Chilean J. Agric. Anim. Sci., ex Agro-Ciencia (2025) 41(2):230-240.
https://doi.org/10.29393/CHJAAS41-21FEMM40021

ISSN 0719-3890 online

IMPORTANCE OF THE MILPA SYSTEM IN ANIMAL FEED IN MIXTEC COMMUNITIES: USE OF PRODUCTS AND BY-PRODUCTS

Floriberto Cortes-Bautista[1a], José C. Carrillo-Rodríguez[1b*], José L. Chávez-Servia[2], José Daniel Carrillo-Castillo[3], Catarino Perales-Segovia[4], Netzahualcóyotl Mayek Pérez[5], and Gisela V. Campos Angeles[1c]

[1a] Instituto Tecnológico del Valle de Oaxaca-TecNM, Ex-Hacienda Nazareno, Santa Cruz Xoxocotlán, C.P. 71230, Oaxaca, Mexico
https://orcid.org/0000-0003-3077-9820
[1b] Instituto Tecnológico del Valle de Oaxaca-TecNM, Ex-Hacienda Nazareno, Santa Cruz Xoxocotlán, C.P. 71230, Oaxaca, Mexico
https://orcid.org/0000-0002-4170-224X
[1c] Instituto Tecnológico del Valle de Oaxaca-TecNM, Ex-Hacienda Nazareno, Santa Cruz Xoxocotlán, C.P. 71230, Oaxaca, Mexico
https://orcid.org/0000-0003-2258- 7124
[2] Instituto Politécnico Nacional, CIIDIR Unidad Oaxaca, Hornos # 1003, Santa Cruz Xoxocotlán, C.P. 71230, Oaxaca, Mexico
https://orcid.org/0000-0002-8816-4127
[3] Centro Interdisciplinario de Investigación y Docencia en Educación Técnica-CIIDET-TecNM, Av. Universidad 282, Centro, Santiago de Querétaro, C.P. 76000, Mexico
https://orcid.org/0009-0006-5786-3829
[4] Instituto Tecnológico del Llano Aguascalientes-TecNM. El Llano Aguascalientes, Aguascalientes, Mexico
https://orcid.org/0000-0002-1568-2388
[5] Centro de Biotecnología Genómica, Instituto Politécnico Nacional. Blvd. del Maestro s/n Esq. Elias Piña, Col. Narciso Mendoza, CP 88710. Reynosa, Tamaulipas, Mexico
https://orcid.org/0000-0001-6960-6287
* Corresponding author: jcarrillo_rodriguez@hotmail.com

ABSTRACT

The milpa system is the foundation of traditional agriculture in Mesoamerica. It is characterized by the polyculture of maize (*Zea mays* L.), beans (*Phaseolus* spp.), and squash (*Cucurbita* spp.), and is associated with a wide diversity of crops and wild species. In Oaxaca, this crop-growing system is closely linked to backyard livestock farming, as its products and by-products serve as an essential source of animal feed. The objective of this study was to evaluate the diversity and quantity of milpa-derived products and by-products used for domestic animal feed in the municipalities of Santo Domingo Yanhuitlán and San Martin Huamelúlpam, Mixtec region, Oaxaca, Mexico. The study used a qualitative approach, supported by site visits, interviews, field trips, and semi-structured surveys conducted with 194 household heads in the two municipalities. The results showed that, among products derived from the milpa system for animal feed, 68.5% of the surveyed households used maize seed and 4.2% used squash. Among by-products, 46.9% used maize stover, while 34.02% combined maize stover with grasses and weeds. Most milpa-derived feed lasted four to six months, after which animals were supplemented with forage species, primarily alfalfa (17%), along with

Received: October 10, 2024 Accepted: August 16, 2025

grazing and/or purchased feed. The main animal species reared in the surveyed households included sheep, goats, poultry, pigs, rabbits, and large livestock. This study highlights the central role of the milpa system in supporting both household livestock production and family subsistence in the Mixtec region, Mexico.

Keywords: forage species, animal species, milpa system.

INTRODUCTION

In Mexico, a significant portion of the population lives under conditions of poverty and marginalization (CONEVAL, 2022). Within these contexts, agriculture and livestock farming are the primary economic activities and constitute the foundation of family self-sufficiency (Solís-Vázquez et al., 2023; Cisneros-Saguilán et al., 2024). These activities are typically carried out in small spaces, commonly backyards or family production units (González et al., 2014). Globally, more than 500 million family-based production systems provide approximately 70% of the food consumed in the basic diet (FAO, 2014; Viesca-González et al., 2022). Each of the units is considered an 'agroecosystem', a productive space in which the active involvement of the family is essential for food production, whether through crop cultivation or livestock management (González et al., 2014).

The milpa system is one of the most traditional agroecosystems, characterized by its high diversity of cultivated crops, alongside other complementary plants (Collin, 2021). In this system, intercropping of maize (*Zea mays* L.), beans (*Phaseolus* spp.), and squash (*Cucurbita* spp.) not only enhances biodiversity but also improves productivity and supports family self-sufficiency (Ramírez-Maces et al., 2023), while cultivated crops contribute approximately 25% of the global food supply (Altieri et al., 2012; Heindorf et al., 2021). Family production units, closely linked the milpa system, trace their origins to Mesoamerican traditions and are vital for rural food security, providing an estimated 63.7% of household food needs (Mariscal et al., 2019).

