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Home / Archives / 2022: EARLY ACCESS (Vol. V)

ARTICLES

Clonal propagation of Roxb Tree Gmelina in cultivation in Southeast México

MARYNOR ELENA ORTEGA RAMIREZ, Adrian Castro-Osorio, Secundin Torres-Lamas, Nicolás González-Cortés
Abstract 147 | EARLY ACCESS 1 (Español (España)) Downloads 0 | DOI https://doi.org/10.32854/agrop.v15i5.1870

Analysis of the structure and function of an agroecological lighthouse. The case of the Los Álamos Agroecological Education Center

Fernando Ríos y Valles-Boyselle, José Regalado López, José A. Méndez-Espinoza, Javier Ramírez-Juárez, Nicolás Pérez-Ramírez, Ignacio Ocampo-Fletes
Abstract 81 | EARLY ACCESS 2 (Español (España)) Downloads 0 | DOI https://doi.org/10.32854/agrop.v15i5.2068

Maize tolerance to Spodoptera frugiperda (J. E. Smith) leaf damage and insecticide application

Antonia Hernandez-Trejo, Jose Alberto Lopez Santillan, Benigno Estrada-Drouaillet, Zoila Reséndiz Ramirez, Sóstenes Edmundo Varela Fuentes, Juana María Coronado-Blanco, Rosa Ana Malvar
Abstract 127 | EARLY ACCESS 3 (Español (España)) Downloads 0 | DOI https://doi.org/10.32854/agrop.v15i4.2135

Effect of selenium on semen quality and fertility of rams

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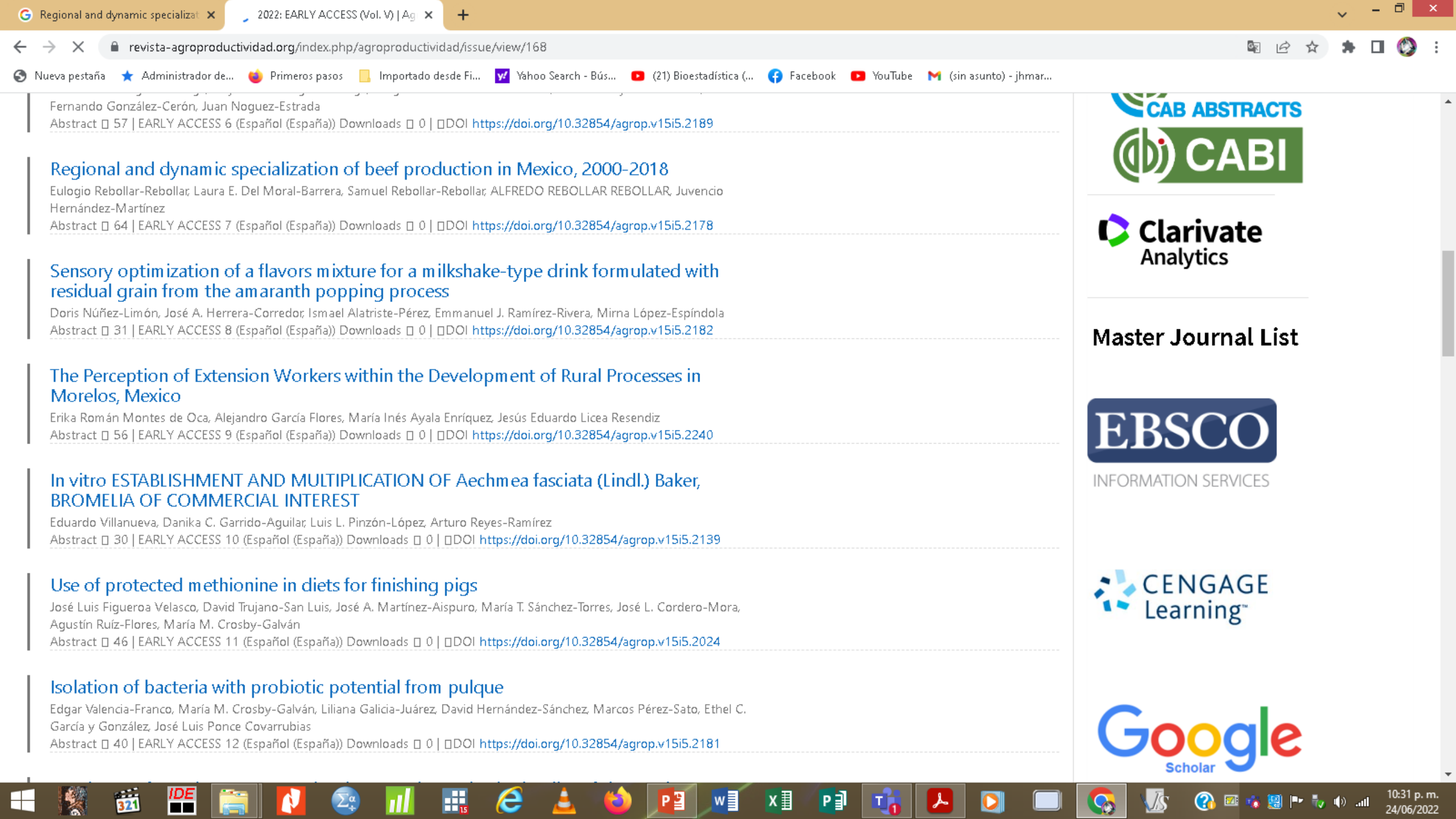
Language

