



## SMALL-FARMERS DYNAMICS IN THE SIERRA OF ECUADOR

### DINÁMICA DE LOS PEQUEÑOS PRODUCTORES DE LECHE EN LA SIERRA CENTRO DE ECUADOR

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#### Resumen

La estructura agraria en el Ecuador tiene una marcada diferenciación debido a la tenencia y acceso a la tierra. El crecimiento de la producción pecuaria dentro de las pequeñas y medianas explotaciones ha sido constante en los últimos años, así como la feminización del campo. En la serranía del Ecuador, estos procesos pueden observarse con mayor detalle, especialmente en aquellas provincias que se encuentran en el centro del país. Esto ha motivado a analizar la dinámica de los pequeños productores de las provincias de Chimborazo, Cotopaxi y Tungurahua, por medio de la aplicación de una encuesta a 793 agricultores, donde se revisan las características socio-productivas relacionadas con la producción de leche de ganado bovino. Los resultados demuestran que, comparativamente, la producción de leche se concentra en extensiones entre 0,5 y 1 hectárea, siendo la provincia de Tungurahua en donde existe una mayor distribución del tamaño de las explotaciones; sin embargo, la provincia de Chimborazo mantiene un rango de ingresos familiares superiores a las otras dos provincias. Se concluye que los incentivos sobre factores que mejoren la modernización de las explotaciones pueden incidir directamente en los ingresos familiares que no superan el 40% la remuneración básica mensual del Ecuador.

**Palabras clave:** Producción lechera, economía familiar, Tungurahua, caracterización agricultura familiar.

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#### Abstract

The agrarian structure in Ecuador has an unequal access to land. The growth of livestock production within small and medium farms has been constant in recent years, as well as the feminization of the agriculture. In the Sierra of Ecuador, these processes can be observed with more detail, especially in provinces located in the Sierra center. This has motivated to analyze the dynamics of the small producers of the provinces of Chimborazo, Cotopaxi and

Tungurahua. This work shows the results of a survey that allows to analyze, from a sample of 793 farmers, the socio-productive characteristics of the bovine milk farms. Results show that, comparatively, milk production is concentrated in extensions between 0.5 and 1 hectares, being the province of Tungurahua the one with more size distribution of the farms; however, the province of Chimborazo maintains a higher range of family income than the other two provinces. Finally, it is concluded that incentives on factors that improve the modernization of farms can affect family income that does not exceed 40% of the basic monthly remuneration.

**Keywords:** Milk production, family income, Tungurahua, household-farming characterization

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# 1 Introducción

Agriculture is an important area in the economies of countries. In many cases, livestock production is more important than agriculture, providing milk and meat with high-demand in the population. According to Steinfeld and Chilonida (2006), since the 1990s the consumption of beef and cow milk has increased as the incomes of the middle class in developing countries have increased. Producing countries such as China, India and Brazil account for 65% of meat production and 52% of milk production worldwide. It is estimated that by 2024, developing countries will expand their supply by about 80% of the world market (OECD-FAO, 2015). As for Latin America, Brazil and Argentina are at the forefront of livestock supply, while Colombia owns 58% (5.8 million cows) of livestock production (Ormel, 2013). On the other hand, Ecuador in 2016 registered about 4.1 million head of cattle above countries such as Peru or Bolivia (Corporación Financiera Nacional, 2017).

Milk production in Ecuador is concentrated in the province of Pichincha with more than 845 000 liters/year (2016); the province of Azuay is in the second place with 561 000 liters/year, and Cotopaxi in the third with approximately 484 000 liters/year. Ecuador's Sierra Andean encompasses the largest amount of milk production domestically, equivalent to 64% of production, while the Costa region occupies 30%, and the Eastern region maintains 6% (INEC, 2016). According to the National Institute of Statistics and Census (INEC, 2016), 73% of milk produced (3.86 million liters) is marketed. During this period, dairy sales totaled USD 23 million, without considering export revenues.

Dairy production maintains a defined structure in each region in Ecuador. For example, in the Sierra, production units have a size of three hectares on average (Requelme and Bonifaz, 2012). However, three production levels are identified between 1-5 ha, 7-20, and between 20-120 hectares. In addition, Requelme and Bonifaz (2012) mention that the average milk production in the first level (1-5 ha) is 4.7 liters/cow/day. For this reason, the aim of this research is to analyze the dynamics of the small milk producers of three provinces that make up the Central Sierra of Ecuador: Cotopaxi, Tungurahua and Chimborazo, through a study comprising 793 surveys carried out to small producers in order to know the socio-productive dynamics, starting from the need to deepen on the studies that analyze small milk farms, income and distribution of the herd in the center Sierra.

## 1.1 Literature review

Agriculture is one of the sectors that generates employment, especially in developing countries. In many cases,

this happens due to the lack of technology of the production units, which requires more labor, both wage-earners and family (Sumpshi, 2010). Therefore, agriculture is a source of income, if not the only one, of peasant families. In Latin America, two production systems are identified: agro-export extensive agriculture, and intensive agriculture or family farming. This division is marked by unequal access to production factors such as: land, irrigation, credit or information, limiting the capacity of farmers, as well as their economic development (Franco-Crespo and Sumpshi Viñas, 2017).

Family farming is credited with 65% of food that reaches local markets. However, reluctance to risk has enabled the adaptation of production systems to earn short-term household income through diversification of family production. On the one hand, the production of vegetables has become a source of income in a short production cycle. Family farms of milk production by women have also been established, generating weekly income (Glikman, 1991).

