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Priority areas to collect germplasm of *Malacomeles* (*Rosaceae*) in Mexico based on diversity and species richness indices

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Abstract

The genus *Malacomeles* (Decne.) G. N. Jones (*Rosaceae* subtribe *Pyrinae*) represents several fruit shrubs, which is mainly distributed in North and Central America, from southern USA to Honduras and Guatemala, although the main distribution of this genus is in Mexico. Five species of the genus *Malacomeles* have been reported to exist in Mexico. *Malacomeles* is widely distributed in several mountainous ranges in Mexico, although it is unknown where most of the diversity of the *Malacomeles* genus is located in the country. The aim of this biogeographic study was to determine the areas of highest diversity of the genus *Malacomeles* in Mexico based on species richness and diversity indices in order to identify the best regions of Mexico to collect germplasm. The results indicated that most of the diversity of the genus *Malacomeles* is concentrated in northeast Mexico, mainly in the biogeographic province of Sierra Madre Oriental. In this province, the highest values on three biodiversity indices were found. Thus, this area can be considered as the priority area to collect the germplasm of *Malacomeles*. *M. denticulata* is the predominant and the most interesting species in Mexico from the viewpoint of collecting plant genetic resources; this species is mainly distributed in the provinces of Trans-Mexican Volcanic Axis, Mexican Plateau and Sierra Madre del Sur, where secondary priority areas to collect germplasm are located.

Keywords: diversity index; estimators of species richness; GIS; underutilized and neglected fruits

Introduction

Mexico is considered a mega diverse country for plant resources (Ramamoorthy *et al*., 1993), and perhaps it is the American country with the highest registered endemism in its territory (Villaseñor, 2003). Notwithstanding, in temperate fruit crops, there are not enough studies about native underutilized fruits. In this respect, the *Rosaceae* family in Mexico has 29 genera and around 200 species (Villaseñor, 2003), but is not considered one of the most diverse botanical families in Mexico (Villaseñor *et al*., 2007). Nevertheless, in the study of plant genetic resources, species of the *Rosaceae* family stand out in Mexico as native temperate fruits (Borys and Leszczyñska-Borys, 2001).

The genus *Malacomeles* represents several fruit shrubs belonging to the family *Rosaceae* subtribe *Pyrinae* (formerly subfamily Maloideae), which is

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distributed in North and Central America, from southern USA to Honduras and Guatemala, although this genus is mainly distributed in Mexico (Phipps *et al*., 1990; Rzedowski and Calderon de Rzedowski, 2005; Turner, 2011).

Jones (1945) described *Malacomeles* as a new genus, but closely related to *Amelanchier* and *Peraphyllum*. The main differences between *Amelanchier* and *Malacomeles* are that *Malacomeles* have barely connate carpels, markedly coriaceous leaves, and suborbicular petals (Robertson *et al*., 1991). Currently, Turner (2011) has rendered a recension of the predominant Mexican genus *Malacomeles* and recognized five species.

Little information about the uses of species of this genus has been reported. However, recently, Núñez-Colín and Hernández-Martínez (2011) reviewed the uses of *Malacomeles denticulata* in central Mexico. They reported in a qualitative preliminary test that the Mexican serviceberry (*M. denticulata*) is tolerant to several environmental conditions such as frost, drought, poor drainage and clay soil conditions with pH between 7 and 8. Moreover, in 2009, the authors found that this species grows naturally in shallow and poor soils, practically on the stones. Furthermore, Núñez-Colín and Hernández-Martínez (2011) also reported that the Mexican serviceberry has vegetative compatibility with apple, making it a probable rootstock of apple and other *Rosaceae* fruits for poor soils.

On the other hand, alternative berry crops belonging to the *Rosaceae* family, such as tejocote (*Crataegus* spp.), mayhaw (*Crataegus* series *Aestivales*), saskatoon berry (*Amelanchier alnifolia*) and other species of the genus *Amelanchier* native to North America, have a great importance in the USA and Canadian agribusiness and some of them have been incorporated into juices and jams with cranberry and blueberry (genus *Vaccinium*), either in blends or as a substitute (Payne and Krewer, 1990; Stushnoff, 1991; Mazza and Davidson, 1993; Núñez-Colín, 2009; Núñez-Colín and Hernández-Martínez, 2011). As with the tejocote (*Crataegus* spp.), Mexican serviceberry has great commercial potential as fresh and processed fruit in Mexico. It has the advantage that it does not have hard endocarps like the tejocote, making it more attractive for processing in juices, syrups and jams (Núñez-Colín, 2009; Núñez-Colín and Hernández-Martínez, 2011).

