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Bioproductive and Financial Efficiency of Private Dairy Farms

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ABSTRACT

A five-year study (2008-2012) was made to determine the bioproductive and financial behavior derived from structures and resources available on ten private rustic farms, in the province of Ciego de Avila, Cuba. Pasture and forage yields were estimated in order to evaluate contribution and efficiency. Decomposition of seasonal time series was made to determine the annual behavior of births using a multiplicative model. Variance analysis for farm comparison was based on efficiency of dairy production indicators and financial indicators (SPSS, 15.0. 2006). Overall, insufficient availability and quality of pastures and forages was evident, with negative annual forage balances. The farms were characterized by birth seasonality, particularly Farm No. 7 (April-May). However, the general birth rates were very low, as a result of inadequate reproduction management. The best productive and financial results were observed on farm No. 7 (1 061 kg/milk/ha/year, and $ 0.87 CUP/kg of milk produced, respectively).

Key words: *efficiency, forage balance, reproduction, milk production*

INTRODUCTION

Livestock raising is highly technical, with long biological and production cycles, and prolonged financial returns of invested capital.

Particularly, dairy production systems are complex, due to the broad variety of technological, environmental, and social and economic factors that can influence production, and must be closely related proportionally to increase management efficiency.

Thus, a system´s efficiency is associated with the procedures implemented in this area, including the subjects of production that run the process. They decide which alternatives can be applied, and the way to manage production systems (Vargas *et al*., 2015). It is important, though to consider that in general terms, the prevailing agro-technological conditions in tropical regions usually determine farm cost/effectiveness (Domínguez *et al*., 2015).

The Cuban private sector is facing serious problems: the farm usufructuaries who bought certain amounts of animals should deal with poorly organized animal care in some cooperatives. Today, livestock raising requires special attention of vertical growth of production in farm areas, as the considerable potential available must be put to good use (CAE-CA, 2016).

In that scenario, it is important to evaluate geographical areas of economic interest, in order to determine the most significant elements of production, based on the specific local conditions. Nowadays, the province of Ciego de Ávila, Cuba, needs farm-based studies to determine the systematic behavior of the factors with effects on dairy production in the cooperatives, and improve dairy systems management.

In that sense, the aim of this paper was to determine the bioproductive and financial behaviors, considering the structure and available resources on private farms.

MATERIALS AND METHODS

This study comprised 10 private farms in the municipality of Ciego de Ávila, province of Ciego de Ávila, and it lasted five years (2008-2012).

The local climate is typical of plains with seasonal humidity, the mean temperatures for the rainy and dry seasons are 23 and 27º C, respectively (provincial weather center). The mean annual precipitation values vary between 1 020 and 1 356; 80% is produced in the rainy season.

The farms are rustic, with crossbred animals (Holstein x Zebu), whose main purpose is dairy production. The total area is 40-45 ha, and the average stocking rate is 1.1 LU/ha, on rational grazing. The farm has 17 enclosures and 7 workers.

Mating is natural, calves are raised naturally, too, with restricted breastfeeding.

The predominant soils are brown with carbonates, productivity level 2. The most abundant grass species are native, averaging 84.7 ha (70%) of the local population (*Paspalum notatum, Bothriochloa pertusa*, *Sporobolus poiretii*, *Dichanthium annulatum* and *Paspalum virgatum*).

Improved grass pastures (*Cynodon nlenfuensis* cv. Jamaican and *Panicum maximun* cv. Common) cover approximately 39.9 ha on all the farms. Besides, they use limited amounts of feedstuff (Norgold[@]) within 7.0 and 10.0 t/DM/farm/year. Common *Pennisetum purpureum* cv. is used as forage (5.4 ha on average). The forage areas average was 4.8 ha (*Saccharum officinarum*).

General methodology

Based on the data collected from technical field charts, variations in the botanical composition of grass were corroborated, using the Step method (Corbea and García Trujillo, 1982), in 10% of all the farm the areas. The dry matter yield values for pastures and forages were gathered according to Oquendo (2006), for dry lands without fertilization in Cuba.

