Iheringia
Série Zoologia

e-ISSN 1678-4766
www.scielo.br/isz

Museu de Ciências Naturais

Article

A niche modeling approach to unveil the absence of pycnothelid spiders (Mygalomorphae: Pycnothelidae) in a mountainous grassland of central Argentina

Micaela Nicoletta[1,2] & Nelson Ferretti[1,2,3]

1. Centro de Recursos Naturales Renovables de la Zona Semiárida (CERZOS-CONICET, UNS), Camino La Carrindanga Km 7, Bahía Blanca (8000), Buenos Aires, Argentina. (mmnicolettal@gmail.com)
2. Grupo de Investigaciones Aracnológicas del Sur - CERZOS, CONICET. Camino La Carrindanga Km 7, Bahía Blanca (8000), Buenos Aires, Argentina.
3. Departamento de Biología, Bioquímica y Farmacia, Universidad Nacional del Sur, San Juan 670, Bahía Blanca (8000), Buenos Aires, Argentina. (nferretti@conicet.gov.ar)

Received 8 May 2024
Accepted 10 October 2024
Published 12 May 2025

ABSTRACT. The family Pycnothelidae comprises medium to small-sized spiders that construct silk tubes under stones or logs or dig burrows in open environments. In Argentina, *Acanthogonatus centralis* Goloboff, 1995 and *Stenoterommata platensis* Holmberg, 1881 are two species commonly found in central region, associated to the mountainous grasslands or to the La Plata River Basin. The Tandilia mountainous grassland is an extended belt located southeastern Buenos Aires province, Argentina. Although some pycnothelid spiders are distributed close to this mountainous system, they are not recorded in Tandilia. Through niche modeling we attempt to evaluate the influence of bioclimatic variables in shaping the distribution of these species and explore their absence in the mountainous belt under past, present and future climatic conditions. We found that Tandilia is a non-suitable area for the establishment of the populations of these species with the exception of *Stenoterommata platensis* under a future scenario of climatic change.

KEYWORDS. SDM, geography, Tandilia, *Acanthogonatus*, *Stenoterommata*.

The Neotropical representatives of Pycnothelidae comprise small to medium-sized spiders that inhabit open areas, mountainous systems and forests (Montes de Oca *et al*., 2022). They can be found inhabit burrows – open, closed with residue or protected by a trapdoor –, loose tubes of silk under stones or fallen logs, or directly among the leaf litter (Goloboff, 1995; Ferretti *et al*., 2010; Schwerdt & Copperi, 2014; Signorotto *et al*., 2023). In Argentina, this family is represented by the genera *Acanthogonatus* Karsch, 1880, *Chaco* Tullgren, 1905, *Lycinus* Thorell, 1894, *Pycnothele* Chamberlin, 1917, *Rachias* Simon, 1892, *Stenoterommata* Holmberg, 1881 and *Xenonemesia* Goloboff, 1989 (World Spider Catalog, 2024). The most diverse genera are *Acanthogonatus* and *Stenoterommata* (both with eight cited species) (Catálogo de Arañas de Argentina, 2024). Most Argentinean *Acanthogonatus* species occur in semiarid or arid environments from central and southern Argentina, mainly at the Patagonian steppe (Goloboff, 1995; Signorotto *et al*., 2023). This region is characterized by a dry and cold climate, with strong and frequent winds and annual rainfall range from 100 to 300 mm. The vegetation consists of a shrub steppe with essentially leafless or small and spiny-leaved bushes, cushion plants, and grasslands of Poaceae (Arana *et al*., 2021). Argentinean *Stenoterommata* representatives are mostly distributed along the La Plata River Basin in northeastern Argentina associated with riparian forests (Goloboff, 1995; Ferretti *et al*., 2018). This main Basin, formed by the contributions of the Paraná and Uruguay rivers, which originate in intertropical latitudes and flow toward temperate latitudes, ends at the La Plata River. These rivers clearly influence the floristic richness of the area and act as corridors for tropical species to reach temperate latitudes (Arana *et al*., 2021).

