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# Intercontinental Cultural Interchange on Crop Diversity

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***Authors' contributions***

*This work was carried out in collaboration between all authors. Author EGV designed the study, identified the species of plant and with author ED they wrote the protocol, managed the literature searches and prepared the first draft of the manuscript. Author AA developed the experimental process. All authors read and approved the final manuscript.*

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## ABSTRACT

This case study compares crop origin and diversity between two villages of similar size and contrasting conditions of human development: Acteal (Chiapas, Mexico) and Tuñon (Asturias, Spain). With an ethnographic approach, we found a significantly higher proportion of imported species and lower crop diversity in Acteal than in Tuñon, opposite to the expected from the respective natural diversity and conservation of local traditions in the two areas. The results are explained based on less priority given to natural resources than to social development in regions affected by conflicts and/or poverty. According to FAO directions, emphasizing the protection of local agricultural varieties in development plans is highly recommended.

*Keywords: Ethnography; case study; crop diversity; traditional plant resources; rural communities; cultural context.*

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## 1. INTRODUCTION

The power of food links nature, human survival, culture and health [1]; however, less than 200 species are massively cultivated for human nutrition [2] and from them only 30 major species feed the world [3]. Not only biodiversity is endangered in agriculture. One of the problems recognized by the FAO [4] is the loss of diversity in crops. Although countries and generations depend on this genetic diversity [5], the risk of genetic erosion and subsequent loss of adaptation is enormous.

On the other hand, interchanges of crops between continents have been derived from human migrations. Human groups carried aliments with them, both animal and plant species, which spread around continents following humans since the expansion of *Homo sapiens* in the Palaeolithic. Translocation of species by human movements, and more particularly those occurred in historical and recent time frames, has been generally envisaged as a way for introducing colonizer species prejudicing native variants [6] but there is an alternative and more positive vision of such interchanges: an increase of crop biodiversity. In traditional rural cultures, interchange of plant varieties among human groups is a way of promoting genetic diversity, preventing genetic erosion and favoring adaptive traits, like resistance and productivity [7,8]. One well known case of cultural interchange is the cross of American and European cultures initiated with Columbus travels in the XV Century. Of enormous transcendence for the history of both continents, human travels and migration have also encompassed a continuous movement of accompanying species like cultivated plants. If the bidirectional interchange has been balanced or asymmetric still remains an open question after several centuries of interchange. Some American crops were acclimatized and naturalized in South Europe, where they contributed to European population growth in the Modern Ages and, more particularly, in Spain in the XVIII century [9]. Moreover, significant decreases of linear enamel hypoplasia, a dental alteration indicator of poor nutritional status, occurred as early as the 16$^{th}$ century in some Spanish populations, suggest the positive influence of increased diversity of nutritional resources attributed to intercontinental (America–Europe) trade [10]. In contrast, it seems that in situ erosion of those American crops paralleled the decline of Amerindian native populations [11].

The objective of the present study was to examine the degree and direction of intercontinental interchange of traditional plant resources. As a case study, we have chosen two rural communities, Acteal from Chiapas, Mexico and Tuñón (Asturias, Trubia valley) from Spain, both two countries with intense mutual migration since Columbus travels. The communities were chosen based on their practices of traditional agriculture that are rare in Europe but have been conserved in the Trubia valley, [12] and similar size. Field work combined direct observation and ethnographic methodology [13]. Expectations were to find higher proportion of local crops in the Mexican village than in the Spanish one, given well known introduction of American crops in Spain.

## 2. METHODOLOGY

### 2.1 Study Sites

The Mexican rural village of Acteal (16º59' N – 92º31' W) from the Highlands of Chiapas and the Spanish community of Tuñón (42º52´ N - 3º28´ W) from Asturias (north of Spain) were the case studies (Fig. 1).

Agriculture is the main economic resource in both communities. The ecological conditions and accordingly the ecosystems are very different (Table 1) as are the anthropogenic modifications and impacts.