The five recognized species of *Malacomeles* are distributed in Mexico (CONABIO, 2011). However, there are not studies about where to collect the germplasm of *Malacomeles* in Mexico. This study aims to map the diversity and species richness of this genus in order to identify the best regions of Mexico to collect germplasm.

Materials and methods

Passport data of 430 herbarium specimens of the five species of *Malacomeles* were obtained. All data were provided by means of the Global Network about Biodiversity Information (Red Mundial de Información sobre Biodiversidad, REMIB) of the Mexico's National Commission for Knowledge and Use of the Biodiversity (CONABIO, 2011; Supplementary Table S1, available online only at http://journals.cambridge.org).

The Mexican species considered in this study were *M. denticulata* (Kunth) Jones (286 passport data), *Malacomeles nervosa* (Decne) Jones (23 passport data), *Malacomeles paniculata* (Rehder) Phipps (24 passport data), *Malacomeles pringlei* (Koehne) Turner (15 passport data) and *Malacomeles psilantha* (Schneid) Turner (82 passport data).

The observed species richness was calculated based on the number of specimens of different species that are located on each cell in a grid of 1° latitude per 1° longitude. Besides, the Chao estimator of species richness was also calculated, which assumes that all cells in the grid have the same collecting points. This estimator of species richness is a non-parametric method to estimate the number of different classes and was originally proposed to be a lower bound (lower limit of integration). This bound is quite sharp and used as a point estimate, and it has recently been justified under practical assumptions (Shen *et al*., 2003). Finally, Brillouin's diversity index was also obtained to estimate potential biodiversity based on the number of specimens and the number of different species on each cell of the grid; this index has the advantage that the measure of diversity is calculated using a fully counted sample, and it is not an estimate measure of an unknown universe; in addition, this index is not greatly affected by sample size (Greene, 1975). All these indices were calculated by DIVA-GIS software version 7.1.7 (www.diva-gis.org; Hijmans *et al*., 2004).

All maps illustrated over the biogeographic provinces proposed by Morrone (2005) for Mexico (Fig. 1), although the states of Mexico are also mentioned that are related to their potential distribution.

Results

The *Malacomeles* species are distributed in several mountainous ranges of Mexico corresponding to six different biogeographic provinces proposed by Morrone (2005) (Mexican Plateau, Trans-Mexican Volcanic Axis, Sierra Madre Oriental, Sierra Madre Occidental, Sierra Madre del Sur and Chiapas; Fig. 1). All have temperate climate, from climate BS (dry steppe climate, 18–22°C average temperature and 300–600 mm rainfall) to climate Cw

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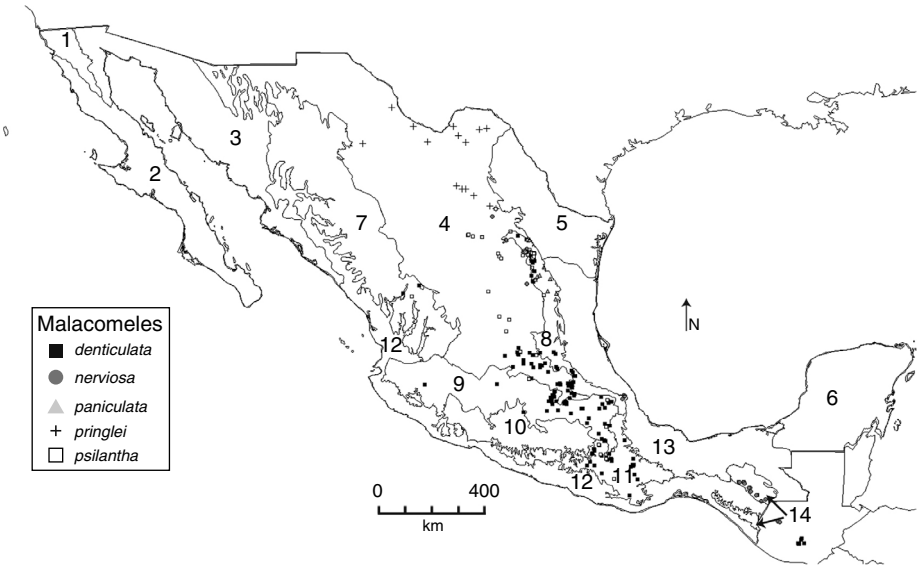

