Impact of biomass banks with *Pennisetum purpureum* (Cuba CT-115) on milk production

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In order to assess the impact of the technology of biomass banks on milk production, the information of 27 indicators was recorded, obtained from nine dairy units of the Basic Unit of Cooperative Production (BUCP) "Desembarco del Granma", in Villa Clara province, from 2000 to the first semester of 2009. The combination semester-year-dairy unit allowed making a general matrix, with 169 cases. A total of 89 cases were analyzed in the first semester or dry period to facilitate the data interpretation, while in the second semester or rainy period, 80 cases were analyzed. The main components analysis (MCA) were used for the interpretation of the results. In the matrixes studied, four main components (MC) explained more than 70 % of the variability. The MC 1 in each matrix explained more than 35 % of the variance, and was highly correlated with indicators of productive importance, such as productivity per cow, production of milk/ha and total production per semester. Only this component was highly correlated with time and with the main technological changes, like paddocking and the percentage increase of Cuba CT-115 pasture. However, the relation was low with the sugarcane percentage and that of artificial pastures, replacement percentage of animals, stocking and birth. These indicators were not highly modified in time. The rotated matrices were used to determine the impact indexes in each scene, which changed their values, from negative to positive, with the years, and were, at the same time, an impact demonstration of this technology. The relation MC 1 allowed reliable regression equations in time, expressing the impact values of the biomass banks on the main productive indicators. Under the conditions of this BUCP, the organizational actions increased the milk production in 60 L/ha/year. The interval parturition-gestation decreased in 6.5 d/year. The milk/lactation increased in 73.3 L/year, the total milk production per dairy unit in 6252 L, and the liter per milking cow in 0.2/year. It is suggested that the BUCP considers a new cycle of developing the technologies and methods of animal management to increase the stocking rate, amount and quality of the feed for the dry season and favor the diminishing of the interval parturition-gestation.

Key words: *milk production, technological impact, multivariant designs*.

The technology of biomass banks with Cuba CT-115 has been studied and extended in Cuban cattle rearing since 1995. It is conducted through the segregation of up to 30 % of the area planted with *Pennisetum purpureum* Cuba CT-115, from August to November, in order to store and graze in three rotations during the dry season, from 20 to 25 t of DM¬/ha (Martínez *et al* 1996). Generally, applying an integral technology is in function of the production, without controls inside the system, and with a wide relation among all the factors involved in the productive process. There are many variables related, hence the interpretation of the results is difficult. However, controlling and assessing the impact of an introduced technology is necessary to measure the progress of an organizational cycle (Gaynor 2006).

Agreeing with Fonti Furnols and Guerrero (2005), this variables multiplicity could be very complicated for human mind, even impossible to assimilate. So, multivariate techniques are used to study and interpret them.

According to Martens and Martens (2000), in a multivariate analysis, the interest is on the variation patterns between the variables instead in the absolute values. The same importance should be given to the different variables, study them simultaneously and obtain a different multi-dimensional reality.

The multivariate techniques, like the analysis of principal components (AMC) and the hierarchical analysis or Cluster, may help interpreting the factors involved, when assessing the adoption of a new technology for milk production.

Torres *et al*. (2008) described a statistical model to measure the impact of the innovation or technological transference in the agricultural branch. The model integrates the analysis of principal components (MC) to obtain the coefficients of factorial measurements and determine the indexes of this impact for each scene, in function of the MC selected with the Cluster analysis to get to characterize or typify the dairy units.

Chacón *et al*. (2008) used the MCA to interpret the impact of the different technologies in function of milk production and applied, also, the model proposed by Torres *et al* (2008). They concluded that the experience as producer is necessary, as well as the acquaintance with the data and the common sense to interpret and explain the results. The Cluster analysis was necessary for reading clearly the progress in time of this new technology in respect to others. In the case of the producers, they need to recognize the impact on the most important productive indicators.

The objective of this study was deepening in the methods to assess the impact of the biomass bank technology on the main indicators of milk production under the representative conditions of the Cuban commercial cattle rearing.

Materials and Methods

Information of 27 variables or attributes of nine dairy units of the Basic Unit of Cooperative Production (BUCP) "Desembarco del Granma" in Villa Clara province was gathered. The information was accumulated in semesters, January-June for the dry season; July-December for the rainy one, from 2000 to the first semester of 2009.