- English
Español (España)

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- For Readers
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Fernando González-Cerón, Juan Noguez-Estrada
Abstract 57 | EARLY ACCESS 6 (Español (España)) Downloads 0 | DOI <https://doi.org/10.32854/agrop.v15i5.2189>

Regional and dynamic specialization of beef production in Mexico, 2000-2018

Eulogio Rebollar-Rebollar, Laura E. Del Moral-Barrera, Samuel Rebollar-Rebollar, ALFREDO REBOLLAR REBOLLAR, Juvencio Hernández-Martínez
Abstract 64 | EARLY ACCESS 7 (Español (España)) Downloads 0 | DOI <https://doi.org/10.32854/agrop.v15i5.2178>

Sensory optimization of a flavors mixture for a milkshake-type drink formulated with residual grain from the amaranth popping process

Doris Núñez-Limón, José A. Herrera-Corredor, Ismael Alatríste-Pérez, Emmanuel J. Ramírez-Rivera, Mirna López-Espíndola
Abstract 31 | EARLY ACCESS 8 (Español (España)) Downloads 0 | DOI <https://doi.org/10.32854/agrop.v15i5.2182>

The Perception of Extension Workers within the Development of Rural Processes in Morelos, Mexico

Erika Román Montes de Oca, Alejandro García Flores, María Inés Ayala Enríquez, Jesús Eduardo Licea Resendiz
Abstract 56 | EARLY ACCESS 9 (Español (España)) Downloads 0 | DOI <https://doi.org/10.32854/agrop.v15i5.2240>

In vitro ESTABLISHMENT AND MULTIPLICATION OF Aechmea fasciata (Lindl.) Baker, BROMELIA OF COMMERCIAL INTEREST

Eduardo Villanueva, Danika C. Garrido-Aguilar, Luis L. Pinzón-López, Arturo Reyes-Ramírez
Abstract 30 | EARLY ACCESS 10 (Español (España)) Downloads 0 | DOI <https://doi.org/10.32854/agrop.v15i5.2139>

Use of protected methionine in diets for finishing pigs

José Luis Figueroa Velasco, David Trujano-San Luis, José A. Martínez-Aispuro, María T. Sánchez-Torres, José L. Cordero-Mora, Agustín Ruíz-Flores, María M. Crosby-Galván
Abstract 46 | EARLY ACCESS 11 (Español (España)) Downloads 0 | DOI <https://doi.org/10.32854/agrop.v15i5.2024>

Isolation of bacteria with probiotic potential from pulque

Edgar Valencia-Franco, María M. Crosby-Galván, Liliana Galicia-Juárez, David Hernández-Sánchez, Marcos Pérez-Sato, Ethel C. García y González, José Luis Ponce Covarrubias
Abstract 40 | EARLY ACCESS 12 (Español (España)) Downloads 0 | DOI <https://doi.org/10.32854/agrop.v15i5.2181>