Fig. 1. Map of the distribution of the species of the genus *Malacomeles* on the biogeographic provinces in Mexico proposed by Morrone (2005). 1, California; 2, Baja California; 3, Sonora; 4, Mexican Plateau; 5, Tamaulipas; 6, Yucatan Peninsula; 7, Sierra Madre Occidental; 8, Sierra Madre Oriental; 9, Trans-Mexican Volcanic Axis; 10, Basin of the Balsas; 11, Sierra Madre del Sur; 12, Mexican Pacific Coast; 13, Gulf of Mexico; 14, Chiapas.

(sub-humid temperate climate, 18–22°C average temperature and 600–1000 mm rainfall) and climate Cf (humid temperate climate, 8–22°C average temperature and 2000–4000 mm rainfall) in the scale of Köppen modified by García (1988). The results indicated that *M. pringlei* is distributed in the states of Chihuahua and Coahuila (only in the biogeographic province of the Mexican Plateau), while *M. paniculata* is distributed in the states of Nuevo Leon and Tamaulipas (only in the biogeographic province of Sierra Madre Oriental).

Besides, *M. psilantha* is distributed in Coahuila, San Luis Potosi, Guanajuato, Queretaro, Puebla and Oaxaca. This species is distributed in the biogeographic provinces of Mexican Plateau, Trans-Mexican Volcanic Axis, Sierra Madre Occidental and Sierra Madre del Sur, while *M. nervosa* is distributed in all east mountainous ranges of the country, from the states of Nuevo Leon and Coahuila in the north to the state of Chiapas in the south (specifically in the biogeographic provinces of Mexican Plateau, Sierra Madre Oriental and Chiapas);

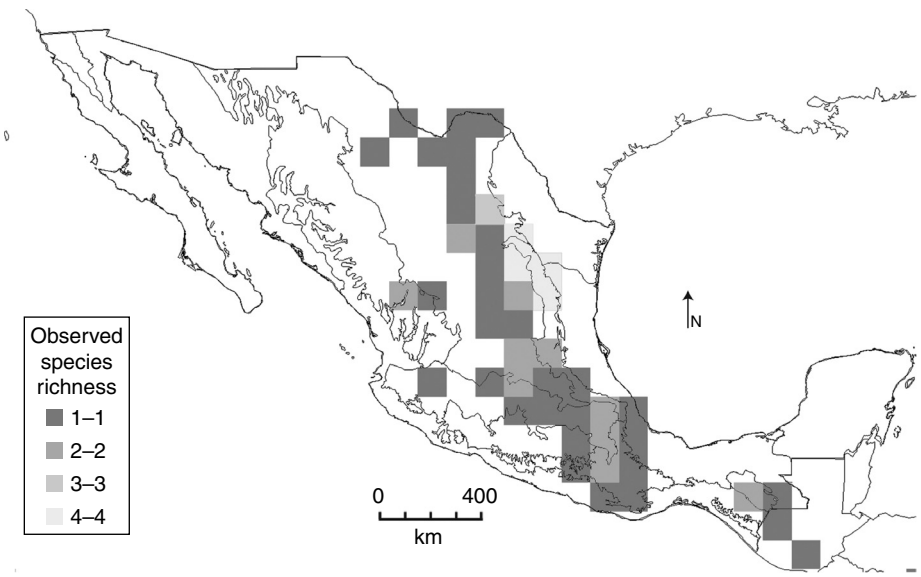

Fig. 2. Map of the observed species richness of the genus *Malacomeles* in Mexico.

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however, this species is mainly distributed in southern Mexico in the biogeographic province of Chiapas.

Finally, *M. denticulata* is the most distributed species of the genus *Malacomeles* in Mexico. *M. denticulata* is mainly distributed in central Mexico, specifically in the States of Guanajuato, Queretaro, Hidalgo, State of Mexico, Puebla, Oaxaca and Tlaxcala; although *M. denticulata* is distributed in five biogeographic provinces: Trans-Mexican Volcanic Axis; Mexican Plateau; Sierra Madre Oriental; Sierra Madre del Sur; Sierra Madre Occidental. However, most of the accessions are located in Trans-Mexican Volcanic Axis, Mexican Plateau and Sierra Madre del Sur (Fig. 1).