Beyond direct human consumption, the milpa system also generates a wide variety of by-products that serve as valuable inputs for animal feed (Naranjo-Piñera et al., 2013; Mateos-Maces et al., 2020). In this context, domestic animals constitute an integral component of the agrobiodiversity within family production units, accounting for a significant proportion of livestock production (approximately 71%) (García and Guzmán, 2014). Commonly reared species in backyard systems include cattle, sheep, goats, and poultry (chickens, turkeys, and ducks), as well as pigs, rabbits, and even working animals (García-Navarro et al., 2022). These species are typically kept in rural facilities or directly in the field under management conditions that require minimal or no sanitary interventions (Alayón, 2015). Their diet primarily relies on locally available resources, as well as on products and by-products generated within the production units themselves (García-Navarro et al., 2022).

The rearing of animal species in communities not only strengthens household economies and provides nutrient-rich food for self-consumption, but also represents an important socioeconomic and cultural contribution (González et al., 2014). A portion of this production is sold locally, either through direct sales or by means of barter/exchange, enabling families to generate additional income to build and maintain savings to handle unexpected expenses (García and Guzmán, 2014). In this way, family production units play a critical role in ensuring food security of indigenous peasant households, while also serving as an important source of income (FAO, 2014; Balcázar-Quiñones et al., 2020).

Recognizing the significance of the milpa system is essential, as in many rural communities the resources obtained from this system constitute the primary source of animal feed (Jimenez et al., 2019). These resources are critical for animal nutrition and, consequently, for the livelihoods of the families that rely on these production units. However, there is the lack of systematic information on milpa-derived products and by-products that are used to feed backyard animals (Collin, 2021). Moreover, despite the challenges faced by family production units and their vital role in sustaining household livelihoods, there are currently no targeted programs or initiatives that specifically support animal production and breeding within these units, particularly with respect to enhancing food security and increasing family income.

The objective of this study was to quantify the milpa-derived products and by-products used for animal feed and to assess the contribution of these animals to household income in the municipalities of Santo Domingo Yanhuitlán and San Martín Huamelúlpam, Mixtec region, Oaxaca, Mexico.

MATERIALS AND METHODS

Study area

This study was conducted in the Mixtec region, Oaxaca State, Mexico, specifically in the communities of San Martín Huamelúlpam (Tlaxiaco area) and Santo Domingo Yanhuitlán (Nochixtlán area). The study sites are located between the coordinates 17°20′ 07′′ and 17°31′ LN, 97°20′ to 97°38′ LO, at altitudes ranging from 2,140 to 2,200 meters above sea level, and temperatures ranging from 3 to 36ºC. Furthermore, there is a frost season from December to February, and the area is characterized by a temperate subhumid climate with summer rainfall. Cultivated soils include Lithosols, Regosols, and Cambisols, with slopes ranging from 10 to 40% (INEGI, 2018). A common feature across the municipalities is the high prevalence of families growing crops under the milpa system and rearing backyard animals.

Study type and survey application

The study used a qualitative approach to identify products and by-products generated using the milpa system. Data were collected through semi-structure surveys, field visits, and interviews with municipal authorities and farmers from both communities. For the semi-structured surveys, a 100% sampling of the household heads in both municipalities was considered, focusing on those who grow crops using the milpa system, rear backyard animals, and were willing to participate in the study. The questionnaire consisted of 13 questions divided into two sections: (i) diversity and number of animals in the household, ranch, milpa area, or crop area; and (ii) direct contribution of domestic animals to the household, specifically the type and quantity of milpa-derived products and by-products used for animal feed. Additional items addressed the sociodemographic characteristics of the surveyed households. In total, surveys were conducted with 194 household heads between January and February 2022.

Statistical analysis

Based on the information obtained from the 194 surveys, an Excel database was compiled with the individual responses of each household head. The data were subjected to descriptive statistical analyses, using means and totals, to determine the number of animal species, the quantity of milpa-derived products and by-products, and the distribution of animals across municipalities.

A correlation analysis was also used to identify significant relationships among selected variables. In addition, a principal component analysis (PCA) was performed on the quantitative variables to describe the variation in responses, and a multiple correspondence analysis (MCA) was performed to identify the variables with the highest descriptive value in relation to the survey questions and responses.

RESULTS AND DISCUSSION

According to the sociodemographic characteristics of the surveyed households (Table 1), a relatively even age distribution was observed, ranging from under 25 years to over 75 years in both municipalities. With respect to education, approximately 20.1% of respondents in each municipality had completed primary education, while 11.34% had completed secondary education. High school completion was reported by 7.22% of respondents in both municipalities, whereas less than 3.09% had pursed studies at the higher education level. Notably, 7.22% of respondents in Santo Domingo Yanhuitlán reported no formal education, compared to 3.09% in San Martín Huamelúlpam. Gender distribution was also relatively balanced across the municipalities. Of the 194 participants, 47.47% were men and 52.57% were women, most of whom engaged in both crop cultivation under the milpa system and rearing of backyard animals.

