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SEED SAFETY DIAGNOSIS. PART II. DIVERSITY OF BASIC FOODS PRODUCED BY SMALL FARMERS

Diagnóstico de seguridad de semillas. Parte II. Diversidad de alimentos básicos producidos por pequeños agricultores

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ABSTRACT. The work was developed in Bahía Honda, Manicaragua and Gibara municipalities, located in the western, central and eastern Cuba respectively. Smallholder farms linked to the Local Agricultural Innovation Programme (PIAL, according its acronyms in Spanish) were visited. For the collection of information a face survey, structured with open and closed questions was used. Basic varietal diversity of species studied for Cuban food such as: rice, beans, corn, tomato, cassava and banana, whose productions depend of an appropriate supply of seeds. The results showed that in Bahía Honda a greater diversity of varieties and generally recorded in the three municipalities, an average of three varieties of each of the basic food species are used. The varietal diversity potentially decreased with the increase in cultivated surface. The coexistence of local and improved varieties was demonstrated in the west and east farms of the country, while in the farms located in the central region food production is based mainly in planting local varieties. Analysis of the spatial distribution of each species, in order to know their potential for seed production in local agrifood strategic projection showed that coincidently maize is grown in small areas in most of the farms in the three municipalities which is an opportunity for diversification, meanwhile, it should be paid more attention to the cultivation of tomato in order to encourage their production as many farms.

Key words: rice, beans, corn, tomato, cassava

RESUMEN. El trabajo se desarrolló en los municipios Bahía Honda, Manicaragua y Gibara, ubicados en el occidente, centro y oriente de Cuba, respectivamente. Se visitaron fincas de pequeños agricultores vinculados al Programa de Innovación Agropecuaria Local (PIAL). Para la recopilación de la información se empleó una encuesta presencial, estructurada con preguntas abiertas y cerradas. Se estudió la diversidad de especies básicas para la alimentación cubana como son: arroz, frijol, maíz, tomate, yuca y plátano, cuyas producciones dependen de un adecuado suministro de semillas. Los resultados mostraron que en Bahía Honda se registró una diversidad mayor de variedades y que generalmente, en los tres municipios, se utilizaron un promedio de tres variedades de cada una de las especies básicas en la alimentación. La diversidad varietal decreció potencialmente con el incremento de la superficie cultivada. El estudio demostró la coexistencia de variedades locales y mejoradas en las fincas de occidente y oriente del país, mientras que en las fincas ubicadas en la región central la producción de alimentos se sustentó fundamentalmente en el cultivo de variedades locales. El análisis de la distribución espacial de cada especie, con vistas a conocer sus potencialidades y desafíos para la producción de semillas en la proyección estratégica agroalimentaria local, mostró que coincidentemente el maíz se cultiva en pequeñas áreas en la mayoría de las fincas de los tres municipios, lo que constituye una oportunidad para su diversificación productiva, en tanto, se le debe prestar más atención al cultivo del tomate con la finalidad de incentivar su producción en mayor número de fincas.

Palabras clave: arroz, frijol, maíz, tomate, yuca

INTRODUCTION

Variety diversity gives cultivated species a plasticity that allows them to extend their cultivation to new areas and respond to changes in their environment. In addition, it constitutes the greatest wealth of the agricultural communities and the source for programs of genetic improvement.

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Contradictorily, during the process of domestication of edible plants, man made a selection based on desirable productive characteristics (1) that is currently reflected in the proliferation of homogenous plant material.

This situation corresponds to the current of dominant economic thought that defends business or agroindustrial production as the only one capable of responding to competitiveness and quality demands of a globalized world (2), where a certain homogenization of food with the consequent loss of diversity of the food repertoires (3).

However, there are authors who consider food among the branches that are irreducible to globalization, due to the existence of a strong predisposition of the population to the consumption of specific and local products, linked to their culture and identity (3-5).

In this context, multiple challenges have arisen in response to the demands of new references that pay tribute to food security in terms of availability, access, quality and stability of food. Among the strategies to face the challenges of food security, it has been suggested that countries should achieve food sovereignty, which consists in producing the necessary staple foods in their own territory, in order to reduce the dependence on imports and the volatility of prices of food market (6).

Of course, this objective is not achieved if the safe production of seeds of the species considered as basic food for the population is not guaranteed.