The map of the observed species richness showed that only in four cells of the grid, the highest species richness of *Malacomeles* was located (Fig. 2). All of them were found in northeast Mexico, mainly in the biogeographic province of Sierra Madre Oriental.

The map using the Chao estimator of species richness showed a similar pattern to that of the observed species richness (Fig. 3), which means the same cells as those in the observed species richness in northeast Mexico had a higher species richness value; nonetheless, in this case, only one cell had the highest species richness which was found in the biogeographic province of Sierra Madre Oriental.

In central Mexico, where most specimens were found, both the aforementioned maps showed a lower species richness than shown in northern Mexico, mainly in the biogeographic provinces of Trans-Mexican Volcanic Axis and Sierra Madre del Sur, and in the southern province of the Mexican Plateau (Figs 2 and 3).

Finally, the map of Brillouin's diversity index showed that northeast Mexico, mainly in the biogeographic province of Sierra Madre Oriental, has the highest diversity, followed by a cell of Coahuila in the biogeographic province of the Mexican Plateau. Moreover, four cells showed intermediate diversity: one cell in the intersection among the provinces of Trans-Mexican Volcanic Axis with the Mexican Plateau; two cells in the intersection among the provinces of Trans-Mexican Volcanic Axis with Sierra Madre del Sur; one cell in the province of Chiapas. All other regions showed a low diversity (Fig. 4).

Discussion

M. denticulata is the most distributed and interesting species from the perspective of plant genetic resources, but there are not enough studies about its diversity. Hernández-Martínez *et al.* (2011) had the first insight into its diversity using seed traits of six *M. denticulata* populations. These authors found that the six populations have high diversity, both intra- and inter-population, in its seeds. In addition, Núñez-Colín (2010) reported the distribution of this species in Mexico and found that *M. denticulata* grows in three different climatic conditions.

Recently, Hernández-Martínez *et al.* (2010) and Núñez-Colín and Hernández-Martínez (2011) described several uses of the Mexican serviceberry in central Mexico. In this sense, this species is used for wood mainly as a fire starter, for construction, as a fodder plant, as a fresh food, and to make jams, juices, syrups, etc.; also, this

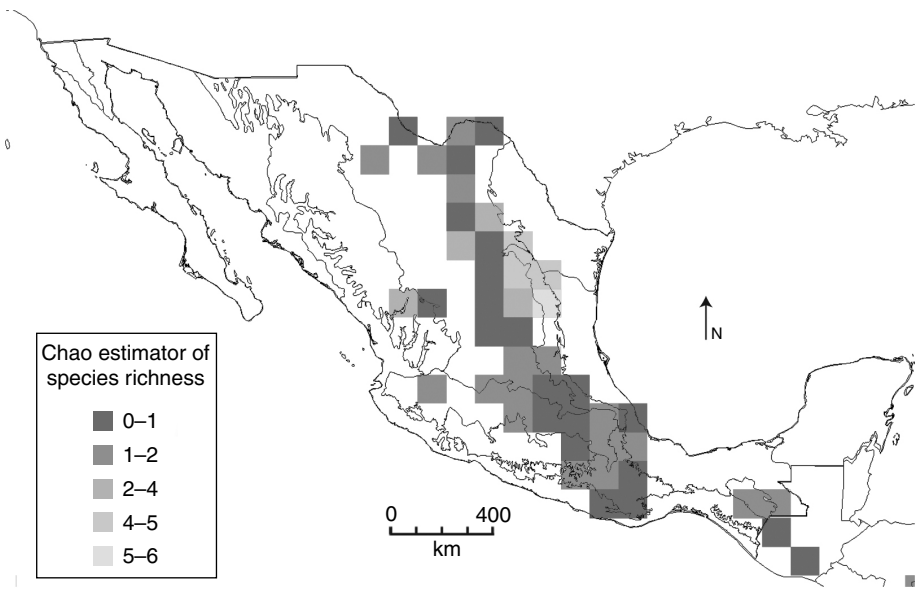

Fig. 3. Map of the Chao's estimator of species richness of the genus *Malacomeles* in Mexico.

