Journal of Animal Production, *32* (1), https://revistas.reduc.edu.cu/index.php/rpa/article/view/e3372

Husbandry and Nutrition

Original

Forage Balance Based on Crop-Cattle Farms in the Lower Basin of Guayas River, Ecuador

Forage Balance Based on Crop-Cattle Farms in the Lower Basin of Guayas River, Ecuador

Willian Filian Hurtado *, Ana Julia Mora Rodríguez*, Jorge Pereda Mouso**, Lino Curbelo Rodríguez**, Redimio M. Pedraza Olivera**, Roberto Vásquez Monte de Oca*

***** Technical University of Babahoyo, Faculty of Agricultural Sciences, Los Rios, Ecuador. Los Ríos, Ecuador.
** Center for Animal Production Studies (CEDEPA). Faculty of Agricultural Sciences University of Camagüey
Corresponding author: wilfilhur@hotmail.es

Received: October 2019; Accepted: December 2019; Published: February, 2020.

ABSTRACT

Background: Crop-cattle farms in the lower basin of Guayas River are different in terms of their chances to maintain animals throughout the year. **Aim:** To evaluate forage balance based on crop-cattle farms in the lower basin of Guayas river, Ecuador.

Methods: This research included 76 farms in the lower basin of Guayas river, Ecuador. Twelve variables were chosen for the analyses. The input variables helped classify the farms into four types through k-mean cluster analysis. The annual percentage of nutritional needs met on the farm was considered as well. The output variables produced the central trend and dispersion statistics, which were related to the types achieved. A simple correlation analysis was performed between the input and output variables, using the Spearman coefficient.

Results: The low typology generated most cases (36), and lowest percentage of the cattle raising area, stocking rate, and days on the farm. The mid-low and mid-high typologies produced similar values as to stocking rate and the days the animals were kept; the high typology kept the animals for more days, with adequate stocking rates and positive forage balance.

Conclusions: The forage balance was positive in the high typology, with better utilization of resources produced and introduced for animal nutrition, and more days on the farm.

Key words: cattle, forage, farms, stalks, foods (Source: *AGROVOC)*

How to cite (APA) Filian Hurtado, W., Mora Rodríguez, A., Pereda Mouso, J., Curbelo Rodríguez, L., Pedraza Olivera, R., & Vásquez Monte de Oca, R. (2020) was conducted. Forage Balance Based on Crop-Cattle Farms in the Lower Basin of Guayas River, Ecuador Journal of Animal Production, *32*(1).

INTRODUCTION

An analysis made on agricultural production in Ecuador by Requelme and Bonifaz (2012), revealed the existence in many cases, of varied natural scenarios, climates, and microclimates that provide many diverse culturing practices to work the land. According to the authors, this sector has complex and diverse characteristics, whose study is indispensable, implying a necessary challenge.

In that sense, Filian *et al*. (2019), characterized agricultural production systems engaged in cattle raising, in the lower basin of Guavas river, Los Rios province, Ecuador. The study found that the indicators related to stalks and used foods determined more than 50% of total variability of the systems studied, and emphasized on the need to establish feeding strategies that guarantee cattle raising in the region.

Concerning nutrition, Orjales *et al*. (2018) claimed it is one of the ultimate goals of cattle production systems, and it is essential for maintenance, reproduction, production, and health of herds. In turn, Giselli *et al*. (2015), on evaluation of cattle rearing in the Ecuadoran coast, concluded that it is combined with farming, especially the double-purpose cattle and maize (*Zea mays* L.), rice (*Oryza sativa* L.), banana (*Musa acuminata Colla*), African palm tree (*Elaeis guineensis Jacq*.), and sugar cane (*Saccharum officinarum* L.). Also, León *et al*. (2018), in reference to the possibility of including grass in the region, mentioned the broad potential to set up grazing systems.

Despite the previous, stalks are used, and the grass is characterized by low productivity, and are subject to seasonal unbalances which are mainly caused by frequent floods in certain periods of the year. These aspects hinder farm management, and call for the need to relocate the animals in areas with better draining and food availability.