Master Journal List





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Search

Home / Archives / 2022: EARLY ACCESS (Vol. V) / Articles

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hairless pig

Carlos Bautista, Josué Herrera, Bernardino Candelaria, Marco Ramirez, Ricardo Antonio Chiquini-Medina
Abstract 27 | EARLY ACCESS 13 (Español (España)) Downloads 0 | DOI <https://doi.org/10.32854/agrop.v15i5.2162>

Agroecological production experiences in four agricultural regions of Mexico

BENJAMIN HERNANDEZ, Rita Schwentesius-Rinderman, Tomás Rivas-García
Abstract 36 | EARLY ACCESS 14 (Español (España)) Downloads 0 | DOI <https://doi.org/10.32854/agrop.v15i5.2195>

Nutrient content and in vitro degradability of palm kernel meal produced in the Chiapas state, Mexico as feed for ruminants

Jose-Ricardo Bárcena-Gama, José C. Escobar-España, Alejandro Ley-De Coss, María M. Crosby-Galván
Abstract 57 | EARLY ACCESS 15 (Español (España)) Downloads 0 | DOI <https://doi.org/10.32854/agrop.v15i5.2235>

The importance of forests in the conservation and prevalence of orchids in Megamexico

Brandon Eduardo Gutiérrez Rodríguez
Abstract 92 | EARLY ACCESS 16 (Español (España)) Downloads 0 | DOI <https://doi.org/10.32854/agrop.v15i5.2187>

Agribusiness potential of castor oil (*Ricinus communis* L.) in Mexico

JOSE FERNANDO VASCO LEAL, Liceth Cuellar-Nuñez, Martín Vivanco-Vargas, Juan A. Solís-Lozano, María E. Díaz-Calzada, S.de J. Méndez-Gallegos
Abstract 38 | EARLY ACCESS 17 (Español (España)) Downloads 0 | DOI <https://doi.org/10.32854/agrop.v15i5.2267>



Regional and dynamic specialization of beef production in Mexico (2000-2018)

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ABSTRACT

Objective: To determine the growth, specialization, and dynamics of beef carcass production in eight regions of Mexico, in the 2000-2018 period.

Design/Methodology/Approach: The annual growth rates from 2000 to 2018 in each of the regions were calculated. Based on this information, we were able to determine the relative and dynamic specialization of beef production through Regional Analysis Techniques, such as the Location Quotient and the Differential-Structural Method.

Results: During the 2000-2018 period, the domestic beef carcass production had diverse annual growth. Most of the location quotients greater than the unit were obtained in Chiapas and Sonora, while Sinaloa and Chihuahua obtained lower location quotients. The results of the Differential-Structural Method showed that Sinaloa was the most dynamic region, while Veracruz and Sonora have been left behind and showed little specialization in all sub-periods.

Limitations/Implications: The differentiated annual growth between regions implied underdevelopment and intra-regional dynamism over time. The change in the productive calling of some regions involved a transformation from being specialized to non-specialized. The dynamics of the regions was determined by hypothetical gains, while the underdevelopment was related to hypothetical losses of various magnitudes.

Findings/Conclusions: Sinaloa had the highest growth and dynamism of all the regions. Veracruz and Sonora were left behind and showed little specialization throughout the analyzed period.

Keywords: Growth, cattle, regional analysis techniques.

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INTRODUCTION

Poultry, beef, and pork meat are the main sources of animal origin protein, which is the basis of human nutrition. In 2018, Mexico produced 6.94 million tons of carcass meat of the following species: poultry (47.98%), beef (28.53%), pork (21.61%), and sheep, goats, and turkey (1.88%) (SIAP, 2020).

Beef has a high protein value and it has great social and economic importance in Mexico (Puebla-Albiter *et al.*, 2018). It is the second most important productive activity (SIAP, 2020). However, the sector's productive structure has undergone substantial changes at regional level.

From 2000 to 2018, the domestic beef production registered an annual average growth rate (TCMA) of 2.02%, increasing from 1.40 million tons (mt) in 2000 to 1.98 mt in 2018.

The cattle production dynamism in the country showed disparities between regions (Puebla-Albiter *et al.*, 2018). In 2018, Veracruz (Ver) and Jalisco (Jal) contributed 25.06% of the national production, while Chiapas (Chis) and Sinaloa (Sin) accounted for 10.69%, while Sonora (Son) and Chihuahua (Chih) contributed 8.13% (SIAP, 2020).

