Ecological niche differentiation of *Magnolia* subsect. *Talauma* (*Magnoliaceae*) in Cuba

Diferenciación del nicho ecológico de *Magnolia* subsect. *Talauma* (*Magnoliaceae*) en Cuba

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ABSTRACT
The taxonomy of *Magnolia* subsect. *Talauma* in Cuba has been largely debated and changed. Some authors have considered the variability of the group in a single taxon while others have divided it into two, three, and four-taxa. The present work aimed to model the ecological niche of the Cuban taxa of *Magnolia* subsect. *Talauma*, and identify which of the three main classification systems for these taxa aligns better with the ecological niche model analysis. We used fieldwork data and herbarium specimens as occurrence data. As niche predictors, we used variables from the *WorldClim* database. After a preparation process (spatial thinning of occurrences, pre-model, candidate models) the ecological niche models were made in *Maxent*, considering different taxonomic classifications proposed. Annual precipitation and precipitation seasonality were the variables with the highest contribution to the models of all the taxa, except for *M. orbiculata* (Maximum temperature and elevation). The ecological niche models of *Magnolia* subsect. *Talauma* in Cuba showed the mountains of Sierra Maestra and Nipe-Sagua-Baracoa as the most suitable areas for these taxa; no matter the classification system used. *Magnolia orbiculata* had the smallest areas of niche suitability, and was the only taxon with a different ecological niche, supporting its status of species. The taxa of the north-eastern showed a high level of ecological similarity, making impossible to determine which classification system has the higher support, and which are the ecological limits of the taxa.

Keywords: current distribution, ecological niche models, ecological species concept, niche identity, potential distribution

RESUMEN
La taxonomía de *Magnolia* subsect. *Talauma* en Cuba ha sido ampliamente debatida y cambiada. Algunos autores han considerado la variabilidad del grupo en un solo taxón mientras que otros lo han dividido en dos, tres y cuatro taxones. El presente trabajo tuvo como objetivos modelar el nicho ecológico de los taxones cubanos de *Magnolia* subsect. *Talauma*, e identificar cuál de los tres principales sistemas de clasificación para estos taxones se alinea mejor con los modelos de nicho ecológico. Se usaron como datos de ocurrencia, datos colectados en el campo y ejemplares de herbarios. Como predictores de nicho se usaron las variables climáticas del *WorldClim*. Luego de un proceso de preparación (reducción de ocurrencias, pre-modelo y modelos candidatos) se realizaron los modelos de nicho ecológico en *Maxent*, donde se consideraron diferentes clasificaciones taxonómicas propuestas. Precipitación anual y estacionalidad de la precipitación fueron las variables con mayor contribución a los modelos de todos los taxones, excepto *M. orbiculata* (Temperatura máxima y elevación). Los modelos de nicho ecológico de *Magnolia* subsect. *Talauma* en Cuba mostraron la Sierra Maestra y Nipe-Sagua-Baracoa como las áreas más idóneas para estos taxones, sin importar el sistema de clasificación que se utilizó. *Magnolia orbiculata* tuvo las áreas con idoneidad de nicho más pequeñas y fue el único taxón con un nicho ecológico diferente, lo que respalda su estado de especie. Los taxones del noreste muestran un alto nivel de similitud ecológica, lo que hace imposible determinar qué sistema de clasificación tiene el mayor soporte y cuáles son sus límites ecológicos.

Palabras clave: distribución actual, modelos de nicho ecológico, concepto ecológico de especie, distribución potencial, identidad de nicho

Citation: Testé, E., Simón, R., Hernández-Rodríguez, M., Bécquer, E.R., Robert, T., Palmarola, A. & González-Torres, L.R. 2022. Ecological niche differentiation of *Magnolia* subsect. *Talauma* (*Magnoliaceae*) in Cuba. *Revista Jard. Bot. Nac. Univ. Habana* 43: 133-142.

Received: 15 July 2021. **Accepted**: 13 September 2021. **Published Online**: 18 August 2022. **Editor**: José Angel García-Beltrán.

INTRODUCTION

One of the most central concepts in modern biology is the ecological niche (Qiao & *al.* 2016); this can be defined as the environmental conditions and requirements that allow a species to maintain stable populations without immigration (Peterson 2003, Pearman & *al.* 2007, Soberón & Nakamura 2009). The niche is an n-dimensional environmental space (fundamental niche) constricted by species interactions, dispersal limitations, and land use (realized niche) (Hutchinson 1957). The ecological niche model (ENM) is one of the most significant and recognized methods to analyze the ecological niche and potential geographic distribution of species (Feng & *al.* 2019, Song & *al.* 2019). ENMs allow answering questions about geographic and environmental isolation, and ecological limits between taxa, which can help with species delimitation and to understand speciation mechanisms (Raxworthy & *al.* 2007, Tocchio & *al.* 2014).