FAO (2013) concludes that economic processes at the territorial level have led to a high concentration of the feminization of agriculture. In this sense, the role of women in agricultural activities is increasingly leading given the need for men to carry out wage activities in the city. In particular, small producers have found in milk production an alternative to earn cash on a weekly basis, as well as establishing a system of insurance and resilience to the risk that can address economic emergencies in the family nucleus through livestock holdings (Mena-Vásconez et al., 2016).

Family farming has an important role in the agricultural structure of Ecuador and other South American countries. The subdivision of the land, as well as the limitations generated by the market failures faced by this group of farmers, causes family farming to be in an environment of inequality in access to resources. As such, family farming is concentrated in extensions of between 1 and 5 hectares (ha), with a majority contribution to the use of family-type labor for agricultural tasks (Schejtman, 2008).

In the case of Ecuador, around 377 434 production units with 1 to 20 hectares are registered by 2013, i.e., 89% of production units, categorized as smallholder farmers, hold about 55% of the total agricultural area available (MAGAP, 2016). If the group of smallholder farmers who own between 1 and 5 hectares is detailed, it is observed that 69% of producers are concentrated with only 5,7% of land tenure (MAGAP, 2016) (Table 1).

In Table 1, a comparison of milk production can be seen between the provinces of Cotopaxi, Tungurahua and

Chimborazo. The comparison between 2015 and 2017 demonstrates instability in the production in the three provinces. In addition, in terms of the yield measured in the number of liters (l) and the Adult Bovine Unit (UBA), it is observed that the province of Tungurahua has a higher yield (8.71 l/UBA), Cotopaxi is in the second place (8.05 l/UBA) and Chimborazo has the lowest yield (6.65 l/UBA).

Limited access to land is the main feature of small agriculture, the same one that is concentrated in the central Sierra of Ecuador. Thus, labor use and the presence of market failures influence the behavior of farmers (Wiggins et al., 2010; Mumba et al., 2011; Louhichi and Paloma, 2014), especially their productive and economic dynamics of milk production in small producers (De Janvry and Sadoulet, 2006; Grisa and Schneider, 2008; Murphy et al., 2014).

**Table 1.** Description of the characteristics of dairy production in the Central Sierra area of Ecuador between 2015 and 2017.

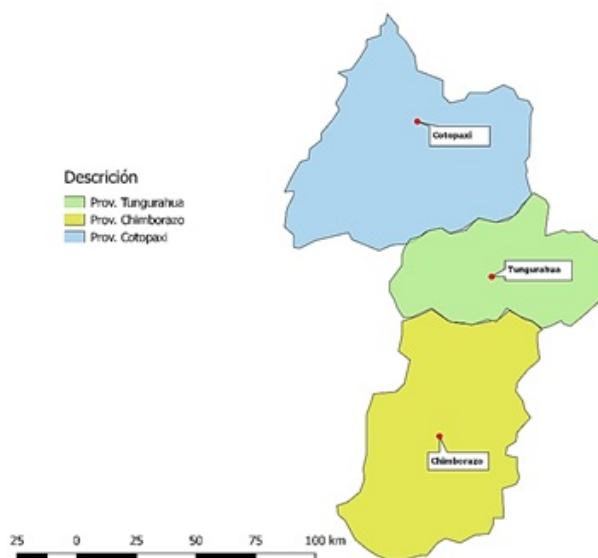
Year	Description	Provinces					
		Cotopaxi		Tungurahua		Chimborazo	
		Quantity	Variation( %)	Quantity	Variation( %)	Quantity	Variation( %)
2016	Positioning of National Milk Production*	7.00 %		6.00 %		7.00 %	
2015	Raw milk production (liters)	529 614		330 239		405 036	
2016		483 699	-9	355 679	8	458 181	13
2017		514 759	6	297 060	-16	431 325	-6
2015	Number of cattle	234 615		120 199		208 509	
2016		221 960	-5	126 754	5	228 500	10
2017		254 709	15	108 133	-15	222 316	-3
2015	Number of cows	65 673		39 505		59 990	
2016		61 179	-7	40 470	2	72 524	21
2017	milked	63 932	4	34 103	-16	64 846	-11

\* National Index

Source: (INEC, 2016; MAGAP, 2016)

On the other hand, studies related to the description of the characteristics of small milk producers focus on an analysis of socio-economic variables that considers the province as the structure in which the dynamics of exchange between rural producers and the cities take place (Escobar and Berdegué, 1990; Tobar, 2010). Thus Landín, in Escobar and Berdegué (1990), proposes the characterization of dairy producers in Ecuador from previous studies (Barsky, 1984; ILDES, 1988). There is a greater presence of medium (>10 ha) and large (>50) holdings in farms between 2300 and 2800 masl (Larrea et al., 2008); meanwhile, holdings with less than 5 ha area located in areas with irrigation problems, between 2900 and 3500 masl (Bretón, 2012).

In Ecuador, a group of renter producers who do not participate in improvement processes and technological innovation is identified; on the other hand, there are other groups of producers where the level of income is in direct proportion to the capacity of technological investment (Barragán, 2010). Then, in the provinces of Cotopaxi, Tungurahua and Chimborazo the role of agriculture, particularly of milk production, can be observed in the family agricultural production units (Chiriboga, 2003). Because of their structure, these provinces have characteristics of family farming participation, in addition to farms that have wage labor. This determines that agriculture becomes a source of family income (Louhichi and Paloma, 2014).