Species distribution and contribution to households

Table 2 presents the number of animals by species. The same species were found in the two municipalities: cattle, horses, sheep, goats, chickens, and turkeys, pigs, and rabbits. Of the 194 households surveyed, 32.9% reported owning large livestock (cattle and horses), which are primarily used for fieldwork, land preparation (for growing typical milpa crops and forage species such as oats, wheat, and alfalfa), as well as for carrying load. These findings align with those reported by Martínez et al., (2023) in communities of Chiapas and Tabasco, Mexico, where animals contribute to household nutrition and family economy, with poultry being the most commonly reared backyard animals due to their provision of protein and income, alongside medicinal plants, fruit trees, and some ornamental species.

With respect to sheep and goats, 73% of households reported rearing these species, primarily for consumption in family events or festivities. They are also sold as barbecue in local markets. In both municipalities, the presence of poultry predominated in 79% of the surveyed households, with chickens and turkeys being the most important species for egg and meat production for either consumption or sale. Their significance is also linked to their protein

Table 1. Sociodemographic characteristics of the household heads surveyed (n=194) from the municipalities of Santo Domingo Yanhuitlán and San Martín Huamelúlpam, Mixtec region, Oaxaca, Mexico.

Variables	Santo Domingo Yanhuitlán	San Martín Huamelúlpam
Age (years)		
<2	1 (0.52)	6 (3.09)
25-3	2 (1.03)	4 (2.06)
30-3	4 (2.06)	6 (3.09)
35-40	12 (6.19)	7 (3.61)
40-45	6 (3.09)	9 (4.64)
45-50	14 (7.22)	12 (6.19)
50-55	9 (4.64)	14 (7.22)
55-6	12 (6.19)	8 (4.12)
60-65	9 (4.64)	8 (4.12)
65-70	9 (4.64)	9 (4.64)
70 -75	5 (2.58)	6 (3.09)
>75 años	13 (6.7)	9 (4.64)
Education		
Primary	41 (21.13)	39 (20.1)
Secundary	22 (11.34)	33 (17.01)
High school	14 (7.22)	14 (7.22)
Bachelor’s degree	5 (2.58)	6 (3.09)
No formal education	14 (7.22)	6 (3.09)
Gender		
Female	51 (26.29)	41 (21.13)
Male	45 (23.2)	57 (29.38)

Table 2. Average values, standard deviation, and total number of animals per species in the municipalities Santo Domingo Yanhuitlán and San Martín Huamelúlpam, Mixtec region, Mexico.

Species	Average	Total	Standard Deviation
Santo Domingo Yanhuitlán			
Years of animal rearing	24.82	1 to 70	
Number of animals per household	25.75	2472	20.55
Large livestock	2.10	82	1.36
Sheep and goats	14.75	1121	15.13
Poultry	13.56	1153	12.74
Pigs and rabbits	6.11	116	3.34
San Martín Huamelúlpam			
Years of animal rearing	20.63	1 - 60	
Number of animals per household	28.80	2822	26.34
Large livestock	3.56	89	2.41
Sheep and goats	22.62	1493	22.87
Poultry	16.90	1166	16.08
Pigs and rabbits	3.22	74	2.36

contribution to the diet of rural families, as observed with the Araucana hen (Rodríguez et al., 2023). Pigs and rabbits were less common, occurring in only 21% of households, with San Martín Huamelúlpam exhibiting the highest number of animals, except for pigs and rabbits. Within these production systems, the diversity of animals is considerable. Alayon-Gamboa (2015) notes that poultry are the most numerous and important species due to their contribution to the family production unit and ease of management. In fact, several studies have indicated that backyard poultry farming is an important activity in rural areas of Mexico (Cuca-García, 2018; Martínez et al., 2023). Additionally, González et al. (2014) reported that 71.4% of the farms reared poultry, including hens, chickens, ducks, and turkeys, followed by pigs (47.6%), cattle (19%), rabbits (9.5%), sheep (4.8%), and horses (3.2%).

Table 3 presents the milpa-derived products and by-products used for animal feed in the two Mixtec municipalities under study. The area dedicated to crop cultivation using the milpa system is noteworthy: on average, 53% of participants cultivate between 0.5 and 1 ha, followed by16% who plant 1 and 2 ha, and another 16% who cultivate more than 2 ha. These areas are representative of the milpa system in both localities. Erenstein et al. (2012) indicated that, in these production units, it is essential to consider the area planted with maize to ensure an adequate supply of animal feed.

With respect to milpa-derived products, maize is the most important, accounting for 68.5%, followed by squash-maize intercropping, which represents 15.6%. These products are mainly used to feed poultry, pigs, rabbits and, in some cases, sheep and goats, depending on the harvest yield. Regarding milpa-derived by-products, the

Table 3. Milpa-derived products and by-products for animal feed in the municipalities of Santo Domingo Yanhuitlán and San Martín Huamelúlpam, Mixtec region, Mexico.