The conservation of *Magnolia* species has been identified as a global priority (Cires & *al.* 2013, Rivers & *al.* 2016), and in the Caribbean, the efforts to preserve the taxa of the *Magnoliaceae* family are on the rise (González-Torres & *al.* 2016, Castillo & *al.*

2018, Veltjen 2020). Within the Antilles, Cuba has the highest diversity of *Magnolia* with seven endemic taxa, six of which belong to *Magnolia* sect. *Talauma* (Juss.) Baill. split into two subsections: *M.* subsect. *Cubenses* Imkhan. and *M.* subsect. *Talauma* (Juss.) Figlar & Noot. (Greuter & Rankin 2017, Veltjen 2020). The taxonomy of the Cuban taxa of this section has been largely debated and in particular the delimitation of taxa of *Magnolia* subsect. *Talauma.* Some authors have considered all the variability of the group in a single taxon (Alain 1969, Borhidi & Muñiz 1971, Lozano-Contreras 1994), while others have divided it into two (León & Alain 1951), three (Palmarola & *al.* 2016), and four taxa (Bisse 1974, 1988).

In the last taxonomy review of Cuban magnolias, Palmarola & *al.* (2016) recognize three taxa of *Magnolia* subsect. *Talauma*: *Magnolia orbiculata* (Britton & P. Wilson) Palmarola, endemic to Sierra Maestra, *Magnolia minor* (Urb.) Govaerts and *Magnolia oblongifolia* (León) Palmarola, both endemic to the Nipe-Sagua-Baracoa massif. The present work aimed to analyze the ecological niche models of the Cuban taxa of *Magnolia* subsect. *Talauma*; and identify which of the three main classification systems (called CS hereafter; two taxa CS [León & Alain 1951], four taxa CS [Bisse 1988], and three taxa CS [(Palmarola & al. 2016]) aligns better with the ecological niche model analysis.

MATERIALS AND METHODS

Occurrence records

We compiled occurrences of all the Cuban taxa of *Magnolia* subsect. *Talauma* throughout their entire distribution range in the mountains of Nipe-Sagua-Baracoa and Sierra Maestra, eastern Cuba. These were obtained during our fieldwork and from herbarium specimens (HAC, HAJB, and B; herbarium acronyms follow Thiers 2022). This last source was used to include individuals from localities we could not visit, and specimens reported before 1950 were not considered. We grouped all the individuals according to the three main classification systems (CS) for the Cuban taxa of *Magnolia* subsect. *Talauma*: (1) two taxa CS: *Magnolia minor* and *M. orbiculata* (León & Alain 1951); (2) four taxa CS: *M. minor*, *M. orbiculata*, *M. oblongifolia*, and *Talauma ophiticola* Bisse (Bisse 1988); and (3) three taxa CS: *M. minor*, *M. orbiculata*, and *M. oblongifolia* (Palmarola & *al.* 2016). León & Alain (1951) considered *T. truncata* (Moldenke) R. A. Howard an independent taxon, however, in the present work, we considered this species as part of the variability of *M. orbiculata* (Bisse 1988, Imkhanitzkaja 1993, Palmarola & *al.* 2016). To avoid autocorrelation and model overfitting (Anderson 2012), we performed a spatial thinning of the occurrences leaving gaps of 3 km between records. This "gap distance" was based on the spatial resolution of the environmental variables (~1 km) and the environmental heterogeneity of Cuban mountains habitats. The original and final occurrence data used in this study are in Supplementary Table I.

Ecological niche model

As niche predictors, we chose a set of 15 bioclimatic variables (spatial resolution: 0.86 km^2) and the digital elevation model (DEM) from the *WorldClim* database (http://www.worldclim.com/, Hijmans & *al.* 2005). We excluded four of the bioclimatic variables (Bio8-9, Bio18-19) from all analyses because they show odd spatial anomalies in the form of discontinuities between neighboring pixels in the absence of environmental gradients on the ground (Escobar & *al.* 2014). The variables were trimmed to eastern Cuba region (extent of the accessible area - M) using *ArcGis 10.2* (ESRI 2014). For model calibration, we used the thinned occurrence data and the bioclimatic variables of the individuals *Magnolia* subsect. *Talauma*, excluding the ones with the lower contribution of any set of correlated variables (r ≥ 0.85). We build the pre-model using *Maxent v.3.4.1* (Phillips & *al*. 2006). To improve the process of model calibration, we designed three sets of variables (Table 1) as recommended by Cobos & *al*. (2019).

TABLE I

Sets of environmental variables used for model calibration of *Magnolia* subsect. *Talauma* in Cuba

Source of the variables: *WorldClim* (Hijmans & *al*. 2005). Sets 2 and 3 did not include variable(s) with the low contribution to the model.