Acteal biotope is a tropical rainforest from a developing region (Chiapas exhibits the lowest index of human development in Mexico), without potable water and with irregular electricity supply. They do not use commercial pesticides, herbicides and fertilizers. Pest control is done removing undesired plants and animals manually. They use occasionally manure (from pigs) as a fertilizer. The agriculture production, principally dedicated to local consumption and very minor commerce in local selling points for neighbors, is carried out in a communal system. The land owner is the community and the agriculture work is organized in turns, allocating generally (in a flexible way) heavy tasks such as preparing the soil to men, and harvesting and manual pest controlling to women and children. Husbandry is limited to pigs (normally only one or two per year for local consumption in the community) and poultry.

On the other hand, Tuñón is located in the middle of temperate Atlantic caduceus forests at only 30 km from the capital town of the Asturias region, with good communication and infrastructures and full access to modern facilities. Pest control is carried out employing commercial pesticides (animal plagues) and manual removal of undesired plants and weeds. Traditional fertilizer (manure) is employed in the valley. The agriculture production is organized in small farms owned by individual families (peasants, small farmers). They use tractors and harvesters in large plots and manual procedures in small parcels. Stock breeding comprises principally cattle and poultry, with some minor porcine and ovine production.

## 2.2 Information Sources

The investigation followed an ethnographic approach [14] in that cultural context. The crops produced in the two villages were directly observed, photographed and noted by the researchers after obtaining permission for visiting the lands from the local owners (the community council in the case of Acteal for communal crops). In addition to direct observation, interviews were addressed to families native to the region to confirm that the observed crops were planted every year at least during the last decade, and to gather complete information about their use (eating the fruit, seed, leaf and root). Interviewees were informed in advance about the research objectives. In Tuñón the interviews were recorded and then transcribed in writing. In Acteal the interviews were directly transcribed in writing. The language employed was Spanish; when informers from Acteal did not know the Spanish name of a plant but only the Tzotzil word (their traditional language), we took photographs for classifying the species employing taxonomic guides.

The Mexican sample was 28 households, and the age range of informers was 27-60. In Tuñón, a total number of 43 household interviews were carried out, and the age range of the interviewees was 67-86.

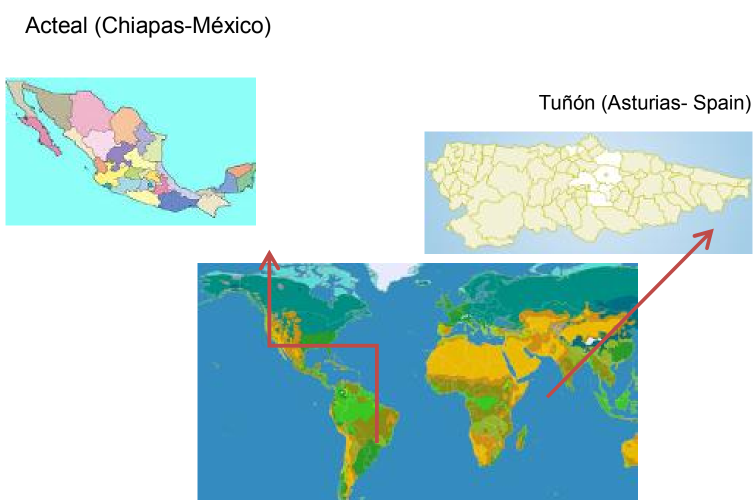


**Fig. 1. Geographical location of the studied communities of Acteal (Mexico) and Tuñon (Spain)**

**Table 1. Geographical and ecological data of the studied regions**

| | **Acteal (Mexico)** | **Tuñón (Spain)** |
|---|---|---|
| Coordinates | 16º 59' N–92º 31' W | 43º 16′ 59.99″ N–5º 58′ 0″ W |
| Altitude over sea level | 1,470 m | 200 m |
| Annual rainfall | 2,000–3,000 mm | 1,000–2,000 mm |
| Annual temperature range | 14-20ºC | 13ºC |
| Landscape | Mountainous highlands | slopes and limestone mountains |
| Ecosystem | Rainforest (pine-cypress) | mixed forests of chestnut and oak in mountain areas and riparian forests |
| Village inhabitants | 424 (last census in 2005) | 265 (last census in 2012) |
| Regional inhabitants/km$^2$ | 281.31 | 10,97 |