Today, cattle farms in the low basin of Guaya river are very heterogeneous, which is determined by their physical dimensions, components of agrobiodiversity, feeding systems, management, and the possibility to keep the animals in their areas for a year. Considering the above, the aim of this paper is to evaluate forage balance of crop-cattle farms in the lower basin of Guayas river, Los Rios province, Ecuador.

MATERIALS AND METHODS

This study was done in the low basin of Guayas river, Los Rios province, Ecuador, made of river valleys and coastal alluvial plains, with few, mostly fertile depressions (savannas). This location has different types of soils, with a predominance of inceptisols (47.2%), followed by entisols (37.2%), and alphisols (8.4%). The climate is megathermal semi-humid, characterized by a single rainy maximum, an a very marked dry season, with mean temperatures of 24-26 °C, and rainfall values of 1 250-2 000 mm (AOICORP, 2014).

According to León, Bonifaz, and Gutiérrez, (2018), the main economic activity is farming, with rice (*Oryza sativa* L.), el banana (*Musa acuminata* Colla), el cocoa (*Theobroma cacao* L.), la soybean (*Glycine max* L.), sugar cane (*Saccharum officinarum* L.); and pastures, such as Guinea grass*(Panicum maximum* Jacq.*)*, African Bermuda grass (*Cynodon nlemfuensis* Vanderhyst, Bull.), molassesgrass *(Melinis minutiflora* P. Beauv.*)*, leguminous trees like algarroba (*Prosopis glandulosa* Torr.), cowbush (*Leucaena leucocephala* Lam. de Wit) and American sumac (*Caesalpinia coriaria* Jacq. Willd.). Besides, there are areas with established paragrass (*Urochloa mutica* Forssk. T. Q. Nguyen), signal grass (*Urochloa decumbens* Stapf R. D. Webster), Caribgrass *(Eriochloa polystachya* Kunth), and Napier Grass (*Cenchrus purpureus* Schumach. Morrone).

Sample and variable selection

A completely randomized collection of samples was performed in the experimental area (Toro, 2011; Álvarez *et al.*, 2014). Out of 680 farms, 76 that combined cattle and cropping were chosen, which were considered study cases. Regarding information collection on the farms, the methodology recommended by Giller *et al.* (2011) was used, which was started with quick rural diagnostic interviews and document reviews. The survey suggested by Filian *et al.* (2019) was conducted. Information was complemented with the production records at the local offices of the Ministry of Farming and Livestock Raising.

A number of 12 variables were selected, which were divided into two groups: The first group had the input variables, which included cattle raising areas (ha); per cent of cattle raising areas in relation to the total farm area (%); animal stocking rate (livestock unit/ha), estimates in relation to the total farm area; farm work days (days), as the number of days in the year in which the animals are exploited; stalks used for animal production (kg of DM/ha/year); pasture production on the farm (kg of DM/ha(year); animal consumption needs (kg of DM/ha), estimated through the procedure described by Pérez Infante (2010); foods introduced on the farm (kg of DM/ha), which include forage and harvest residues from other areas, and forage balance (kg of DM/ha), according to the methodology used by Macedo *et al.* (2008). The output variable selected were milk and beef (kg/ha); obtained using the set equation between the total annual production of both and the total farm area; cattle raising income (dollars/ha), as sales of milk and beef throughout the year; and the contribution of cattle raising to the farm overall income (%), estimated via the set per cent from cattle raising and the farm total income.

Data normality was verified using the Kolmogorov-Smirov (1933), and Levene (1960) tests for variance homogeneity; the samples did not meet the assumptions for the said analyses. According to Juárez *et al*. (2017), the central trend and dispersion measurements used were the mean, median, and interquartile range.

Information analysis procedure

A first stage included the input variables to classify the study cases; they were used as per cent criterion of the annual needs met by the farm. *K-mean* cluster analysis was utilized for classification, as it partitions disjoint groups. That analysis produced groups of farms, so the ones within the same group were similar. Inclusion was made differently in each group. To achieve a more heterogeneous distribution, four groups were selected to obtain better characterization, based on the criteria of Segura and Torrez (2014), and Javadi *et al.* (2017).