Fodder balance was estimated according to the needs of 400 kg livestock units. The consumption percentage was estimated in 3% (12 kg DM/UGM/day) of live weight (LW). Fifty percent of the average annual use was determined for the grass pasture species, whereas 90% was estimated for the forage species, in order to know the Potential Use of Forage Produced (PUFP) by the animal. The balance between the rainy and dry seasons was made using the method suggested by Guevara (1999, cited by Soto *et al*., 2010b), taking into account that the rainy season lasts 155 days and the dry season lasts 210.

Statistical analysis

SPSS 15.0 (2006) for Windows, was used.

Seasonal time series decomposition was made for births, using a multiplicative method, considering a ± 10 %, to determine the seasonal behavior.

Assuming that milk production is a dependent variable, one-criterion variance analysis was made to determine the differences among farms; it also included the efficiency variables stocking rate, feed concentrate/cow/year, milk production per hectare (kg), milk production per cow per day (kg), milk production per work unit (kg), total feed consumed (T), feed consumed by cows (T), potential use of forage produced (PUFP) (T), total expenses per hectare (CUP/ha), total income per hectare (CUP/ha), milk production costs (CUP/kg), income/milk kg (Tukey test).

RESULTS AND DISCUSSION

Regardless of the tools used to evaluate a farm, several barriers may appear that can affect sustainability (Marchand *et al*., 2014). Evaluation of farm resources revealed various zootechnical management issues, closely linked to forage management and the general efficiency of the system.

In most cases, the stocking rates were above 1.1 LU/ha, particularly higher on the largest farms. Thus, the botanical composition and yields of pastures and forages were expected to be associated with production efficiency in all cases (Table 1).

Additionally, various difficulties were observed in milking cows and births, not to mention the probable effects of stocking rates on production efficiency.

Limitations in the control of productive activities seemed to determine the low percent values of births, which are more striking on larger farms, with the ensuing effect on the milking cows. The previous was expected, particularly due to the poor organization of work and natural mating, in detriment of reproductive specialization and the very necessary artificial insemination in dairy systems.

Nutrition was another factor that limited the reproductive behaviors; it was associated with insufficient feed consumption, poor feeding management, and unbalanced diets (Balarezo *et al*., 2015). It may have also been influenced by the body conditions of the females, and low birth rates.

In that sense, Vargas *et al.* (2015) considered that reproduction defines the structure of the herd, the relative production potential expected in the system, and the feeding program to be implemented in dairy systems.

However, an interesting result was observed in terms of annual birth behavior, with marked seasonal indexes in the period between mid-July and early September (Fig. 1 *a*). Particularly, Farm No. 7 had the highest number of births between April and May (Fig. 1 *b*), which may have influenced dairy production. Soto *et al.* (2010); Guevara *et al*. (2012) and Soto *et al*. (2014 a y b) stressed the advantages of using larger birth concentrations between April and August to set the production peaks when there is more forage available.

Even so, no significant impacts on milk production are expected in this scenario due to the low birth rates observed on all the farms (less than 20%). However, this behavior may be a reference point to explore new developments in efficiency of production and reproduction, because a great deal of it depends on the system´s management that ensures productive and reproductive flows on the farm (del Risco *et al*., 2007).

Paradoxically, restricted calf feeding is usually practiced in semi-intensive dairy systems; however, it is often used on large dairy farms and rustic farms, where natural raising is more usual.

Ybalmea (2015) noted that the live weight gain of weaned calves (70 days) with restricted milk feeding was similar to calves under artificial feeding, at weaning (35 days), both higher than suckler cow use. Likewise, he noted that in the tropics, approximately 90% of parasitic infestation of calves is acquired during grazing. This issue could be addressed with the implementation of supplemented forage banks during the first six months of age.

Coincidentally, the availability and management of dry matter guaranteed better animal selection with better live weight gains. Therefore, lower availability produced with the coming of the dry season and animal weight increases caused more serious problems in terms of dry matter and nutrient requirements. The previous indicated the need to make changes in management, search for new more efficient technologies for biomass production or diet complementation to maintain the same weight in the biological stage, and even improving them (Mejías *et al*., 2015).

