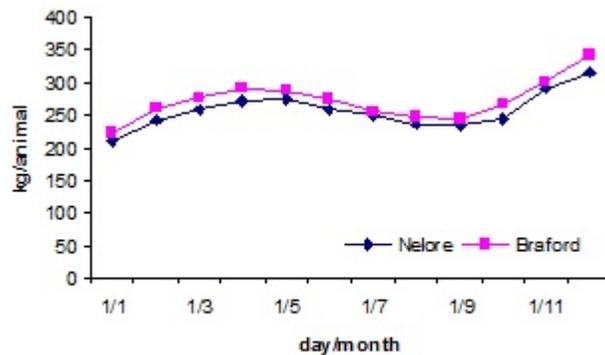
Monthly live body weight for the Nelore and Braford heifers grazing under a rotational system showed significantly ( $P<0.05$ ) higher body live weight in Braford heifers compared to that from Nelore heifers for all measured dates, including the month one (Figure 1).



**Figure 1.** Rotative grazing system: Nelore vs. Braford

Because the weights at starting day had this statistical ( $P<0.05$ ) difference also, and it was maintained all over the trial, no significant ( $P<0.05$ ) differences between the breeds could be determined.

However, in the alternative grazing system, where the breeds had no statistical differences in starting body live weights, Braford heifers presented significantly ( $P<0.05$ ) higher live body weight than that of Nelore heifers at dates F-28, M-28 and D-28 (Figure 2).

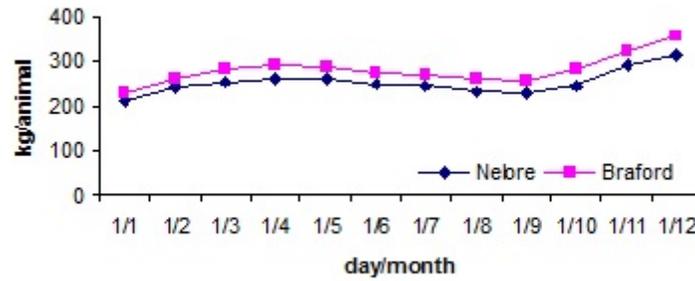


**Figure 2.** Alternative grazing system: Nelore vs. Braford

This significant ( $P<0.05$ ) difference agrees with a similar Braford advantage when an early

research comparing Nelore and Braford growing calves grazing a Buffel Grass var. Texas 4464 pasture, but free of trees, showed a highly significant ( $P < 0.001$ ) live body weight difference for the Braford heifers (Ayerza 1988).

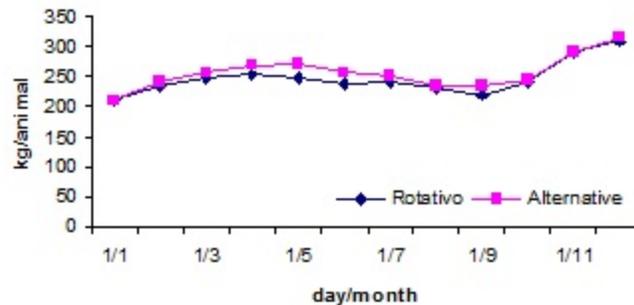
As in the results between the breeds, overall statistics differences cannot be attributed to a real cause, because the difference was present at the trial starting date, also (Figure 3.)



**Figure 3** Overall: Nelore vs. Braford

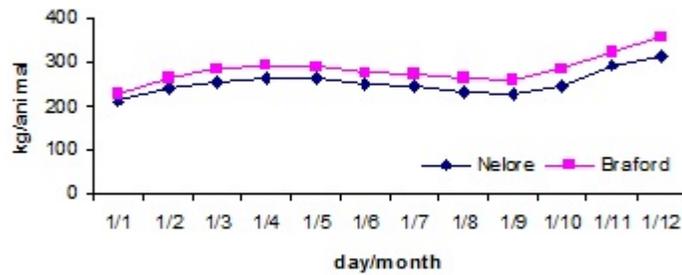
#### Body live weights: results between grazing systems

No significant ( $P < 0.05$ ) difference in live body weight between grazing systems within Nelore heifers was detected (Figure 4).