In the case of Cuba, a developing country, food security has been declared by the highest government leadership as a national priority (7), however, it is considered that its achievement is still pending (8).

However, in recent years there has been a gradual evolution from mainly technological approaches of food production to others that take into account environmental, social and cultural factors that affect the quality of the population's food, which in a certain way, go paying to achieve food security.

Undoubtedly, producing food in harmony with the environment, involves a challenge that can only be solved by implementing strategies that take advantage of the opportunities that are generated, for the production of food, in the local territorial area.

In this context, studies conducted show the relationship between food and socio-cultural reality (5), as well as economic and political aspects, which, when used properly, it can guarantee access to food in a safe and stable manner (9).

It is convenient to clarify that the Cuban food culture has been shaped by the influence of immigrant groups, mainly Spanish and African and to a lesser extent Asian, and that this process of transculturation has played an important role in their current eating habits, represented by a high consumption of foods made with corn, rice, beans, taro, sweet potato, potato, lettuce, avocado and tomato (5).

As a result of this transculturation, the production of basic foodstuffs may not adjust to the requirements of climate and soil resources, becoming a source of environmental pollution and excessive use of natural resources, as is the case with the high volumes of water that they are required for rice cultivation.

In this sense, the Program of Local Agricultural Innovation (PIAL according its acronyms in Spanish) led by the National Institute of Agricultural Sciences (INCA) has among its purposes to strengthen the resilience of the Cuban food system, through the interspecific and intra-specific diversification of crops. To this end, it has been proposed to revitalize the agricultural sector through the participation of farmers in the system of food production and environmental protection, managing alternatives to adapt production to local agroecosystems (10).

Taking into account these antecedents, the present work was carried out with the objective of evidencing aspects related to the diversity, potentialities and challenges of the species used for the production of staple foods in farms of small farmers linked to the PIAL, located in the Bahía Honda Manicaragua and Gibara municipalities.

MATERIALS AND METODOS

The work gives continuity to the study Seed Safety Diagnosis. Part I: Results of the analysis of agricultural systems in CCS and CPA located in three municipalities of Cuba (11) that was developed during 2014 in the municipalities of Bahía Honda, Manicaragua and Gibara belonging to the province of Artemisa, Villa Clara and Holguín (Figure 1), respectively, linked to the Local Agricultural Innovation Program (PIAL).

For the collection of information, a structured face-to-face survey with open and closed questions was used. In addition interviews were conducted with key informants (representatives of the agricultural spheres at the municipal level) and focus group discussions composed of farmers with extensive knowledge of the agroecosystem under study.

In the previous analysis to determine the size of the sample to be studied, the similarity between the totals of the rural population by municipalities was demonstrated and the sample size was determined from 22 to 34 farms per municipality, for which the limitations were taken into account in terms of budget,

Figure 1. Geographic location of the three municipalities studied[A]

human resources and the social context of peasant communities (dispersion of farms and difficulties with transportation). Likewise, the sampling strategy for the survey was based on the selection of farms in a targeted manner to ensure adequate representation of the diversity of staple foods produced on the farms.

As basic foods were studied: rice (*Oryza sativa* L.), beans (*Phaseolus vulgaris* L.), corn (*Zea mays* L.); tomatoes (*Solanum lycopersicum* L.); cassava (*Manihot esculenta* Crantz.) and banana (*Musa* x *paradisiaca* L.).

For each municipality, it was calculated:

- Percentage of cultivated area in the sample diagnosed.
- Percentage of farms that grow staple foods.
- Number of varieties of each cultivated species.
- Type of variety (local, improved).

Local variety was considered to be that traditional variety that, according to the species, has been selected locally, including local variants, geographic races, improved varieties of hardened and interracial hybrids that have been cultivated for several years and that farmers conserve and sow from lots of seeds (12).

As an improved variety, it was taken into account that from the improvement programs of research centers that have a certain level of uniformity and well-defined characteristics, generally higher yield than local varieties, as well as favorable conditions of quality, precocity, resistance to pests and diseases and potential use for the regions for which it is recommended (13).

It is convenient to clarify that generally, farmers are not familiar with the commercial names of the varieties they sow on the farm. Given the uncertainty generated by this situation, when we intend to register varietal diversity based on the names of the varieties, we opted for the numerical analysis of the different varieties that are grown in the local system.