TABLA I

Conjuntos de variables ambientales utilizadas para la calibración del modelo de* Magnolia *subsect.* Talauma *en Cuba

Fuente de las variables: WorldClim *(Hijmans &* al. *2005). Los conjuntos 2 y 3 no incluyeron variable(s) con la contribución baja al modelo.*

Climatic variables	Code	Set 1	Set 2	Set 3
Annual precipitation	Bio12	x	x	x
Precipitation seasonality (Coefficient of variation)	Bio15	x	x	x
Maximum temperature of warmest month	Bio5	x	x	x
Digital elevation model	DEM	x	x	x
Temperature annual range (BIO5-BIO6)	Bio7	x	x	x
Temperature seasonality (standard deviation ×100)	Bio4	x	x	-
Isothermality (BIO2/BIO7) (* 100)	Bio3	x	-	-

Lumped models provide a simplified overview of the spatial distribution of heterogeneous groups, like *Magnolia* subsect. *Talauma*. Considering all the individuals as only one species (lumped), we built 1,044 candidate models that integrated 12 values of regularization multiplier (0.5 to 6, at intervals of 0.5), all combinations of the five features classes (linear = l, quadratic = q, product = p, threshold = t, hinge = h), and the three sets of environmental variables. The background extent selected for the models was based on a minimum convex polygon with a buffer distance of 0.5 degrees. The performance of the candidate models was evaluated considering the significance (partial ROC), omission rates (E = 5 %), and model complexity (AICc). The selected best models were the significant models with omission rates ≤ 5 % and delta AICc ≤ 2. The model calibration process was done using *kuenm* (Cobos & *al.* 2019), an *R* (R Core Team 2022) package for detailed development of ENM using *Maxent*.

The parameter combination of the best model was used for niche modelling according to the different classification systems of *Magnolia* subsect. *Talauma* (lumped, two, three, and four taxa CS). We created the final models with the full set of thinned records and the selected sets of variables. Modelling was performed in *Maxent v.3.4.1* with 50 bootstrap replicates, and the best configurations obtained during the evaluation process. The median models of the logistic output were converted into a binary map in *ArcGis v.10.2*. The minimum training presence was used as a threshold. It considers as suitable habitats all the pixels with higher values than the smallest value of probability corresponding to a real presence point. The contribution of each variable to the final model was assessed with a Jackknife analysis, and the total suitable area was calculated for each model.

Niche Identity Test

We used the Niche Identity Test to examine the niche divergence within *Magnolia* subsect. *Talauma*. This test is based on the assessment of significant niche differences generated by ENM (Warren & *al*. 2010). Two indices for niche identity (Schoener's D and Hellinger's-based I) were computed with the software *ENMTools v.1.4.3* (Warren & *al*. 2008). Schoener's D calculates the suitable range for a given species based on the probability distributions for inhabiting particular regions and assumes that the suitability scores produced by *Maxent* are proportional to the species abundance. Hellinger's-based also estimates habitat suitability from probability distributions but without the assumption of Schoener's D (Warren & *al*. 2010). Both indices range from zero (no overlap) to one (complete overlap) (Warren & *al*. 2008). We used the continuous probabilities of habitat suitability generated by *Maxent*.

Point-based analysis

Using the best suitable dataset of variables (from ENMs analysis), pixel values for each environmental layer were extracted at each point of occurrence of *Magnolia* subsect. *Talauma*, and used to assess niche differences between taxa. A principal component analysis (PCA) was performed in *R* to explore the relation across the climate variables. To test the differences of elevation over sea level between taxa, a MonteCarlo analysis in add-ins *PopTools v.3.23 MSExcel* with 10,000 randomnesses was made. We used the total number of geographical records (before spatial thinning) for *Magnolia* subsect. *Talauma* (858 records, see Table II).

RESULTS

Ecological niche model and identity test

The best model resulted from the combination of 1.5 regularization multipliers, feature classes threshold, and set 3 of variables (Bio5, Bio7, Bio12, Bio15, and DEM; Table I). Annual precipitation (Bio12) and precipitation seasonality (Bio15) were the variables with the highest contribution to the models for all taxa, except for *Magnolia orbiculata*, in which maximum temperature (Bio5) and elevation (DEM) were those who contributed the most. Almost all ENMs performed for each taxon independently showed potentially suitable regions in large areas of the mountain of Nipe-Sagua-Baracoa and the Sierra Maestra (Figure 1A-F). *Magnolia orbiculata* was the taxon with the smallest potential area of suitability (Figure 1G), which was restricted to the Sierra Maestra and few places in northeastern Cuba. Based on the minimum training presence (MTP) suitability area, *M. oblongifolia* (four taxa CS) and *M. minor* (two taxa CS) were the taxa with the largest predicted area, and *M. orbiculata* had the lowest value of predicted area (Table III). Niche overlap analysis indicated that most of the groups have high levels of niche overlap with each other no matter the classification system used (Table IV). *Magnolia orbiculata* had the lowest value of Schoener's D index, while the rest had values of similarity over 60 %. On the other hand, each taxon had over 80 % of similarity when using the Hellinger's-based I index.