Each group was considered as a farm type, and it was given a code in relation to the mean values achieved, as low (lower need of foods), mid-low (intermediate values of lower need of forages), mid-high (intermediate values of higher needs of forage), and high (food needs met on the farm). A second stage included the output variables and the farm groups from the previous analysis. Finally, a simple correlation analysis was performed between the input and output variables, using the Spearman coefficient. IBM SPSS Statistics 22 (2013) was employed for analysis.

RESULTS AND DISCUSSION

The outcome, based on the typologies of farms made in the experimental area, is shown in Table 1. The first typology (low) included the largest number of cases, and accounted for 47% of the sample. It comprised the lowest total area and percentage of cattle areas (30%), with the lowest stocking rate, and low values, in relation to the days used on the farm to perform the activities analyzed (only 247 days with the cattle in their premises). In that sense, Haro (2003), said that the producing groups that cultivate less than 10 ha of their land, are considered small. According to the author, these types are prevailing, combining crops and cattle, nationally-bred cattle, poor technology, low-mid fertility soils, and low yields. In the low group, cattle raising is performed as an alternative of household self-supply of milk, and the generation of income from the sale of animals at certain times of the year. The farms within the low typology showed negative forage balances, though food deficiencies were fewer than the second and third groups. This condition was determined by a lower stocking rate, which ensured greater food availability when the animals are within their premises.

Analysis of second and third group typologies (mid-low and mid-high, respectively), showed similar values as to the number of days the animals can be kept on their farms, and animal stocking rate, which led to similar behaviors, despite the different premises and proportion of cattle.

The farms included in the mid-low category produced more harvest residues for animal nutrition, according to the farming areas, but not in the same quantity of available grass. On the other hand, the mid-high category showed lower quantities of consumed residues; however, pasture production was higher than in the other typologies. This behavior was conditioned by a greater total area, and percentage allocated to cattle raising. The analysis of the amount of food introduced in either category revealed that the deficiencies regarding pasture and crop residue production on the farms were not met by the farms, and they were below the animal consumption needs, which led to negative forage balances.

Coinciding with the results, Márquez *et al.* (2008), evaluated systems combining breeding cattle with crops in flooded plains, in Mexico. They noted that increasing the animal stocking rate has been the main action taken to improve productivity, with no need to perform complementary actions to enhance the stocking capacity of prairies, leading to overexploitation and degradation. Under those circumstances, the authors recommended 1.9 ha to maintain one animal unit during the year. Also, Pereda *et al.* (2017) evaluated this indicator in mid-fertility soils, using cattle farms with different agricultural integration levels, and found maximum values of 1.5 LU/ha, considered as extremes for the farm conditions observed.

In the high typology, the animals were kept 280 days (more days), of which 60% was engaged in cattle production, with stocking rates within the adequate range, considering the amounts of food they can produce and introduce on the farms, and the consumption needs of animals. The results achieved in this group are related to the reports made by Funes (2008), who evaluated different cattle-farming integration proportions on several Cuban locations, with 70-30% as the best result. Upon evaluation of a three-phase conversion program to accomplish food self-sufficiency in the Cuban agricultural sector, the above author recommended 30-50% crop proportions on cattle farms with less than 20 ha; thus increasing productive and energy efficiencies, as well as the capacity of supplying more energy and protein to people (9.9 and 14.4, respectively) (Funes, 2016). Considering the results presented by the author cited, and the distribution of farming and cattle components found on the high typology farms (40% cropping and 60% cattle), it might be inferred that most days used to maintain the animals were related to better distribution and use of forage resources in their premises (pasture and residues), and the foods introduced from areas other than in the production system.