**Figure 1.** Identification of the provinces participating in the study between June and October 2018.

## 2 Materials and Methods

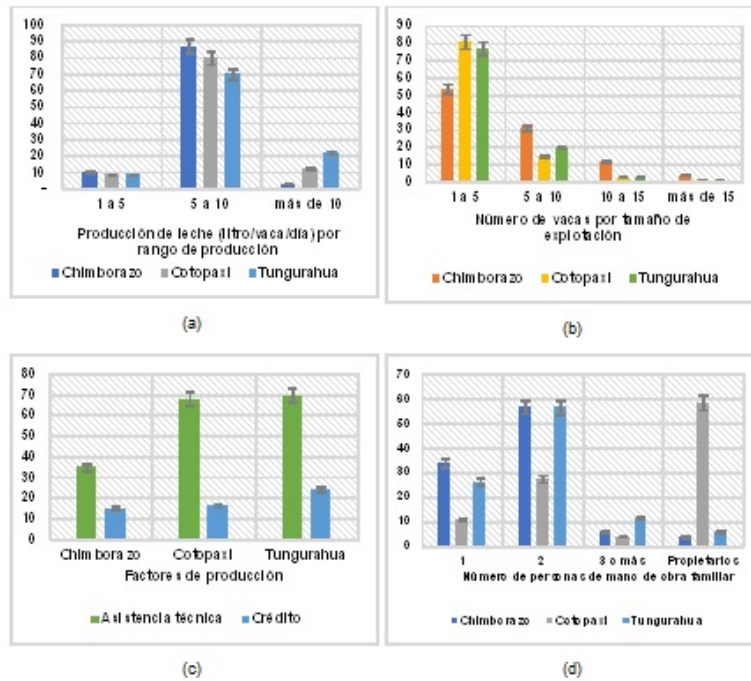
This study is based on three provinces of the central Sierra of Ecuador: Cotopaxi, Tungurahua and Chimborazo. The purpose of this research is to know the characteristics of small milk production farms between provinces. To meet this objective, a sample was established based on information from the Ministry of Agriculture and Livestock (MAG) for the databases of raw milk producers in the three provinces in 2017. The classification conditions according to Landín in Escobar and Berdegúe (1990) were also analyzed.

The information instrument was applied according to the randomized sample. The components of the survey were fixed on the collection of information about the socio-economic situation of producers, as well as their relationship to production factors and market access. The formula used (Mantilla, 2015) for the calculation of the sample is indicated in Equation 1. Where  $n$  = the sample,  $Z$  = is the deviation from the mean value accepted to achieve the desired confidence level (95%),  $p$  = proportion of the population, and  $e$  = is the accepted margin of error (3%).

$$n = \frac{Z^2 p(1-p)}{e^2} \quad (1)$$

The survey was applied between June and October 2018. A total of 793 surveys were collected. In this regard, the simple random sampling formula was applied to a population of 28 270 producers of Cotopaxi (Salcedo, Latacunga), Tungurahua (Pelileo, Píllaro), Chimborazo (Riobamba, Chunchi and Guamote). Surveys conducted by province are 366 in Cotopaxi, 321 in Tungurahua and 106 in Chimborazo.

The survey form had as pilot in the year 2015 the application in San Andrés parish, canton Píllaro, Tungurahua province. The structure of the instrument referred to the Living Conditions Survey, developed by INEC in 2015. The information and evidence are in the archives of the Project 'The milk and productivity production chain of Cotopaxi, Latacunga canton.' and 'Productive chain of the dairy sector in the province of Tungurahua, canton Píllaro'. Producer records were codified according to each province, and verification questions were asked in the production and revenue cases for more accuracy of the results obtained. For the validation of the questionnaire, a pilot was applied with a total sample of 10 producers per canton with a total of 140, once the pilot test adjustments were made to the instrument applied. In this way, 8 blocks of questions were raised.



**Figure 2.** Summary of data from the sample of the provinces of Chimborazo, Cotopaxi and Tungurahua, (a) Milk production by production range, (b) Number of cows by operating size, (c) Production factors accessed by producers, and (d) Number of family workforce.

The survey was conducted in the parishes of the three provinces. The questionnaire collected the information based on a group of variables and indicators. For the correlation validation of the instrument, tabulated results were analyzed by the application of Cronbach's Alpha, and Cotopaxi (0,561), Chimborazo (0,686) and Tungurahua (0,657) were observed. Excel was used for the statistical processing, as well as for obtaining correlations by establishing comparative graphs, simple correlations, and a measurement analysis of variation and overall quadratic value, respectively. The variables correspond to the production factors, as well as parameters related to technology, such as pastures and livestock breed, relative to

the improvement of productivity. The analyses presented select the relationships that show a level of significance less than 0.05 with a confidence level of 95%, which allows an inference to the entire population. In Table 2 is the descriptive results of the milk producers in the three provinces.

Table 3 presents the descriptive statistic of the sample, considering the variables studied in this work. This table shows the statistical values that indicate the data distribution for the total data obtained by surveys in the three provinces.

### 3 Results and Discussion

The study identifies that 92,01 % of producers in Cotopaxi with up to 1 hectare own between 1 and 10 bovine units in production. In Tungurahua province, 86,36% own between 1 and 5 bovine units. Also, in Chimborazo province, 82,64% are in the same range of bovine units. In general, farms are identified by land size given in three categories: (1) 0.1 to 0.5 ha, (2) more than 0.5 to 1 ha, and (3) more than 10 hectares. Table 2 shows the production system, available resources (number of cows, cultivated area, irrigation and labor) and other production factors (cre-

dit and technical assistance), found among the producers. In addition, Table 4 provides a description of the socioeconomic factors of the population analyzed. It can be observed the composition by labor in the production unit, source of credit and technical assistance. In general, it is observed that the family workforce is more common compared to the hired labor, as well as the eventual workforce. As for technical assistance in Chimborazo, more than two-thirds report not receiving it, unlike Cotopaxi and Tungurahua. Also, the Cooperatives are the main source of funding in the three provinces.