TABLE II

Number of initial and final records (after 3 km spatial thinning) used to create the ecological niche models of *Magnolia* subsect. *Talauma* in Cuba

TABLA II

Número de registros inicial y final (después de 3 km de refinado espacial) usados para crear modelos de nicho ecológico de Magnolia subsect. Talauma en Cuba

Classification systems and taxa		Initial	Final
Two taxa	*M. minor*	780	35
	M. orbiculata	78	6
Three taxa	*M. minor*	371	28
	M. orbiculata	78	6
	M. oblongifolia	409	18
Four taxa	*M. minor*	371	28
	M. orbiculata	78	6
	M. oblongifolia	58	10
	Talauma ophiticola	351	15
Magnolia subsect. *Talauma* (lumped)		880	41

 ISSN 2410-5546 RNPS 2372 (DIGITAL) - ISSN 0253-5696 RNPS 0060 (IMPRESA)

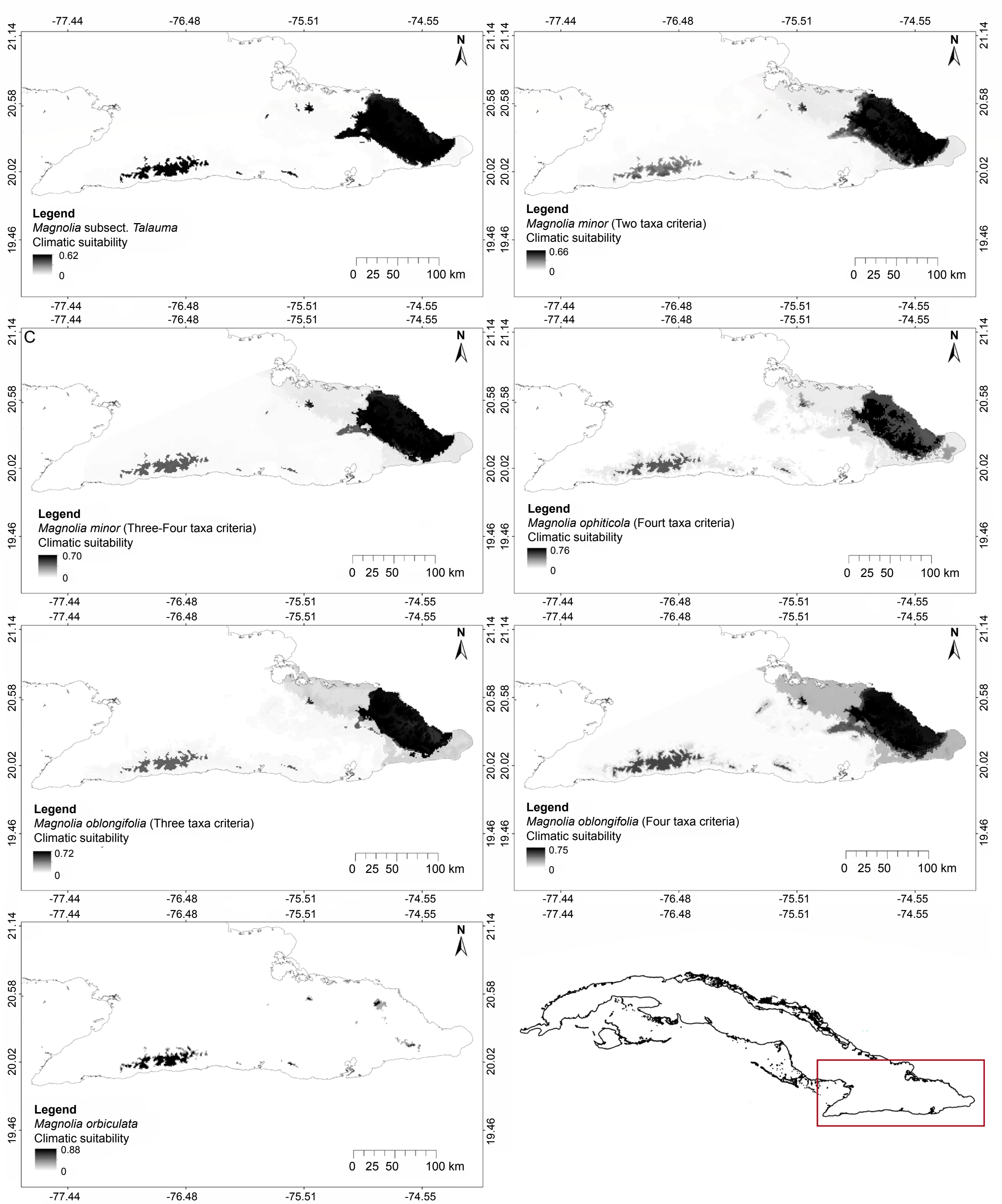

Fig. 1. Areas of climatic suitability for the taxa of *Magnolia* subsect. *Talauma* in Cuba, based on the classification systems that consider two (*M. minor* and *M. orbiculata*), three (*M. minor*, *M. oblongifolia* and *M. orbiculata*) and four taxa (*M. minor*, *M. oblongifolia*, *M. orbiculata* and *Talauma ophiticola*).

Fig. 1. Áreas *idóneas para los taxones de* Magnolia *subsect.* Talauma *en Cuba, basado en los sistemas de clasificación que consideran dos* (M. minor *y* M. orbiculata)*, tres* (M. minor, M. oblongifolia *y* M. orbiculata) *y cuatro taxones* (M. minor, M. oblongifolia, M. orbiculata *y* Talauma ophiticola).