The Tandilia mountainous system is located in southeastern Buenos Aires province in central Argentina and comprises a northwest trending of ranges and hills that rise 50–400 meters above the surrounding Pampean plain. It is extended for about 350 kilometers long and represents a Proterozoic crystalline basement belonging to the La Plata River craton (Dalla Salda, 1999). This mountainous belt is characterized by Granitoids, Migmatites, Amphibolites, and hypabyssal igneous rocks overlain by Precambrian and lower Palaeozoic sedimentary rocks (TERUGGI & KILMURRAY, 1975; PANKHURST *et al*., 2003). It represents a limit to the extent of extensive agriculture fields in Pampean plains, acting as a biodiversity refuge for native, endemic and threatened species, playing a key role for their conservation (KRISTENSEN *et al*., 2014).

Indeed, the mygalomorph fauna in the Tandilia System is highly diverse, including nine species belonging to four families: *Mecicobothrium thorelli* Holmberg, 1882 (Mecicobothriidae) (HOLMBERG, 1882); *Grammostola burzaquensis* Ibarra, 1946 (SCHIAPELLI & GERSCHMAN, 1961; FERRETTI *et al*., 2011), *G. vachoni* Schiapelli & Gerschman, 1961, *Plesiopelma longisternale* (Schiapelli & Gerschman, 1942), and *Catumiri argentinense* (Mello-Leitão, 1941) (Theraphosidae) (FERRETTI *et al*., 2014); *Actinopus balcarce* Ríos-Tamayo & Goloboff, 2018, *A. casuhati* Ríos-Tamayo & Goloboff, 2018 and *A. puelche* Ríos-Tamayo & Goloboff, 2018 (Actinopodidae) (RÍOS-TAMAYO & GOLOBOFF, 2018); and *Calathotarsus fangioi* Ferretti, Soresi, González & Arnedo, 2019 (Migidae) (FERRETTI *et al*., 2019a). However, no Pycnothelidae species are known to occur in Tandilia. The most geographically close species are *Acanthogonatus centralis* and *Stenoteromata platensis*, both found 260 km and 295 km far away from Tandilia, respectively. From a biogeographic standpoint, this is interesting because many mygalomorph taxa present in Tandilia are also distributed in other geographically close mountainous ranges such as Ventania or even mountainous systems from Uruguay (FERRETTI *et al*., 2018).

Therefore, we aimed to unveil the influence of past, present and future climatic conditions of Tandilia for the establishment of those species. To achieve this, we implemented a niche modeling approach for each species under different climatic scenarios.

MATERIALS AND METHODS

Studied species. We selected *Acanthogonatus centralis* and *Stenoterommata platensis* because they represent the pycnothelids with the most geographical proximity to Tandilia system and they are present in other mountainous systems, alongside other mygalomorph spiders. The presence points represented by geographical coordinates along the entire distributional range of the species were obtained from the literature (GOLOBOFF, 1995; FERRETTI *et al*., 2010, 2012a,b, 2018; SIGNOROTTO *et al*., 2023). In cases of inexact points, we obtained geographic coordinates with Google Earth (https://earth.google.com).

Distributional data and environmental variables. We obtained 35 presence points for *Acanthogonatus centralis* and 25 points for *Stenoterommata platensis* (Tab. I). The 19 bioclimatic layers for past (two scenarios), present and future conditions were downloaded from EcoClimate (LIMA-RIBEIRO *et al*. 2015) at a resolution of 0.5° (Tab. II). Past scenarios

Tab. I. Records set of *Acanthogonatus centralis* and *Stenoterommata platensis*, with locality names, geographical coordinates. Latitude and longitude are in decimal degrees.