**Table 2.** Descriptive statistics of the sample.

Statistics	Credit	Food Type (Balanced)	Food Type (Banana)	Family Workhand	Hired Labor	Eventually Hired Labor	Amount of Hectares Cropped With Grass	Quantity of Natural Hectares Of Grass	Irrigation	Area Irrigated	Access to Technical Assistance
Average	2563	1295	1842	1704	1176	1333	469	854	1081	2553	1359
Typical Error	78	20	16	29	128	142	29	30	10	30	17
Median	2000	1000	2000	2000	1000	1000	180	625	1000	3000	1000
Mode	2000	1000	2000	2000	1000	1000	90	350	1000	3000	1000
Standard deviation	903	456	365	694	529	492	527	666	273	834	480
Variance Sample	815	208	134	482	279	242	277	443	74	696	231
Kurtosis	-1032	-1188	1532	3593	9795	-1650	4874	3249	7533	-235	-1659
Assimetry Coefficient	921	904	-1878	1150	3136	812	2066	1957	3085	-1329	587
Rank	3000	1000	1000	5000	2000	1000	2960	3750	1000	2000	1000
Minimum	1000	1000	1000	1000	1000	1000	40	100	1000	1000	1000
Maximum	4000	2000	2000	6000	3000	2000	3000	3850	2000	3000	2000

**Table 3.** Characterization of farms by province, according to the information collected in 2018.

Factor	Description (ha)	Province					
		Chimborazo		Cotopaxi		Tungurahua	
		Frequency	Percentage (%)	Frequency	Percentage (%)	Frequency	Percentage (%)
Number of Cows	1 to 5	57	53.77	296	80.87	247	76.95
	5 to 10	33	31.13	55	15.03	63	19.63
	More than 10	16	15.09	15	4.1	11	3.42
	<b>Total</b>	<b>106</b>	<b>100</b>	<b>366</b>	<b>100</b>	<b>321</b>	<b>100</b>
Production (Liter/Cow/Day)	1 to 5	11	10.38	31	8.47	27	8.41
	5 to 10	92	86.79	291	79.51	224	69.78
	More than 10	3	2.83	44	12.02	70	21.81
	<b>Total</b>	<b>106</b>	<b>100</b>	<b>366</b>	<b>100</b>	<b>321</b>	<b>100</b>
Quantity of Hectares cultivated with grass	0.1 to 0.5	33	31.13	201	54.92	18	5.61
	0.5 to 1	-	-	46	12.57	40	12.46
	More than 1	-	-	16	4.37	8	2.49
	Does not have	73	68.87	103	28.14	255	79.44
<b>Total</b>	<b>106</b>	<b>100</b>	<b>366</b>	<b>100</b>	<b>321</b>	<b>100</b>	
Quantity of natural hectares of grass	0.1 to 0.5	49	46.23	28	7.65	45	14.02
	0.5 to 1	57	53.77	73	19.95	137	42.68
	More than 1	-	-	8	2.19	85	26.48
	Does not have	-	-	257	70.22	54	16.82
<b>Total</b>	<b>106</b>	<b>100</b>	<b>366</b>	<b>100</b>	<b>321</b>	<b>100</b>	
Has water to irrigate the land	Yes	106	100	347	94.81	276	85.98
	No	-	-	19	5.19	45	14.02
	<b>Total</b>	<b>106</b>	<b>100</b>	<b>366</b>	<b>100</b>	<b>321</b>	<b>100</b>
Irrigation source	Public	85	80.19	22	6.01	61	19.00
	Junta de Agua	21	19.81	344	93.99	218	67.91
	N/C	-	-	-	-	42	13.08
	<b>Total</b>	<b>106</b>	<b>100</b>	<b>366</b>	<b>100</b>	<b>321</b>	<b>100</b>

**Table 4.** Identification of socio-economic factors by province, according to the information collected in 2018.

Factor	Description	Chimborazo		Cotopaxi		Tungurahua	
		Frecuency	Percentage( %)	Frecuency	Percentage( %)	Frecuency	Percentage( %)
Quantity of family labor in the milk production	1	36	33.96	39	10.66	84	26.17
	2	60	56.60	100	27.32	181	56.39
	3 or more	6	5.66	14	3.83	37	11.53
	Owners	4	3.77	213	58.20	19	5.92
	<b>Total</b>	<b>106</b>	<b>100</b>	<b>366</b>	<b>100</b>	<b>321</b>	<b>100</b>
Quantity of hired labor in the milk production	1	4	3.77	2	0.55	9	2.80
	2	-	-	-	-	1	0.31
	3 or more	-	-	-	-	1	0.31
	Do not hire	102	96.23	364	99.45	310	96.57
	<b>Total</b>	<b>106</b>	<b>100</b>	<b>366</b>	<b>100</b>	<b>321</b>	<b>100</b>
Quantity of eventual hired labour in the milk production	1	-	-	3	0.82	5	1.56
	2	-	-	1	0.27	3	0.93
	3 or more	-	-	-	-	-	-
	Do not hire	106	100	362	98.91	313	97.51
	<b>Total</b>	<b>106</b>	<b>100</b>	<b>366</b>	<b>100</b>	<b>321</b>	<b>100</b>
Access to technical assistance	Yes	37	34.91	248.0	67.76	223	69.47
	No	69	65.09	118.0	32.24	98	30.53
	<b>Total</b>	<b>106</b>	<b>100</b>	<b>366</b>	<b>100</b>	<b>321</b>	<b>100</b>
Financing sources of the activities	Own	90	84.91	306	83.61	243	75.70
	Credit	16	15.09	60	16.39	78	24.30
	<b>Total</b>	<b>106</b>	<b>100</b>	<b>366</b>	<b>100</b>	<b>321</b>	<b>100</b>
Source of credit	Suppliers	-	-	-	-	1	1.28
	Coop. de Ahorro y Crédito	11	68.75	47	78.33	47	60.26
	Financing	-	-	-	-	3	3.85
	Banks	1	6.25	12	-2	25	32.05
	Family	4	25.00	-	-	-	-
	Do not require	-	-	1	1.67	2	2.56
	<b>Total</b>	<b>16</b>	<b>100</b>	<b>60</b>	<b>100</b>	<b>78</b>	<b>100</b>