Since forage is more economical, and because it is the base of ruminant production systems in most tropical areas where at least 80/90% nutrients required by the animals are found in pastures (Cruz y Pereda, 2015), the results of fodder balance (Table 2) showed strong limitations of dry matter (DM) in the dry season, annual balance, and animal percapita, which is more stressing in larger farms. In addition to it, achieving individual and area production values close to the least production potential needs that the production females should at least double their DM consumption requirements.

A situation like this was reported by other authors on dairy farm studies in the municipality of Jimaguayu, Camagüey (Soto *et al.*, 2010; Guevara *et al.*, 2012), and the municipality of Ciego de Ávila, Ciego de Ávila province (Soto *et al*., 2014 a and b), who found limited DM availability per animal, per day, annually, perhaps due to the prevalence of low productive native species with poor nutritional values.

The above results have a critical effect not only on the availability, but also on the quality of the nutritional base. The largest presence of native species, like *Paspalum notatum*, *Bothriochloa pertusa* and *Paspalum virgatum*, dramatically limited the production and reproduction results. Muñoz *et al*. (2013) and Alonso *et al.* (2015) noted that these were invading species not regularly accepted by the animals; they required agro technical labor in order to improve the quality of the nutritional base, stop deterioration of the grassland, and mitigate erosion (Pereda *et al*., 2013).

Senra (2011) claimed that combining the farm grass with enhanced forage is a strategic choice to improve the diet. The possibilities for ruminants to use large amounts of forages produced in the tropics should be advantages to develop efficient and sustainable livestock production (Cáceres *et al*., 2010).

The implementation of forage graminaceae banks (*Pennisetum* sp and other technologies), depending on the production possibilities, characteristics, and resources, may result in significant increases of forage availability as bulk feedstuffs. It may be particularly used efficiently when calving is highest, coinciding with more grass availability (Soto *et al.*, 2010a).

Regarding the available resources to measure economic efficiency of grazing systems, a number of technical and economic indicators must be included, such as production per animal, production per area, and production per amount of inputs, and so forth, which might be determining in relation to analysis of farm sustainability (Senra, 2005).

The results of milk production reported on these farms (Table 3) may be considered good, particularly on Farms No. 2 and 7, according to Pérez Infante (2010), who reported individual production values of 2-6 kg/cow/day, on average grass, when availability was not limiting, even when it was not the same on the farms studied.

Certainly, the application of any validated technology would improve the results in that direction. Lamela *et al.* (2001) achieved 8 kg/cow/day using a protein bank of *L. leucocephala* cv. Cunningham, associated with improved pasture (*C. nlemfuensis* cv. Jamaican), with 1.7 cow/ha. Similar results were reported by Soto *et al.* (2010a) for dry land grazing and protein banks of *L. leucocephala*in 30% of the area, and 80% of births in April-August.

Precisely, analyses of production systems have concluded that the priority to succeed in any kind of exploitation usually relies on the use of available forage (Espejo, 2007). Overall, milk production per hectare over time, is one of the main indicators to evaluate the sustainable character of a dairy farm (Deming *et al.*, 2013).

As to the preferred values of milk/hectare based on the stocking rate and available resources in Cuba (Ruiz, 2011), only the results of Farm No. 7 were similar to the 1 000 kg/ha estimated for grazing in six enclosures and a complementation area (stocking rate: 1 LU/ha), though similar to or slightly higher production than this author achieved (4.1 kg/caw/day) was reported in four enclosures, indicating greater efficiency of Farm No. 7.

Some key factors to increase productivity based on the cow´s genetic potential include greater efficiency in pasture use (more production and harvesting of DM/ha), and the assimilation of more resistant and stable complementation and supplementation strategies during the year, to minimize risks both from climate and price variability (Gallardo, 2012).

Dairy production depends on many factors important factors, like organization of operations and management of financial resources, and knowledge-information. Hence, it is a very complex activity (Guevara *et al.*, 2012).

The study of economic indicators in production systems is fundamental to characterize production entities commercially (Cino *et al.*, 2006). It may encourage sound planning of local and territorial allocation of available financial resources to be used more efficiently.

However, it would require adequate control of primary economic data to make periodic evaluations of livestock systems (Senra, 2005).