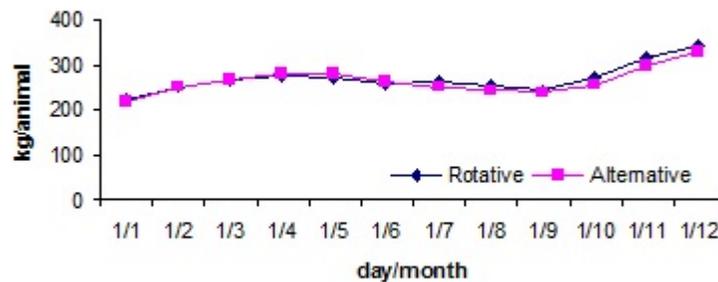
**Figure 4.** Nelore: alternative vs. rotative grazing system

The statistical ( $P < 0.05$ ) difference between grazing systems, within the Braford breed, as it was reported for the results between the breeds also, cannot be attributed to a real one because the difference was measured all over the trial since the first weight was performed (Figure 5).



**Figure 5.** Braford: alternative vs. rotative grazing system

In support of that, when overall results between grazing systems were compared, no significant ( $P < 0.05$ ) differences were detected (Figure 6) at any date.



**Figure 6.** Grazing systems: alternative vs. rotative

Daily weight gains were negative at date M-28, J-28, J-28, A-28, and S-28 (Data not showed). All these months received one or more frosts (Table 1). As the Buffel Grass is a non frost resistant plant, its growing season length is a frost free period dependent. The first frost occurred at the trial on May 5 and the last one on September 8, with a total of 13 days with frosts (Table 1). During that period, Buffel Grass had no green vegetation, showing low levels of crude protein (Table 2).

The weight gains measured after the last frost (October, November, and December) were the highest of the trial (Table 3).

**Table 3.** Liveweight gains per year

System	Genotype	Liveweight gain/year <sup>1</sup>		
		kg/head	kg/head/day <sup>2</sup>	kg/ha
Rotational	Nelore	98.4 <sup>b2</sup>	0.285 <sup>b</sup>	196.9 <sup>b</sup>
	Braford	135.1 <sup>a</sup>	0.392 <sup>a</sup>	270.3 <sup>a</sup>
	LSD <sup>4</sup>	24.137	0.069	48.279
Alternative	Nelore	106.4 <sup>a</sup>	0.308 <sup>a</sup>	212.9 <sup>a</sup>
	Braford	119 <sup>a</sup>	0.345 <sup>a</sup>	238 <sup>a</sup>
	LSD	21.756	0.063	43.512
Rotational	Nelore	98.4 <sup>a</sup>	0.285 <sup>a</sup>	196.9 <sup>a</sup>
Alternative	Nelore	106.4 <sup>a</sup>	0.308 <sup>a</sup>	212.9 <sup>a</sup>
	LSD	22.741	0.066	45.482
Rotational	Braford	135.1 <sup>a</sup>	0.392 <sup>a</sup>	270.3 <sup>a</sup>
Alternative	Braford	119 <sup>a</sup>	0.345 <sup>a</sup>	238 <sup>a</sup>
	LSD	23.212	0.067	46.424
Overall	Nelore	102.4 <sup>b</sup>	0.297 <sup>b</sup>	204.9 <sup>b</sup>
Overall	Braford	127.07 <sup>a</sup>	0.368 <sup>a</sup>	234.1 <sup>a</sup>
	LSD	15.597	0.452	31.194
Rotational	Overall	116.8 <sup>a</sup>	0.339 <sup>a</sup>	233.6 <sup>a</sup>
Alternative	Overall	112.7 <sup>a</sup>	0.327 <sup>a</sup>	225.4 <sup>a</sup>
	LSD	18.419	0.053	36.838