In summary, the figure above highlights that milk production maintains absolute frequencies between 5 and 10 l/UBA/day, being Chimborazo province the one with the highest production (Figure 2a). In the case of the number of cows per production unit, the absolute frequency is observed in 1 and 5 UBAs, with the largest quantity for the province of Cotopaxi (Figure 2b). In addition, it is noted that technical assistance is most commonly developed in the provinces of Tungurahua and Cotopaxi (Figure 2c). Finally, as regards the family workforce employed by production unit, Cotopaxi concentrates the largest number of direct owners working on the farm, while in Chimborazo and Tungurahua the average is two family members working in the farm (Figure 2d).

On the other hand, with regard to uncultivated pastures, the percentage has the same relationship. Thus, in Cotopaxi province, 87,16% of producers own between 1 and 10 bovine units in production. In Chimborazo province, 96,97% of producers are in the same range; however, in Tungurahua province only 67,79% of the interviewed are in this range. As regards the variation between bovine units and size of production units, Figure 3a shows the concentration of bovine units between production units

not exceeding 1 ha, especially those between 0.5 and 1 ha. Compared to Figure 3b, there is a dispersion of bovine unit tenure between units of smaller size at 0.5 ha up to 1 ha. (Figure 3).

Meanwhile, Figure 3c shows that the distribution of the number of bovine species is distributed among the production units of 0.5 ha and 3 ha. However, the largest number is between 0.5 and 1 ha. The comparative analysis mentions that Cotopaxi maintains dairy farms with extensions of less than 0.5 ha. Moreover, in the Province of Chimborazo these milk production farms are located between 0.5 and 1 ha. By contrast, milk production farms in Tungurahua province have a wider range, although the concentration between 0.5 and 1 ha persists.

When analyzing this comparison between larger farms (more than 101 cases analyzed), in Tungurahua farms that have a larger size tend to be more efficient compared to those located in Cotopaxi province. If these results are analyzed with the description presented in Figure 2c and Figure 2d, technical assistance is higher in the provinces of Tungurahua and Cotopaxi. However, the greatest amount of family labor occurs in Chimborazo



province.

Figure 4 shows the results of direct revenue from consolidated milk production for the three provinces. By comparison, the number of UBAs in the three ranges considered (1-5, 6-10 and 11-20) poses a productivity condition based on the amount of income earned from the sale of milk. Farms with between 1 and 5 cows earn income under USD 386.00 per month. On the other hand,

herds between 6 and 10 cows obtain incomes between USD 386/month and USD 900/month. Lastly, there are farms with more than 11 bovine units that generate more than USD 900/month. As a particular case, Tungurahua presents in the range of 1-5 UBAs income of more than \$900. On the other hand, Cotopaxi presents in the range 6-10 UBAs the same level of income, while Chimborazo is the province with the lowest number of UBAs in this income range

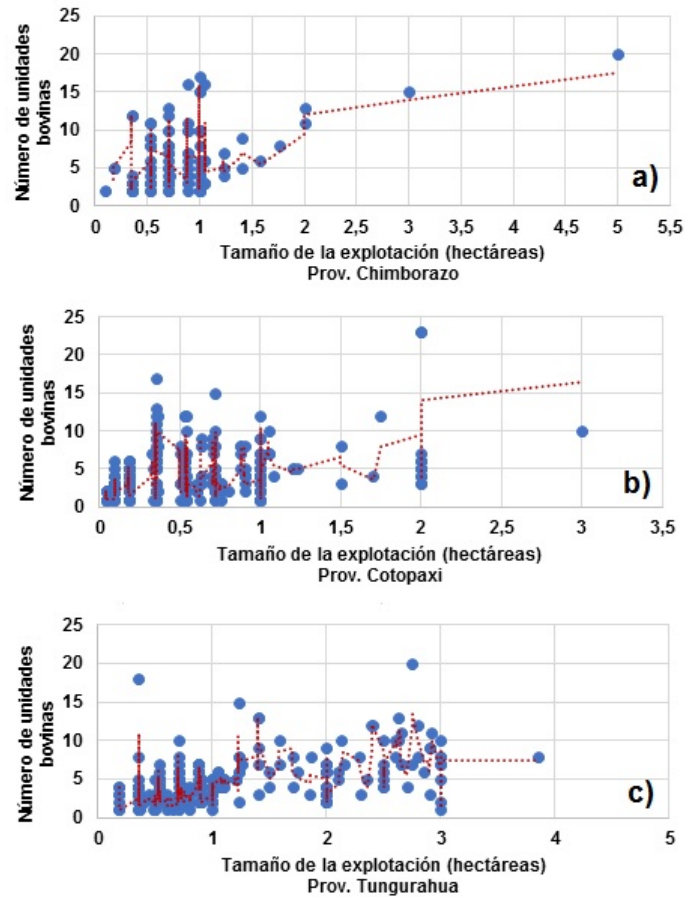


Figure 3. Ratio of the number of bovine units per farm size per province (a) Bovine Units in Chimborazo Province, (b) Bovine Units in the Cotopaxi Province, and (c) Bovine Units in the Tungurahua.