Variables	Santo Domingo Yanhuitlán	San Martín Huamelúlpam	Total (%)
Milpa area (ha) (X^2=9.6156, P<0.05)			
< 0.5	17 (8.76)	10 (5.15)	27 (13.91)
0.5 to 0.75	32 (16.49)	22 (11.34)	54 (27.83)
0.75 to 1.0	22 (11.34)	27 (13.92)	49 (25.25)
1.0 to 1.5	5 (2.58)	15 (7.73)	20 (10.30)
1.5 to 2.0	5 (2.58)	7 (3.61)	12 (6.18)
> 2.0	15 (7.73)	17 (8.76)	32 (16.49)
Milpa products (X^2= 9.1909, P<0.05)			
Maize seeds	73 (37.63)	60 (30.93)	133(68.55)
Squash	3 (1.55)	5 (2.58)	8(4.12)
Maize and squash seeds	12 (6.19)	10 (5.15)	22(11.34)
No use of milpa-derived products	8 (4.12)	23 (11.86)	31(15.97)
Milpa by-products (X^2=7.3917, P<0.05)			
Maize stover	49 (25.26)	42 (21.65)	91 (46.90)
Fresh grasses and weeds	3 (1.55)	5 (2.58)	8 (4.12)
Combinations	36 (18.56)	30 (15.46)	66 (34.02)
No use of milpa-derived by-products	8 (4.12)	21 (10.82)	29 (14.94)
Animal forage crops (X^2=15.6765, P<0.05)			
Alfalfa	15(7.73)	18(9.28)	33(17.01)
Oats	2(1.03)	17(8.76)	19(9.79)
Wheat	2(1.03)	2(1.03)	4(2.06)
Alfalfa/Oat	5(2.58)	5(2.58)	10(5.15)
Alfalfa/Wheat	1(0.52)	1(0.52)	2(1.03)
Oat/Wheat	2(1.03)	0(0)	2(1.03)
No forage	69(35.57)	55(28.35)	124(63.91)

most important is maize stover (46.9%), followed by a combination of maize stover with fresh grasses and weeds (34.02%). These by-products are primarily used to feed large livestock, sheep, and goats. The surveyed household heads reported that current harvests no longer yield the quantities obtained in the past, which limits their capacity to rear more animals, as most livestock depend on milpa-derived products and by-products. Consequently, some participants cultivate additional forage species such as alfalfa (17%), oats, or wheat, either alone or intercropped, while others allow animals to graze after harvest to take advantage of the milpa-derived residues or remaining maize stover (Caballero et al., 2017). These findings are consistent with those of Hellin et al. (2013) in three regions of Mexico, who reported that maize stover was the predominant feed, exceeding 70%. This finding underscores the importance of maize stover in meeting livestock fodder requirement (Borja-Bravo et al., 2016; Salinas-Vargas et al., 2022).

The correlation analysis revealed highly significant relationships between the number of animals in the household and several variables, including the number of sheep and goats, the number of poultry, the weekly amount of maize seed used for feed, and the quantity of maize stover supplied to animals (Table 4). These associations reflect the livelihood strategies of local farmers, who rely on both milpa-derived resources and grazing. This confirms that agricultural activities constitute an important source of supplementary feed for livestock species (Vargas-López et al., 2017). Maize seed and stover emerged as the most important products and by-products of the milpa system for animal feeding, respectively. In both municipalities, most households reared sheep, goats, and poultry, which benefited most from these resources. According to Jiménez et al. (2019), 91.5% of production units in Oaxaca rear these species, while peasant families complement livestock feeding by planting grasses and legumes and allocating 35.8% of their harvest products and by-products to animal feed.

The number and use of these species showed a significant relationship with both family self-consumption and household income. Specifically, the number of animals was significantly associated with the number of sheep and goats destined for consumption and sale. This pattern is consistent with the findings of Mariscal et al. (2019) in the Central Valleys region of Oaxaca, where backyard livestock farming represents an important source of both food and income. Moreover, backyard animal husbandry provides temporary access to products for household consumption, family celebrations, barter/exchange, and sale.

Table 4. Correlation matrix (r) among respondents' answers regarding animals reared and milpa-derived products and by-products used for animal feed.

Variables	AH	HLL	HSG	HP	MPF	SAF	SLLF	SSGF	SGS	SGC
Animals in the household (AH)	1	0.16	0.74**	0.53**	0.28**	0.10	0.09	0.55**	0.60**	0.27**
Heads of large livestock (HLL)		1	0.06	0.07	0.08	-0.16	0.86**	0.04	0.12	0.01
Heads of sheep and goats (HSG)			1	-0.12	-0.16**	0.00	0.02	0.77**	0.73**	0.37**
Heads of poultry (HP)				1	0.69**	0.14	0.04	-0.10	-0.01	-0.03
Maize seed for poultry feed (MPF)					1	0.00	0.08	-0.12	0.00	-0.06
Squash for animal feed (SAF)						1	-0.18	0.05	0.01	0.00
Maize stover for large livestock feed (SLLF)							1	0.04	0.09	0.05
Maize stover for sheep and goat feed (SSGF)								1	0.61**	0.56**
Sheep and goats for sale per year (SGS)									1	0.34**
Sheep and goats for consumption per year (SGC)										1

** Significat at P≤0.001.

The PCA of quantitative variables (Table 5) revealed that the first four principal components accounted for 92% of the variability in the responses from the surveyed household heads. The first component (PC1) was primarily driven by the total quantity of maize stover produced

Table 5. Vectors and eigenvalues of the principal component analysis (PCA) for the variables with the highest descriptive value.