An evaluation was also carried out to know the territorial potential of each species, for the production of seeds and food, based on its spatial distribution based on two criteria: number of farms that grow staple foods and size of the area in which they are planted.

To discern between the terms many farms or few farms the formula was used $\frac{n}{2} + 1$,

where **n** is the total number of farms in the sample surveyed by municipality, considering a species cultivated in many farms when its presence in the sample responded to the equation ($\geq \frac{n}{2} + 1$) and in few farms ($< \frac{n}{2} + 1$).

For the size it was considered as a large area when the crop was planted in 1.0 ha or more and as a small area when it was planted in less than 1.0 ha.

[A] ONE. Codificador de la División Político-Administrativa. Republica de Cuba, [cited: 2013 feb 25], Available from: http://www.one.cu/publicaciones/08informacion/mapasdecuba/dpa.pdf.

[B] Alimento básico, como un concepto, es un término relativo muy ligado a las diversas culturas culinarias así como a los contextos geográficos. Por regla general, es un alimento que proporciona energía (calorías) y que posee un cierto contenido de hidratos de carbono. Su elaboración está muy ligada a los ingredientes más disponibles en la comunidad. Davidson A. The Oxford Companion to Food. 2nd ed. Oxford; 1999. Available from: https://es.wikipedia.org/wiki/Alimento_b%C3%A1sico#cite_note-Davidson-1

The evaluation was based on the location of the species in a scheme similar to a SWOT matrix (scheme 1) where each quadrant responds to a specific combination of criteria that result in a strategic quality (strength, weakness, opportunity, threat).

	Mnay farms	Few farms
Large area	Strengths	Weakness
Small area	Opportunities	Threats

Scheme 1. Matrix to determine the potential of each crop in the local agricultural environment

The data obtained during the study were tabulated and filed in Microsoft Excel 2013 data sheet. To comply with the normal distribution assumption, the counting data related to varietal diversity and number of farms were transformed by means of the expression: $\sqrt{x+1}$, while the cultivated area was transformed by the expression log (x) and the percentage by 2 arc sen $\sqrt{\%}$. Los análisis se realizaron con ayuda del paquete estadístico STATGRAPHICS Centurión XV versión 15.2.14 (14).

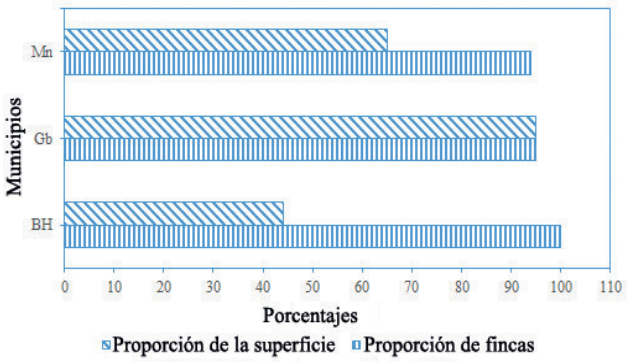
RESULTS AND DISCUSSION

No statistically significant differences were detected in the total cultivated area or in the area cultivated with basic foods per municipality (Table I).

This similarity between the different municipalities in the cultivated area, both total and with basic foods is clear evidence that Cuban agrarian policies have facilitated equitable access to land in different regions of the country.

The detailed analysis of the previous result (Figure 2) showed that in Gibara there was a high proportion of farms and area dedicated to the cultivation of staple foods, while in Manicaragua and Bahia Honda, although in a large number of farms, basic foods are also grown, the surface dedicated to them is minor. This is due to the fact that in these locations 35 and 56 % respectively of the agricultural area of the farms is destined to other commercial crops such as cane, coffee and fruit trees.

In Gibara there are no records of rice cultivation, since the conditions of aridity typical of this municipality are not favorable for its establishment (15). However, in this territory the agricultural areas are located mainly in flat areas where anthropic pressure is traditionally greater because in the plains there are better conditions for the establishment of a technified agriculture (mechanized and commercial) with predominance of monoculture such as beans (16).