This reflects the differences in the beef production behavior between different regions of Mexico. Therefore, the objective of this work was to determine the beef carcass production growth, specialization, and dynamics in eight regions of Mexico from 2000 to 2018. The aim was to generate indicators that allow the implementation of policy strategies that encourage the production of this type of meat.

MATERIALS AND METHODS

To determine the regional dynamics of beef carcass production (2000-2018), Mexico was divided into eight production regions: Veracruz (Ver), Jalisco (Jal), Chiapas (Chis), Sinaloa (Sin), Sonora (Son), Chihuahua (Chih), and Baja California (BC), which together accounted for 51% of the national total (SIAP, 2020). All other Mexican states were grouped in a region called the rest of Mexico (rM).

The study period was divided into three sub-periods: 2000-2006, 2007-2012, and 2013-2018. To determine the beef production behavior, the annual growth rates (2000-2018) in each of the regions were calculated. To determine the relative specialization and production dynamics, Regional Analysis Techniques (TAR) were used, including the Location Quotient and the Differential-Structural Method (MDE) (Boisier, 1980).

The dynamism and specialization indicators were obtained from the SECRE (sector-region) matrix, which is a double-entry table, where the rows are the sectors and the columns are the regions (Boisier, 1980). The sectors were the years of study and the columns, the regions (Del Moral-Barrera *et al.*, 2008). The analysis variable was beef carcass production measured in thousands of tons, which was processed with the TAREA software (Lira and Quiroga, 2003) and Microsoft Excel - 2013.

The Location Quotient (Q_{ij}) indicates the proportion of beef production in a specific year (sector "i") in a given region (region "j"), compared to the relative size of the same activity at the national level. This quotient was used to measure the relative or inter-regional specialization of cattle production for each year, using formula 1.

$$Q_{ij} = \frac{V_{ij}}{\sum_i V_{ij}} \bigg/ \frac{\sum_j V_{ij}}{\sum_i \sum_j V_{ij}} \quad (1)$$

Where V_{ij} =Value of V for sector “ i ” in region “ j ”; $\sum_i V_{ij}$ =Value of V for the regional total; $\sum_j V_{ij}$ =Value of V for the national total of the sector “ i ”; $\sum_i \sum_j V_{ij}$ =Value of V for the national total of sector “ i ” and region “ j ”.

The values of Q_{ij} are:

$Q_{ij}=1$ indicates that the relative size of sector “ i ” in region “ j ” is identical to the relative size of the same sector in the country. Therefore, there is no regional specialization in that sector (year).

$Q_{ij}<1$ indicates that the relative size of sector “ i ” in region “ j ” is smaller than the relative size of the same sector in the country. Consequently, there is no regional specialization in that sector (year).

$Q_{ij}>1$ indicates that the relative size of sector “ i ” in region “ j ” is greater than the relative size of the same sector in the country. In this case, there is a regional specialization in sector “ i ” (year).

The Differential-Structural Method consists of comparing the change observed in a variable during a period, both at regional and national level. This change is compared with what would have happened in the region, if the variable in question had shown an identical behavior, both in the region and in the country. The method determines changes both in the regions’ relative position and in the territories’ productive structure over time (Boisier, 1980). The Differential-Structural Method is divided into three components: total effect (ET), differential effect (ED), and structural effect (EE). The ET compares the final value (year t) of the variable under study, in region j , with the hypothetical value that the said variable would have had, if the region had had the same growth behavior as the country. The “expected or hypothetical” value is obtained by applying the national variation coefficient (rSR) to the initial value of the variable in year zero. ET is obtained using formula 2.

$$ET_j = \sum_{i=1}^n V_{ij}(t) - \left[\sum_{i=1}^n V_{ij}(0) * rSR \right] \tag{2}$$

V_{ij} =Value of variable V for year i , in region j . 0=Year zero or initial year (given the study period, year zero would be 2000, until 2017). t =Final year (given the study period, year t would be 2001, consecutively, until 2018). rSR =National variation coefficient.

$$rSR = \frac{\sum_i \sum_j V_{ij}(t)}{\sum_i \sum_j V_{ij}(0)}$$

A positive ET indicates a “hypothetical gain” or an expected gain of the activity in the study region, because the regional growth is higher than the national growth. A negative