Table 1. Input variable values achieved by the farm groups

Input variables	Low n=36		Mid-low n=13		Mid-high n=11		High n=16	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Farm days (days)	247 (238) IQR=30.0	23.1	255 (245) IQR =30.0	15.1	256 (245) IQR =30.0	15.1	280.6 (275) IQR =30.0	44.1
Cattle area (ha)	3.4 (3) IQR=3.0	2.3	31.7 (20) IQR=31.5	16.2	89.0 (90) IQR=10.0	11.3	19.5 (19) IQR=16.0	9.05
Cattle area %	32 (25) IQR=33.0	21.4	50 (42) IQR=42.0	25.2	90 (81.7) IQR=10.0	11.6	60 (63) IQR=52	28.0
Stocking rate (LU/ha)	0.4 (0.4) IQR=0.1	0.1	0.7 (0.7) IQR=0.0	0.0	0.8 (0.8) IQR=0.0	0.0	0.5 (0.5) IQR=0.2	0.1

Residues used (kg DM/ha/year)	7.3 (4.4) IQR=6.7	8.3	32.4 (33.5) IQR=28.5	18.5	14.2 (11.1) IQR=11.2	15.9	18.7 (8.9) IQR=29.9	17.2
Pasture production (kg DM/ha/year)	5.6 (5.1) IQR=4.9	3.8	54.1 (36.2) IQR=55.7	28.8	150.3 (145.0) IQR=16.1	25.0	35.5 (34.4) IQR=27.1	16.6
Consumption need (kg DM/ha)	19.0 (14.6) IQR=15.1	13.3	159.2 (160.0) IQR=38.9	25.8	298.3 (298.6) IQR=72.8	43.0	68.2 (71.6) IQR=34.0	23.6
Foods introduced on the farm (kg DM/ha)	5.6 (4.6) IQR=4.4	3.0	23.1 (26.2) IQR=23.0	12.9	40.9 (31.6) IQR=48.9	21.0	18.4 (22.0) IQR=14.8	8.1
Final FB (kg DM/ha)*	-0.7 (-0.9) IQR=9.4	7.4	-49.6 (-40.2) IQR=26.9	24.5	-92.8 (-117.6) IQR=77.5	34.5	4.5 (4.1) IQR=14.7	16.6

n: number of cases; SD: standard deviation; (): median; IQR: interquartile range
***It only considers animal consumption on the farm.**

A dispersion stagraph analysis of the output variables was performed, depending on the farm typology (Table 2), the low group showed the lowest mean productions of milk and beef; however, it accomplished the best total yields compared to the other typologies. It was determined by the contribution made by cropping, corresponding to the behavior observed in the indicators evaluated, the income from cattle raising, and the percentage obtained from the total income, only accounting for 17%. The cases within typology had the lowest number of days used to maintain the animals, and the ones with the smallest area dedicated to cattle, with a negative forage balance, justifying the outcome of variables linked to cattle production. In that sense, FAO (2018) said that 92% of Ecuadoran cattle belongs to household agriculture, on small farms with poor technical development, and production aimed to self-consumption and some barter of excess production.

Following analysis of this typology, an increase was observed in the production response to milk and beef, including total yields, when compared to the low typology. The farmers within the mid-low typology showed greater total area and cattle proportion (50%), which was linked to better management and feeding conditions that ensure greater animal response. However, despite having the highest total income, the profit percentage from cattle raising was not far from the previously analyzed typology. These farms are focused on cropping, with more inputs and derived productions from the sector, stimulated by sale opportunities and the agroproductive conditions of the region.

According to Filian *et al.* (2019), the productive systems of the low basin of Guayas river, Ecuador, have increased, driven, among other factors, by an increase in input use, which are mainly allotted to cropping, which may be related to the outcome of the mid-low typology, with the highest percentage of crop area, coinciding with Peñuela and Fernández (2010) in a study of cattle in flooding savannas, in Orinoquia, Colombia. They remarked that although it was an important economic activity for the country, it employs little technical methods and training, thus reporting poor productivity and cost effectiveness, apart from deteriorating the ecosystems and the environment, similar to the outcome of this study.