All the information was organized in a data matrix, the rows identified the years-semesters-dairy units and the columns a total of productive variables.

The combination of years, semesters and dairy units allowed analyzing a total of 169 cases or individuals. The analysis for each semester was conducted independently to facilitate the interpretation of the data and diminish the variability between the attributes. For the first semester or dry season, 89 cases were considered and 80 for the second semester or the rainy period.

The variance explained for each MC was analyzed in all cases and the components explaining more than 70 % of the total variation were selected. The Varimax rotation was used for a better factors reading and the impact indexes of each combination year-semester-dairy unit of year-dairy unit were determined, according to the whole or individual analysis (Torres *et al*. 2008). The year, with values from 1 to 10, were incorporated in the analysis as a quantitative variable.

All the data processing were made in SPSS for Windows, version 11.5 (Visauta B., 2002) and InfoStat version 1 (Balzarini *et al*. 2001).

Results and Discussion

The first results are related with preparing the information. It was important to separate the year into semesters, as the milk production in the seasonal tropics has important productive deficiencies between the first and second semester of the year. As adopted technology, the biomass bank is designed to improve the performance of the dairy units during the dry season. The inclusion of both semesters in the same matrix increases the number of values (in cases or individuals). However, it increases the typical deviation of the data; that's why three matrices were studied, one general and other two for the dry and rainy seasons. Another way of interpreting the deviation and impact among cattle units was the analysis of the relative indicators. The total milk production showed high variability due to the influence of other variables under study. The use of the indicator milk/ha and other relative measurements (expressed in %) allowed weighing up some indicators to improve the interpretation of the results.

Table 1 shows the descriptive statistics of the variables analyzed in each matrix. Expressing the variables in different units does not influence on the results, as they are related with them. The MAC was conducted form the use of the correlation matrix, as proposed by Philippeau (1990). The need of using relative indicators causing less variability, such as milk/ha, birth and others was proved. The empty spaces correspond to the data originally these relative indicators in the season matrixes.

The correlation matrices resulted to be inexhaustible source of analysis. First, they corroborated that the variables studied are related, being this a premise for obtaining new latent variables or MC. Figure 1 shows the correlation coefficients found between 1 and -1 for the general matrix.

The majority has highly significant probabilities, logic when studying a productive system with multiple interactions.

In the matrices studied, four main components explained more than 70 % of the variability (table 2). The MC 1 was the one explaining the highest variability percentage. However, the performance was different in the three matrices considered; the total variability was always superior, explained in the matrices corresponding to the semesters. This indicates that the distribution per semesters was correct, occurring the same in the MC1. Nevertheless, the performance was variable in the rest of the components, and showed that the measures studied have different expressions in one and other semester.

The impact of a technology is the response in time of applying a group of technical knowledge to design, create or produce goods or services for adapting to the environment and satisfy the people's needs. In this sense, the MC 1 grouped all the variables reflecting the impact better, due to two main reasons: the MC 1 has a high correlation with the variable years, that is, with the changes in time. The variables of productive importance and those of the technological changes are included in this component, with high positive and negative weighted indexes. This component has a very poor relation with the percentage of sugarcane, artificial pastures, animal replacement, stocking or birth rate, indicators that did not change much in time. However, high indexes were recorded with all the productive indicators per cow and milk production. It is important, for demonstrating the impact, that the MC 1 is also highly correlated with the principal technological changes occurred in time, such as paddocking and the percentage increase of CT-115. Even with 15 % of CT-115 in the areas, there was productive impact (Martínez *et al* 2005), therefore the new variable or MC 1was named productive component. The results are similar for the three matrices, except in those indexes highlighted in one season or another, some of them with very different values. The lactation duration of the cows, for instance, reached a much higher weight with the MC 1 in the rainy season compared to the dry one. This indicator is calculated from the parturition to the day

Table1. Descriptive statistics of the matrices used for one semester.