Legenda: BH Bahia Honda, Mn Manicaragua, Gb Gibara

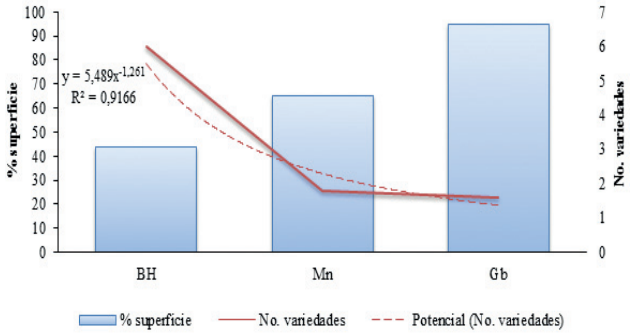
Figure 2. Proportion of farms and area cultivated with basic foods in the municipalities of Bahía Honda, Manicaragua and Gibara

Table I. Number of farms and total cultivated area and with basic foods per municipality

Municipality	Quantity of studied farms	Total cultivated area (ha)	Area cultivated with basic foods (ha)
Bahía Honda	32	876,75	385,37
Manicaragua	34	508,06	330,24
Gibara	30	164,39	156,17
Total	96	1549,20	871,78
Media	32	516,40	290,59
DS	0,18	0,85	0,48
CV (%)	3,13	14,14	8,62
ESx	0,10 *ns*	0,49 *ns*	0,28 *ns*

Non-significant means according to the Bonferroni test for p≤0.05

Figure 3 shows that the number of varieties per municipality describes a line of decreasing potential trend with respect to the increase in cultivated area, which is precisely influenced by the agricultural technification promoted on the surface of more than 1 ha and which undermines diversity of species and varieties because of the specificity of the technological packages that usually contain mainly certified seed, fertilizers and agro-inputs for certain varieties.



Legend: BH Bahia Honda, Mn manicaragua, Gb Gibara

Figure 3. Varietal diversity by municipality concerning the area cultivated

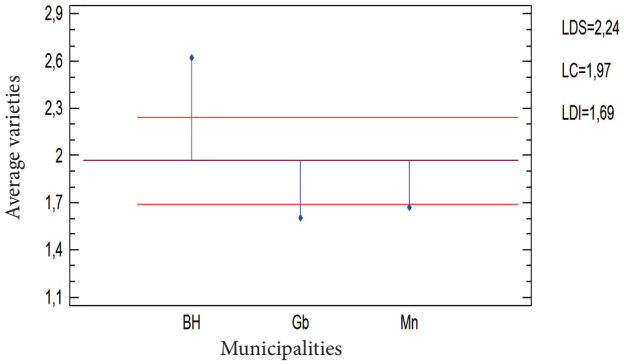
In most of the area planted with staple foods (68 %), three varieties of the basic species for food are planted on average (Table II), although a relatively high variability is detected that can be justified with the specific characteristics of each region that make Bahia Honda handle a greater number of varieties (Figure 4).

The result may be conditioned to the persistence of serious problems with transportation to and from different locations. The proximity of Bahia Honda to the PIAL headquarters has favored a better management of diversity and greater adoption of new varieties from the research programs of national and international institutes. However, the work of PIAL has been transversal in all localities of incidence, in terms of the dissemination of new varieties of food species.

No significant differences were detected in the number of crop varieties with respect to the general average; however, cereals: corn and rice showed values below the average (Figure 5), reflecting a dangerous dependence on a few varieties in these two cereal species, perhaps well adapted to local conditions and to the tastes and needs of farmers and their families, but this limited genetic base places them in a difficult situation to face the adverse changes in the environment and the incidence of pests that could affect these few varieties.

Tabla II. Estadígrafos correspondientes al porcentaje de superficie cultivada y número de variedades de alimentos básicos

Estadígrafos	Porcentaje de superficie	Promedio de variedades
	68,00	3,13
Desviación Estándar	0,63	0,13
Coeficiente de Variación (%)	31,42	39,80
Error Estándar	0,36	0,08



Legend: BH Bahia Honda, Mn Manicaragua, Gb Gibara

Figure 4. Behavior by municipalities of the average of basic food varieties with respect to the general average

