Dynamic classification of the dairy cooperative sectors in the Ciego de Avila province, Cuba

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The productive records of each cooperative sector in all the municipalities, from 2002 to 2009, were obtained for classifying dynamically each cooperative sector of the Ciego de Avila province, Cuba. The methods of principal components (PC) and clusters were combined to classify the cooperative sectors. The amount of animals, total milk yield, births and deaths, explaining between 51.3 and 65.7 % of the total variance, were included in the first PC. Four groups of cooperative sectors were obtained for the years classified. In 2009, group 1 only included the cooperative sectors where producers work together: no land owners (C1) and land owners with only 107207 L a year (C2). Groups 2, 3 and 4 included 60, 83.3 and 100 % of the cooperative sectors, respectively. In them, the producers owned the land, worked individually and (C3) had higher milk yield. Group 4 was outstanding with 1 833 500 L. It is concluded that, in time, the cooperative sectors C3 separated from C1 and C2. Those groups where the cooperative sectors C1 and C2 predominated had lower amount of animals and milk yield. However, when the percentage of the cooperative sectors C3 increased in the groups, the results were superior, indicating the productive potentialities of the latter.

Key words: *milk yield, multivariate analysis, cooperative production.*

The study and integral analysis of the productive systems, specifically the agricultural, have been conducted in regions like Argentina (Castaldo *et al*. 2003), where one-year productive cycles have been analyzed, as well as the most important variables in the fattening periods. In Venezuela, Páez *et al*. (2003) conducted the physico-productive characterization of dual-purpose cattle systems and proposed analysis methods in cattle rearing systems (Valerio *et al*. 2004), including characterization, classification and assessment of cases for validating technological propositions. Recent studies have used the cattle unit as productive scale, but the variation in time of the productive elements is not known. However, researches of Acosta (2008), conducted at larger scale at cooperative level included different units, where the environmental effect of cattle rearing was determined, although the classification of the cooperatives was not carried out dynamically.

At present, dynamic studies are required, at larger scale, involving the results and the performance of many milk producing units for several years. Decision making and the elaboration of productive improvement strategies depend on the results, in a way that they contribute to sustainable management and development in certain geographical areas. Besides, it is needed the application of statistical methods of analysis that permit determining the indicators of greatest importance and variability, and grouping them depending on the productive effect. This research has as object to classify, in a dynamic form, the cooperative milk producing sectors in the Ciego de Avila province, Cuba.

Materials and Methods

Out of the cattle productive information recorded by the Ministry of Agriculture (MINAGRI), a database was created monthly with the ten municipalities of the province and per type of cooperative sector. The records were from 2002 to 2009.

The three cooperative sectors represented in the ten municipalities were: C1) cooperatives where farmers are not land owners and work in association (Basic Units of Cooperative Production) (UBPC), C2) cooperatives where farmers are land owners and work in association (Cooperatives of Agricultural Production) and C3) cooperatives where farmers are land owners and work individually (Cooperatives of Credits and Services).

Out of the monthly database, an annual one was established, calculating the averages for the variables: existence of the herd, breeders and milking cows. The sum of the variables was performed: births, total deaths and milk yield. Later, the secondary variables were generated: annual milk liters produced per total of cows, annual milk liters produced per milking cows, and percentage of birth rate in each cooperative for each municipality.

The multivariate statistical model was applied to measure the impact (Torres *et al*. 2006) and it

was tested through the methodology of Torres *et al*. (2008). Among the variables under study each year, the descriptive statistics and the correlations of Pearson were determined. The analysis of principal components for each year was used in an iterated form, with the object of selecting the indicators that contributed the most to the differences between the cooperative sectors.

The principal components (PC) having Eigen value superior to 1, and the variables of importance that showed weighed factors superior to 0.75 were determined. With the variables of greatest variability, the clustering of the cooperative sectors of the municipalities was performed for 2003, 2005, 2007, and 2009, by being considered representative of the changes in the period under study. The method of hierarchical clusters was used for the classification. The clusters formed for each year were described by their means and standard deviations. All the methods were processed through the SPSS software on Windows, version 11.5.1 (Visauta 1998)

Results and Discussion

The variables that accounted for the first principal component (PC1) (table 1) were kept similar for all the years: existence of the herd, amount of breeders, annual births, annual deaths, milk yield, and average of milking cow. They changed the order of importance according to the weighed factor. The PC1 accounted for more than 50 % of the variability for all the years, and reached up to 65.73 % for 2009. This result indicated high level of heterogeneity between the cooperative sectors for the variables of the PC1 that can be used as criterion for the classification.

