# Rescue and participatory conservation of Creole goats in the agro-silvopastoral systems of the Mountains of Guerrero, Mexico

## Rescate y conservación participativa de las cabras criollas en los sistemas silvo-agropecuarios de la Montaña de Guerrero, México

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Originales: *Recepción:* 21/10/2021 - *Aceptación:* 10/05/2022

**Abstract**

The objective was to implement a participatory process involving rescue and conservation of Creole goats in agro-silvopastoral systems, as a development strategy for the indigenous and marginalized region of the Mountains of Guerrero (MG), Mexico. The study focused on the caprine agroecosystem, documenting aspects of goat development and identifying caprine areas in 13 municipalities, zoometrically characterizing 680 goats. One hundred and ten goat producers were interviewed for evaluating farmer perception of goat production. Fifty-seven producers were trained in holistic management, and four producers raised 300 goats in outstanding herds. Data were analyzed using social networks, principal component analysis and correspondence analysis. Two goat agroecosystems were identified: 1) agro-silvopastoralism, with crossbreeding of goat populations and, 2) traditional systems, involving grazing of Creole goats on native vegetation. We identified three types of goats: 1) Mixteco mosaic (61%), 2), Pastoreña (31.8%), and 3) Crossbreeds (7.2%), based on bicoastal diameter, chest depth, body length, thoracic perimeter, height at withers, shoulder point width and liveweight. Smallholder goat farmers in the MG preferred Creole goats for their greater productivity and better environmental adaptation.

**Keywords**
pastoreña goats • Mixteco mosaic goats • outstanding herd • goat areas

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## Resumen

El objetivo fue llevar a cabo un proceso participativo de rescate y conservación de caprinos criollos en los sistemas silvoagropecuarios, para incorporarlos a una estrategia de desarrollo de la región indígena y marginada de la Montaña de Guerrero(MG), México. El agroecosistema caprino se estudió para describir la dinámica de desarrollo, identificación de las zonas caprinas en 13 municipios y la caracterización zoométrica de 680 cabras. Se encuestó a 110 productores para evaluar la percepción de la producción de cabras, 57 productores fueron formados en manejo holístico y cuatro productores para la crianza de 300 cabras en rebaños sobresalientes. Los datos se analizaron utilizando redes sociales, componentes principales y correspondencia. Se identificaron dos agroecosistemas caprinos: 1) Agrosilvopastoralismo, con proceso de hibridación alta de las poblaciones de cabras y 2) el tradicional, de pastoreo en vegetación nativa con cabra criolla. Se caracterizaron tres tipos de cabras: 1) mosaico mixteco (61%), 2) cabras pastoreñas (31,8%) y 3) cruzas (7,2%), discriminadas por el diámetro bicostal, profundidad de pecho, longitud del cuerpo, perímetro torácico, alzada a la cruz, distancia entre encuentros y peso vivo. Los productores de caprinos de la MG prefieren las cabras criollas porque son más productivas y mejor adaptadas a las condiciones ambientales.



**Palabras clave**

cabra pastoreña • mosaico mixteco • rebaño sobresaliente • zonas caprinas


## Introduction

Resource diversity in Creole genetics constitutes one major global concern (12). Threats to the Creole goat population include interbreeding with exotic breeds (6, 26), the economic pressure related to traditional breed abandonment towards intensive management systems (41), and the global trend regarding livestock intensification, specialization, and desertion of marginal lands (2).

Conservation programs for Creole goats enable smallholders to prevent Creole breed loss (10, 14, 28). These breeds are adapted to adverse climatic conditions (1), surviving in semi-arid and arid environments (5, 8, 38), and consuming forage grown on marginal lands (27). These capacities have promoted the preservation of pastoral traditions (38), while also promoting sustainability (5, 26, 42). Creole goat raising in rural communities represents a global security system, ensuring a sustainable food source for families (1, 31), and household finance sustains (27, 43), strengthening biodiversity (37) and breed conservation (22, 25, 40).