ET indicates a “hypothetical loss” of activity in the region, since the activity growth is lower in the study region than in country (Boisier, 1980). The ET is explained by the combination of two effects: differential effect and structural effect.

$$ET_j = ED_j + EE_j$$

The differential effect compares the final value (year t) of the variable under study, recorded in year i , in region j , with the hypothetical value of the said variable during the same year. The said effect represents the comparison of the production dynamics for each year i , in region j , with the national dynamics during the same year. It is expressed through formula 3.

$$ED_j = \sum_{i=1}^n \left\{ V_{ij}(t) - [V_{ij}(0) * rS_i] \right\} \tag{3}$$

rS_i =Annual variation coefficient at national level

$$rS_i = \frac{\sum_j V_{ij}(t)}{\sum_j V_{ij}(0)}$$

If a region obtains a positive differential effect, the annual production in the said region surpassed the national production for the same year. Consequently, the regions with positive differential effects were identified as dynamic (Boisier, 1980) and competitive (Lira and Quiroga, 2003) and they also had better productive conditions (Del Moral-Barrera *et al.*, 2008). Regions with a negative ED were underdeveloped and non-competitive, and had worse production conditions.

The structural effect is the consequence of the fact that, on a national scale, production grows more on some years than in others. Consequently, in years (sectors) of rapid growth (SRC) at the national level, regions that have a specialized productive structure will tend to show positive relative changes. Meanwhile, in years (sectors) of slow growth (SLC), regions with specialized productive structure will present negative relative changes. The EE reflects the relative weight of the different years (sectors) at the regional level, compared to the relative weight of the same years at the national level (Boisier, 1980). The EE is expressed through formula 4.

$$EE_j = \sum_{i=1}^n \left\{ rS_i * \left[\frac{V_{ij}(0)}{\sum_i V_{ij}(0)} - \frac{\sum_j V_{ij}(0)}{\sum_i \sum_j V_{ij}(0)} \right] \right\} * \sum_{i=1}^n V_{ij}(0) \tag{4}$$

A positive EE indicates that the region specializes in SRC at the national level, while a negative EE indicates that the region specializes in SLC at the national level (Lira and Quiroga, 2003).

RESULTS AND DISCUSSION

During the 2000-2018 period, the national beef carcass production underwent diverse cyclical annual growth, which caused changes in its productive distribution (Table 1). From 2001 to 2002, the national production grew 3.74%, as consequence of the greater contribution made by Sin and Son. This behavior was motivated by the income and world population increase, in addition to changes in diets and the global meat trade liberalization reported in the previous year (Dyck and Nelson, 2003).

During 2004 and 2005, production maintained positive growth; however, Jal, Chis, Son, and Chih reported negative increases. Since the end of 2005, a noticeable growth in the price of corn significantly impacted production costs in all branches of intensive livestock farming, both in Mexico and abroad (SAGARPA, 2009).

From 2010 to 2011, national beef production increased by 3.39% due to the participation of Chih (10.42%) and Son (7.97%). This dynamic was the result of favorable market conditions and it was influenced by the increase in the calf export price, which benefited producers and exporters (Cruz-Jiménez and García-Sánchez, 2014).

From 2016 to 2017, national production increased by 2.57%, driven by the general growth in most regions. The wide availability of feed grains and pastures, combined with

Table 1. Annual growth rates of beef production per region, 2000-2018 (%).