## 2.3 Data Analysis

Diversity indices were calculated employing the program *PRIMER*. The indices chosen were: Margalef's species richness (d), which measures the number of species presents in a place, making some allowance for the number of individuals; diversity indices, in this particular case we use Simpson λ+, it takes into account the number of species in the habitat and their relative abundance, it represents the probability that two individuals within a habitat, randomly selected belong to the same species; taxonomic indices depend on the taxonomic structure that we determine in the previous taxonomy options, in this particular case we use the total taxonomic distinctness sΔ + in order to determine the taxonomic structure of both sampling point; phylogenetic indices are a measure of taxonomic distinctiveness, the phylogenetic diversity is the total path length constituting the full taxonomic tree, in this case we use the total phylogentic diversity sPhi + to know the phylogenetic structure of each sampling point.

Plots and graphs were prepared employing the Microsoft Excel software 2013 version. Comparison between sites for distribution of plants by continents was made by contingency Chi-Square tests with the software SSPS 19 version.

## 3. RESULTS

In Acteal, a total of 20 crops (Table 2) were planted in 2010 and at least the 10 previous years.

In Acteal, at present, only 40% of the crops that are planted are autochthonous. Meanwhile, in Tunon, almost 80% of species grown they are locally sourced (Fig. 2).

**Table 2. Crops planted in Acteal (Mexico, M) and Tuñon (Spain, S) for human consumption. common and scientific name; taxonomy and geographic origin**

| Order | Crop | Species | Family | Origin | Country |
|---|---|---|---|---|---|
| *Order Asparagales* | Garlic | *Allium sativum* | Amaryllidaceae | Eurasia | M, S |
| | Onion | *Allium cepa* | Amaryllidaceae | Eurasia | M, S |
| | Chives | *Allium schoenoprasum* | Amaryllidaceae | Eurasia | S |
| *Order Asterales* | Lettuce | *Lactuca sativa* | Asteraceae | Eurasia | S |
| | Chicory | *Centaurea cyanus* | Asteraceae | Eurasia | M, S |
| | Artichoke | *Cynara cardunculus* | Asteraceae | Eurasia | S |
| *Order Brassicales* | Cabbage | *Brassica oleracea* | Brassicaceae | Eurasia | M, S |
| | Radish | *Raphanus sativus* | Brassicaceae | Eurasia | M, S |
| | Oilseed rape | *Brassica napus* | Brassicaceae | Eurasia | M, S |
| *Order Caryophyllales* | Beet | *Beta vulgaris* | Amaranthaceae | Eurasia | S |
| | Venezuelan pokeweed | *Phytolacca rivinoides* | Phytolaccaceae | America | M |
| *Order Fabales* | White beans | *Vicia faba* | Fabaceae | Eurasia | S |
| | Beans | *Phaseolus vulgaris* | Fabaceae | America | M, S |
| *Order Gentianales* | Coffee | *Coffea arabica* | Rubiaceae | Africa | M |
| *Order Laurales* | Avocado | *Persea americana* | Lauraceae | America | M |
| *Order Orchidales* | Vanilla | *Vanilla planifolia* | Orchidaceae | America | S |
| *Order Poales* | Wheat | *Triticum aestivum* | Poaceae | Eurasia | S |
| | Maize | *Zea mays* | Poaceae | America | M, S |
| | Barley | *Hordeum vulgare* | Poaceae | Eurasia | S |
| *Order Rosales* | Strawberry | *Fragaria x ananassaa* | Rosaceae | Eurasia | S |
| | Apple | *Malus domestica* | Rosaceae | Eurasia | M, S |
| | Peach tree | *Prunus persica* | Rosaceae | Eurasia | M, S |
| | Pear tree | *Pyrus communis* | Rosaceae | Eurasia | S |
| *Order Sapindales* | Lemon tree | *Citrus x limon* | Rutaceae | Eurasia | M, S |
| | Orange tree | *Citrus auriantum* | Rutaceae | Eurasia | M, S |
| *Order Solanales* | Tomato | *Solanum lycopersicum* | Solanaceae | America | M, S |
| | Potato | *Solanum tuberosum* | Solanaceae | America | M, S |
| | Bell pepper | *Capsicum annuum* | Solanaceae | America | M, S |
| | Chili pepper | *Capsicum baccatum* | Solanaceae | America | M |
| *Order Zingiberales* | Banana tree | *Musa x paradisiaca* | Musaceae | Eurasia | M |