TABLE III

Values of minimum training presence (MTP) and area of the habitat suitability of the taxa of *Magnolia* subsect. *Talauma* in Cuba, based on the classification systems that consider two (*M. minor* and *M. orbiculata*), three (*M. minor*, *M. oblongifolia* and *M. orbiculata*) and four taxa (*M. minor*, *M. oblongifolia*, *M. orbiculata* and *Talauma ophiticola*)

TABLA III

***Valores de presencia de entrenamiento mínima (MTP) y área de hábitat idóneo de los taxones de* Magnolia *subsect.* Talauma *en Cuba, basado en los sistemas de clasificación que consideran incluyen dos* (M. minor *y* M. orbiculata)*, tres* (M. minor, M. oblongifolia *y* M. orbiculata) *y cuatro taxones* (M. minor, M. oblongifolia, M. orbiculata *y* Talauma ophiticola)**

Taxa and classification systems	MTP	MTP Suitability area (km^2)
Magnolia subsect. *Talauma*	0.054	4,624
M. minor (two taxa classification system)	0.078	5,661
M. minor (three and four taxa classification system)	0.097	5,206
T. ophiticola (four taxa classification system)	0.225	4,058
M. oblongifolia (three taxa classification system)	0.169	4,933
M. oblongifolia (four taxa classification system)	0.298	7,765
M. orbiculata (all classification system)	0.347	832

TABLE IV

Niche overlap between the taxa of *Magnolia* subsect. *Talauma* in Cuba, based on the classification systems that consider two (*M. minor* and *M. orbiculata*), three (*M. minor*, *M. oblongifolia* and *M. orbiculata*) and four taxa (*M. minor*, *M. oblongifolia*, *M. orbiculata* and *Talauma ophiticola*)

Numbers above diagonal refer to Schoener's D and below to Hellinger's-based I values.

TABLE IV

***Superposición de nicho entre los taxones de* Magnolia *subsect.* Talauma *en Cuba, basado en los sistemas de clasificación que consideran incluyen dos* (M. minor *y* M. orbiculata)*, tres* (M. minor, M. oblongifolia *y* M. orbiculata) *y cuatro taxones* (M. minor, M. oblongifolia, M. orbiculata *y* Talauma ophiticola)**

Números encima de la diagonal se refieren al índice D de Schoener y debajo al índice I de Hellinger.

Taxa and classification systems	1	2	3	4	5	6	7
Magnolia subsect. *Talauma*		0.914	0.907	0.713	0.792	0.592	0.416
M. minor (two taxa classification system)	0.987		0.927	0.752	0.825	0.636	0.453
M. minor (three and four taxa classification system)	0.986	0.991		0.794	0.874	0.671	0.498
T. ophiticola (four taxa classification system)	0.936	0.954	0.965		0.888	0.823	0.681
M. oblongifolia (three taxa classification system)	0.947	0.967	0.976	0.989		0.760	0.598
M. oblongifolia (four taxa classification system)	0.905	0.925	0.941	0.982	0.965		0.781
M. orbiculata (all classification system)	0.800	0.814	0.842	0.922	0.889	0.968	

Point-based analysis

Principal component analyses showed that *Magnolia orbiculata* has a distinct environmental niche with no overlap (p<0.001) with other taxa (Figure 2A). Figure 2B showed the clear disjointed geographic distribution of *M. orbiculata* concerning the rest of the taxa. This is consistent with the distribution of this species, which is the only one restricted to higher elevations (795-1,200 m), while *Talauma ophiticola* was the taxon with the highest variability on its elevation range (34-987 m) (Figure 3). Individuals of *M. minor* and *M. oblongifolia* were found to be present at the same altitudes (p = 0.033) when based on the three taxa CS, and similar results were found for *M. minor* and *T. ophiticola* (p = 0.109), when following the four taxa CS.

DISCUSSION

Two precipitation variables, annual precipitation-Bio12, and precipitation seasonality-Bio15 presented the highest contribution to the ENM of the Cuban taxa of *Magnolia* subsect. *Talauma*, except for *M. orbiculata*, which was more influenced by extreme temperature (Bio5). Rainfall and temperature are among the factors that influence the most distribution of

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plants because both climatic parameters are the primary control of biomes and are closely correlated with terrestrial net productivity (Hull 2008, Zhao & *al*. 2019). In the specific case of magnolias, some authors (Song & *al*. 2019, Song & Liu 2019, Rodríguez-Ramírez & *al*. 2020) have already reported the importance of these bioclimatic variables in the distribution of this group of plants.

The differences observed between *Magnolia orbiculata* and the remaining taxa in the contributions of the variables used to the niche model reflect the differences that exist between the Sierra Maestra and the massif Nipe-Sagua-Baracoa. The latter is the region with the highest annual rainfall values in Cuba, above 3,000 mm per year, (Borhidi 1996); and Sierra Maestra is the one with the highest elevation in Cuba, 1,974 m over the sea level. Song & Liu (2019) reported a high correlation between elevation and maximum temperature of the warmest month, the most influencing variables for *M. orbiculata*. This correlation was not detected in our taxa dataset, but a possible association between both variables could explain the high influence on the model of *M. orbiculata*.