Variables	General matrix N = 169		Matrix semester 1 N = 89		Matrix semester 2 N = 80	
	Mean	Typical deviation	Mean	Typical deviation	Mean	Typical deviation
Cows and heifers BPI	74.89	7.41				
Cows low PI	68.75	7.84				
Semestral milk production	38155.40	14186.40				
Duration of the lactation,	305.21	34.21	310.29	20.94	299.56	44.04
Milking cows (MC)	45.91	8.11				
Liters/MC/d	4.48	1.23	3.83	0.99	5.19	1.08
Milk per lactation	1315.61	473.46	1071.06	359.91	1587.69	435.97
Births	29.46	6.56				
Birth rate, %	36.78	6.62	37.79	6.51	35.66	6.61
Replaced cows hd	4.63	2.05				
Total area, ha	96.16	18.76				
Total of paddocks	18.32	5.68	18.53	5.73	18.09	5.65
Area with CT-115, ha	14.52	4.38				
Paddocks with CT-115	12.40	5.12	12.54	5.12	12.24	5.16
Area with artificial pastures, ha	9.84	12.05				
Area with natural pastures, ha	64.31	10.45				
Area with sugarcane, ha	2.53	0.53				
Milk production/ha/semester	401.80	142.60	334.69	114.21	476.45	134.15
Parturition-gestation time, d	173.62	10.46	173.85	11.12	173.36	9.75
Total of animals/ha	0.80	0.10	0.79	0.10	0.80	0.10
CT115 in the area, %	15.28	4.42	15.39	4.41	15.16	4.46
Artificial pastures in the area, %	11.03	9.91	9.26	8.70	9.09	8.73
Sugarcane in the area, %	2.68	0.54	2.67	0.54	2.68	0.55
MC, %	67.32	11.01	66.27	12.08	67.93	9.97
Milking animals, %	61.12	9.85	60.40	10.42	62.48	9.20
Repalcement, %	6.21	2.79	6.75	3.17	5.65	2.15
Years	1 a 10	1 a 10	1 a 10	1 a 10	1 a 10	1 a 10

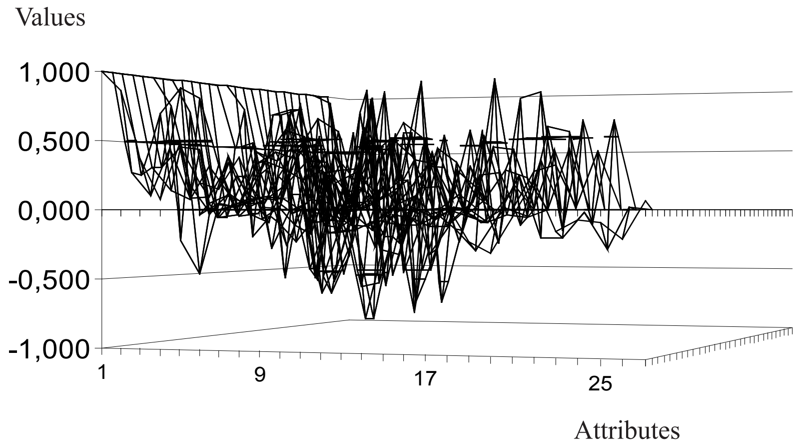

Figure 1. Correlation range between the variables

the cow dries off, and it is obvious that the pasture availability influenced on the differences between the dry and rainy seasons. The rest of the components, all together, explain lower variability than that of the MC 1 and have low relation with time. They are orthogonal (without relation) with the MC 1, and, although they may be of technical interest, as the case of the relations birth-season, their contribution to defining factors related

Table 2. Correlation coefficients of each principal component with the variables studied in each of the three matrices.