Variables	CP1	CP2	CP3	CP4
Total number of animals in the household	0.0249	-0.0084	0.1332	0.0889
Heads of sheep and goats	0.0196	-0.0139	0.1899	0.1202
Years of animal rearing	0.0115	0.0368	0.0356	0.0502
Maize stover for large livestock	0.0871	0.6137	-0.4374	0.6487
Maize stover for sheep and goats	0.0637	0.0250	0.8074	0.5130
Grasses and weeds as fodder	0.0223	0.7839	0.3175	-0.5324
Area of milpa cultivation (Local measurement)	0.0356	0.0325	-0.0087	0.0250
Amount of stover produced	0.9927	-0.0741	-0.0277	-0.0839
Eigenvalue	766.70	38.42	31.49	23.12
Proportion of explained variance	0.885	0.044	0.036	0.027
Proportion of cumulative explained variance	0.885	0.929	0.966	0.992

using the milpa system by the farmers. The second component (PC2) was associated with the amount of fresh grasses and weeds obtained from the system, as well as the maize stover used for the feeding of large livestock.

Figure 1 illustrates the behavior of the quantitative variables with the highest descriptive value, specifically the number of years of livestock rearing and the duration (in months) of the feed resources obtained from the milpa system for animal nutrition. The PCA revealed that the first four principal components (PC1, PC2, PC3, and PC4) explained 99.2% of the variation in respondents' responses. The first principal component (PC1) was primarily driven by the amount of maize stover for animal feed, whereas the second component (PC2) was mainly associated with the variables 'amount of maize stover obtained' and 'quantity of grasses and weeds' collected from the milpa system for animal feed, thereby confirming that 60-80% of maize stover is effectively utilized (Hellin et al., 2013; Caballero et al., 2017). The dispersion of the respondents is shown in the plane defined by the first two principal components. Regarding the number of years of livestock rearing, the majority of respondents fall within the 40-50 year-range, while for duration (in months) that feed obtained from the milpa sustains animals, the predominant pattern is 4 to 6 months.

Figure 2 shows the dispersion of respondents in relation to their responses, in the plane defined by the two dimensions obtained from the multiple correspondence analysis of qualitative variables. It was determined that the sixth dimension explains 83.01% of the variability of the respondents' answers regarding animal species reared in their backyards. This dimension had an eigenvalue of 0.140 and X^2=142.61. The analysis revealed that, in the first dimension, the most descriptive variables were the types of animals kept in the household and the milpa-derived products used as animal feed, while the remaining variables were of lesser relevance. In the second dimension, the most descriptive variables were the sown forage species, and the pests and diseases that primarily affect poultry. This finding is noteworthy, as poultry are the most commonly reared species in household settings. Within family production units, poultry contribute substantially to both household consumption and the family economy (Cuca-García, 2018; FAO, 2014).

CONCLUSIONS

The results underscore the importance of milpa-derived products and by-products for animal feed in the two Mixtec municipalities. Notably, 53% of the surveyed household heads grow crops using this ancient agricultural system, predominantly on plots of 0.5 to 1 ha.

The most commonly reared animal species were poultry, sheep, goats, pigs, rabbits, and some large livestock species. Sheep, goats, and poultry, which are reared for both sale and household consumption, were particularly prominent.

The milpa-derived products used for animal feed are primarily maize (68.55%), which is mainly used to feed poultry, pigs, rabbits, and, in some cases, sheep and goats. Maize is intercropped with squash in 15.6% of the surveyed households.