Acanthogonatus centralis			
State, province or department	Locality	Latitude (S)	Longitude (W)
ARGENTINA			
Buenos Aires	Funke	-38.0719	-62.0486
	Sierra de la Ventana	-38.1333	-61.7917
	Chasicó	-38.3953	-62.8425
	Curamalal	-37.7200	-62.2206
	Abra del Hinojo	-37.7592	-62.1419
	Parque Provincial Ernesto Tornquist	-38.0558	-61.9908
	Bahía Blanca	-38.6908	-62.2667
Córdoba	Salsipuedes	-31.1500	-64.3166
	La Cumbre	-30.9666	-64.5000
	Alta Gracia	-31.6666	-64.4333
	Los Gigantes	-31.4000	-64.7833
	Cuchilla Nevada	-31.3556	-64.5936
	El Sauce	-31.9833	-64.5500
	Yacanto de Calamuchita	-32.1166	-64.7500
	Capilla del Monte	-30.8500	-64.5166
	Agua de Oro	-31.0666	-64.3000
	Las Jarillas	-31.0000	-64.9500
	Anisacate	-31.7333	-64.4000
	Los Molles	-31.1667	-64.3333
	Bosque Alegre	-31.5833	-64.5666

Tab. I. Cont.

Acanthogonatus centralis			
State, province or department	Locality	Latitude (S)	Longitude (W)
Córdoba	Jesús María	-30.9833	-64.1000
	San Francisco del Chañar	-29.7833	-63.9333
	Mina Clavero	-31.7166	-65.0000
	Cabana	-31.2166	-64.3666
	Pampilla	-31.5983	-64.7139
	El Cóndor	-31.6378	-64.6797
	El Cuadrado	-31.1225	-64.3642
	Ascochinga	-30.9406	-64.3158
	Tanti	-31.3836	-64.5942
	Deán Funes	-30.4411	-64.2794
San Luis	Merlo	-32.3500	-65.0333
	Papagayos	-32.6833	-65.0000
	Cortaderas	-32.5000	-65.0000
	San Felipe	-32.8500	-65.4833
	Valle Fértil	-30.6660	-67.4333
Stenoterommata platensis			
State, province or department	Locality	Latitude (S)	Longitude (W)
ARGENTINA			
Buenos Aires	Magdalena	-35.0666	-57.5333
	Capital Federal	-34.5999	-58.4500
	Hudson	-34.7833	-58.1666
	Punta Indio	-35.2666	-57.2333
	Tigre	-34.4166	-58.5666
	Punta Lara	-34.8166	-57.9833
	San Isidro	-34.4500	-58.5000
	Baradero	-33.8106	-59.5084
	Escobar	-34.3500	-58.7833
	Isla Martín García	-34.1833	-58.2500
Entre Ríos	El Palmar	-31.8531	-58.3225
	Colón	-32.2166	-58.1333
Misiones	Deseado	-25.7833	-54.0500
	Parque Nacional Iguazú	-25.5166	-54.1333
	Reserva Urugua-í	-25.9758	-54.1131
	Islas Malvinas	-27.4833	-55.1333
	Arroyo Uruzú	-25.9166	-54.2833
	El Dorado	-26.4000	-54.6333
	Piñalito	-26.9166	-54.1333
	Puerto Bemberg	-25.9166	-54.5999
Santa Fé	San Nicolás	-33.2833	-60.6666
	Rosario	-32.9511	-60.6663
	Arroyo del Medio	-33.6500	-60.5833
Santiago del Estero	Tintina	-27.0333	-62.7167
URUGUAY			
Río Negro	Fray Bentos	-33.1325	-58.2955

Tab. II. Bioclimatic variables (19) obtained from EcoClimate.

Code	Bioclimatic variable	Variable selection
BIO1	Annual Mean Temperature	×
BIO2	Mean Diurnal Range (Mean of monthly (max temp - min temp))	✓
BIO3	Isothermality (BIO2/BIO7) (×100)	×
BIO4	Temperature Seasonality (standard deviation ×100)	✓
BIO5	Max. Temperature of Warmest Month	×
BIO6	Min. Temperature of Coldest Month	✓
BIO7	Temperature Annual Range (BIO5-BIO6)	✓
BIO8	Mean Temperature of Wettest Quarter	×
BIO9	Mean Temperature of Driest Quarter	✓
BIO10	Mean Temperature of Warmest Quarter	✓
BIO11	Mean Temperature of Coldest Quarter	✓
BIO12	Annual Precipitation	✓
BIO13	Precipitation of Wettest Month	×
BIO14	Precipitation of Driest Month	✓
BIO15	Precipitation Seasonality (Coefficient of Variation)	✓
BIO16	Precipitation of Wettest Quarter	✓
BIO17	Precipitation of Driest Quarter	✓
BIO18	Precipitation of Warmest Quarter	✓
BIO19	Precipitation of Coldest Quarter	✓