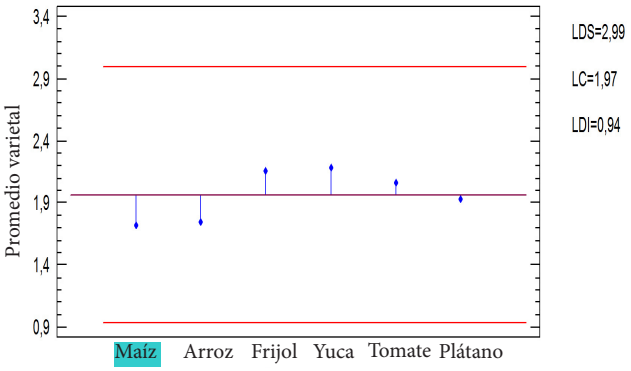


Figure 5. Average varietal diversity of the basic species in the diet

It is possible to argue about the varietal and food status of the species studied, in the local context. In the case of corn, it is a cross-pollinated plant, so under field conditions, genetic recombination of existing populations occurs, which obviously results in the existence of genetic conglomerates in the farms (17), which makes it difficult to distinguish to a pure variety.

These conglomerates are usually called Creole, local, traditional or native corn. However, farmers year after year select the seeds of the phenotypes

with better behavior, so it is possible that a new variety emerges, which is clearly distinguishable and appreciated by farmers (12) as in the case of the variety "Felo "officialized in the register of Cuban commercial varieties[C], where 41 maize materials have been registered (between varieties, lines and single and double hybrids).

Maize is used mainly for human consumption, emphasizing the acceptable nutritional quality of Cuban accessions, which makes it an excellent complement in the diet (18). It is also used for cattle feed, as a component of creole animal feed.

On the other hand, rice is part of the daily intake of the Cuban population, 37 commercial varieties have been registered in the cited record. Its cultivation requires special conditions such as soils that allow retaining a sufficient layer of water for its development, which has adverse consequences for the environment due to among other effects, to the generation of methane in the atmosphere[D], which is also unintentionally stimulated with the application of agrochemicals (19), so it is important to know the magnitude of the emissions of the different management factors (variety, irrigation, fertilization).

In the case of bananas, it constitutes an important energy supplement in the population's diet. It is generally grown on farms, for family self-consumption, not for commercial purposes. Given their permanent non-arboreal species quality (16), local plantations tend to remain unaltered for years with respect to the acquisition of new varieties.

The species with values in varietal diversification higher than the general average were bean, cassava and tomato.

In Cuba, bean is a phyto-resource of importance for food security. It is almost exclusively used for human consumption. It constitutes an excellent complement in the daily diet when combining its consumption with rice. Because of its importance in food, it is involved in import substitution of this species. More than 41 commercial varieties have been registered.

For its part, cassava is a food with a high energy value. It is used not only for human consumption, but also in animal feed, mainly pigs and birds. From the agronomic point of view it is very appreciated for its easy and wide adaptability to diverse environments, the little work required for its cultivation and its high productivity. It can also thrive in poor soils and in conditions of low rainfall. Ten clones have been registered that allow this species to be available during the 12 months of the year, which makes it a very competitive crop of extraordinary value to guarantee food security.

The tomato occupies the first place in importance in the production of vegetables in Cuba. In 2015 it reached a production of 551,0 thousand tons (20) of this production more than half was destined to fresh consumption for the population and the rest to industrial processing, but the current productions do not satisfy even the demand of neither of the two destinations.

It has been reported that the climatic conditions prevailing in Cuba are so close to the limits of biological tolerance of this species, that small differences in climatic variables (solar radiation and temperatures) greatly affect the productive results (21), so which farmers need an insurance market for catastrophic climate events that are very difficult to generate without government intervention, given its systemic impact (6) of this species, 137 commercial varieties have been registered.

In developing countries, where diets consist mainly of starchy foods, it has been shown that lack of diversification is crucial. However, it is warned (22) that the diversification of the productive systems in itself is not a factor that determines an increase in productivity, but the design of functional biodiversity in terms of resource use such as nutrients, water and energy.

The study of varietal diversity based on the number of varieties and their types showed that local and improved varieties coexist in Bahía Honda and Gibara, and that a greater number of varieties per crop is recorded in Bahía Honda, while in Manicaragua they are recognized mainly local varieties (Table III).