The milpa-derived by-products for animal

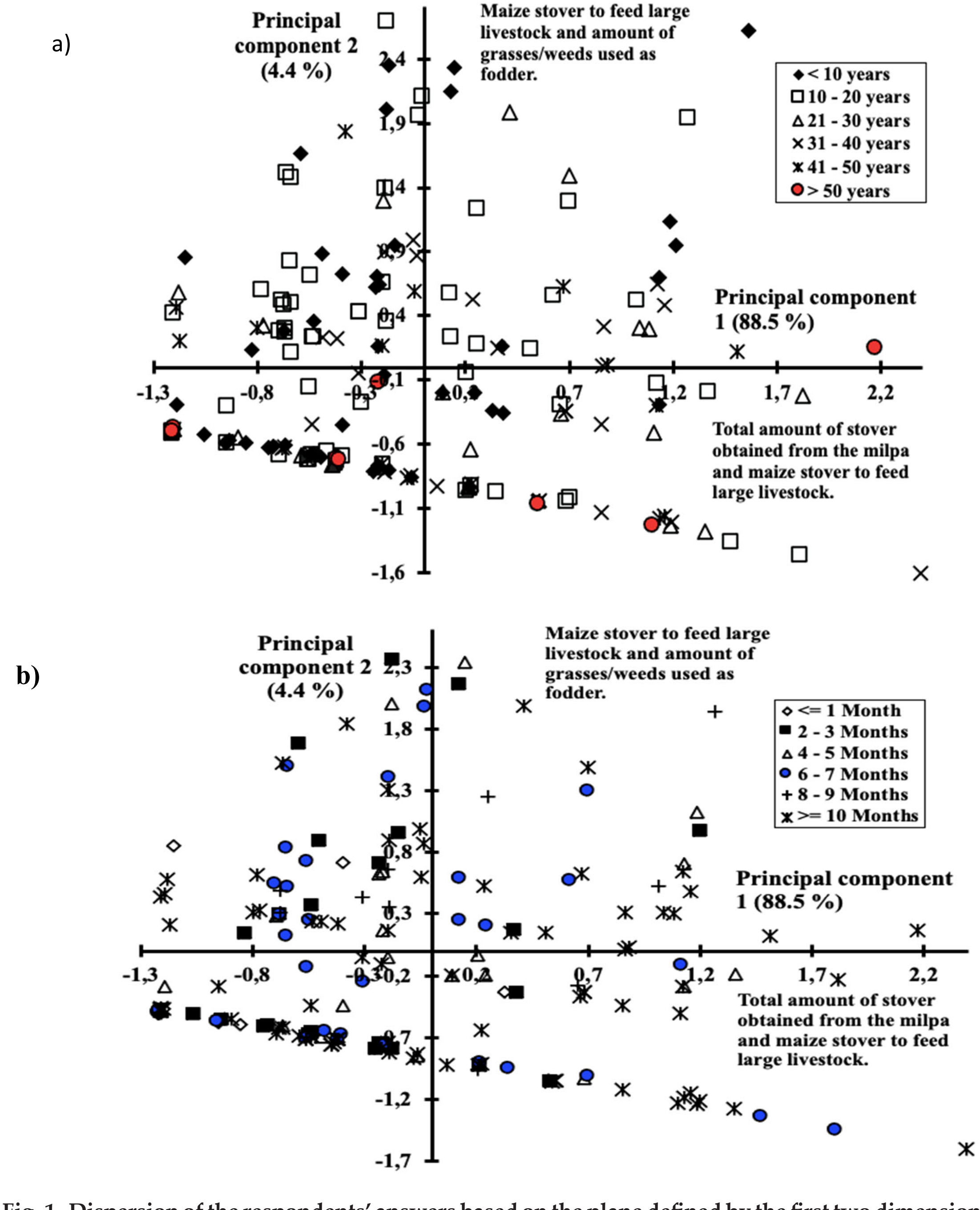

Fig. 1. Dispersion of the respondents' answers based on the plane defined by the first two dimensions of the principal component analysis: a) years of livestock rearing, and b) number of months that feed obtained from the milpa system lasts for feeding animals.

feed include maize stover (46.9%) and the combination of maize stover with grasses and weeds (34.02%).

Author contributions

Floriberto Cortes Bautista and José Daniel Carrillo Castillo: active participation in the bibliography review; Netzahualcóyotl Mayek Pérez: active participation in the development of the methodology; Catarino Perales-Segovia, and Gisela V. Campos Angeles: active participation in the discussion of results; José C. Carrillo Rodríguez and José L. Chávez Servia: review and approval of the final version of the article.

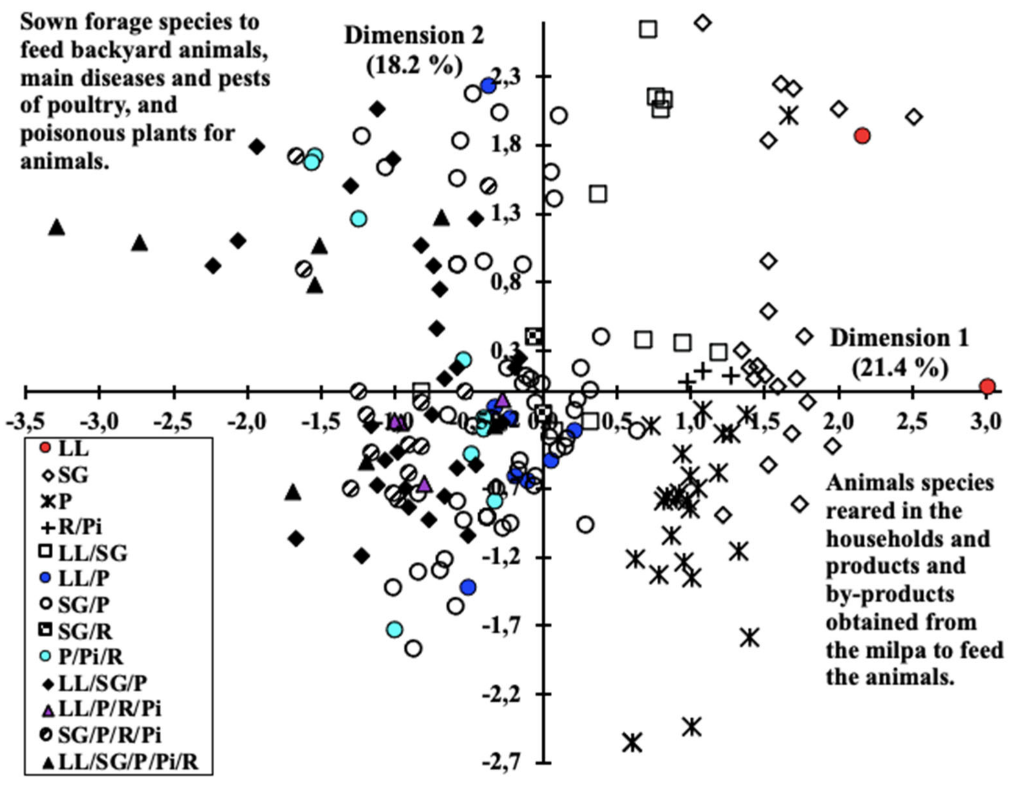

Fig. 2. Dispersion of respondents' answers regarding the animal species reared in household backyards, based on the plane defined by the first two dimensions of the multiple correspondence analysis.