Milk and beef production in the high typology was similar to the mid-high, which used 90% of the land in cattle raising, and was higher than the low and mid-low typologies. It was different when the total yield was evaluated with a lower value, compared to the low and mid-low typologies, with greater cropping proportion, influencing on the results achieved. The total yield in the high category was better than the mid-high category, with 90% of land used for cattle raising. In this category, as in the previous ones, the percentage of various crops determined the response of total yield.

In that sense, Ocampo and Peñuela (2014) studied breeding cattle productivity in flooding savannas of the Orinoco region, and stressed on the need to implement a systemic approach to achieve favorable development of their productive goal and the supporting environment. The authors claimed that the search for higher productivity will necessarily have to be within the analysis capacity of each of the components of the system and their relationships. Hence, identification of the positive aspects and other aspects requiring adjustment or change will be possible, in order to accomplish higher productivity of the system. Based on this outcome, the farmers who were part of the high typology kept a proper global stocking rate, which ensured better management of forage resources, and greater balance of cattle-cropping components in the production system, influencing on the response.

Table 2. Dispersion statgraphs of output variables depending on the farm groups

Output variables	Low		Mid-low		Mid-high		High	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Milk production (kg/ha)	175.5 (165.6) IRQ=72.0	57.0	303.5 (304.9) IRQ=19.9	19.7	339.1 (354.2) IRQ=5.8	18.5	331.0 (365.2) IRQ=83.5	59.8
Beef production (kg/ha)	25.4 (24.6) IRQ=9.15	11.1	69.5 (70.0) IRQ=25.2	12.8	79.7 (81.3) IRQ=32.3		76.3 (73.6) IRQ=29.3	16.8
Total yield (kg/ha)	1.0 (1.1) IRQ=0.8	0.4	1.2 (1.5) IRQ=0.8	0.4	0.6 (0.6) IQR=0.1	0.1	0.8 (0.8) IRQ=1.1	0.5
Cattle income (dollars/ha)	138.6 (134.3) IQR=55.7	48.2	309.0 (302.4) IRQ=85.0	43.8	381.6 (359.1) IRQ=111.6	49.5	234.4 (216.2) IRQ=84.5	63.4
Contribution of cattle raising to total farm income (%)	17 (6.6) IRQ=7.8	29.8	17 (11.6) IRQ=14.0	10.2	57 (44.3) IQR=55.7	29.0	24 (17.7) IQR=27.1	26.7

SD: standard deviation; (): median; IQR: interquartile range

The analysis of correlations (Table 3) revealed high significance values (P ≤ 0.01) in most input and output variables, which demonstrates their interrelation. However, there were no significant differences between the total area and the farm days for cattle raising, which demonstrates the possibilities of the area to perform other productive actions unrelated to cattle. Similar results were observed between the various crop areas and the stocking rate, the farm days, and milk production. These aspects corroborate a low utilization of residues from the crop land, particularly in milk production.

In three of the typologies, the high stocking rates were factors that caused negative forage balances, and, as a minor result, the capacity to maintain the animals on the farms throughout the year. The correlations of variable stocking rates showed no significance in relation to farm days or residues used. In that sense, Estelrich and Castaldo (2014), linked the stocking rate to the pressure of grazing, and noted that the capacity of a cattle system is determined by environmental factors, including the type of soil, the topography, and the climate, as well as the plant community involved in its structure, richness, and specific abundance. According to the author, these factors have an influence on the availability of biomass, the main determinant factor of cattle receptivity within an area or region. The analyses made by the authors above demonstrate the need to seek proper stocking rate, according to the edaphoclimatic characteristics, the production capacity, and use of available biomass for animal nutrition.