Studies on Creole goats in certain regions of Mexico have demonstrated several advantages of local genotypes over the improved, recently introduced breeds. Tarahumara goats in Chihuahua´s Mountains (3), local goats in the Comarca Lagunera (24), black goats of Querétaro (4), and pastoreña goats in the Mixteca region (39, 45, 46, 47) exemplify these facts. Farmer-participatory evaluation of exotic goat breeds and their crosses with the native Creole goat breeds of the MG region of Mexico, has not yet been reported. In this sense, the hypothesis stated that by taking advantage of the adaptive capacity and productivity of the MG Creole goats, integrating them into a poor smallholders-participatory program for their rescue and conservation, became possible. The objectives of this study were: 1) to establish farmer-participatory programs to rescue and conserve the Creole goat breed in agro-silvopastoral systems with low resource smallholders; and 2) to incorporate them into a development strategy related to the agro-silvopastoral systems of the indigenous and marginalized region of the MG, Mexico.

## Materials and methods

### Study site

The study was conducted in the MG region, with a population of about 406,000 inhabitants. The site is part of the “Sierra Madre del Sur”, located northeastern of the

state of Guerrero, Mexico, at 17°20'25'' and 17°42'29'' North latitude and 98°26'48'' and 98°48'37'' West longitude. Site topography consists of mountains, hills, and inter-montane valleys, ranging from 500 to 3000 meters a.s.l. Site climates include temperate humid and sub-humid, semi-warm sub-humid and humid, and semi-arid warm (18). Annual precipitation varies between 700 and 900 mm. The most common types of soil include Regosol, Litosol, Cambisol, and Rendzinas. The dominant vegetation is low deciduous forest, groves of pine-oak, and pine forest.

This study shows information recorded during the process of rescue and conservation of Creole goats, with farmer participation, from 2012-2021. We recorded data from 36 communities in the municipalities of Alcozauca, Alpoyeca, Cochoapa el Grande, Malinaltepec, Atlixtac, Tlapa de Comonfort, Huamuxtitlán, Xochihuehuetlán, Tlalixtaquilla, Olinalá and Cualác, following the guidelines indicated for in vivo conservation of animal genetic resources (10, 15).

**Data collection**

Goat agro-ecosystem dynamics were analyzed with the historical information from the MG, compiled since 1979 by the Mountain Guerrero Plan and Mountain Prioritize Attention Micro-region (MAP) of the "Colegio de Postgraduados-Campus Puebla".

Caprine areas in 36 communities throughout the region were identified with the support of extension services and members of farmers organizations. For each community, the following information was recorded: geographical location, predominant type of goats (Creoles, Pastoreña, and crosses), vegetation type for grazing, and the willingness of smallholder goat keepers to participate in the project.

Zoometric and liveweight (LW) characterization of adult goats were undertaken following recommended procedures (13, 19, 21): 1) length (HL) and head width (HW), 2) height at withers (HaW), 3) thoracic perimeter (TP), 4) body length (BL), 5) bicoastal diameter (BD), 6) shoulder point width (SW), 7) chest depth (CD), 8) rump width (RW), and 9) rump length (RL).

Perceptions on goat raising were documented from a sample of 112 households. The variables considered were: 1) breed preference; either Creole or exotic commercial breed, and 2) criteria for selecting goat breeding stock.

Farmers were trained to follow a holistic goat management approach with dialogue of knowledge between farmers and technicians (44), in order to develop more consistent strategies with farmer perception (23, 32). Discussed topics included: 1) feeding (use of pasture farms), 2) goat health, 3) drinking water management, and 4) selection of breeding stock. A group of four farmers was selected for productive, reproductive, economic, and marketing evaluation of the breeding stock of 300 Creole goats.

**Data processing**

Information from goat areas was analyzed using the Social Network Technique with UCINET (Version 6.730 | June 18, 2021) from Analytic Technologies. Initially, a symmetric matrix of the goat region indicated either the existence of goat tradition (represented by 1) or the loss of goat tradition (represented by 0). In the first matrix, two more matrices were incorporated: Goat genetic type (Pastoreña and Creole goats; Mixteco mosaic and goat crosses), and type of vegetation (deciduous forest, pine-oak forest, and agricultural areas-pasturelands). Results showing the relationship among goat tradition, type of goat and foraging vegetation are presented in figure 1 (page 156).