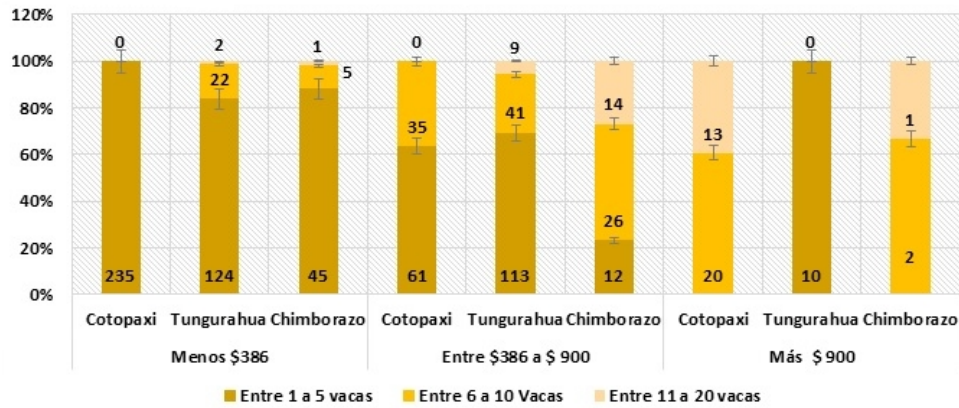


Figure 4. Range of bovine units and income level from milk sales by province.

In relation to the comparative income generated by farms according to their province, those in Chimborazo have an income of between USD 300/month and USD 800/month on farms over 0.5 ha and 1 ha. Farms of more than 1 have generated higher incomes in the same province, but the number of cases is lower. Furthermore, it should be noted that farms of more than 1 ha of Cotopaxi and Tungurahua maintain a constant in the generation of income (less bovine units in production) between USD 100 and 200/month (Figure 5).

Family income from milk sales is highest in Chimborazo province at USD 485/month. In second place, Tungurahua province maintains farms that allow household income of more than USD 360/month. By contrast, farms located in Cotopaxi province generate just over half of the income earned in the first case, with family income being more than USD 260/month (Figure 6).

In this case, the variables that influence a better yield of the livestock herd are those that have led to the modernization of the farms, i.e., it is assumed that farms that maintain these innovation characteristics will have the capacity to produce income, even if they correspond to small size extensions (0.5 to 1 ha) or have fewer bovine units (1 to 5 cows). The results obtained show that the province of Chimborazo has a higher yield compared to Cotopaxi and Tungurahua. While the results proposed by INEC for 2015 indicate that the province of Chimborazo maintains, comparatively with the other two provinces, a lower yield (6.65 l/UBA); also the revenue analyzed by families by concept of milk production and sales (up to five bovine units equivalent to 42,25%), achieve less than a unified wage (USD394). When comparing household income by province, Cotopaxi Province shows that the farms analyzed receive less than USD260/month.

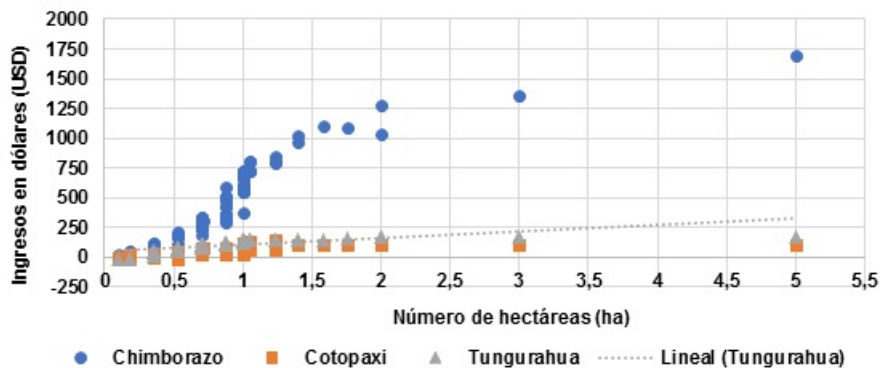


Figure 5. Comparative income per province.

Furthermore, Table 5 presents the correlation results of the variables determined at the beginning of the application of the instrument. These significant correlations correspond to those factors that relate to the innovation of livestock production farms in the three provinces. Factors related to cultivated pasture surface, genetic improvement, complementary food, technical assistance and technical facilities appear as significant.

**Table 5.** Results of the correlation analysis for the proposed variables of the sample in each province.

	Has Cultivated Grass	Cattle Breed Hobstein	Cattle Breed Bown Swiss	Mixed Breed Cattle	Jersey Breed Cattle	Food Type (Grass)	Food Type (Balanced)	Food Type (Banana)	Training Assistance	Access to Technical Assistance	Dairy Breed Improvement	Information to Technological Improvements	Installation modernization	Food Improvements	Number of cows	Milking Type
<b>TUNGURAHUA PRODUCTION (HERD/MONTH)</b>	Pearson Correlation Sig. (bilateral) N	.644** 0 66	.856** 0 201	.b - 1	.149* -.0334 -.205	0.09 0.655 .27	-.156** 0.005 -.321	-.402** 0 -.321	-.083 0.139 -.321	-.388** 0 -.321	-.124* 0.026 -.321	.189** 0.001 -.321	.155** 0.006 -.321	0.038 0.501 -.321	.911** 0 -.321	.447** 0 -.321
<b>CHIMBORAZO PRODUCTION (HERD/MONTH)</b>	Pearson Correlation Sig. (bilateral) N	.547** 0 104	.745** 0 49	-.b - 0	.614** 0 0.81	0.761 0.239 0.4	-.212* 0.029 0.106	-.b - 0	-.b - 0	-.b - 0	-.b - 0	-.b - 0	-.b - 0	-.b - 0	.965** 0 106	.390** 0 106
<b>COTOPAXI PRODUCTION (HERD/MONTH)</b>	Pearson Correlation Sig. (bilateral) N	.481** 0 282	.767** 0 77	-.0409 0.42 6	.666** 0 0.338	0.421 0.104 0.16	-.034 0.656 0.364	.216** 0 176	-.009 0.998 0.176	0.024 0.748 0.176	0.022 0.768 0.176	-.049 0.52 0.176	-.159* 0.035 0.176	-.019 0.806 0.176	.950** 0 364	.363** 0 364