Our results of the niche overlap analyses, both, the point-based and the elevation based, combined with the fact that *Magnolia orbiculata* is the only taxon of *Magnolia* subsec. *Talauma* that lives in the Sierra Maestra (more than 50 km apart from the other taxa of the group), support the distinctness of the species. They do not support what has been proposed by several authors (Howard 1948, Alain 1969, Borhidi & Muñiz 1971, Lozano-Contreras 1994), who included *M. orbiculata* in *M. minor*. These results, on the other hand, are consistent with the molecular phylogeny of the taxa in the subsection proposed by Veltjen (2020), who considers that *M. orbiculata* forms a lineage independent from the other taxa of *Magnolia* subsect. *Talauma*. The small areas found to be suitable for this species could be explained by the low number of known individuals and their closed geographic distribution.

The taxa of *Magnolia* subsect. *Talauma* occurring in the north-eastern region of Cuba, have an unclear ecological delimitation, non-matter which CS was used. We expected this result due to their sympatric distribution. According to Prata & *al*. (2018), this group can be considered a species complex based on their ecological limits, and the number of species is unclear. The taxonomic delimitation of species complex is a complicated process (Prata & *al*. 2018, Yang & *al*. 2019), even more, if using only a single line of evidence, like ecology in this case. According to our results, all the taxa exclusive to this area (north-eastern region of Cuba) have large areas of environmental suitability in the region of Sierra Maestra. The absence of these taxa in this area could be due to the presence of large unsuitable areas between them. Another possible explanation may be that the common ancestor of the taxa of *Magnolia* subsect. *Talauma* lived in the Sierra Maestra, and the current taxa that diverged from it maintain similar niche characteristics. According to Wiens & Graham (2005), the species tends to retain ancestral ecological aspects of their fundamental niche over time.

The significant contribution of annual precipitation, precipitation seasonality, and maximum temperature of the warmest month to the distribution of the Cuban taxa of *Magnolia* subsect. *Talauma* is indicative of the sensitivity of these taxa to climate change. Global warming is likely to raise between 1-5ºC in 2100, depending on the model, and the precipitation could likely decrease (Stocker & *al*. 2013). Climate change could exceed the adaptive capacity of these trees, causing geographic displacement and local extinctions. *Magnolia orbiculata*, with a constrained distribution to the higher elevations in Sierra Maestra, will be the species with the higher risk of extinction. However, other species of the group may be also affected by climate change as proposed by Fuentes-Marrero & *al*. (2019). These authors reported that by 2050, under different climatic scenarios, the suitable areas of distribution of *M. minor* (sensu Palmarola & *al.* 2016) will be considerably reduced.

CONCLUSIONS

For all the classification systems analyzed, the areas with higher values of niche suitability for the Cuban taxa of *Magnolia* subsect. *Talauma* were in the mountains of Sierra Maestra and Nipe-Sagua-Baracoa. *Magnolia orbiculata* had the most restricted area of potential distribution, and was the only species with a different ecological niche, supporting its species status. The taxa of the north-eastern of Cuba showed high ecological similarity, making impossible to determinate which classification system has the higher support, and which are the ecological limits of the taxa.

ACKNOWLEDGEMENTS

This work was conducted thanks to the support of Planta!, International Association of Plant Taxonomy (IAPT), *Campus France,* Cuban Botanical Society, National Botanic Garden of the University of Havana, National Enterprise for the Conservation of the Flora and the Fauna, National Center of Protected Areas, Fauna and Flora International, Arboretum Wespelaar, Fondation Franklinia, Whitley Fund for Nature. Lastly, we are deeply grateful to Adonis Sosa, Alexander López-Cantero, Aysel García, Banessa Falcón, Jorge Días, José Luis Gómez, Leandro Galano, Loynaz Mateo, Sandra Lafargue, Sergio Hernández, Yenia Molina, Yoira Rivero, and all the people to contribute to this work.

AUTHORS' CONTRIBUTIONS

E. Testé conceived the original idea, coordinated the research, analysed the data, and wrote the first version of the manuscript. R. Simón, M. Hernández-Rodríguez, E.R. Bécquer and A. Palmarola took part of the data and contributed to its analysis. T. Robert and L.R. González-Torres contributed to the writing and final revision of the document. All authors participated actively in the discussion of the results and the critical review of the manuscript.

COMPLIANCE WITH ETHICAL STANDARDS

Conflict of interest: The authors declare that they have no conflict of interest.
Ethics approval: All authors have carried out fieldwork and data generation ethically, including obtaining appropriate permitting.
Consent for publication: All authors have consented to publishing this work.

