Factors determining the efficiency of milk production in systems of double purpose in Pastaza province, Ecuador

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In order to identify the factors determining the productive efficiency of dairy cattle in Pastaza, Ecuador, a non-experimental design was used, which controlled the effects of the climatic areas and height levels, for applying a survey system in 116 farms with more than 10 heads and five years of consecutive activity. The Statistical Model of Impact Measuring (SMIM), which is a combination of multivariate methods, was applied to identify the impact of these factors on cattle rearing systems. The discrete variables were analyzed by means of contingency tables, which combined the identified groups and the variables that influence on productive efficiency, environment and social risks related to cattle rearing sustainability. The factors determining the productive efficiency of the main step of milk production were production, environmental situation and size of exploitation. These factors explain the 73.76 % of the accumulated variance. The efficiency of the evaluated systems is related to the procedures carried out in the cattle rearing processes and to the social performance of the leading actors, who decide the alternatives to be applied and the way of managing productive systems. In Amazonic ecosystems, sustainable cattle rearing can be feasible if the productive activity is organized, the proper alternatives to ecosystem demands are adopted, and the environmental management programs, adequate for this region, are implemented.

Key words: *productive efficiency, impact, productive chain, Amazonia*

Pastaza is the largest province from the Republic of Ecuador. It is located in the center of the Ecuadorian Amazon Region (RAE, initials in Spanish), between the coordinates 1º 10´ SL, 78º 10 WL and 2º 35´ SL, 76º 40´ WL. It has an area of 29.773 km^2, which is divided into 25.5 % of the RAE and 12 % of national territory. It is characterized by having 81 % of its territory occupied with non intervened woods. Its ecosystems have an extraordinary richness of natural resources and biodiversity. Due to the nature of its relief, climate and edaphic formation of its woods, it is considered as a fragile territory, especially opposed to the use of economical activities that affect its woods and ecosystems (INIAP 2010).

Agricultural frontier is name of the he surface in which the different anthropic activities take place. In Pastaza province, this frontier has a surface of 413.3 ha, which goes from the 1.900 m o.s.l. of the Andean foothill to the 350 m o.s.l. near the Amazonic plains (Vargas *et al.* 2014). In the agricultural frontier, soil is mainly used for cattle rearing and permanent crops, which were established without an order based on policies of territorial organization. Consequently, lands dedicated to agriculture and animal husbandry were more used than their own stocking rate capacity. Specifically, during the last ten years, the surface used for cattle increased in 154 %, which had severe negative effects for the environment (INIAP 2010).

According to sources of the Ministerio de Acuacultura, Ganadería, Agricultura y Pesca (MAGAP 2014), there are more than 38,000 heads of cattle in this territory, which means 5.9 % of all the cattle in RAE. This heads are located in 1,663 cattle farms in exploitation, which mainly use double purpose systems. These systems generate 24.94 thousands of liters of milk daily, which represent 6.5 % of the volume reached at national level (ATPA 2014 and ESPAC 2014).

The alternative of generalized production is based on tethering grazing. A reduced amount of producers used electrical fences for controlling their animals. Therefore, a grass surface per animal, similar to the one used in tethering grazing is established. Concentrates are used as grass complement, which are provided without a rational pattern, and their intake frequency varies from two to three times a week, even once a day. Providing minerals is considered a necessity, and popular formulas in the market, designed without considering soil limitations or environmental characteristics of Amazonia, are used for this purpose.

The objective of this study was to identify the factors determining productive efficiency in the primary link of milk production chain in double purpose systems from Pastaza.

Materials and Methods

Diagnosis and survey. A survey with 56 variables was designed to evaluate the performance of social, economic, environmental and productive dimensions of cattle rearing systems from Pastaza. The survey was applied according to a non-experimental design, which

controlled the effects of climatic areas and height levels that determine the differences of the edaphoclimatic performance of the agricultural frontier of the province, and modify productivity of cattle rearing systems and animal performance.