\*\* The correlation is significant at 0.01 (bilateral).

\* The correlation is significant at 0.05 (bilateral).

c. It cannot be calculated, because at least one of the variables is constant.

By applying the measurement variation analysis along to the data obtained in the three provinces (Cotopaxi, Tungurahua and Chimborazo), significant differences are found between them, for which a post-hoc test (Tukey) is applied, in order to identify the province with more differences from the others, depending on the most

significant variables (Table 6). Table 6 presents the results of the variation measurement analysis between the group of variables identified with significant correlation, so that they are used to perform Tukey post-hoc that are presented in the following tables.

**Table 6.** Result of the variation measure and quadratic value for the three provinces.

Description		Sum of Squares	gl	Quadratic Mean	F	Sig.
Type of Livestock Feed (Banana)	Among groups	10.791	1	10.791	95.985	.000
	Inside groups	55.651	495	.112		
	Total	66.443	496			
Number of cows per herd	Among groups	528.929	2	264.465	28.875	.000
	Inside groups	7217.336	788	9.159		
	Total	7746.265	790			
Production (Herd/mounth)	Among groups	40645527.511	2	20322763.756	24.544	.000
	Inside groups	652466338.734	788	828002.968		
	Total	693111866.245	790			
Quantity of cultivated hectares of Grass	Among groups	13.419	2	6.709	25.760	.000
	Inside groups	111.738	429	.260		
	Total	125.157	431			
Quantity of natural hectares of Grass	Among groups	23.419	2	11.709	26.975	.000
	Inside groups	175.799	405	.434		
	Total	199.217	407			
Quantity of livestock Holstein breed	Among groups	169.186	2	84.593	9810	.000
	Inside groups	2794.031	324	8.624		
	Total	2963.217	326			
Quantity of livestock mixed/ creole	Among groups	571.364	2	285.682	74.019	.000
	Inside groups	2389.073	619	3.860		
	Total	2960.437	621			
Access to technical assistance	Among groups	10.474	2	5.237	24.055	.000
	Inside groups	171.559	788	.218		
	Total	182.033	790			
Modification of herd facilities	Among groups	5.723	1	5.723	26.857	.000
	Inside groups	105.488	495	.213		
	Total	111.211	496			

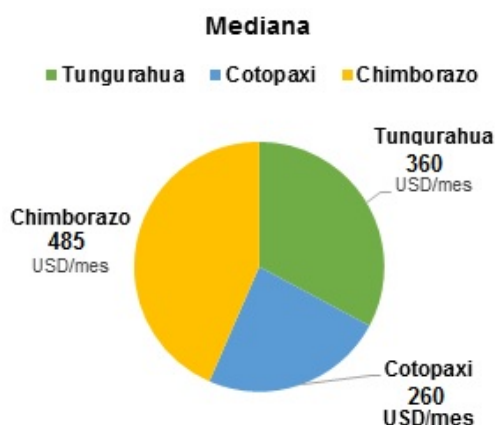
Table 7 shows that the province with the greatest differences from the number of cows per herd is Chimborazo. The average number of cows per herd in Chimborazo corresponds to 6, higher than the average of Tungurahua and Cotopaxi, both with an average of 4.

Moreover, in Table 8 the comparative results show that the province with the greatest differences in the variable number of hectares cultivated of grass is Cotopaxi. The average of Cotopaxi is 0.39 hectares of cultivated pasture, lower than in the provinces of Chimborazo (0.74 ha) and Tungurahua (0.76 ha).

**Table 7.** Results of the correlation analysis by number of cows per herd.

Multiple comparisons				
Dependent variable: HSD Tukey				
(I) Provinces		Mean differences (I-J)	Standar erros	Sig.
TUNGURAHUA	COTOPAXI	.,665*	0.232	0.012
	CHIMBORAZO	-1.869*	0.339	0
COTOPAXI	TUNGURAHUA	-.665*	0.232	0.012
	CHIMBORAZO	-2.534*	0.334	0
CHIMBORAZO	TUNGURAHUA	1.869*	0.339	0
	COTOPAXI	2.534*	0.334	0

\*. The mean difference is significant at 0.05 level.



**Figure 6.** Family income of dairy production by province.

In Table 9 the province of Tungurahua exhibits greater differences in the variable natural hectares of pasture. The province of Tungurahua has the largest area of natural pastures with an average of 1.10 ha, compared to Cotopaxi (0.65) and Chimborazo (0.45 ha).

Table 10 shows that the province of Cotopaxi reflects the largest differences from Holstein cattle with an ave-

rage of 3 cows (Holstein) per herd, lower than Tungurahua (5) and Chimborazo (4). Finally, Chimborazo province has the biggest differences in technical assistance. Sixty-five percent of respondents in Chimborazo say they have not received technical assistance, i.e., only 35% have. Moreover, 68% in Cotopaxi and 69% in Tungurahua indicate that they received technical assistance (Table 11).