<sup>1</sup> 346 days; <sup>2</sup> average; <sup>3</sup> means in a column within a group with the same letter are not statistically different ( $P < 0.05$ ); <sup>4</sup> least significant difference for  $P < 0.05$ ;

When they were compared to the first three months (February, March, and April) of the trial as a percentage of the live body weight, results showed an 80% and 70% of higher daily weight (Data not showed) in the last three months than in the first three months, for overall rotational and alternative system, respectively. These comparative higher gains could be explained by a phenomenon known as compensation growing process. This well known effect took place after a period of weight lost, and followed by a period where the animals have availability of good quality and quantity of feed (Lofgreen and Kiesling 1985).

In addition, a temperature increment effect on daily weight gains, between 10°C and 27°C of air temperature, was reported for the Brahman breed (*Bos indicus*) by Johnson (1982). In the present study, the highest daily weight loses (Data not showed) of both breeds was measured in July, which was the month with the lowest mean, minimum mean, minimum extreme temperatures and highest number of days with frost of all trial's months (Table 1). Thus, not just the low quality of the forage, but the environment low temperature as well, could have affected the daily weight gain on both Nelore and Braford heifers.

### Farm productivity

The most significant finding of this study was the silvopastoral system capacity of supporting two growing heifers/ha without any feed supplementation, with a live weight gain up to 270kg/ha/year (Table 3). The kg/ha yield in the silvopastoral system means a great improvement compared to the actual yields (4-10 kg/ha/year) obtained at the Arid Chaco with traditional beef

cattle production systems (Ayerza et al 1988; Bocco et al 2007; Blanco et al 2008).

In addition, at the end of the trial, heifers were palpated for sexual organs development, and all of them were certified as ready for reproduction (C. Taboada Candiotti 1983, Corrientes, Argentina, personal communication). These determinations mean that heifers can be growing at the same farm and that they are physiologically ready for reproduction with 24 months old, which is normal for these two breeds (Dias et al 2004).

## Conclusions

Results showed that Nelore and Braford heifers are sensitive to the seasonal dynamics of Buffel Grass quality in the Arid Chaco ecosystem. However, although this study provides only limited information on the relations tree-grass-animal and additional studies should be undertaken to fully characterize the productive system, results indicate the great potential that the silvopastoral system has for beef cattle production in the Arid Chaco, without needs of performing a complete elimination of the natural tree stratus.

## Acknowledgements

These results were partly supported by Semillero y Cabaña La Magdalena S.A., Buenos Aires, Argentina. The author is also grateful to Eng. Enrique Seia Goñi, Eng. Raúl Díaz and Eng. Ola Ulf Karlin for technical assistance.

## Bibliography

- Ainalis A B, Tsiouvarasb C N and Nastis A S 2006** Effect of summer grazing on forage quality of woody and herbaceous species in a silvopastoral system in northern Greece. *Journal of Arid Environments* 67:90–99.
- AOAC 1980** Official methods of analysis. Association of Official Analytical Chemist, 13<sup>th</sup> ed. Washington D.C., USA., 376-384.
- Ayerza R 1981a** Pasturas tropicales en el noroeste argentino. *Rangelands* 3(4):149-150. (in Spanish).
- Ayerza R 1981b** El Buffel Grass: utilidad y manejo de una promisoria gramínea. Hemisferio Sur, Buenos Aires, Argentina (in Spanish).
- Ayerza R 1982** Buffel Grass and Nelore Cattle: a legacy from India for the arid zones of Argentina. *Rangelands* 4(4):155-157.
- Ayerza R 1988** Engorde de vaquillonas Braford y Nelore en el Chaco Seco. *Gaceta Agronómica* 8(43):238-249. (in Spanish)
- Ayerza R 1991** Viabilidad de la producción animal en zonas áridas y semiáridas. In: Proceedings of the 28a. Reuniao Anual da Sociedade Brasileira de Zootecnia, July 21-26, 1991 Joao Pessoa, Paraiba, Brazil, Sociedade Brasileira de Zootecnia, 13-46. (in Portuguese).
- Ayerza R 1992** Nuevas alternativas para el desarrollo de las regiones áridas y semiáridas argentinas. In: Problemas y soluciones ambientales argentinos. Galloni M del C, ed. Roemmers S.A, Buenos Aires, Argentina, pp. 17-50 (in Spanish).
- Ayerza R, Díaz R and Karlin U 1988** Management of Prosopis in livestock production systems in the Dry Chaco, Argentina. In: The current state of knowledge on Prosopis juliflora. FAO-Food and Agriculture organization of The United Nations, Rome, Italy, pp. 479-494.