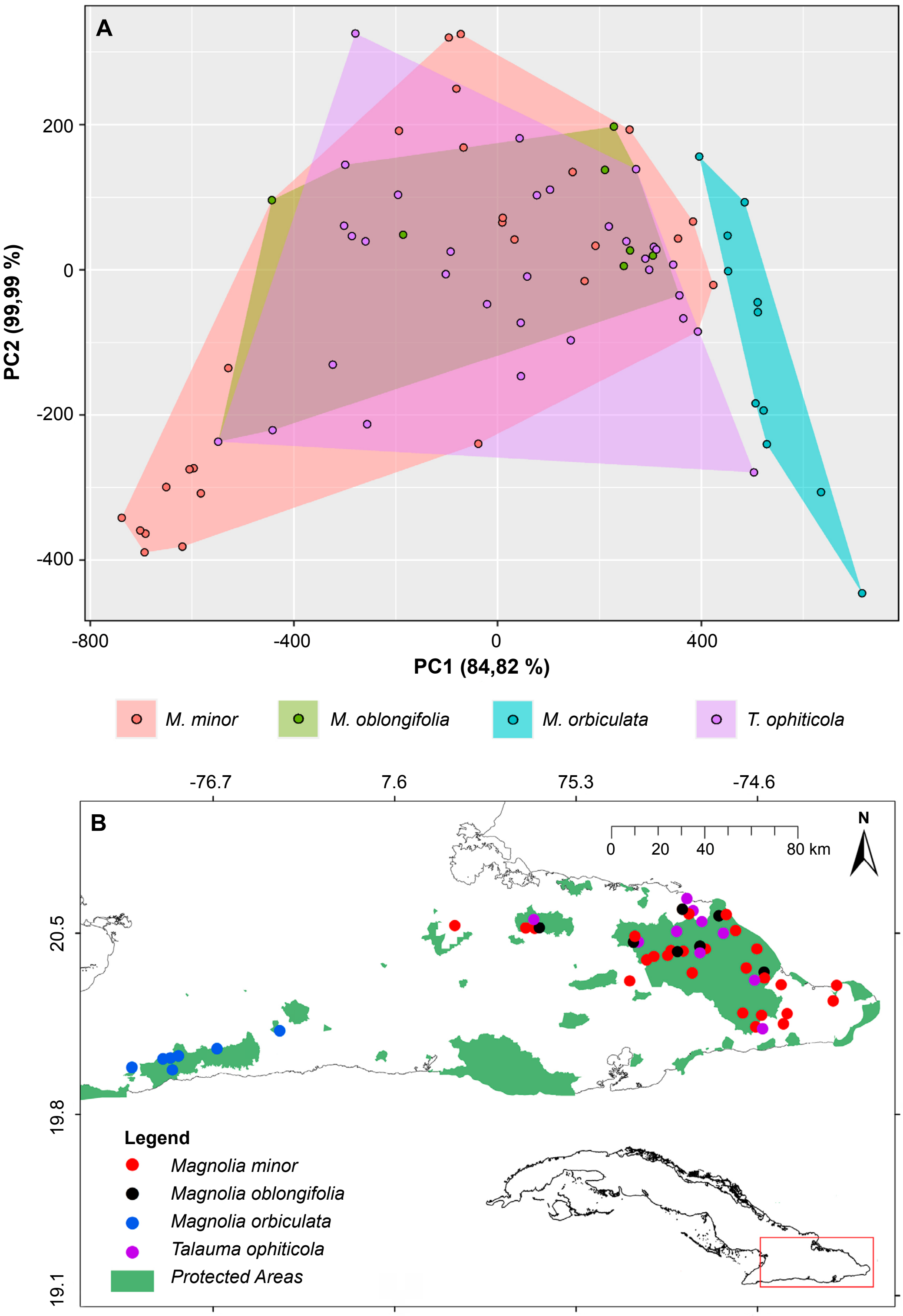

Fig. 2. A. Results of the principal component analysis (PCA) performed with five bioclimatic variables (set 3, see Table I) used in the description of the ecological niche of the taxa of *Magnolia* subsect. *Talauma* in Cuba. **B.** Current geographic distribution of *Magnolia* subsect. *Talauma* in Cuba. The PCA and the map show the four taxa classification system, for the three taxa *M. oblongifolia* = *M. oblongifo*lia + *Talauma ophiticola*, and for two taxa *M. minor* = *M. minor* + *M. oblongifolia* + *T. ophiticola*.

Fig. 2. A. *Resultados del análisis de componentes principales (PCA) realizado con cinco variables bioclimáticas (conjunto 3, ver Tabla I) utilizadas en la descripción del nicho ecológico de los taxones de* Magnolia *subsect.* Talauma *en Cuba.* ***B.*** *Distribución geográfica actual de* Magnolia *subsect.* Talauma *en Cuba. El PCA y el mapa muestran el sistema de clasificación de cuatro taxones, para tres taxones* M. oblongifolia = M. oblongifolia + Talauma ophiticola, *y para dos* M. minor = M. minor + M. oblongifolia + T. ophiticola.