### 3.1 Discusión de los resultados

The results obtained in this research show that there are parameters that increase the capacity of small dairy farmers. Considering the inequitable access to production factors, in particular the size of the holdings (1 ->10 ha) this is a limitation by the availability of pastures for food of the UBAs. In this sense, a concentration of the number of cows in the range of 1-5 UBAs in the three provinces is observed, highlighted Cotopaxi province by having

the highest value (80,87%). In addition, on average the amount of milk produced per day in the herd is higher for the range between 5-10 UBAs. Also, the employment of family labor predominates.

Differences observed at the level of the three provinces identify that the province of Tungurahua maintains a higher participation level of (a) technical assistance and (b) credit for producers, while Cotopaxi is in the second place and Chimborazo in the last. In this regard, the size

**Table 8.** Results of correlation analysis by number of hectares of pasture grown.

<b>Multiple comparisons</b>				
Dependent variable: HSD Tukey				
(I) Provinces		Mean differences (I-J)	Standar error	Sig.
TUNGURAHUA	COTOPAXI	.37435*	0.07029	0
	CHIMBORAZO	0.02267	0.08032	0.957
COTOPAXI	TUNGURAHUA	-.37435*	0.07029	0
	CHIMBORAZO	-.35168*	0.05915	0
CHIMBORAZO	TUNGURAHUA	-0.02267	0.08032	0.957
	COTOPAXI	.35168*	0.05915	0

\*. The mean difference is significant at 0.05 level.

**Table 9.** Results of correlation analysis by number of hectares of natural pastures.

<b>Multiple comparisons</b>				
Dependent variable: HSD Tukey				
(I) Provinces		Mean differences (I-J)	Standar error	Sig.
TUNGURAHUA	COTOPAXI	.44687*	0.07513	0
	CHIMBORAZO	.64429*	0.12157	0
COTOPAXI	TUNGURAHUA	-.44687*	0.07513	0
	CHIMBORAZO	0.19742	0.13105	0.289
CHIMBORAZO	TUNGURAHUA	-.64429*	0.12157	0
	COTOPAXI	-0.19742	0.13105	0.289

\*. The mean difference is significant at 0.05 level.

**Table 10.** Results of correlation analysis in the three provinces by quantity of Holstein cattle.

<b>Multiple comparisons</b>				
Dependent variable: HSD Tukey				
(I) Provinces		Mean differences (I-J)	Standar error	Sig.
TUNGURAHUA	COTOPAXI	1.439*	0.394	0.001
	CHIMBORAZO	-0.739	0.468	0.256
COTOPAXI	TUNGURAHUA	-1.439*	0.394	0.001
	CHIMBORAZO	-2,178*	0.537	0
CHIMBORAZO	TUNGURAHUA	0.739	0.468	0.256
	COTOPAXI	2.178*	0.537	0

\*. The mean difference is significant at 0.05 level.

**Table 11.** Results of correlation analysis for the three provinces for accessing to technical assistance.

Multiple comparisons				
Dependent variable: HSD Tukey				
(I) Provinces		Mean differences (I-J)	Standar error	Sig.
TUNGURAHUA	COTOPAXI	-0.016	0.036	0.894
	CHIMBORAZO	-.346*	0.052	0
COTOPAXI	TUNGURAHUA	0.016	0.036	0.894
	CHIMBORAZO	-.330*	0.051	0
CHIMBORAZO	TUNGURAHUA	.346*	0.052	0
	COTOPAXI	.330*	0.051	0

\*. The mean difference is significant at 0.05 level.

of farms per province varies in terms of their extent. In other words, in the province of Chimborazo, there is a concentration 0.5-1 ha, Cotopaxi varies between 0.1 and 1 ha, however, in Tungurahua this concentration expands in the range of 0.5 and 3 ha. In this way, it is generally observed that the ranges of about 1 ha can reach incomes of between USD 250 and 500/unit. However, the provinces of Cotopaxi and Tungurahua are those with the lowest threshold of revenue received.

On the other hand, the variables that have a significant correlation are: herd size, milking type, modernization of facilities, breed of livestock and type of feed. In particular, this condition is maintained in the three provinces. In other words, policies aimed at improving the capacities of family farms that incentivize these factors can increase farmers' incomes, as well as the quality of life of families

## 4 Conclusions

The purpose of the research was to analyze the dynamics of small milk producers in three provinces that make up the central Sierra of Ecuador: Cotopaxi, Tungurahua and Chimborazo, through a study comprising 793 surveys of small producers. The results achieved in this study describe the conditions of family farming, specifically milk production. The typology identified from the methodology allows to recognize extension lands between 1 and more than 10 hectares, such as the farms that predominate in the sample analyzed. In this sense, there are differences in the production capacities by province. In other words, in the case of Tungurahua, there are better conditions for developing a small-scale dairy production, considering limitations on land access, technology and production factors.

Access to resources related to the modernization and innovation of herds represents an important factor with

a positive impact on the production and generation of household income. Therefore, those farms where the modernization (technology, food and livestock breed) has been incorporated favor the improvement of their productivity.

Finally, it is concluded that public policy over the past few years, where resources were introduced for the development of agriculture, does not present evidence of improved resource access in the characteristics for small producers, impacting the amount of family income received, i.e., income levels remain below minimum wage at the household level, even though there are attempts so the performance exceeds the national average. In addition, limitations on sub-units and the establishment of livestock 'micro-herds' that provide income to the families of producers continue, with limitations that frame it as subsistence production units.

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