SG: sheep and goats; P: poultry; LL/SG: large livestock and sheep and goats; SG/P: sheep and goats, and poultry; P/R/Pi: poultry, rabbits, and pigs; LL/SG/P: large livestock, sheep and goats, and poultry; SG/P/R/Pi: sheep and goats, poultry, rabbits, and pigs; LL/SG/P/R/Pi large livestock, sheep and goats, poultry, rabbits, and pigs.

Declaration of conflicts of interest

The authors declare no conflicts of interest.

LITERATURE CITED

Alayón-Gamboa J.A. 2015. Ganadería de traspatio en la vida familiar. Ecofronteras 19(54): 6-9. https://revistas.ecosur.mx/ecofronteras/index.php/eco/article/view/1578

Altieri, M.A., R.F. Funes-Monzote, and P. Petersen. 2012. Agroecologically efficient agricultural systems for smallholder farmers: contributions to food sovereignty. Agronomy of Sustainable Development 32: 1-13. https://link.springer.com/article/10.1007/s13593-011-0065-6

Balcázar-Quiñones, A., L. White-Olascoaga, C. Chávez-Mejía y C. Zepeda-Gómez. 2020. Los quelites: Riqueza de especies y conocimiento tradicional en la comunidad Otomí de San Pedro Ariiba, Temoaya, Estado de México. Polibotanica 49: 219-242. https://doi.org/10.18387/polibotanica.49.14

Borja-Bravo, M., M. L. Reyes, G. J.A. Espinosa y I. A. Vélez. 2016. Estructura y funcionamiento de la cadena productiva de esquilmos agrícolas como forraje en la región del Bajío, México. Revista Mexicana. Agronegocios 39: 451- 464. https://doi.org/10.22004/ag.econ.252881

Caballero Salinas, J.C., A. Moreno Reséndez, J.L. Reyes Carrillo, J.S. Valdez, W. López Báez y J.A. Jiménez Trujillo. 2017. Competencia del uso del rastrojo de maíz en sistemas agropecuarios mixtos en Chiapas. Revista Mexicana de Ciencias Agrícolas 8(1): 91-104. https://doi.org/10.29312/remexca.v8i1.74

Cisneros-Saguilán, P., J. Martínez-Vásquez, A. de la Rosa-Galindo, B. Candelaria-Martínez y R. Portillo-Salgado. 2024. Caracterización tipológica de la ganadería bovina doble propósito en Santiago Pinotepa Nacional, Oaxaca, México. Ecosistemas y Recursos Agropecuarios 11(3): e3560. https://doi.org/10.19136/era.a11n3.3560

Consejo Nacional de Evaluación de la Política de Desarrollo Social (CONEVAL). 2022. Informe de la pobreza en los municipios de México 2010-2020. México. 155 p. https://www.coneval.org.mx/Medicion/Paginas/Pobreza-municipio-2010-2020.aspx

Collin Harguindeguy, L. 2021. La milpa como alternativa sustentable orientada al buen vivir. Scripta Ethnologica (43): 9-36. https://www.redalyc.org/journal/148/14869377001/html/

Cuca-García, J. 2018. La avicultura de traspatio en México: Historia y caracterización. Agro Productividad 8(4). https://mail.revista-agroproductividad.org/index.php/agroproductividad/article/view/669

Erenstein, O., K. Sayre, P. Wall, J. Hellin and J. Dixon. 2012. Conservation agriculture in maize- and wheat-based systems in the subtropics: lessons from adaptation initiatives in South Asia, Mexico, and Southern Africa. Journal of Sustainable Agriculture 36(2): 180-206. https://doi.org/10.1080/10440046.2011.620230

FAO. 2014. Organización de las Naciones Unidas para la Alimentación y la Agricultura: Ganadería mundial - La ganadería en la seguridad alimentaria. 156 p. https://www.fao.org/3/i2373s/i2373s00.pdf

García Flores, A. y E. Guzmán Gómez. 2014. La ganadería familiar en Juan Nepomuceno Álvarez. Sitientibus série Ciências Biológicas 14: 1-14. https://doi.org/10.13102/scb282

García-Navarro, M., B. Ramírez-Valverde, A. Cesín-Vargas y P. Juárez-Sánchez. 2022. Ganadería familiar de traspatio en una comunidad indígena totonaca. Abanico Veterinario 12: e2021-20. http://dx.doi.org/10.21929/abavet2022.5

González, O.F., A. Pérez Magaña, I. Ocampo Fletes, J.A. Paredes Sánchez y P. de la Rosa Peñaloza. 2014. Contribuciones de la producción en traspatio a los grupos domésticos campesinos. Revista Estudios Sociales 22: 146–170. https://www.scielo.org.mx/pdf/estsoc/v22n44/v22n44a6.pdf

Heindorf, C., J.A. Reyes-Agüero and A. van´t Hooft. 2021. Local markets: Agrobiodiversity reservoirs and access points for farmers' plant propagation materials. Front. Sustain. Food Syst. 5: 597822. https://doi.org/10.3389/fsufs.2021.597822

Hellin, J., O. Erenstein, T. Beuchelt, C. Camacho and D. Flores. 2013. Maize stover use and sustainable crop production in mixed crop–livestock systems in Mexico. Field Crops Research 153: 12-21. https://doi.org/10.1016/J.FCR.2013.05.014

Jiménez, A.N.A., M.Á.M. Magaña y L.C. Uc Contreras. 2019. Factores socioeconómicos asociados la diversidad pecuaria del traspatio en comunidades mayas de Yucatán y Campeche. Biotecnia 21(3): 5-12.