 ISSN 2410-5546 RNPS 2372 (DIGITAL) - ISSN 0253-5696 RNPS 0060 (IMPRESA)

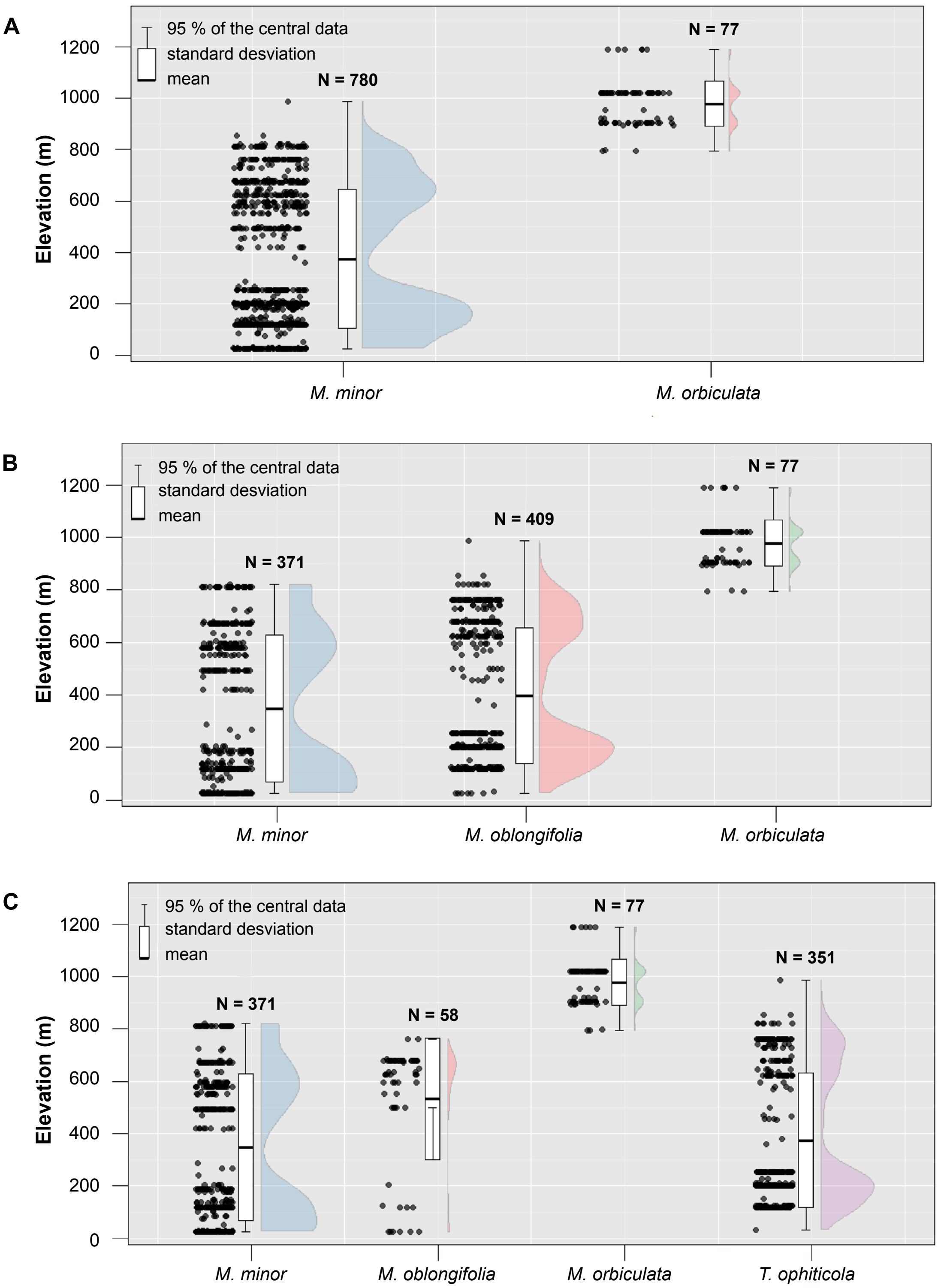

Fig. 3. Graphical representation of digital elevation model values extracted from the geographic position of the individuals of *Magnolia* subsect. *Talauma* in Cuba, according to the different classification systems. **A.** Two taxa classification system: *M. minor* and *M. orbiculata*. **B.** Three taxa classification system: *M. minor*, *M. oblongifolia* and *M. orbiculata*. **C.** Four taxa classification system: *M. minor, M. oblongifolia, M. orbiculata* and *Talauma ophiticola*.

Fig. 3. *Representación gráfica de los valores del Modelo Digital de Elevación extraídos a partir de la posición geográfica de los individuos de* Magnolia *subsect.* Talauma *en Cuba.* ***A.*** *Sistema de clasificación de dos taxones:* M. minor *y* M. orbiculata. ***B.*** *Sistema de clasificación de tres taxones:* M. minor, M. oblongifolia *y* M. orbiculata. ***C.*** *Sistema de clasificación de cuatro taxones:* M. minor, M. oblongifolia, M. orbiculata *y* Talauma ophiticola.

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