The results (Table 4) showed no significant differences according to the unitary cost of milk production. However, a more comprehensive perspective estimated a better situation on Farm No. 7, considering the relationship between the production indicators and cost/kg of milk produced.

The costs may have been influenced by several factors. One important point observed on Farm No. 7 was the optimization of workforce depending on the production needs. This farm had lower figures in relation to production per work unit (worker), in comparison to Farms No. 8 and 9 (Table 2), which may have been caused by the excess workers in relation to the actual needs, taking costs into account.

In that sense, Granados *et al*. (2011), studied the production costs of a milk kg produced by double-purpose cattle in Mexico. They reported that the highest percent of milk kg (58%) was related to workers. Other authors (Roca and González, 2014), indicated that nutrition of dairy cattle accounted for more than 60% of costs associated with the production system, the key element to achieve a significant reduction in costs. In that sense, very limited supplementation was observed on the farms studied.

The behavior of income per milk kg indicated the usual occurrence of variability in the quality of products used on rustic farms, based on milking by hand, few resources, poor staff training, inadequate quality methods, and the time of milk collection and distance from industry.

CONCLUSIONS

Insufficient pasture grass and forage availability linked to animal stocking rate was determinant in the occurrence of negative fodder balances. Besides, inappropriate reproduction management and others limited the efficiency of the bioproductive and financial indicators of the farms in the study.

The best response in maximizing the use of available forage (8.2 kg/LU/day) was observed on Farm No. 7, even with insufficient feed availability. The highest values of production efficiency found on the farm (1 061 kg/ha/year) were determined by seasonal patterns.

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Table 1 Physical resources and general indicators of the herd

Indicators/farm	1	2	3	4	5	6	7	8	9	10	±SE
Total area (ha)	50	45	68	70	76	140	120	132	143	145	-
Total LU (U of 400 kg LW)	58	55	68	69	68	157	158	169	170	174	-
Global stocking rate (LU/ha)	1.2^{ab}	1.2^{ab}	1.0 ^{c}	0.9 ^{c}	0.9b ^{c}	1.1^{ab}	1.3^{a}	1.3^{a}	1.2^{a}	1.2^{a}	0.02
Number of females incorporated (U)	52	46	59	64	67	155	155	162	162	168	-
Cows (U)	46	40	56	56	58	145	145	155	155	160	-
Milking cows (%)	60.8^{a}	60.0^{ab}	59.3^{ab}	58.9^{ab}	53.4^{ab}	38.6 c	51.0^{b}	54.2^{ab}	55.5^{ab}	51.9^{b}	0.90
Natality (%)	61.5^{a}	15.1 ^{c}	54.2^{ab}	18.7 ^{c}	51.7 b^{b}	9.6 ^{c}	16.7 ^{c}	11.1 ^{c}	13.6 ^{c}	19.0 ^{c}	2.74
Conc. Avg/cow (t DM)	0.24^{b}	0.29^{b}	0.19^{b}	0.14^{b}	0.20^{b}	0.59^{a}	0.69^{a}	0.60^{a}	0.55^{a}	0.59^{a}	0.29