The correlation coefficient of farm days in the year was generally low in all the related variables. Significance was only found (P≤0.05) in the production of pastures and food on the farm. These elements make the basis of animal maintenance; however, no correlation was found to the residues produced, the consumption needs, and foods introduced, which are not taken into account, but determine animal stability, and help ensure their nutritional requirements. Similar results were observed by evaluating the relationship between the days used for animal production and variables milk production, beef production, and total income. Inside them are those provided by cattle raising. Generally, they show the low priority of cattle raising; rather, they are an alternative of family self-consumption, and it is sometimes used to counteract economic unbalances and deficiencies caused by crop production. In that sense, Torres *et al*. (2014), expressed the need to apply technologies that develop double purpose cattle on the Ecuadoran coast area. The authors also highlighted that cattle responds to a mixed system of agriculture, with significant forage limitations in economically depressed marginal areas.

Low correlation coefficients were found in variable used residues and milk production, as well as evaluation of pastures, with the income made by cattle raising as a contribution to the total income. These results demonstrate the low utilization of food resources on farms with low income and little contribution to the local economy.

Table 3. Correlations between input and output variables found in the analysis

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	1.000	**.556****	**.856****	**.675****	.168	**.555****	**.859****	**.944****	**.974****	**.813****	**.673****	**.747****	**.752****	**.456****

2		1.000	**.317****	.194	.132	**.962****	**.324****	**.573****	**.492****	**.243***	.193	**.313****	**.301****	**-.373****
3			1.000	**.711****	**.227***	**.317****	**.997****	**.922****	**.874****	**.770****	**.711****	**.752****	**.751****	**.557****
4				1.000	.174	.194	**.709****	**.701****	**.799****	**.730****	**.999****	**.915****	**.961****	**.624****
5					1.000	.133	**.281***	**.230***	.189	.185	.169	.191	.167	.181
6						1.000	**.323****	**.572****	**.492****	**.243***	.194	**.313****	**.301****	**-.374****
7							1.000	**.925****	**.876****	**.771****	**.709****	**.749****	**.745****	.558**
8								1.000	**.931****	**.749****	**.701****	**.768****	**.766****	**.358****
9									1.000	**.861****	**.798****	**.849****	**.857****	**.546****
10										1.000	**.728****	**.744****	**.756****	**.621****
11											1.000	**.914****	**.960****	**.622****
12												1.000	**.980****	**.568****
13													1.000	**.593****
14														1.000

1, Total real area, ha; 2, Crop area, ha; 3 Cattle area, ha; 4 Stocking rate LU/ha; 5, Farm days; 6, Residues used (kgDM/ha/year); 7 Pasture production (kgDM/ha/year); 8, Food production on the farms (kgDM/ha); 9, Consumption needs (kgDM/ha); 10, Foods introduced on the farm in the year (kgDM/ha); 11, Milk production (kg/ha); 12, Net beef production (kg/ha); 13, Income from cattle (dollars/ha); 14, Contribution of cattle income to total farm income *Indicates a significant correlation P<0.05; **Indicates significant correlation P < 0.01

CONCLUSIONS

The forage balance was positive in the high typology, with better utilization of resources produced and introduced for animal nutrition, and more days staying on the farm.

REFERENCES

Alvarez, S., Paas, W., Descheemaeker, K., Tittonell, P., & Groot, J.C.J. (2014). *Construcción de tipologías, una forma de manejar la diversidad de las fincas: directrices generales para Humidtropic. Informe para el programa de investigación del CGIAR sobre Sistemas de los Trópicos Humedos.* Universidad de Wageningen, Grupo de Ciencia de las Plantas. Wageningen, Paises Bajos: Humidtropics. http://edepot.wur.nl/375028

AOICORP. (2014). *Plan de desarrollo y ordenamiento territorial del Cantón Baba. Diagnóstico del territorio por componentes 2014-2019.* Los Ríos, Ecuador. http://www.municipiodebaba.gob.ec/Abril_2017/PLAN_DE_ORDENAMIENTO_TERRITORIAL_DEL_CANTON_BABA.pdf

Estelrich, HD., & Castaldo, A. (2014). Receptividad y carga ganadera en distintas microregiones de la provincia de la Pampa (Argentina) y su relación con las precipitaciones. *SEMIÁRIDA Revista de la Facultad de Agronomía UNLPam, 24*(2), 7-19. https://cerac.unlpam.edu.ar/index.php/semiarida/article/view/2727/2623