- Ayerza R and Ortubia E 1986** Variabilidad en la producción de 26 accesiones de Buffel Grass (*Cenchrus ciliaris* L.) y 1 de Birdwood Grass (*Cenchrus setigerus* V.) en el Chaco Seco de Argentina. In: V Reunión de Intercambio Tecnológico en Zonas Áridas y Semiáridas, Abril 1986. La Rioja, Argentina. Orientación Grafica Editora, Buenos Aires, Argentina, pp. 210-246 (in Spanish).
- Blanco L J, Aguilera M O, Paruelo J M and Biurrún F N 2008** Grazing effect on NDVI across an aridity gradient in Argentina. *Journal of Arid Environments* 72:764-776.
- Bocco M, Coirini R, Karlin U and von Müller A 2007** Evaluación socioeconómica de sistemas productivos sustentables en el Chaco Arido, Argentina. *Zonas Aridas* 11(1):70-84 (in Spanish).
- Cohort Stat 2006** Cohort Stat 6.311. Cohort Software Inc., Monterey, California, USA,
- Calella H 1986** Características de la actividad ganadera en la Provincia de La Rioja. In: V Reunión de Intercambio Tecnológico en Zonas Áridas y Semiáridas, Abril 1986, La Rioja, Argentina. Orientación Grafica Editora, Buenos Aires, Argentina, pp. 154-174 (in Spanish).
- Dias L T, Faro L E and Alburquerque L G 2004** Efeito da idade de exposicao de novillas a reproducao sobre estimativas de heredabilidade da idade ao primeiro parto em bovinos Nelore. *Arquivo Brasileiro de Medicina Veterinária e Zootecnia* 56(3):370-373 (in Portuguese).  
<http://www.scielo.br/pdf/abmvz/v56n3/v56n3a13.pdf>
- Díaz R O 2003** Efectos de diferentes niveles de cobertura arborea sobre la produccion acumulada, digestibilidad y composición botánica del pastizal natural del Chaco Arido (Argentina). *Agriscientia* 20:61-68 (in Spanish).
- Díaz R and Karlin U O 1984** Importancia de las leñosas en los sistemas de producción ganadera. In: III Reunión de Intercambio Tecnológico en Zona Áridas y Semiáridas, Abril 1984, Catamarca, Argentina. Orientación Grafica Editora, Buenos Aires, Argentina, pp. 84-101 (in Spanish).
- FAO 2008** FAOSTAT. Food and Agricultural Organization.  
<http://faostat.fao.org/site/569/DesktopDefault.aspx?PageID=569>
- Ferrando C A, Namur P, Aguirre E, Vera J C and Paredes G 1985** Utilización del Buffel Grass (*Cenchrus ciliaris*) en la recría de vaquillonas. In: IV Reunión de Intercambio Tecnológico en Zonas Áridas y Semiáridas, Abril 1985, Salta, Argentina. Orientación Grafica Editora, Buenos Aires, Argentina, pp. 598-604 (in Spanish).
- Johnson H D 1982** Role of physiology in cattle production in the tropics. In *Animal production in the tropics*, edited by M K Yousef, Praeger, New Cork, New Cork, USA, pp. 3-28.
- Karlin U O and Díaz R 1984** Potencialidad y manejo de algarrobos en el Árido Subtropical Argentino. *Secretaría de Ciencia y Tecnología*, Buenos Aires, Argentina (in Spanish).
- Le Houérou H N 1987** Indigenous shrubs and trees in the silvopastoral systems of Africa. In: *Agroforestry, a decade of development*. Steppeler H A and Nair P K R, editors. ICRAF, Nairobi, Kenya, pp. 39-156.