FactoMineR package (20) from R Programming language (34) was chosen to analyze zoometric variables and live weight data creating a two-dimensional figure with goat population groups. A simple correspondence (ca) procedure (29) revealed criteria related to objective and selection, as applied by farmers.

## Results and discussion

**Smallholder identification and goat preference**

This study revealed that Creole goats predominate in 36.1% of municipalities (figure 1, page 156).

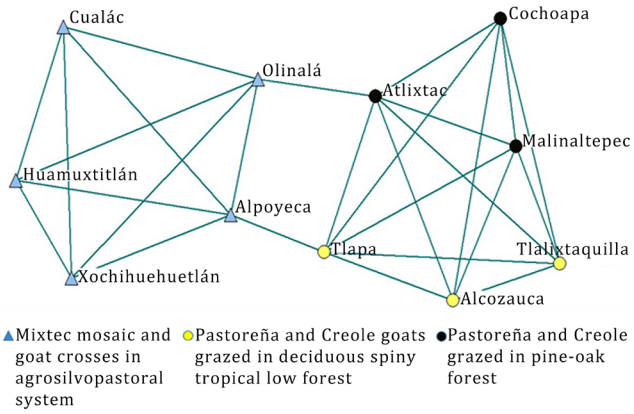



**Figure 1.** Relationship between caprine tradition, type of goat and vegetation in the municipalities of the MG, Mexico.

**Figura 1.** Relación de la tradición caprina, tipo genético y vegetación utilizada en las zonas productoras de cabras en la MG, México.

Farmers from Alpoyeca, Huamuxtitlán, Xochihuehuetlán, Olinalá, and Cualác predominantly owned crossbreeds of Creole with exotic commercial breeds (Alpine, Boer and Nubian crosses), grazed in the agro-silvopastoral system. Farmers from Alcozauca, Cochoapa el Grande, Malinaltepec, Tlalixtaquilla, Atlixtac, and Tlapa de Comonfort predominately owned Creole goats, which they grazed on pine-oak and low spiny deciduous forests. They also raised Pastoreña goats, being the most traditional farmers.

Figure 1 presents two goat producing regions and management systems. The left side shows municipalities, where goat crossbreeding is relatively intense, predominantly between Mixteco mosaic and exotic commercial goats (Alpine, Boer and Nubian crosses). The goats graze agricultural (arable land) areas and communal pastures. Government programs that promote exotic commercial goat production with little or no consideration for the opinions and customs of the smallholder farmers have a high impact on these municipalities. The right side shows municipalities where Creole goats predominate (Pastoreña and Creole goats) and where the government program for promoting commercial goat production has had little or no impact. The goats are grazed in the deciduous spiny tropical low forest (Tlalixtaquilla, Alcozauca, and Tlapa de Comonfort) and pine-oak forest (Atlixtac, Malinaltepec, and Cochoapa el Grande), indicating that Creole goats are an invaluable resource for environmental adaptation in the context of climate change (38).

Figure 2 (page 157) presents a correspondence analysis of goat populations as perceived by smallholders. Data indicates that farmers preferred Creole goats. Goat crosses preference (Alpine and Nubian crosses) as selection criteria, stands far from the origin of the axes, indicating lower frequency among interviewed smallholders. This observation is in contrast with the findings for Pakistani Beetal goats (33), where milk and meat production constituted selection criteria. In this study, goat producers indicated that environmental adaptation correlates with meat production among Creole goats, evidencing an increased awareness of their biological qualities, behaviour and environmental adaptability, as stated in Tanzania (30).

Goat body size was the primary selection criterion (figure 3, page 157). Specifically, farmers related body size to height at withers. Tall goats are valued for their ability to move during grazing and browsing in the shrubby vegetation, concurring with previous reports from Pakistan (33).

Secondly, some farmers do not use any specific criteria, especially in the selection of kid goats and at herd level.