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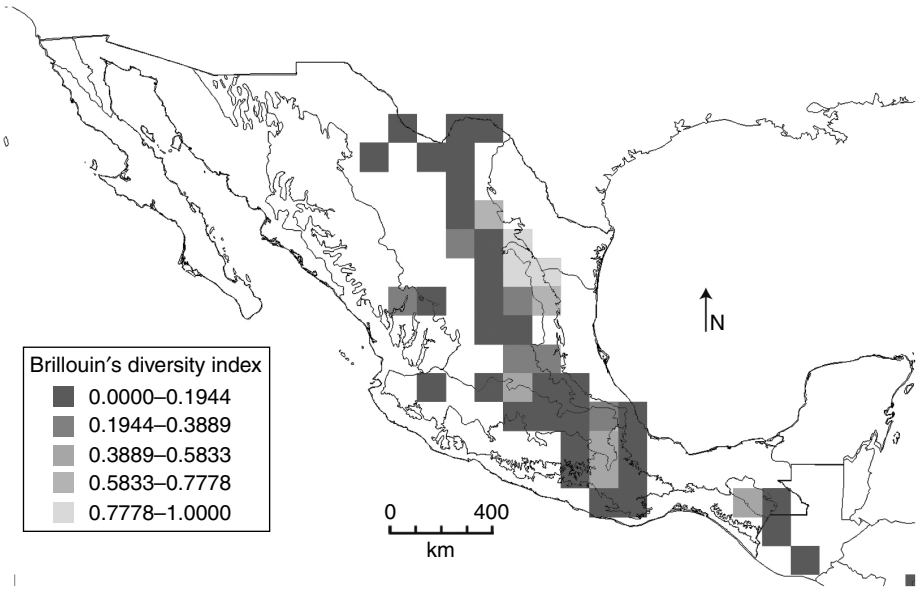

Fig. 4. Map of Brillouin's diversity index of the genus *Malacomeles* in Mexico.

species can be used as a rootstock for apple and other *Rosaceae* because it has a good vegetative compatibility (Núñez-Colín and Hernández-Martínez, 2011). Nonetheless, all other species of *Malacomeles* in Mexico unfortunately only have taxonomic information.

On the other hand, this study showed that *M. denticulata* is the most widely distributed species in Mexico followed by *M. psilantha*, with both species converging in central and southern Mexico. These results agree with the study by Turner (2011). In addition, although *M. nervosa* is distributed in three biogeographic provinces, its main distribution is in southern Mexico, which agrees with the study by Turner (2011), who mentioned that this species is only distributed in Chiapas and Central America.

Conversely, the other two species had a restricted distribution in Mexico: *M. paniculata* is only distributed in south Nuevo Leon and southwest Tamaulipas (Hinton and Hinton, 1995; Turner, 2011), while *M. pringlei* is restricted to Chihuahua and Coahuila (Turner, 2011).

The highest values of species richness and diversity were concentrated in cells of northeast Mexico, where the majority of the taxonomical studies in *Rosaceae* were done (Hinton and Hinton, 1995; Phipps, 1997). In addition, it is one of the most important regions in Mexico with reference to plant diversity and endemism (Hinton and Hinton, 1995; Villarreal-Quintanilla and Encina-Domínguez, 2005). Consequently, this area can be considered as the priority area to collect the germplasm of *Malacomeles* (Guarino *et al.*, 2002). The results of this study also showed that it is important to collect into the four cells with intermediate diversity, which are located in the intersection among the provinces of Trans-Mexican Volcanic Axis with the Mexican Plateau, in the intersection among the provinces of Trans-Mexican Volcanic Axis with Sierra Madre del Sur, and in the province of Chiapas; thus, this can also be considered as a secondary priority area for germplasm collection (Guarino *et al.*, 2002).

This study showed that it is important to collect germplasm in regions with endemic species to preserve the diversity of *Malacomeles* in Mexico. However, the germplasm to be collected must be focused in the predominant Mexican species of *Malacomeles* found in this study: *M. denticulata*. That is because this species has a greater probability to be found with higher genetic variability, it can be used in a breeding programme (Zagaja, 1988). In this study, this species is mainly distributed in central and southern Mexico, which agrees with several botanical studies about *Malacomeles* distribution (Phipps *et al.*, 1990; Rzedowski and Calderon de Rzedowski, 2005; Vibrans *et al.*, 2006; Núñez-Colín, 2010; Turner, 2011).

Acknowledgements

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el centro de México'. The authors thank Dr Eduardo Espitia-Rangel and Dr Irail Cortinas-López for the review of the manuscript and for editing the English language.

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