Sample size. Farms having a herd of more than 10 cattle heads and more than five years of consecutive activity were considered as population of this study. The sample size was determined according to Snedecor and Cochran (1989), starting from 650 milk producer farms in double purpose systems, located in this territory (Agrocalidad 2011). When applying the criterion of maximum variance (Torres1987) to guarantee an adequate sample size for all the variables to measure, the value of 31.2 of s2muestral was considered with 3 % of prefixed error and 95 % of reliability level. The estimated sample size was 130 farms.

The field work demonstrated that, in specific sectors, the amount of existing farms decreased due to different causes associated to the change of productive activity, loss or sale of herds because of the effect of devastating diseases or lack of profitability leading to farm abandonment. The amount of visited farms was reduced to 116 due to these reasons. According to the calculated variance for the real sample obtained, the statistics were achieved again and the validity of the sample was demonstrated for the research purpose.

Creation of a data matrix. The information obtained during the samplings was organized in data matrixes of Excel worksheets. The visited cattle rearing systems were located in lines and the study object variables were located in columns. Each database was strictly examined and those farms that lacked of relevant information were removed, because the survey taker did not specified with precision the section. Besides, the cases in which appeared atypical values or those not having more than five years of consecutive activity and a minimal amount of animals of ten or more cattle heads were eliminated. After eliminating the farms with atypical data or incomplete information, the sample size was reduced to 90 farms, which is big enough to endure the evaluation validity of cattle rearing systems with double purpose in Pastaza province.

Determination of essential factors for productive efficiency. The Statistical Model of Impact Measuring (SMIM) of Torres *et al.* (2013) was applied to summarize the gathered information. The discrete variables, which influence on system performance and are related to social, environmental and productive dimensions, were also analyzed in order to characterize their performance in each identified group, evaluate the risks that cattle rearing undergo and the implementation of inefficient livestock practices. Contingency tables were used, in which the identified groups and the variables of interest that influence on productive efficiency, as well as the negative environmental effect of cattle rearing and social risks associated to sustainability of animal husbandry in Pastaza.

Results and Discussion

Table 1 shows the factors determining productive efficiency of cattle rearing systems dedicated to milk production. The production factor is related to the indicators that define productive efficiency, size of herd in exploitation and production volume. The rest of evaluated variables, associated to this component, maintain their relative importance to evaluate these systems. However, the presented homogeneity of variance has a low contribution to the component modeling, although these variables are essential to explain or adopt sustainable production alternatives for this Amazonian territory.

Table 1. Factors determining efficiency of cattle farms with double purpose in Pastaza

Component	Related variables	Weight factor	Auto value	Explained accumulated variance, %
Production	Cows, heads	0.84	5.82	41.62
	Total bovines, heads	0.75		
	Reproductive females, heads	0.89		
	Parturitions per year	0.93		
	Relation cows.studs^{-1}	0.67		
	Milking cows, heads	0.86		
	Annual milk production, thousands of liters	0.81		
Environmental situation	Slope, %	0.94	2.89	62.29
	Area compatible with grazing, %	-0.90		
	Gullies.ha^{-1}	0.85		
	Soil depth, cm	-0.63		
Size of exploitation	Area for cattle use, ha	0.82	1.60	73.76
	Size of the paddocks, ha.	0.85		
	Sold bulls, heads	0.68		

Reproduction is considered as the most important process of any cattle rearing exploitation. It defines herd structure, relative potential of production expected from cattle rearing system, feeding program established for obtaining high and stable production, modeling of health system, management system, expected amount of sales, insurance foreseen for system management and productive practices that should be established for its optimal functioning (Benítez *et al.* 2010 and Moreno Sandoval *et al.* 2011). In cattle rearing systems from Pastaza, the production component explains 41.62 % of the extracted variance according to the model fixed to the performed evaluation.

The environmental situation component explains up to 62.29 % of the accumulated variance due to the fixed model. This component is related to variables that indicate the environmental situation of these cattle rearing systems. The land slope conditions the rainfall pattern, maximum intensity of rains and infiltration capacity of soil. The land covering conditions the erosion danger. While the land slope increases, the speed of drainage also increases, as well as the rain erosive ability and land degradation associated to these natural phenomena (FAO 2000 and Murgueitio and Ibrahim 2004).