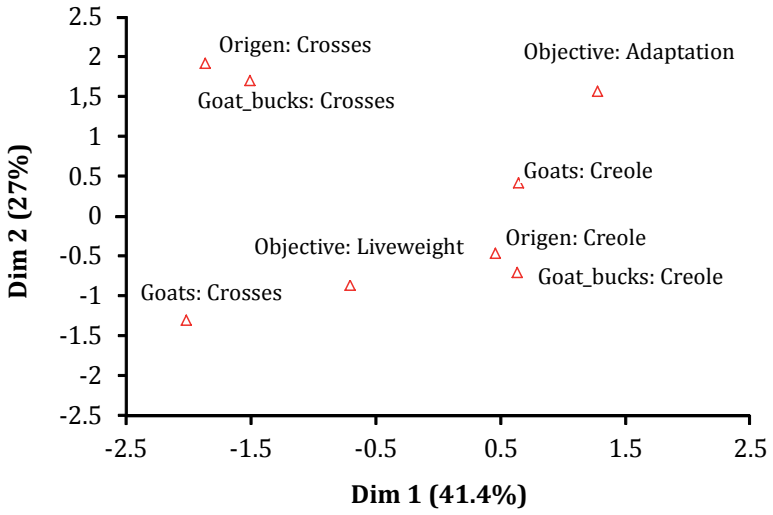



**Figure 2.** Graphical representation of the correspondence analysis on origin, breed and objective of goat selection in the MG, Mexico.

**Figura 2.** Representación gráfica del análisis de correspondencia del origen, raza y objetivo de selección de los caprinos señalados por los campesinos en la MG, México.

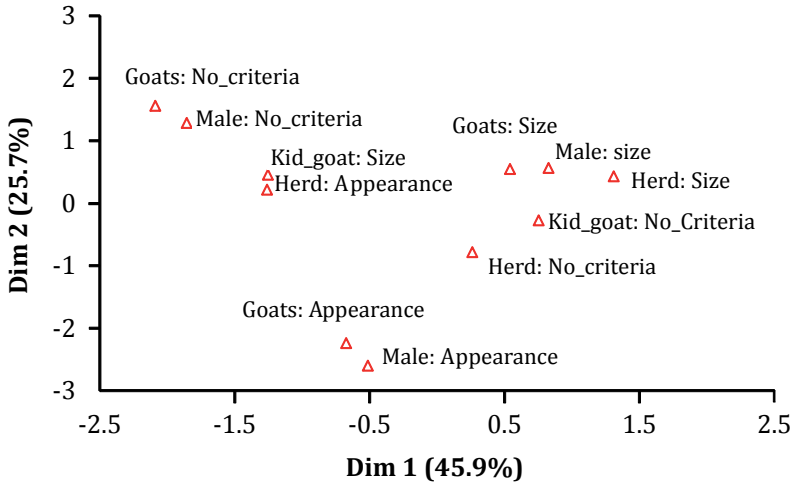
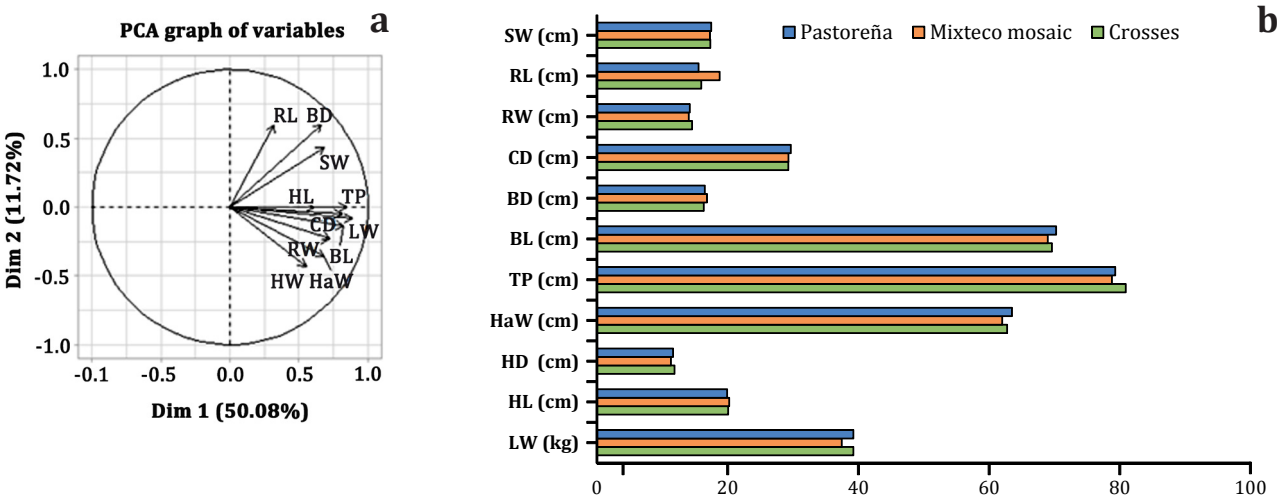