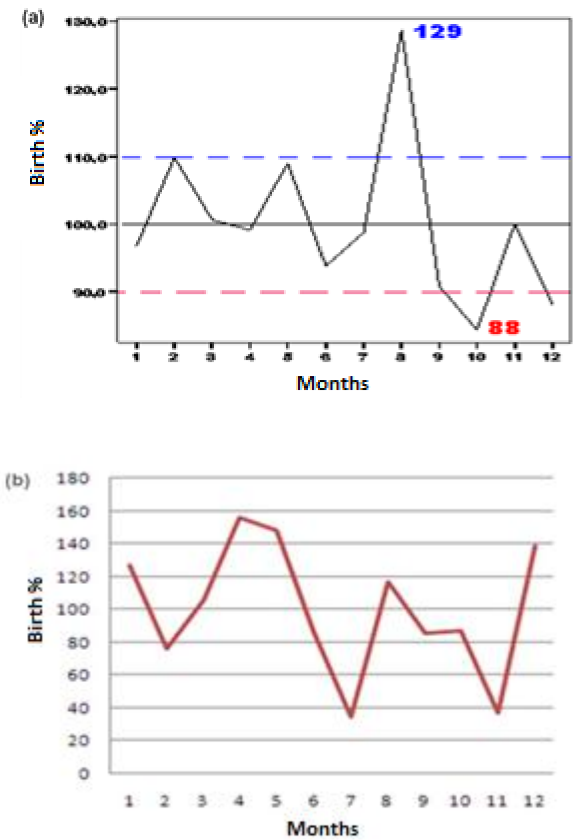

Fig. 1. Seasonal behavior of births on all farms (a), and Farm No. 7 (b)

Table 2. Fodder balance on the farms studied (t DM) per season

Indicators/farm	1	2	3	4	5	6	7	8	9	10
Rainy season Contribution of native grass	78	72	115	123	131	250	215	242	252	258
Contribution of improved grass	0	0	8	8	19	23	15	23	31	23
Contribution of forages	123	81	85	68	68	102	102	68	102	119
Total PUFP	201	153	208	199	218	375	332	333	385	400
Total requirements	108	103	127	129	127	292	294	315	317	324
Fodder balance	93	50	81	70	91	83	38	18	68	76
Dry season Native grass	17	16	25	27	29	55	48	54	56	57
Improved grass	0	0	2	2	4	4	3	4	6	4
Forage plants	104	93	95	75	62	113	100	75	113	119
Total PUFP	121	109	122	104	95	172	151	133	175	180
Total requirements	146	139	172	174	172	396	398	426	429	439
Fodder balance	-25	-30	-50	-70	-77	-224	-247	-293	-254	-259
Annual forage balance anual de forrajes	68	20	29	0	14	-141	-209	-275	-186	-183
Average forage/LU	5.5	4.8	4.7	4.4	4.6	2.9	3.0	2.8	2.7	3.3
Forraje kg/UGM/d	15.0	13.1	12.8	12.0	12.6	7.9	8.2	7.7	7.4	9.0

Table 3. Average anual behavior of efficiency indicators for milk production per farm (kg)

Indic/farm	1	2	3	4	5	6	7	8	9	10	± SE
Produc/ha	838^{b}	823 bc	717^{vd}	$693d^{e}$	593^{ef}	542^{f}	$1\ 061^{a}$	931^{b}	887^{b}	841^{b}	102.48
Produc/c/y	911^{a}	927^{a}	871^{b}	866^{b}	777^{c}	523^{d}	885^{ab}	793^{c}	818^{c}	762^{c}	52.21
Produc/c/d	4.1^{b}	4.2^{a}	3.9^{b}	4.0^{b}	4.0^{b}	3.7^{b}	4.7^{a}	4.0^{b}	4.1^{b}	4.0^{b}	0.05
Produc/TU	10 480	7 415	9 753	12 239	9 017	8 426	12 731	13 648	37 186	10 156	-

Table 4. Results of financial indicators of the farms (CUP - Cuban peso)

Indicators/farm	1	2	3	4	5	6	7	8	9	10	± SE
Total expenses/ha	784^{abc}	797^{abc}	692^{bc}	680^{bc}	660^{c}	670^{bc}	901^{a}	820^{ab}	781^{abc}	751^{abc}	14.23
Total income/ha	$1\ 637^{abc}$	$1\ 976^{a}$	980^{c}	963^{c}	$1\ 137^{bc}$	$1\ 122^{c}$	$2\ 045^{a}$	$1\ 990^{a}$	$1\ 871^{a}$	$1\ 832^{ab}$	75.81
Cost/kg milk produc.	0.96^{bcde}	1.00 bc	0.98^{bcd}	1.03^{ab}	0.91^{cde}	1.10^{a}	0.87^{e}	0.89^{de}	0.88^{e}	0.89^{de}	0.01
Income/kg milk	1.99^{abc}	2.44^{a}	1.41^{d}	1.45^{d}	1.60^{cd}	1.75^{bcd}	1.99^{abc}	2.17^{ab}	2.11^{abc}	2.17^{ab}	0.05