FAO. (3 de octubre de 2018). *Buenas prácticas ganaderas impulsan la economía de pequeños productores en Ecuador*. http://www.fao.org/ecuador/noticias/detail-events/es/c/1151391/

Filian, W., Alvarado, H., Pereda, J., Curbelo, L., Vázquez, R., & Pedraza, R. (2019) was conducted. Caracterización de sistemas de producción agrícolas con ganado vacuno en la cuenca baja del río Guayas, provincia de Los Ríos, Ecuador. *Revista de Producción Animal*, *31*(1), 1-10. http://scielo.sld.cu/pdf/rpa/v31n1/2224-7920-rpa-31-01-1.pdf

Funes Monzote, F. (2016). Integración agroecológica y soberanía alimentaria. En F. Funes, Avances *de la agroecología en Cuba* (págs. 403-420). La Habana, Cuba: Estación *Experimental de Pastos y Forrajes Indio Hatuey*. http://repositorio.geotech.cu/jspui/handle/1234/2020

Funes-Monzote., F.R. (2008). Farming like we're here to stay. The mixing farming alternative for Cuba. *PhD Thesis. Wageningen University*, 211. Wageningen, The Netherlands. https://library.wur.nl/WebQuery/wurpubs/369587

Giller, K. E., TIttonell, P., Rufino, M. C., Van Wijk, M.T., Zingore, S., & Mapfumo, P. (2011). Com-municating Complexity: Integrated Assessment of Trade-Offs Concerning Soil Fertility Management within African Farming Systems to Support Innovation and Development. *Agricultural systems*, *104*(2), 191-203. https://doi.org/10.1016/j.agsy.2010.07.002

Giselli, Y. García,A. Rivas, J., José Perea, J., Angón, E., & De Pablos-Heredero, C. (2015). Caracterización socioeconómica y productiva de las granjas de doble propósito orientadas a la producción de leche en una región tropical de Ecuador. Caso de la provincia de Manabi. *Revista Científica FCV-LUZ*, *XV*(4). https://www.redalyc.org/pdf/959/95941173009.pdf

Haro, R. (2003). *I Informe sobre Recursos Zoogeneticos de Ecuador*. Dirección para la implementación del desarrollo agropecuario, agroforestal y agroindustrial. Quito – Ecuador: Ministerio de Agricultura y Ganadería. http://www.fao.org/ag/againfo/programmes/en/genetics/documents/Interlaken/countryreports/Ecuador.pdf

Javadi,S., Hashemy, S.M., Mohammadi, K., Howard, K.W.F., & Neshat, A. (2017). Classification of aquifer vulnerability using K-means cluster analysis. *Journal of Hydrology 549*, 27-37. https://doi.org/10.1016/j.jhydrol.2017.03.060

Juárez, M., Arriaga, C., Sánchez, E., García, J., Rayas, A., Rehman, T., Dorward, P., & Martínez, C. (2017). Factores que influyen en el uso de praderas cultivadas para producción de leche en pequeña escala en el altiplano central mexicano. *Rev Mex Cienc Pecu*, *8*(3), 317-324. http://dx.doi.org/10.22319/rmcp.v8i3.4509

Kolmogorov-Smirov, A. (1933). Sulla determinazione empirica di una legge di distribuzione. *Giornaledell' Intituto Italiano degli Attuari, 4*, 83-91.