Other studies in cattle units (Páez *et al*. 2003 and Torres *et al*. 2008) have not managed to account for a high percentage of the variability in the first component, but including other variables: economic, type of feeding and technological. However, Benítez *et al*. (2008) managed to explain 58 % of the variability in the first PC, and with only two PCs explained 73.9 % of the variance, which was related to the cattle exploitation efficiency in farms of the mountainous area of Granma, Cuba. In order to present the differences between farms, these authors determined as of greatest importance the variables defining the dimensions, those related to the management system or technological alternatives and the land slope.

In 2002 and 2003, the variable of greatest weighed factor of this component (PC1) was the amount of breeders, whereas the deaths, milk yield, and average amount of milking cows, per cooperative sector of the municipalities, were of lower weight, but in the same order for both years. In 2004, the births, the existence of the herd, and the breeders had higher factorial charges. In 2005, the milking cows and the milk yield had greater importance within this component. This proves

Table 1. Variables included in the first principal component from 2002 to 2009

2002	2003	2004	2005	2006	2007	2008	2009
Amount of breeders	Amount of breeders	Annual births	Average of milking cows	Average of milking cows	Average of milking cows	Herd existence	Herd existence
Herd existence	Annual births	Herd existence	Milk yield	Annual deaths	Annual deaths	Amount of breeders	Amount of breeders
Annual births	Herd existence	Amount of breeders	Annual deaths	Herd existence	Herd existence	Annual births	Annual births
Annual deaths	Annual deaths	Average of milking cows	Amount of breeders	Milk yield	Milk yield	Milk yield	Average of milking cows
Milk yield	Milk yield	Milk yield	Herd existence	Annual births	Annual births	Average of milking cows	Milk yield
Average of milking cows	Average of milking cows	Annual deaths	Annual births	Amount of breeders	Amount of breeders	Annual deaths	Annual deaths
5.27	5.50	5.41	4.62	5.33	5.01	5.67	5.91
58.63	61.14	60.15	51.39	59.23	55.71	63.05	65.73

The values of the penultimate and last rows correspond to the Eigen value and the percentage of explained variance of the component, respectively

that in the cattle systems under study there are changes in time, thereby being needed to know the dynamics and performing systematic measures and fits to attain sustainable development (Senra 2005) and diagnosing systems that demand technology transference (Díaz 2008).

The amount of milking cows and the annual milk yield are two variables that have high and positive correlation, with value of 0.9. Besides, the explained that the total annual milk yield of these milk cooperative sectors depends in a high percentage on the annual average amount of milking cows. However, the correlation of the milk yield and the milk liters per total of cows and milking cows with the birth rate percentage was low.

Similar relations were obtained by Menéndez Buxadera *et al*. (2004), when studying the monthly milk controls in 19 dairy units during two years. These authors attained a positive relation between the increment in the percentage of milking cows, due to the favorable reproductive performance and the total production of the herd, which bring about high economic benefits.

In 2005, 2006, and 2007, the milking cows kept the first order of importance in the variables that marked the differences between the cooperative sectors. This proved the importance of this indicator as one of those determining the productive level of the cattle systems. The amount of annual deaths was highly correlated with amount of the herd and of breeders, as well as with the births. Nevertheless, it is necessary to find out the ratio between the born and the dead animals, to determine if there is growth in the herds in the different cooperative sectors.

The existence of the herd, the breeders, and the annual births occupied the first, second, and third rank in this component for 2008 and 2009. However, the amount of deaths was less important to account for the differences between the cooperative sectors. This could be related to the decline in mortality. The variables of this PC managed to account for more than 60 % of the variability for both years. These variance percentages were considered adequate (Pérez Infante *et al*. 1998 and Torres *et al*. 2008) in order to utilize these indicators as criterion to group the cooperative sectors. Thus, heterogeneous groups between themselves could be identified and their productive potentials could be determined, serving to decide the development and adoption of sustainable technologies in the dairy units (Solano *et al*. 2000, Macedo *et al*. 2003 and Valerio *et al*. 2004).

The PC2 (tabla 2) explained from 15.8 to 21.9 % of the variability. The year 2009 was outstanding, accounting for 87.6 % of the variability. The annual amount of milk yield per the total number of cows had importance of first order, since 2003 up to 2009. The PC1 and the PC 2 accounted for more than 70 % of the variability for all the years, results considered trustworthy (Guevara 2004 and Torres *et al*. 2008) for explaining the differences between the cooperative sectors of the province.