**Figure 3.** Graphical representation of the correspondence analysis regarding selection criteria in terms of herd, goats, male and goat kids employed by farmers in the MG, Mexico.

**Figura 3.** Representación gráfica del análisis de correspondencia de los criterios de selección del rebaño, cabras, sementales y crías utilizados por los campesinos en la MG, México.

**Creole Goats phenotypic characteristics**

Zoometric evaluation of goat populations revealed that farmers breed crosses (7.2%), Pastoreña goats (31.8%), and Mixteco mosaic goats (61%). The correspondence analysis in figure 4a (page 158) shows body traits and liveweight indicating differences between populations, probably corresponding to system diversity as observed among Cuban goats (21). In order of importance: bicoastal diameter, chest depth, body length, thoracic perimeter, height at withers, shoulder point width, and liveweight.




HL: head length, HW: head width, HaW: height at withers, TP: thoracic perimeter, BL: body length, BD: bicoastal diameter, SW: shoulder point width, CD: chest depth, RW: rump width, RL: rump length.

HL: longitud de cabeza, HW: ancho de cabeza, HaW: altura a la cruz, TP: perímetro torácico, BL: longitud del cuerpo, BD: diámetro bicostal, SW: anchura de pecho, CD: profundidad del pecho, RW: ancho de grupa, RL: longitud de grupa.

**Figure 4.** Variation in zoometric body traits and liveweight (LW) among goat population in the MG, Mexico.
**Figura 4.** Variabilidad de las medidas zoométricas y peso vivo (PL) de las poblaciones de cabras en la MG, México.

Breed profile and conformation of goats from the MG are presented in figure 4b. Pastoreña goat showed the greatest body length, height at withers and liveweight; characteristics associated with meat production. Goat height relates to adaptation and transhumance travel ability. The commercial genetic type influenced crossbreed and Mixteco mosaic goats with a greater thoracic perimeter, rump length and width, and less height at withers. The presence of commercial goats in the region indicates a need for an urgent conservation program for Creole goats, similar to that implemented in other areas of America (17, 42), Africa (27), and Italy (7, 9).

The principal component analysis (PCA) showed overlapping goat populations in a two-dimensional space (figure 5, page 159), indicating a slight difference in zoometric measurements and liveweight among the populations. Smallholders know that Creole goats are superior to exotic commercial goats, partly because they are better adapted to marginal areas, where forage is scarce (35). Herds of Pastoreña goats are uniform in terms of their morpho-structural characteristics and liveweight, key factors associated with natural selection for meat production over several centuries (11, 16, 36, 46).

**Holistic training**

Using dialogue of knowledge, the following training topics were identified for rescuing these goats: health-environment, transboundary goat diseases resulting from the introduction of exotic commercial goats, disease prevention and treatment, nutritional blocks, breeding stock supplementation, identification, and selection of Creole goats. In addition, smallholders helped with data collection in order to identify goat populations, evaluate productivity (adult live weight, kid daily weight gain, and body condition), and identify unproductive goats to reduce pressure on pastureland. Dialogue of knowledge allowed innovation of the traditional goat production systems in the region, reducing smallholders resistance, who did not show any inclination towards modern knowledge (48).