Variables	Matriz complete				Matriz S-1				Matriz S-2			
	CP1	CP2	CP3	CP4	CP1	CP2	CP3	CP4	CP1	CP2	CP3	CP4
Lactation duration	0.52	-0.05	-0.02	-0.35	0.11	0.01	0.07	0.41	0.63	-0.25	-0.06	0.04
Liters/MC/d	0.60	0.17	-0.01	0.49	0.64	0.47	0.00	0.37	0.80	0.17	-0.15	-0.16
Milk per lactation (l)	0.52	0.09	-0.02	0.80	0.78	0.41	0.04	-0.15	0.57	0.24	-0.08	0.59
Natality, %	0.09	0.08	-0.06	-0.75	-0.19	-0.18	-0.04	0.74	0.17	-0.19	-0.02	-0.80
Replaced cows	0.06	-0.08	0.98	0.03	0.13	0.93	-0.06	-0.06	-0.06	-0.1.0	0.98	-0.02
Total of paddocks	0.67	0.17	0.12	-0.01	0.67	0.13	0.18	0.14	0.66	0.1.0	0.09	0.06
Paddocks in the CT-115	0.79	0.21	0.10	-0.07	0.68	0.13	0.12	0.52	0.84	0.11	0.09	-0.13
Milk production /ha	0.75	0.24	-0.12	0.49	0.87	0.23	0.19	0.17	0.84	0.25	-0.23	0.24
Parturition-gestation time	-0.80	0.17	-0.09	-0.17	-0.81	-0.18	0.13	0.04	-0.79	0.22	0.07	-0.27
Animales /ha	-0.11	0.75	-0.03	0.12	-0.07	0.09	0.83	-0.19	-0.09	0.75	-0.24	0.15
% of pasture CT-115	0.75	0.39	0.07	0.01	0.65	0.15	0.32	0.43	0.84	0.31	-0.04	-0.07
Artificial grasslands, %	-0.07	-0.84	0.07	0.05	-0.03	0.10	-0.85	-0.18	-0.08	-0.83	0.03	-0.09
Sugarcane, %	0.01	0.81	-0.02	-0.01	-0.02	-0.06	0.79	0.15	0.09	0.81	0.05	-0.09
MC/d, %	0.76	-0.24	-0.09	0.13	0.85	-0.19	-0.13	-0.11	0.63	-0.27	0.02	0.54
Milking animals, %	0.74	-0.29	-0.16	0.13	0.81	-0.28	-0.17	-0.12	0.60	-0.32	-0.03	0.58
Replacement, %	0.05	-0.04	0.98	0.01	0.11	0.92	-0.02	-0.06	-0.05	-0.05	0.98	0.01
Years	0.87	-0.25	0.15	0.06	0.87	0.19	-0.23	0.10	0.85	-0.31	0.00	0.24
Variance explained, %	35.20	15.00	11.60	9.20	38.30	14.60	12.2	7.30	38.00	16.30	10.90	9.10
Variance accumulated, %	35.20	50.2	61.80	71.00	38.30	52.90	65.1	72.4	38.00	54.4	65.30	74.30

S-1 Semester 1(January-June)
S-2 Semester 2 (June-December)

with the technological impact is low.

The interpretation of the impact on the indicators is not only important, but also that of the variables when necessary. According to Torres *et al*. (2008), the coefficients of factorial means express impact indexes for each scene, in function of the main components. The results of this analysis for the MC 1 of the matrices of dry and rainy seasons are presented in figures 2 and 3.

The bars represent the impact of the MC 1 in the case of cattle unit-semester ascending, from 2000 to 2009. The changes from negative values to positive indicate the time impact on the results. In this study, the majority is in the last six months of the period 2007-2009. This shows that the productive component changed in time in the dairy units.

This impact is better seen in figure 3 for the MC of the second semester or rainy season, where most of the cases of each dairy unit were superior to 0, indicating the progress in time of this component.

The MCA demonstrated the relation of the MC 1 with time. However, the challenge was valuing the impact, hence the producer or extensionist could interpret it for their development programs under similar conditions. Going back to the correlation matrices was necessary for this.

The inclusion of time as variable allowed finding highly significant relations between the years of applying the technologies and the variables of economic importance. Table 3 shows the correlation coefficients of the variables studied versus time, expressed from 1 to 10.

In respect to time, the number of total cows or per hectare, the total area and the changes in natural, artificial pastures or sugarcane were not important. The replaced animals or birth were not important either, highlighting the importance of the relations between the establishment of biomass banks and the productive indicators.

The correlation indexes are highlighted in black with the years of milk production /ha, the interval gestation and the percentage of milking cows. Among others, these are consequence of indicators correlated also with time, responding to the technological changes, as area and number of plots with Cuba CT-115, main stack holders of feeding in the dry season.

The regression equations obtained for the variable years and those most important dependent ones and highly correlated with time offered impact values on the productive indicators. Table 4 offers the regression equations obtained between the years and five indicators with high preponderance in the MC 1 of each matrix. The values of dependent variables correspond to one semester.