In the agricultural frontier of Pastaza, the rainfall pattern and relief influence on land degradation due to erosion provoked by grazing (Vargas *et al.* 2014). Erosion intensity and extension increase with land slope. Degradation is also related to the area percentage considered adequate for grazing, which are those with slopes lower than 30 %. This variable and land slope are related to soil depth, which decreases while the slope increases in the system (Ramírez *et al.* 2012).

The size of exploitation, which is related to grazing area and size of used paddocks, is the third component that explains 73.76 % of the accumulated variance of the model.

Figure 1 shows the impact of these components on each cattle farm evaluated in the milk production system of Pastaza. Each farm represented in the x axis obtains three indicators in a scale of values that indicates their relative situation regarding the rest of the evaluated farms, which are represented by colored bars in the y axis. Procedures leading to cattle rearing processes have a decisive influence on the efficiency of systems dedicated to milk production. Table 2 shows some of the most highlighted procedures.

The 83 % of the systems have no associations with grasses and legumes with enough extension to contribute to positive changes in the processes of feeding and environmental protection in these systems. The 68 % of herds use the mount as a reproductive method and 63.7 % serve the female reproducers using a technique of intensive reproduction. Traceability of cattle rearing procedures is another essential factor for achieving a high efficiency in dairy exploitations. The 72.5 % have no controls on reproductive process, and 98.9 % have no register of the activities they carry out. In 80.2 % of the studied cases, there are no health licenses to mobilize their herds and 91.2 % have no prevention programs designed by specialists. No producer practices the quarantine when the animals enter their lands.

The plan of environmental management for a cattle rearing entity implies the application of procedures to mitigate or stop land degradation, the establishment of health security measures, use of biologically and economically efficient production alternatives, and guarantee high incomes and low costs, as well as improving life quality of producers and their family (FAO 2009 and 2012). In 95.6 % of the studied cases, no environmental management program or plan was applied and 76.9 % of the cases did not protect properly the water sources existing in the cattle rearing systems.

Efficiency achieved in the productive systems is mainly related to the social performance of the actors that

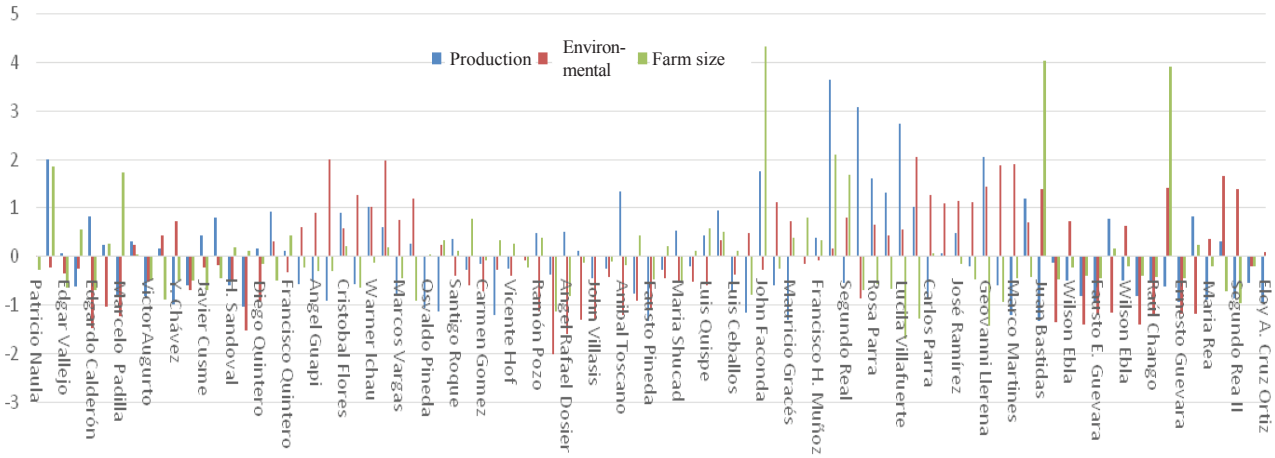

Figure 1. Estimation of management impact, production efficiency and environmental situation in cattle farms with double purpose in Pastaza province

Table 2. Practices of cattle production in percentages, related to the evaluated farms.