In the PC2, the annual production per the total amount of cows, occupied the greatest factorial charge since 2003. This outcome proved the importance of the biological efficiency, as element marking differences between the cooperative sectors. In this instance, the variable is also related to the reproductive efficiency of the herd, considering the total of cows incorporated to reproduction. The annual production per the total number of cows, as well as the amount of milk per milking cow and the birth rate percentage had low correlation (lower than 0.2) with the variables of the PC1. This explained that the fact that in these cattle systems the milk yield is determined, at a high percentage, by the number of animals under production.

The preceding statement also supported the fact that the dairy cooperative sectors of the province are more different rather by the amount of animals and their total milk production than by the amount of milk per the total of cows and per milking cows, as well as by the birth rate percentage. Therefore, it is required their classification to determine differences and similarities that characterize the existing high

Table 2. Variables included in the second principal component from 2002 to 2009

2002	2003	2004	2005	2006	2007	2008	2009
L per milking cows	L per total of cows	L per total of cows	L per total of cows	L per total of cows	L per total of cows	L per total of cows	L per total of cows
Birth rate percentage		L per milking cows				Birth rate percentage	Birth rate percentage
L per total of cows						L per milking cows	L per milking cows
2.00	1.43	1.86	1.83	1.33	1.61	1.65	1.97
22.29	15.89	20.71	20.42	14.81	17.99	18.37	21.94
80.93	77.03	80.86	71.81	74.05	73.71	81.43	87.68

The values of the antepenultimate, penultimate and last rows correspond to the Eigen value, the percentage of the explained variance of the component and to the percentage of the total explained variance of both components, respectively

degree of heterogeneity. These responses can be the consequence of not recording the measurements, the controls, and the systematic analyses demanded by the efficient and sustainable cattle production (Senra 2005).

The variables of the PC1 from each year were considered those of greatest importance to explain the differences between the milk production sectors corresponding to different municipalities in Ciego de Ávila. This analysis evidenced the need for studies using basic biological data at the level of the dairy unit, and involving indicators related to the feeding basis and the management system. This information will contribute to interpreting the productive results and to applying measures for guaranteeing the system sustainability.

The dairy cooperative sectors were classified into four groups, for the four years selected (table 3). In 2003 (table 3) the cooperatives C1 type from group 4 were noteworthy, they belonged to the Ciego de Ávila municipality. They had the highest values, as to the amount of milking cows, total annual milk yield and milk liters per total of cows. In the group 3, the cooperative sectors of the type C3 from four municipalities were located, having more than 800000 L of milk per year, lower amount than the group 4, but higher than 1 and 2. The latter involved larger number of cooperative sectors per municipalities, and included only 40 and 22.2 % of the cases from the C3 cooperative sectors, respectively.

In 2005 (table 4), the group 4 was repeated, corresponding to the cooperative sector type C1 from the Ciego de Ávila municipality. However, in the 2 and the 3, cooperative sectors, type C3, from six municipalities were included, whereas the 1 grouped most of the cases of the cooperative sectors under study (70.8 %). The 4, although keeping lower amount of breeders than in the 2 and the 3, had larger annual average amount of milking cows. This provoked higher production per total of cows and higher annual production. The group 1, including 85.7 % of the cases from the C1 sectors, and 100 % of those from the C2 sectors of the province, had lower amount of animals and productive level. The levels of efficiency were inferior to those of Guevara (2004) in dairy units of the C1 cooperative sector, with values that reached up to 1 025 L per total of cows in the herd from the groups that belong to units of greater efficiency, applying milk production technologies. In the group 4, this higher value in milk yield per the total number of cows explained the best reproductive performance of the herds. The feeding and the reproductive management could influence these results, among other factors, because in the rest of the groups the values were inferior and, thus, the growth of the herds was affected (Viamonte 2010).

In 2007 (tabla 5), the group 3 was formed from the C1 cooperative sector of the Ciego de Ávila municipality

Table 3. Groups of cooperative sectors and their statistics for 2003

Variables	Group 1 (5)		Group 2 (18)		Group 3 (4)		Group 4 (1)	
	3 C1 and 2 C3		4 C1, 10 C2 and 4 C3		4 C3		1 C1	
	Mean	SD	Mean	SE	Mean	SD	Mean	SD
Herd existence, U	3377.88	3248.07	2449.28	2149.32	13615.83	2686.28	9127.80	
Breeders, U	1368.94	1264.85	1085.62	1037.69	6007.85	391.04	4153.20	
Milking cows, U	146.80	145.63	269.09	206.73	671.25	243.16	1295.21	
Births, U	574.80	426.11	481.94	510.47	3069.25	480.36	2142.00	
Deaths, U	85.80	72.61	68.39	45.06	431.75	221.22	618.00	
Milk yield, L	159056.00	138517.15	315769.44	266105.53	832127.50	300079.08	1800510.00	
Milk yield per total cows, L	105.04	31.01	321.89	90.02	139.13	49.71	433.51	
Milk yield per milking cow, L	1005.84	161.85	1178.24	344.19	1243.78	104.34	1390.22	
Birth rate, %	35.26	12.40	41.59	11.58	50.93	5.77	51.61	

( ) Number of cases of cooperative sectors per groups. SD: Standard deviation. C1: The are not land owners and work collectively. C2: The are land owners and work collectively.. C3: The are land owners and work individually.