The variables milk production/semester /ha must

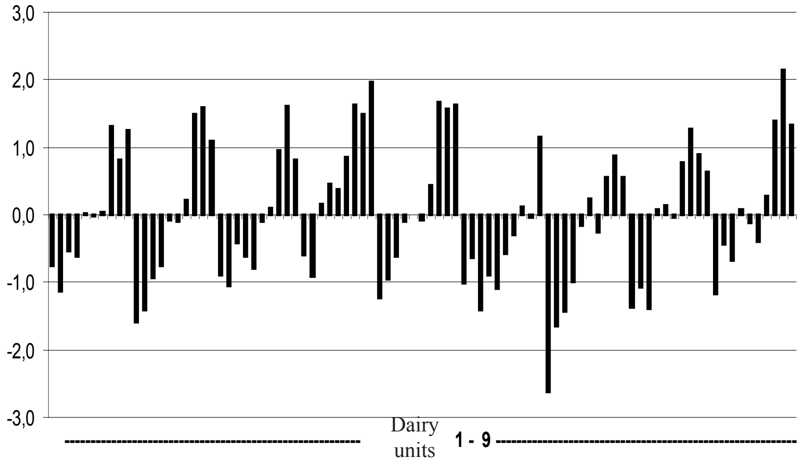

Figure 2. Impact factors per dairy unit, MC 1 for the semester 1 of 10 years

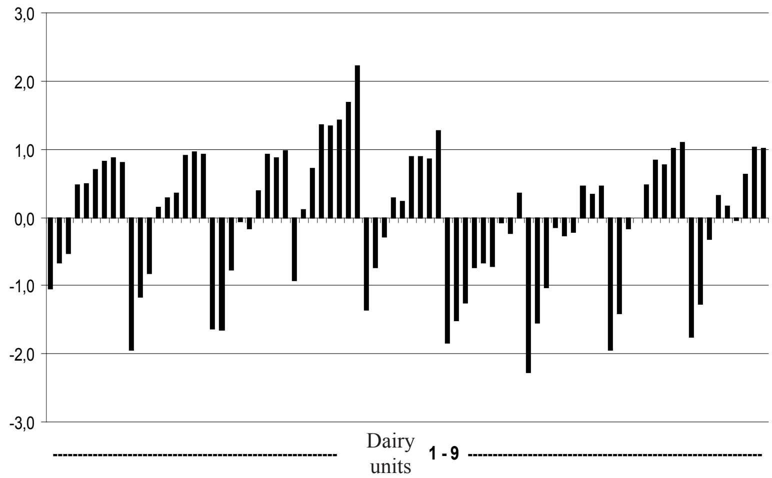

Figure 3. Impact factors per dairy unit, MC 1 for the semester 2 of 9 years

be added to determine what happened in the year. The rest of the variables are not additives and reflex the measurements of the year.

In these nine dairy units representing the commercial Cuban livestock, with the technology of biomass banks and with their organizational adjustment, milk production increased in 59.4 L/ha/year, the interval parturition-gestation decreased in 6.5 d/year, the milk/lactation increased in 73.3 l /year, as well as the total milk production per dairy unit in 6252 L per year and the liter per milking cow in 0.2/year. These data, although they are discrete compared with more developed enterprises, show a continued and sustainable development of economic, social and environmental aspects. They were conducted in ten years of work, considering the development possibilities of the case studied. The impact could be substantially increased, if the changes would be conducted with similar results in half time.

It is concluded the multivariate analytical method of main components allowed interpreting the results of a development cycle in function of the dairy production from those units applying the new technologies. Due to the characteristics of the seasonal tropic, dividing the information into two semesters was positive, as well as the use of relative variables to diminish the typical variation of the data. Once the productive component was defined as the best related with time, the impact was estimated. Under the conditions of this BUCP, milk production/ha increased every year in 59.4l, the interval parturition-gestation diminished in 6.5 d and milk/lactation increased in 73.3l. The total milk production per unit increased in 6 252.l and the liter per milking cow in 0.2.

It is suggested to the headquarters of the BUCP consider applying new technologies and methods of animal management in a new development cycle to increase the quantity and quality of the feed for the dry season and favor, also, the continuous diminishing of the interval parturition-gestation.