Criteria	Category	Groups				Total
			2	3	4	
Presence of associations in grass	It has	7.7	0.0	1.1	0.0	8.0
	It does not have	84.6	3.3	2.2	1.1	83.0
Reproductive method	Mount	62.6	1.1	3.3	1.1	68.1
	AI	29.7	2.2	0.0	0.0	31.9
Reproductive controls	It has	26.4	1.1	0.0	0.0	27.5
	It does not have	65.9	2.2	3.3	1.1	72.5
Programs of health prevention	It has	7.7	0.0	1.1	0.0	8.8
	It does not have	84.6	3.3	2.2	1.1	91.2
Entering of animals	With health license	17.6	1.1	1.1	0.0	19.8
	Without health license	74.7	2.2	2.2	1.1	80.2
Records	There are records	1.1	0.0	0.0	0.0	1.1
	There are no records	91.2	3.3	3.3	1.1	98.9
Plan for environmental management	There is a plan	4.4	0.0	0.0	0.0	4.4
	There is no a plan	87.9	3.3	3.3	1.1	95.6
Criteria for innovation	There are criteria for improving products	38.0	3.3	2.2	0.0	43.5
	There are no criteria for improving products	53.3	0.0	1.1	2.2	56.5
Training	Receive training	29.3	0.0	1.1	0.0	30.4
	No training received	62.0	3.3	2.2	2.2	69.6
Cost control	Controlled costs	4.3	0.0	0.0	0.0	4.3
	Non controlled costs	87.0	3.3	3.3	2.2	95.7
Age ranges of farm owners	Under 31 years old	7.6	0.0	0.0	0.0	8.0
	From 31 to 40 years old	18.5	1.1	1.1	0.0	21.0
	From 41 to 50 years old	26.1	0.0	1.1	0.0	27.0
	From 51 to 60 years old	17.4	1.1	0.0	0.0	18.0
	Older than 60 years old	21.7	1.1	1.1	2.2	26.0
Hired labor force	Non hired labor force	66.3	1.1	2.2	2.2	71.7
	Hired labor force	25.0	2.2	1.1	0.0	39.3

lead to it. Therefore, in 56.5% of the evaluated systems, there are no criteria for improving their products, 69.6 % do not receive training on alternatives for livestock production, environmental management, cost control or management of their productive systems. An amount of 95.7 % of the systems has no control of their management costs, which increases risks and vulnerability of these systems in exploitation.

Only 46.7 % of the producers having areas for cattle use are specialized in this productive activity. The 35.9 % carries out other agricultural activities besides animal husbandry and 17 % have other jobs not related to agriculture. In cattle rearing systems dedicated to milk production, the labor force constituted by family represents 71.7 % of the labor force involved in this productive activity, while the 31.5 % hire labor forces for productive management. Out of these figures, 86.3 % hires a person for management and the rest hires up to two workers. In 44 % of the farms, the people are older than 51 years old and 18% are older than 60 years old. Out of them, 26.6 % have nobody to replace them in the production process.

Factors determining productive efficiency of cattle rearing systems depend on the adopted productive alternative, which determines production level. They also depend on the characteristics of land relief, which is related to environment degradation and dimensions of the system in exploitation.

The ability of producers is another dimension that influence on efficiency reached in cattle rearing systems. Indicators related to this attribute are the ability of innovation, traceability achieved in livestock productions, application of efficient cattle rearing practices, health program performed and ability to protect the environment. This ability is reflected on quantitative indicators determining livestock production in Pastaza.

The environmental dimension is the most unprotected

of the livestock production systems due to a generalized ignorance regarding the function of environmental services on sustainability of productive systems. There are no designs or programs implemented for protecting the environment and assuring good agricultural practices in cattle rearing systems from Pastaza. There are no innovation programs designed for typified ecosystems in Pastaza province, aimed to improve the ability of producers to manage their cattle rearing systems and to make them sustainable.

It is necessary to identify and adapt technological alternatives that should be adequate for a sustainable food production from livestock in Pastaza. In Amazonian ecosystems, sustainable cattle rearing is feasible if productive activity is organized, proper alternatives to ecosystems demands are adopted and environmental management programs are implemented, which have to be in correspondence to the characteristics of the ecosystems of this region.

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