Year	Ver	Jal	Chis	Sin	Son	Chih	BC	rM	National
2000-2001	3.27	-2.67	-2.78	13.80	0.00	0.37	-1.63	-0.03	0.43
2001-2002	1.51	1.00	3.32	16.45	10.34	3.31	-8.62	4.45	3.74
2002-2003	1.08	-2.21	7.37	-2.39	4.73	6.80	3.71	3.20	2.47
2003-2004	-3.99	1.33	3.10	0.75	-4.96	1.88	12.94	5.17	2.66
2004-2005	3.69	-1.00	-3.16	0.90	-3.66	-0.75	12.38	0.81	0.91
2005-2006	7.85	1.34	0.46	0.70	4.40	-1.61	10.36	3.31	3.55
2006-2007	1.41	0.39	1.09	1.73	0.97	0.82	5.77	1.23	1.37
2007-2008	3.73	0.13	0.54	2.91	-2.23	19.99	-4.32	1.41	1.96
2008-2009	3.58	0.27	5.95	2.55	-0.23	8.08	-3.05	1.98	2.27
2009-2010	4.12	4.21	0.49	0.09	5.95	-1.35	12.35	1.02	2.33
2010-2011	3.15	3.46	2.33	-0.33	7.97	10.42	7.07	2.40	3.39
2011-2012	-4.18	2.41	3.75	29.56	-9.39	-6.52	-6.90	1.86	0.92
2012-2013	-3.83	4.76	1.21	-14.27	-0.52	-19.73	2.92	1.84	-0.76
2013-2014	-1.96	-2.13	-2.19	3.67	-4.72	-3.37	-0.67	3.95	1.13
2014-2015	2.23	-0.49	1.04	-2.03	-1.70	-0.71	0.66	1.65	0.99
2015-2016	1.28	6.33	0.69	1.40	-3.68	5.81	2.31	1.23	1.81
2016-2017	2.31	4.77	-9.54	10.82	4.16	2.88	3.52	2.58	2.57
2017-2018	-0.11	5.17	0.99	5.01	6.18	8.40	3.23	2.25	2.80

Ver: Veracruz, Jal: Jalisco, Chis: Chiapas, Sin: Sinaloa, Son: Sonora, Chih: Chihuahua, BC: Baja California, rM: rest of Mexico. Source: Table prepared by the authors based on data from the Sistema de Información Agroalimentaria y Pesquera (SIAP, 2020).

the high beef prices in the country, encouraged ranchers to fatten their cattle for longer periods (FIRA, 2017).

Positive production growth continued during 2018 —particularly in Son (6.18) and Chih (8.40). Such increases were consequence of the gradual growth of the cattle herd and the relative stability of grain prices that influenced the growth of national production (FIRA, 2019).

Regional relative specialization

Production specialization is a source of increased competitiveness for a given sector (Bustamante-Lara *et al.*, 2020). During the analyzed period, Chis was the region that reported the highest number of location quotients greater than the unit, which indicated that the relative size of cattle production was greater than the relative size of the same activity at the national level. This indicator reflected that Chis specialized in beef production during this period. In contrast, Sin recorded the highest number of location quotients lower than the unit, which indicated that the meat production relative size in that region was smaller than the activity's relative size in the country. This value indicated a regional specialization absence of the activity.

During the 2000-2006 sub-period, Chis and Son recorded location quotients greater than the unit, indicating that these regions specialized in beef production, while Sin and BC showed a relative lack of specialization in this livestock activity.

In the 2007-2012 sub-period, Chis and Son continued to specialize, reporting coefficients greater than the unit; they were joined by Ver, which also reported numbers greater than one. Sin continued to show a lack of specialization and Jal started to behave the same way (Table 2).

From 2013 to 2018, Sin, Jal, and BC recorded location quotients greater than the unit. The first two regions maintained a similar behavior to the previous sub-period. For its part, Ver no longer specialized in bovine production; just like Chih, it recorded location quotients lower than the unit.

Regional dynamics of beef production

The results of the Differential-Structural Method showed that the dynamics of beef production in Mexico was different between the regions and periods studied.

During 2000-2006, BC and Sin obtained a positive total effect (ET), as a consequence of the contribution of the differential effect (ED) and the structural effect (EE). This implied that these territories were dynamic and specialized, a behavior that entails hypothetical gains of 9.90 and 8.72 thousand t, respectively. Ver, Jal, Chis, Son, and Chih obtained a negative ET, as a consequence of a greater contribution made by the negative ED. This meant that the territories were left behind (in terms of growth), reflecting hypothetical losses of various magnitudes (Table 3).

During 2007-2012, Sin, Chih, and Chis obtained a positive ET, resulting from the greater contribution made by the likewise positive ED. However, only Sin continued with the dynamic trend and the same productive calling as during the previous sub-period; in practice, this dynamism meant 19.34 thousand tons of expected profit. The rest of the

Table 2. Location quotients of beef production per region in Mexico (2000-2018).