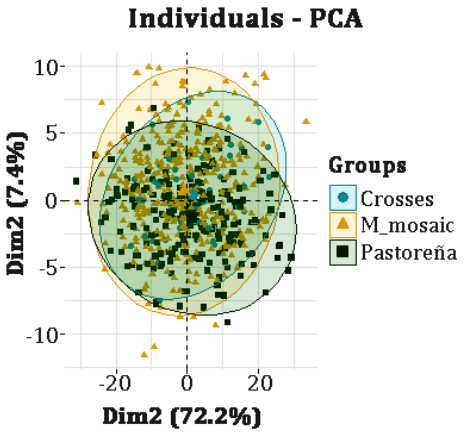



**Figure 5.** Scatter plot showing goat population breeds according to zoometric variables and liveweight in the MG, México. M_mosaic, Mixteco mosaic goats.

**Figura 5.** Diagrama de dispersión de las razas de cabras según variables zoométricas y peso vivo en la MG, México. M_mosaic, cabras mosaico Mixteco.

**Rescue process**

Figure 6 shows the participatory management of Creole goats, as part of the rescue process. We categorized four smallholders as participants with outstanding herds. Three hundred goats raised in outstanding herds were selected as goats and bucks with above-average zoometric measurements and liveweight, grazed on shrubby vegetation of low deciduous forest, free from brucella, white or bay in colour and spiral horns; typical of the Pastoreña goat. Likewise, Creole goats from outstanding herds manifested the least weight loss in the annual dry season, which improved goat selling price, and increasing family income. In this study, producers classified Creole goats as part of their cultural tradition, as a means to preserve cultural heritage (28).

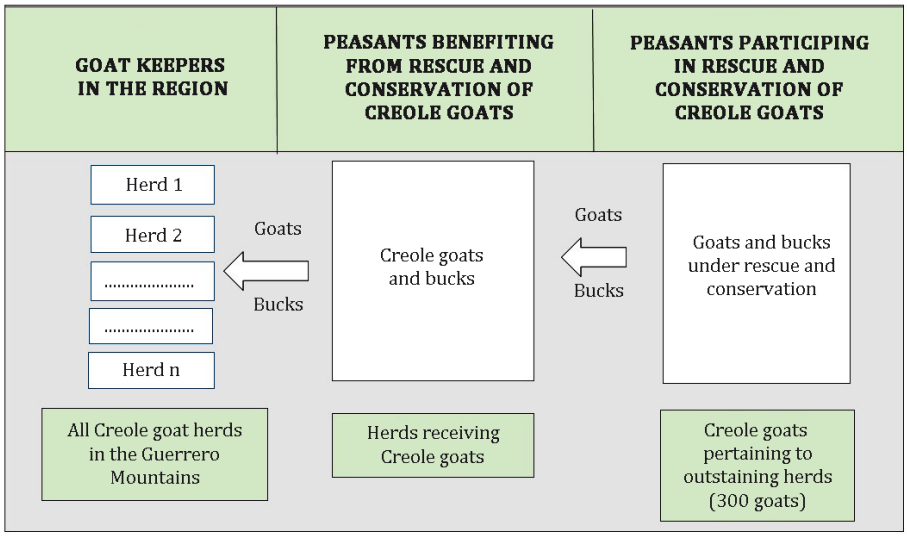



**Figure 6.** Rescue and conservation processes for Creole goats by peasants in the MG, México.

**Figura 6.** Proceso de rescate y conservación de los caprinos criollos por los campesinos en la MG, México.

## Conclusion

This preliminary study on goat production systems in the Mexican MG showed two production systems, namely: agro-silvopastoralism with crosses between Creole and exotic goats (Nubian, Boer and Alpine crosses), and traditional production, involving grazing of Creole goats on native vegetation. Crossbreeding of Pastoreña and Creole with commercial exotic breeds represents the main threat to the sustainable farming of Creole goats in the MG. Producers cite both adaptation and body size as selection criteria promoting Creole goat maintenance. Pastoreña goats are considered the best meat producers in the MG, due to a greater body length, height at the withers and live weight, and grazing ability in mountain areas. Producers used traditional knowledge and low-input technology for the rescue and *in situ* conservation of Creole goats in the MG, through an assisted holistic management. Government agencies must consider participative planning to rescue Creole goat populations, if traditional goat production and breeding systems in marginalized areas, are to continue.

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