León, R., Bonifaz, N., & Gutiérrez, F. (2018). *Pastos y forrajes del Ecuador. Siembra y producción de pasturas.* Quito, Ecuador: Editorial Universitaria Abya-Yala. https://dspace.ups.edu.ec/handle/123456789/17928

León, R., Bonifaz, N., & Gutiérrez, F. (2018). *Pastos y forrajes del Ecuador* (Primera edición ed.). Ecuador: Editorial Universitaria Abya-Yala . http://dspace.ups.edu.ec/handle/123456789/17928

Levene, H. (1960). Robust tests for equality of variances, p 278–292. *Contributions to probability and statistics: essays in honor of Harold Hotelling. Stanford University Press, Palo Alto, CA*. http://www.oalib.com/references/21128277

Macedo, R., Galina, M., & Zorrilla, J. (2008). Balance forrajero, energético y proteico de un sistema de producción tradicional de doble propósito en México. *Zootecnia Tropical*, *24*(6), 455-463. http://www.researchgate.net/publication/43564492

Márquez, R., De Jong, B., Eastmon, A., Ochoa-Gaon, S., Hernández, S., & Sandoval, J. (2008). Programas gubernamentales y respuestas campesinas en el uso del suelo: el caso de la zona oriente de Tabasco, México. *Región y Sociedad, 20*(43), 98-129. http://www.scielo.org.mx/pdf/regsoc/v20n43/v20n43a4.pdf

Ocampo, A., & Peñuela. L. (2014). Sabana inundable y ganadería, opción productiva de conservación en la Orinoquia. En L. S. Peñuela, *Enfoque sistémico base fundamental para la productividad de la ganaderia de cría en sabana inundable.* (págs. 48-60). Orinoquía: La Imprenta Editores S.A. http://www.horizonteverde.org.co/attachments/article/29/LIBRO%20GANADERO%20G5%20FINAL.pdf

Orjales, I., Lopez, M., Miranda,M., Alaiz-Moretón, H., Resch, C., & López,S. (2018). Dairy cow nutrition in organic farming systems. Comparison with the conventional system. *Animal*, 1-10. https://doi.org/10.1017/S1751731118002392

Peñuela, L., & Fernández, A. (2010). La ganadería ligada a procesos de conservación en la sabana inundable de la Orinoquia. *Orinoquia, 14*(1), 5-17. https://www.redalyc.org/pdf/896/89622691002.pdf

Pereda, J., Curbelo, L., Pardo, G., Vázquez, R., & Figueredo, R. (2017). Clasificación de fincas lecheras según dimensiones de la intensificación productiva en un nuevo modelo de gestión. *Revista de Producción Animal, 29*(2), 50-56. http://scielo.sld.cu/pdf/rpa/v29n2/rpa07217.pdf

Pérez-Infante, F. (2010). Ganadería del futuro producción y eficiencia. *Editorial. PALCOGRAF, La Habana, Cuba*.

Requelme, N., & Bonifaz, N. (2012). Caracterización de sistemas de producción lechera de Ecuador. *La Granja*, *15*(1), 55-69. https://doi.org/10.17163/lgr.n15.2012.05

Segura, E., &Torres, V. (2014). Criterios de comparación robustos en la clasificación y tipificación,según el Modelo Estadístico de Medición de Impactos en un estudio de caso en Pastaza, Ecuador. *Revista Cubana de Ciencia Agrícola*, *48*(4), 329-332. https://www.redalyc.org/pdf/1930/193033033003.pdf

Toro, M. P. (2011). Análisis técnico, económico y social del sistema ovino lechero ecológico en Castilla la mancha: eficiencia y sustentabilidad. *Universidad de Córdoba, Córdoba, España.* http://www.uco.es/zootecniaygestion/img/pictorex/10_13_43_tesis_completa.pdf

Torres, Y., Rivas, J., De Pablos, C., Perea, J., Toro-Mujicae, P., Angónd, E., & García, A. (2014). Identificación e implementación de paquetes tecnológicos en ganadería vacuna de doble propósito. Caso Manabí-Ecuador. *Rev Mex Cienc Pec*, *5*(4), 393-407. http://www.scielo.org.mx/pdf/rmcp/v5n4/v5n4a2.pdf

AUTHOR CONTRIBUTION

Conception and design of research: JPM, LCR, RMPO, RVMO.

Analysis and data interpretation: WFH, AJMR, JPM, LCR, RMPO, RVMO

Redaction of the manuscript: WFH, JPM, LCR, RMPO

CONFLICT OF INTERESTS

The authors declare no conflict of interests.