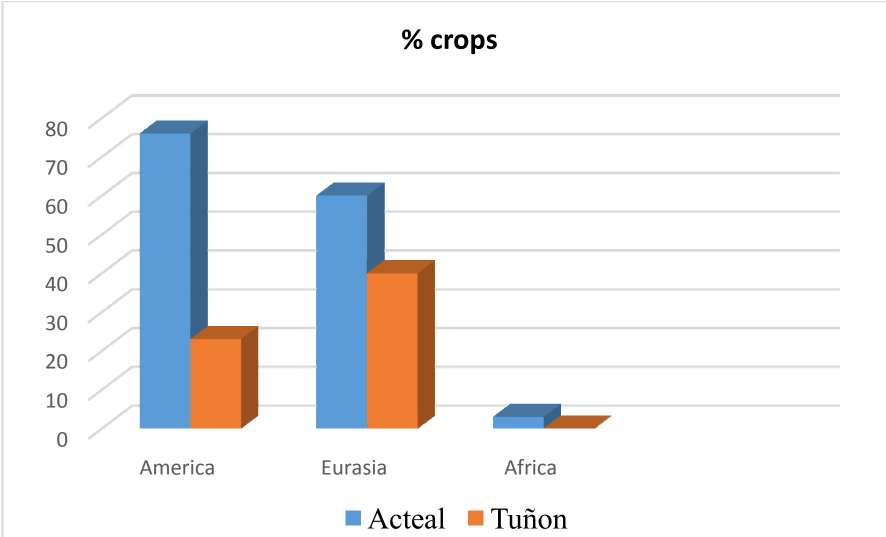


**Fig. 2. Distribution of crops by origin continent, for each locality**

Significant differences about the origins of crops were found in both communities (Table 3).

**Table 3. Observed and expected (from equal distribution in the two villages studied) number of local and imported crops produced in Acteal (Mexico) and Tuñon (Spain)**

| | | Local | Imported | Total |
|---|---|---|---|---|
| Acteal | Observed | 8 | 12 | 20 |
| | Expected | 11.8 | 8.2 | |
| Tuñon | Observed | 18 | 6 | 24 |
| | Expected | 14.2 | 9.8 | |

Crop biodiversity was higher in Tuñón than in Acteal (Table 4), as it corresponds to a higher number of species cultivated in the first location.

**Table 4. Diversity of crops planted in Acteal (Mexico) and Tuñon (Spain)**

| Indices analyzed | Acteal | Tuñon |
|---|---|---|
| Margalef d | 6.342 | 7.673 |
| Simpson λ+ | 263 | 315.6 |
| sΔ + | 1916 | 2467 |
| sPhi + | 1467 | 1533 |

## 4. DISCUSSION

In the observations we could make, in Acteal we found that 20 different crops were planted. They corresponded to 12 different taxonomic orders and families. Coffee was cultivated principally for external commercialization, and it was also consumed locally in every meal. The rest of the plants were not commercialized but consumed at home and occasionally traded with neighbouring villages. They can therefore be considered subsistence agriculture. The most conspicuous culture for local consumption was a mixed crop growing together corn and five different varieties of beans, corn stalks being the support for bean plants. The other plants, including potatoes, peppers, cabbage and tomatoes, were cultivated in small gardens. Fruit trees (avocado, banana, lemon, orange, peach), only one or two trees of each species, were grown in the middle of the village and by the houses.