Table 4. Groups of cooperative sectors and their statistics for 2005

Variables	Group 1 (17)		Group 2 (4)		Group 3 (2)		Group 4 (1)	
	6 C1, 7 C2 and 4 C3		4 C3		2 C3		1 C1	
	Mean	SD	Mean	SE	Mean	SD	Mean	SD
Herd existence, U	1901.07	1534.76	10073.05	4746.98	13553.10	1306.87	6373.10	
Breeders, U	829.69	643.83	4284.61	1543.92	5899.40	259.65	2812.50	
Milking cows, U	115.27	91.28	203.92	87.56	553.41	80.89	736.20	
Births, U	304.24	281.36	2311.25	954.69	2367.01	57.98	1203.00	
Deaths, U	116.12	80.87	325.50	116.94	939.02	28.28	1127.00	
Milk yield, L	125102.65	106703.33	301576.25	127122.43	532865.03	117132.24	882960.00	
Milk yield per total cows, L	154.02	80.02	69.90	23.33	90.85	23.83	313.91	
Milk yield per milking cow, L	1081.61	291.15	1493.35	238.37	957.70	71.70	1199.42	
Birth rate, %	36.05	12.96	53.35	7.92	40.15	0.78	42.83	

( ) Number of cases of cooperative sectors per groups. SD: Standard deviation. C1: The are not land owners and work collectively. C2: The are land owners and work collectively.. C3: The are land owners and work individually.

Table 5. Groups of cooperative sectors and their statistics for 2007

Variables	Group 1 (1)		Group 2 (16)		Group 3 (2)		Group 4 (4)	
	1 C1		4 C1, 7 C2 and 5 C3		1 C1 and 1 C3		4 C3	
	Mean	SD	Mean	SE	Mean	SD	Mean	SD
Herd existence, U	154.30	0	1943.45	1494.31	6331.80	1578.26	14442.45	4150.36
Breeders, U	77.61	0	975.21	774.34	2978.45	845.91	6163.35	616.10
Milking cows, U	20.20	0	127.28	80.34	439.80	204.78	512.08	186.15
Births, U	59.00	0	343.06	287.95	1503.10	319.61	3070.00	903.09
Deaths, U	39.00	0	101.56	60.52	441.02	148.49	584.25	304.90
Milk yield, L	37810.02	0	155101.90	118899.00	827960.10	159014.00	716982.50	177655.01
Milk yield per total cows, L	487.30	0	200.24	97.20	297.60	137.89	116.25	25.86
Milk yield per milking cow, L	1874.90	0	1178.98	372.72	2017.10	577.56	1462.31	288.54
Birth rate, %	76.00	0	38.09	11.45	50.95	3.75	49.60	12.73

( ) Number of cases of cooperative sectors per groups. SD: Standard deviation. C1: The are not land owners and work collectively. C2: The are land owners and work collectively.. C3: The are land owners and work individually.

(group 4 in 2003 and 2005) and a C3 cooperative sector from the group 2 of the year 2005, by having similar performance in the indicators under study. This indicated rise in the amount of animals and in the milk yield for the C3 sector, which corresponded to the Baraguá municipality. This group kept higher annual average production, with smaller amount of milking cows than the 4, which included the C3 cooperative sectors from four municipalities. This result was related to the higher annual production per milking cow from the group 3. The group 1 encompassed the C1 cooperative sector from the Baraguá municipality that with only 20.2 milking cows as annual average kept higher production per total of cows and higher birth rate percentage. Meanwhile, the 2, with 66.6 and 100 % of the cases of the C1 and C2 cooperative sectors of the province, respectively, kept smaller amount of animals and lower productive efficiency compared with the 3 and 4.

These results demonstrated the dynamic changes in the productive systems under study. With these classifications, the cooperative sectors with higher productive potentials were determined. In them, it is necessary to study other elements of their basic dairy units to determine physical and technological aspects, productive and reproductive indicators, as well as the state of the feeding basis, in a way that they can be used for the correct design of strategies that lead to the increase in the productive efficiency.