Mariscal, M.A., R.J. Morin y C.L.C. Ricardi. 2019. Unidades de producción familiar del municipio de Santa Gertrudis, Zimatlán, Oaxaca, México. Actas Iberoamericanas de Conservación Animal 14: 154-158. https://www.cabdirect.org/cabdirect/abstract/20203461636

Martínez Valdés, M.G., F. Sánchez Gutiérrez, C.O. Pozo Santiago, L. Ríos Rodas y J.C. Gerónimo Torres. 2023. La diversidad biológica de los traspatios: su uso en la alimentación y salud de las familias en Chiapas y Tabasco, México. Acta Universitaria 33: 1-17. https://doi.org/10.15174/au.2023.3578

Mateos-Maces, L., J.L. Chávez-Servia, A.M. Vera-Guzmán, E.N. Aquino-Bolaños, J.E. Alba-Jiménez and B.B. Villagómez-González. 2020. Edible leafy plants from Mexico as sources of antioxidant compounds, and their nutritional, nutraceutical and antimicrobial potential: A Review. Antioxidants 9: 541. https://doi.org/10.3390/antiox9060541

Naranjo-Piñera, E.J., E. Bello-Baltazar, E.I.J. Estrada-Lugo, R. Mariaca-Méndez y P.A. Macario-Mendoza. 2013. La milpa comedero-trampa como una estrategia de cacería tradicional maya. Estudios de Cultura Maya 42: 87-118. http://www.scielo.org.mx/scielo.php?script=sci_arttext&pid=S0185-25742013000200003

Ramírez-Maces, H.O., M. Tadeo-Robledo, Y. Villegas-Aparicio, F. Aragón-Cuevas, A. Martínez-Gutiérrez, G. Rodríguez-Ortiz, J.C. Carrillo-Rodríguez, A. Espinosa-Calderón y M. de la O Olán. 2023. Diversidad biológica del sistema milpa y su papel en la seguridad alimentaria en la Sierra Mixe, Oaxaca. Revista Fitotecnia Mexicana 46(2): 105-113. https://doi.org/10.35196/rfm.2023.2.105

Rodríguez Ríos, H., G. Abud, M. Figueroa, M. Tima Péndola y J. Campos Parra. 2023. Evaluación y características de la gallina Araucana (*Gallus inauris* Castelloi) como ave de postura. Chilean Journal of Agricultural & Animal Sciences 30(2): 139-146. https://revistas.udec.cl/index.php/chjaas/article/view/10532

Salazar-Barrientos, L. de L., M.A. Magaña-Magaña, A.N. Aguilar-Jiménez y M.F. Ricalde-Pérez. 2016. Factores socioeconómicos asociados al aprovechamiento de la agrobiodiversidad de la milpa en Yucatán. Ecosistemas y Recursos Agropecuarios 3(9): 391-400. https://doi.org/10.19136/era.a3n9.724

Salinas-Vargas, D., M.A. Maldonado-Peralta, A.R. Rojas-García, A. Graciano-Obeso, J. Ventura-Ríos y R. Maldonado-Peralta. 2022. Evaluación de rastrojo y de grano en maíces nativos en Guasave Sinaloa. Revista Mexicana de Ciencias Agrícolas 3(8): 1481-1488. https://doi.org/10.29312/remexca.v13i8.3354

Santiago Vera, T., P.M. Rosset, A. Saldívar Moreno, V.E. Méndez y B.G. Ferguson. 2021. La milpa: sistemas de resiliencia campesina. Estudio de dos organizaciones campesinas. Agroecología 16(1): 1-14. https://revistas.um.es/agroecologia/article/view/493311

Solís-Vázquez, O.O., W.O. Cruz-Macías, R.A. Campos-Saldaña y V. Hernández-García. 2023. Caracterización socio productiva de sistemas ganaderos bovinos en el municipio de San Pedro Pochutla, Oaxaca, México. Ciencia Latina Revista Científica Multidisciplinar 7(2): 3795-3810. https://doi.org/10.37811/cl_rcm.v7i2.5611

Vargas-López, S., A. Bustamante-González, J. Vargas-Monter, J.S. Hernández-Zepeda, I. Vázquez-Martínez and F. Calderón-Sánchez. 2017. Domestic animal diversity and breeding practices in rural communities of the State of Mexico. Agroproductividad 10(7): 15-20.

Viesca-González, F.C., D. de J. Alvarado-Carrillo y B. Quintero-Salazar. 2022. Los quelites en la ciudad de Toluca, México: una alternativa alimentaria desde la agricultura urbana. Estudios Sociales 32(59). https://doi.org/10.24836/es.v32i59.1158