In Tuñón, 24 plant species were cultivated, corresponding to 10 different orders and families. Most of them are commercialized in local and regional markets: chives, chicory, artichoke, radish, oilseed rape, beet, beans, vanilla, barley, strawberry, pear tree, peach tree, lemon tree, orange tree. Only a part of the production is for household consumption: garlic, onion, tomato, bell pepper, lettuce, cabbage, white beans, wheat, maize and apple.

Concerning the origin of the crops planted in each locality, 60% species now cultivated in Acteal were of non-American origin (Fig. 2), while only 23.1% species grown in Tuñón were imported from America (none from Africa). The difference between the two communities regarding the local or imported origin of the crops was statistically significant: contingency Chi-square of 5.475 for one degree of freedom, with $p<0.025$ (critical value for significance at $P=0.05$ being 3.482). Finally, as we can see in the results shown in Table 4, in addition to cultivating more biodiversity (different species), with higher species richness and Simpson index, the taxonomic and phylogenetic structure is more complex in Tuñón too.

## 5. CONCLUSIONS

The results of this comparative study showed that the diversity of crops was lower in a Mexican than in a Spanish village of similar dimension. This was a surprising result because it could be expected a higher local diversity in the rural area of Chiapas, a region of rich natural diversity and well preserved indigenous traditions, than in Spain where natural diversity is much lower and modern agriculture prioritizes only a few commercial species. The continental origin of the crops was also unexpected because in the Spanish village the proportion of local (or at least Eurasian) crops was higher than in Mexico, although the opposite situation would be expected. American legumes (principally beans of diverse varieties), potatoes and corn have been recognized as the main food resources that enabled European demographic expansion after the famines occurred in the 18$^{th}$ century [15] and they are maintained as naturalized crops until now.

The explanation is not easy. Globalization is often viewed as a threat to cultural and linguistic diversity and therefore is a central concern of educational practices and policy. A historical exploration reveals that there has been a continuing struggle by Mexican indigenous peoples to maintain locally relevant traditions. Indigenous peoples have increasingly used technology to maintain their languages and local cultural practices (Reinke 2004). However, it seems that the same effort has not been applied to prioritizing local crop diversity. Traditional food systems of indigenous peoples have changed worldwide, at least partly due to introduction of foreign crops [16]. Even in some Brazilian regions where native plant diversity is widely used by indigenous communities for medicinal purposes, such local plant diversity is much less used for food resources [17].

The results point to a relatively lower diversity of crops in Acteal. It is possible that such low diversity of agricultural resources is a consequence of a more general status of lack of resources. The region of Chiapas exhibits indicators of poor health and development status following conflicts and post-conflict settings such as the Zapatista armed conflict, with related disruptions in access to and utilization of health services [18,19] and extreme material deprivation [20]. Indigenous populations in the state of Chiapas suffer from endemic poverty [21] and their struggle has been historically addressed to recovering political autonomy and restoring their own dignity [22,23,24]. Likely less emphasis was put on preservation of local natural resources and diversity. This suggests that political conflicts and poverty can contribute to accelerate diversity losses at local level, promoting the use of popular easy-growing imported plants and neglecting native products.

In conclusion, this case study, although modest in size, is an example of an asymmetrical cross-continent interchange of crop resources when it is seen at a local dimension. More local resources and higher crop diversity are exploited in the Spanish village of Tuñon than in the Mexican Acteal, of similar size. Introducing the protection and restoration of local crops and agricultural varieties in development plans should be a priority for safeguarding natural biodiversity, especially in regions hit by poverty.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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