Year	Ver	Jal	Chis	Sin	Son	Chih	BC	rM
2000	1.03	1.16	1.07	0.82	1.14	0.99	0.88	0.96
2001	1.06	1.13	1.04	0.92	1.14	0.99	0.86	0.96
2002	1.03	1.10	1.04	1.04	1.21	0.99	0.76	0.97
2003	1.02	1.05	1.09	0.99	1.24	1.03	0.77	0.97
2004	0.95	1.03	1.09	0.97	1.15	1.02	0.85	1.00
2005	0.98	1.01	1.05	0.97	1.09	1.00	0.94	1.00
2006	1.02	0.99	1.02	0.94	1.10	0.95	1.00	0.99
2007	1.02	0.98	1.01	0.95	1.10	0.95	1.05	0.99
2008	1.04	0.97	1.00	0.96	1.05	1.12	0.98	0.99
2009	1.05	0.95	1.03	0.96	1.03	1.18	0.93	0.98
2010	1.07	0.96	1.02	0.94	1.06	1.14	1.02	0.97
2011	1.07	0.96	1.01	0.90	1.11	1.21	1.06	0.96
2012	1.01	0.98	1.03	1.16	1.00	1.13	0.98	0.97
2013	0.98	1.03	1.05	1.00	1.00	0.91	1.01	1.00
2014	0.95	1.00	1.02	1.03	0.94	0.87	1.00	1.03
2015	0.97	0.99	1.02	1.00	0.92	0.86	0.99	1.03
2016	0.96	1.03	1.01	0.99	0.87	0.89	1.00	1.03
2017	0.96	1.05	0.89	1.07	0.88	0.89	1.01	1.03
2018	0.93	1.08	0.87	1.10	0.91	0.94	1.01	1.02

Ver: Veracruz, Jal: Jalisco, Chis: Chiapas, Sin: Sinaloa, Son: Sonora, Chih: Chihuahua, BC: Baja California, rM: rest of Mexico. Source: Table prepared by the authors, based on the interpretation of TAREA software.

Table 3. Coefficients obtained from the application of the Differential–Structural Method in the beef producing regions in Mexico (thousands of tons).

Region	Periods								
	2000-2006			2007-2012			2013-2018		
	ET	ED	EE	ET	ED	EE	ET	ED	EE
Ver	-1.04	-1.21	0.17	-2.40	-2.46	0.06	-31.47	-22.12	-9.35
Jal	-28.88	-28.70	-0.18	-2.28	-5.14	2.86	13.24	15.12	-1.88
Chis	-5.68	-5.58	-0.10	2.03	2.01	0.01	-23.03	-18.70	-4.32
Sin	8.72	8.55	0.17	19.34	19.30	0.04	-8.72	-5.09	-3.63
Son	-2.92	-2.90	-0.02	-7.89	-7.82	-0.07	-9.55	-6.67	-2.88
Chih	-2.87	-2.86	-0.01	12.86	12.83	0.04	-18.04	-14.81	-3.23
BC	9.90	9.87	0.03	-2.36	-2.31	-0.06	-0.15	2.97	-3.12
rM	22.77	22.83	-0.06	-19.30	-19.32	0.02	11.34	43.93	-32.59

ET: total effect, ED: differential effect, EE; structural effect. Source: Table prepared by the authors, based on the interpretation of TAREA software.

regions recorded a negative ET, as a consequence of the greater relative weight of ED values, which were also negative.

In the 2013-2018 sub-period, Jal achieved a positive ET, caused by the contribution made by the ED, changing its behavior in the previous sub-periods, from an underdeveloped region to a dynamic region. In the rest of the regions, the ET was negative, resulting in underdeveloped territories, with worse productive conditions.

CONCLUSIONS

During the study period, beef carcass production in Mexico revealed discrepancies in relation to growth and dynamism between the regions. Chiapas and Sinaloa recorded the highest amount of positive growth in the analyzed years. Chiapas and Sonora specialized in beef production in the first two sub-periods, but stopped specializing and changed their productive calling during the third sub-period. Sinaloa was dynamic and specialized in the first two sub-periods, but became underdeveloped and lacked specialization in the last sub-period. Chiapas and Chihuahua were originally underdeveloped, became dynamic in the second sub-period, and returned to an underdeveloped state in the third sub-period. In contrast, Veracruz and Sonora remained underdeveloped and showed little specialization throughout the entire period.

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