The analysis to know the potentialities of the different species in the production of food in the territorial area (Table IV) showed that most of the species are cultivated in small areas (less of 1 hectare) with a fundamental purpose of family self-consumption.

These include maize that is also planted in most of the farms studied in the three municipalities, which shows that among farmers there is a culture to manage this species, which has been stimulated by the holding of agrobiodiversity fairs (10, 18, 23) that promote the selection, adoption, exchange and dissemination of new varieties, adapted to localities (24).

[C] MINAG. Lista Oficial de Variedades Comerciales. Registro de variedades comerciales. Dirección de Semillas y Recursos Fitogenéticos; 2016. 58 p.

[D] Sanchiz JE. Emisiones de gases en el cultivo del arroz: Efecto de la gestión de la paja. [Tesis de Maestría]. Universitat de Valencia - Escuela Técnica Superior de Ingenieros de caminos, canales y puertos; 2014 [cited: 2016 jun 20], Available from: http://riunet.upv.es/bitstream/handle/1025/47780/01-Memoria.pdf.

Table III. Varietal diversity of key crops in the three municipalities studied

Cultivos Clave	No. de variedades			Tipos de variedades*		
	Bahía Honda	Gibara	Manicaragua	Bahía Honda	Gibara	Manicaragua
Maíz	3	2	1	3	3	1
Arroz	7	0	1	3	0	1
Frijoles	8	2	2	3	3	1
Yuca	7	3	2	3	3	1
Tomate	5	2	3	3	3	3
Plátano	6	1	2	3	1	2

* Types of varieties: 1. Local; 2. Improved; 3. Both
Source: farmers' surveys

Table IV. Spatial distribution (territorial) of the crops, according to the size of the area and the number of farms that grow it

Tamaño del área	Cantidad de fincas*	Bahía Honda	Gibara	Manicaragua
Área pequeña (menos de 1 ha)	Muchas fincas	Frijol, Maíz, Plátano	Maíz	Frijol, Maíz, Yuca
	Pocas fincas	Arroz, Tomate	Yuca,Tomate, Plátano	Plátano, Tomate, Arroz
Área grande (más de 1 ha)	Muchas fincas	Yuca	Frijol	-
	Pocas fincas	-	-	-

*Muchas fincas: más de 16 fincas en la muestra estudiada. Pocas fincas: menos de 16 fincas en la muestra estudiada

The opposite happens with the tomato that unfortunately is sown in few farms and in small areas, despite having a high demand. This situation is due to the vulnerability of this crop to the negative effects of the climatic variables that determine its low productivity, which is compounded by the incidence of pests and diseases characteristic of tropical conditions, the use of low quality seeds, varieties little adapted to the conditions of the locality and use of cultivation technologies not appropriate to the agroecological characteristics of the sowing site (25).

However, this situation can be reversed with the help of those trained, who have taken part in the realization of agrobiodiversity fairs in the different localities, which will allow instructing and involving a greater number of farmers in the tomato crop in order to strengthen local seed systems and increase the diversity of the species.

Generally, farmers in Bahia Honda plant cassava in plots larger than 1 ha, as well as beans in Gibara. In the first case, it is justified by the fact that this municipality has a livestock tradition, with cassava also used as a supplement in cattle feed (26). In the case of Gibara for its predominantly flat agricultural lands, it is the main bean producer in Holguín province (27), although in the last years the eastern region has been affected by the drought, which has generated a decrease in its production (28).

Rice and plantain show a differentiated territorial behavior, pointing towards the need for particularized transformations in local contexts.

CONCLUSIONES

It is concluded that the varietal diversity of the crops destined to the production of staple foods, potentially decreases with the increase of the cultivated area and its production is generally done in small areas of the farms. In this context, small farmers use an average of three varieties per crop, but local and improved varieties coexist, which favors, in the case of maize, the diversity of populations adapted to the different localities and needs that allow their cultivation in many farms, while the tomato represents a challenge due to its vulnerability to biotic and abiotic stresses that result in it being cultivated in a few farms.

RECOMMENDATIONS

Taking into account the results of this study, it is recommended to hold agrobiodiversity fairs with an emphasis on the cultivation of tomatoes with the purpose of encouraging the conservation and use of seeds of local and improved varieties, and favoring their cultivation by a larger number of farmers.

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