In 2009 (table 6) there was a movement of the C3 type cooperative sectors toward the groups 2 and 3, which could show that this sector (C3) increased the amount of animals and the milk yield. In the group 3, the C1 sector of the Ciego de Ávila municipality (group 4 of 2003 and 2005) was added five C3 cooperative sectors, representing 83.3 % of the cases for the group, with production superior to 1000000 milk liters, value surpassed by the 4, including only C3 sectors from two municipalities; whereas the group 2, which included 60 % of cases from the C3 sector, had lower averages of animals and milk yield than the 3 and 4, but superior to the 1, which only included C1 and C2 cooperative sectors.

The births and deaths per group had the same performance as the existence of animals. However, the ratio born per dead animals was more favorable for 2, 3 and 4, with values of 11.2, 7.6 and 6.4 respectively, compared with the 1, which had 2.7 births per each death. This showed the disadvantage in respect to the cattle increase for the 1, which included only cases from the cooperative sectors of the C1 and C2. This result could be related to the feeding, health and herd management in the different cooperative sectors, where the socioeconomic and technological factors played an important role. The cooperative sectors C3 were organized in small family farms, having generally smaller amount of animals. In them, the care to the small herds as to nutritional and reproductive management improvements (Pérez-Clariget

Table 6. Groups of cooperative sectors and their statistics for 2009

Variables	Group 1 (13)		Group 2 (5)		Group 3 (6)		Group 4 (2)	
	7 C1 and 6 C2		1 C1, 1 C2 and 3 C3		1 C1 and 5 C3		2 C3	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Herd existence, U	1099.70	1054.44	3297.37	2361.95	6702.30	3428.27	17207.15	2609.72
Breeders, U	505.31	493.79	1490.11	1278.97	3377.10	1843.54	7547.35	687.80
Milking cows, U	104.82	81.02	370.45	355.86	612.01	295.02	1368.90	301.23
Births, U	159.50	164.77	783.41	618.74	1539.50	989.05	3736.50	1014.70
Deaths, U	57.50	40.78	69.80	64.13	201.80	166.21	576.50	109.60
Milk yield, L	107207.70	84332.24	765108.01	683126.11	1007516.71	484075.92	1833500.01	32385.49
Milk yield per total cows, L	217.00	89.36	499.78	59.01	308.42	57.86	243.75	17.89
Milk yield per milking cow, L	982.20	282.84	1743.28	568.84	1662.91	185.12	1375.30	326.26
Birth rate, %	29.20	7.00	61.54	15.40	45.20	7.80	49.10	8.91

( ) Number of cases of cooperative sectors per groups. SD: Standard deviation. C1: The are not land owners and work collectively. C2: The are land owners and work collectively.. C3: The are land owners and work individually.

et al. 2007), could be better and cheaper than in the dairy units with more than 100 animals, as it is predominant in the C1 and C2 sectors. Thus, higher percentage of birth rate could be attained (Tamminga 2008).

The litters produced per the total of cows had values inferior to those of Guevara (2004) in a group of dairy units of the C1 cooperative sector, with levels of 1242 L per total of cows annually, due to the rise in the areas with sugarcane and other forages and to the establishment of legume areas. Similar results were reported by Yamamoto *et al*. (2007) in a study of 74 dairy farms, where they found higher milk yield in the farms with higher ratios of silvopastoral and improved pasture areas. The birth rate percentage showed differences per group. The 2 was outstanding reaching 61 %. Meanwhile, in the rest of the groups, the birth rate was inferior to 50 %. These values showed that these herds were under unsustainable conditions (Senra 2005) and affected the efficient growth of cattle (Bertot *et al*. 2006).

The analysis proved that the dairy cooperative sectors from this province formed a heterogeneous population. The variables of greater importance accounting for the differences between them were determined. They were classified dynamically and described the characteristics of the groups. Besides, the cooperative sectors with outstanding milk yield were defined.

Studies of characterization and classification are required at the level of the productive units from these cooperative sectors, involving indicators of the feeding basis, reproduction, biological and land efficiency (Martín and Rey 1998 and Connell *et al*. 2007). Besides, technological factors should be included (Somda *et al*. 2005) to contribute to the sustainability of the exploitation systems.

Four groups of cooperative sectors were obtained for the years under study. In time, the C3 cooperative sectors were separated from the C1 and C2. The groups with C1 and C2 sectors predominance had smaller amount of animals and lower milk yield. When the C3 cooperative sector percentage was increased in the groups, the productive results were better, showing the productive potentials of the latter sector. Further studies are required at the level of dairy unit to determine the needs for adopting efficient and sustainable technologies.

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