The repeatability of the results under other conditions will depend on the resources to carry out the technological changes in shorter term, as well as on the effectiveness of the rest of the organizational changes. Nevertheless, it was proved that the technological changes adopted

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Table 3. Correlation coefficients between the variables studied and the variable year.

Variables	General matrix general N =169	Dry season N = 89	Rainy season N = 80
Lactation duration, d	0.41	0.18	0.59
Liters/MC/d	0.44	0.63	0.56
Milk per lactation	0.43	0.65	0.50
Natality, %	-0.06	-0.13	-0.01
Replaced cows	0.19	0.29	-0.03
Total of paddocks	0.55	0.57	0.52
Paddocks in the CT-115	0.62	0.61	0.64
Milk production/ha	0.57	0.75	0.68
Parturition-gestation interval	-0.85	-0.86	-0.85
Animales /ha	-0.19	-0.18	-0.21
Pasture CT-115, %	0.59	0.58	0.61
Artificial pastures,%	0.20	0.20	0.20
Sugarcane, %	-0.18	-0.18	-0.18
MC/d, %	0.68	0.67	0.72
Milking animales, %	0.67	0.66	0.73
Replacement, %	0.18	0.27	-0.02
Years	1.00	1.00	1.00
Total milk production, L	0.61	0.75	0.73
Cows and heifers BPI	0.06		
Cows BPI	0.02		
Milking cows, MC/d	0.63		
Births	0.36		
Total area, ha	0.12		
Area with CT-115, ha	0.62		
Area with artificial pastures, ha	0.12		
Area with natural pastures, ha	-0.13		
Area with sugarcane, ha	-0.05		

Table 4. Regression equations of five productive indicators with high preponderance in the MC 1 of the general matrix.

Dependant variable	Initial situation Constant (a)	Pendent (b)	Changes in 10 years		R	Sig.
			Semester	Year 10		
Milk production, L/ha/ semester	245.3	29.52	540.5	1081.0	0.57	***
Parturition-gestation interval	190.7	-3.21	158.6	158.6	-0.85	***
MC/d, %	53.0	2.71	80.1	80.1	0.68	***
Milk per lactation	927.0	73.30	1660.0	1660.0	0.43	***
Total milk production/ semester/cattle unit, L	21581.412	3126.122	52842.0	105648.0	0.61	***
L/cow/d	3.4	0.20	5.4	5.4	0.44	***

*** Signification for $P < 0.001$

were effective.

References

Balzarini Mónica, G., Casanoves, F., Di Rienzo, J.A., González, L.A. & Robledo, C.W. 2001 InfoStat. Version 1. Software estadístico, manual de usuario. Córdoba, Argentina

Chacón, M., Martínez R.O. & Torres, V. 2008. Evaluación del comportamiento económico-productivo de lecherías con diferentes sistemas de producción en la empresa "El Tablón" de la Provincia de Cienfuegos. Evento Agrociencias. Universidad Agraria de La Habana "Fructuoso Rodríguez Pérez". Cuba

Font i Furnols, M. & Guerrero, L. 2005. Estadística aplicada al análisis sensorial. Monografías INIA. España. 429 pp.

Gaynor, E. 2006. El ciclo PHCA de Shewhart. <http://www.

gestiopolis.com/canales5/ger/modergay.htm. > [Consulted: July 2010]

Martens, H. & Martens M. 2000. Multivariate Analisis of Quality. An Introduction. John Wiley & Sons. Ltd. Chichester, Inglaterra. 445 pp

Martínez, R.O. & Herrera, R.S. 2005. Empleo del pasto Cuba CT-115 para solucionar el déficit de alimentos durante la seca. In: *Pennisetum purpureum* para la Ganadería Tropical. Ed. S.R. Herrera, G. Febles y G. Crespo. Instituto de Ciencia Animal. La Habana. Cuba

Philippeau, G., 1990. ¿Como interpretar los resultados de un análisis de componentes principales? Institut Technique des Céréales et des Forrages. Paris. Francia. 63 pp

Torres, V., Ramos, N., Lizazo, D., Monteagudo, F. & Noda, A. 2008. Statistical model for measuring the impact of innovation or technology transfer in agriculture. Cuban J. Agric. Sci. 42:131

Visauta, B. 2002. SPSS para Windows versión 11.5. Volumen II. Mc Graww-Hill/Interamericana de España. S.A.V. 358 p

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