- Le Houérou H N 1993** Environmental aspects of fodder trees and shrubs plantation in the Mediterranean basin. In: *Fodder trees and shrubs in the Mediterranean Production System: Objectives and Expected Results of the EC Research Contract*. Agriculture, Agrimed Research Programme, Commission of the European Communities, EUR 14459 EN, pp. 11-33.
- Lofgreen G P and Kiesling H E 1985** Effects of receiving and growing diets on compensatory gains of stressed calves. *Journal of Animal Science* 61:320-328  
<http://jas.fass.org/cgi/reprint/61/2/320>
- Morello J and Saravia Toledo C 1959** El bosque chaqueño. II. La ganadería y el bosque en el oriente de Salta. *Revista Agronómica del Noroeste Argentino* 3(1-2):209-258 (in Spanish).
- Pandeya S C, Sharma S C, Jain H K, Pathak S J, Paliwaland K C and Bhanot V M 1977** The environment and *Cenchrus* grazing lands in Western India. Department of Biosciences, Saurashtra University, Rajkot, India.
- Rotolo G C, Rydberg T, Lieblein G and Francis C 2007** Emery evaluation of grazing cattle in Argentina's Pampas. *Agriculture, Ecosystems and Environment* 119:383-395.
- Saravia Toledo C 1984** Manejo silvo-pastoril en el Chaco Nor-Occidental de Argentina. In: III Reunión de Intercambio Tecnológico en Zona Áridas y Semiáridas, Abril 1984, Catamarca, Argentina. Orientación Grafica Editora, Buenos Aires, Argentina, pp. 26-50 (in Spanish).
- Saravia Toledo C 1989** Compatibilización de manejo de pastizales, bosque y fauna en los sistemas agrosilvopastoriles del Chaco Semiárido. In: *Forrajeras y cultivos adecuados para la región Chaqueña Semiárida*. Casas R, editor. FAO, Santiago, Chile, pp. 99-106 (in Spanish).
- SECYT-Secretaría de Ciencia y Tecnología 1986** Lineamientos para una política de desarrollo del Árido Subtropical Argentino: Panel de Expertos. *Secretaría de Ciencia y Tecnología*, Buenos Aires, Argentina (in Spanish).
- Seia Goñi E J 1985** Un sistema de producción en zonas marginales. In: IV Reunión de Intercambio Tecnológico en

Zonas Áridas y Semiáridas, Salta, Argentina. Orientación Grafica Editora, Buenos Aires, Argentina, pp. 99-105 (in Spanish).

**Tefera S, Mlamboa V, Dlamini B J, Dlamini A M, Korlagama K D N and Mouldb F L 2007** Chemical composition and in vitro ruminal fermentation of common tree forages in the semi-arid rangelands of Swaziland. *Animal Feed Science and Technology* 142(1-2):99-110

*Received 21 February 2010; Accepted 29 March 2010; Published 1 May 2010*

*Citation of this paper* : **Ayerza R 2010**: *Bos indicus* and *Bos indicus* x *Bos taurus* heifers' performance under two grazing systems in The Arid Chaco of Argentina. *Livestock Research for Rural Development*. Volume 22, Article #96. Retrieved printDate() May 15, 2010, from <http://www.lrrd.org/lrrd22/5/ayer22096.htm>