involved climatic conditions from Last Glacial Maximum (21Ka) and Pliocene (3Ma), modern scenario includes climatic conditions from 1950-1999, and future scenario considers climatic conditions from 2080-2100 with a high emissions scenario (RCP 8.5). From those, using Pearson's correlation as implemented in ENM-Tools ver. 1.4.4, we selected a subsample (WARREN *et al*., 2008). The following choice of a variable from a correlated (r > 0.75) pair (or trio) was done in a preliminary run of the model with all the variables, retaining those with the best percent contribution and permutation importance in MaxEnt. Additionally, the selected variables were considered to be more relevant regarding physiological and ecological requirements of the two species. Thus, the selected variables were: BIO2 [Mean Diurnal Range (Mean of monthly (max temp - min temp)], BIO4 Temperature Seasonality (standard deviation ×100), BIO6 (Min Temperature of Coldest Month), BIO7 [Temperature Annual Range (BIO5-BIO6)], BIO9 (Mean Temperature of Driest Quarter), BIO10 (Mean Temperature of Warmest Quarter), BIO11 (Mean Temperature of Coldest Quarter), BIO12 (Annual Precipitation), BIO14 (Precipitation of Driest Month), BIO15 [Precipitation Seasonality (Coefficient of Variation)], BIO16 (Precipitation of Wettest Quarter), BIO17 (Precipitation of Driest Quarter), BIO18 (Precipitation of Warmest Quarter) and BIO19 (Precipitation of Coldest Quarter) (Tab. II).

Modeling procedure. We performed all analyses covering an extended area of Southern South America to include the distributional range of the species treated in this work. We predicted the distribution of both species under different climate scenarios using MaxEnt 3.3.3k (PHILLIPS *et al*., 2006). MaxEnt searches for the maximum entropy density using Robust Bayes Estimation and requires only presence points as input data (ELITH *et al*., 2011). This program produces a model of environmental suitability for the occurrence of a given organism by estimating the relation between species presence and environmental variables in a geographic space. We ran the MaxEnt using default settings, which have been validated in studies involving many species and environmental data (ZANK *et al*., 2014; JIANG *et al*., 2016; FERRETTI *et al*., 2018). We set the random training data as 100% of the sample given the number of occurrence records. The output of the MaxEnt model gives continuous habitat suitability, and hence a threshold must be set to define the predictive presence or absence of a species. We selected the "equal training sensitivity and specificity option", which minimizes the absolute differences between sensitivity and specificity (CANTOR *et al*., 1999). Additionally, we set the run to 20000 maximum iterations, allowing the logistic output format to remove the duplicates from the same grid cell. The model maps were edited with the software QGIS ver. 3.32.2 (http://www.qgis.org) and classification and shape file of ecoregions follow OLSON *et al*. (2001). To evaluate the model performance of each species we calculated the AUC (Area Under the receiver operating characteristics Curve), which are frequently used to evaluate distribution models based on presence-absence algorithms (PETERSON *et al*., 2011). This parameter ranges between "0" and "1", where 1 indicates that the model can perfectly distinguish between presences and absences. In the present work, the AUC for variables are expressed as percentages of contribution. The program automatically estimates statistical significance of the prediction, using a binomial test of omission (BALDWING, 2009).

RESULTS

The distribution records of *Acanthogonatus centralis* and *Stenoterommata platensis* are shown in Fig. 1.

The models produced by MaxEnt of suitable areas yielded AUC values between 0.994-0.997, which suggest that an accurately representativeness of the spider habitat relationships were found.

Based on the AUC values, the bioclimatic variables that provided the highest contributions to the climatic suitability models for *A. centralis* were the temperature seasonality (BIO4, AUC=59.6) and temperature annual range (BIO7, AUC=16.6), while for *S. platensis* the mean diurnal range (BIO2, AUC=44.2) and the precipitation of the driest month (BIO14, AUC= 20.9).

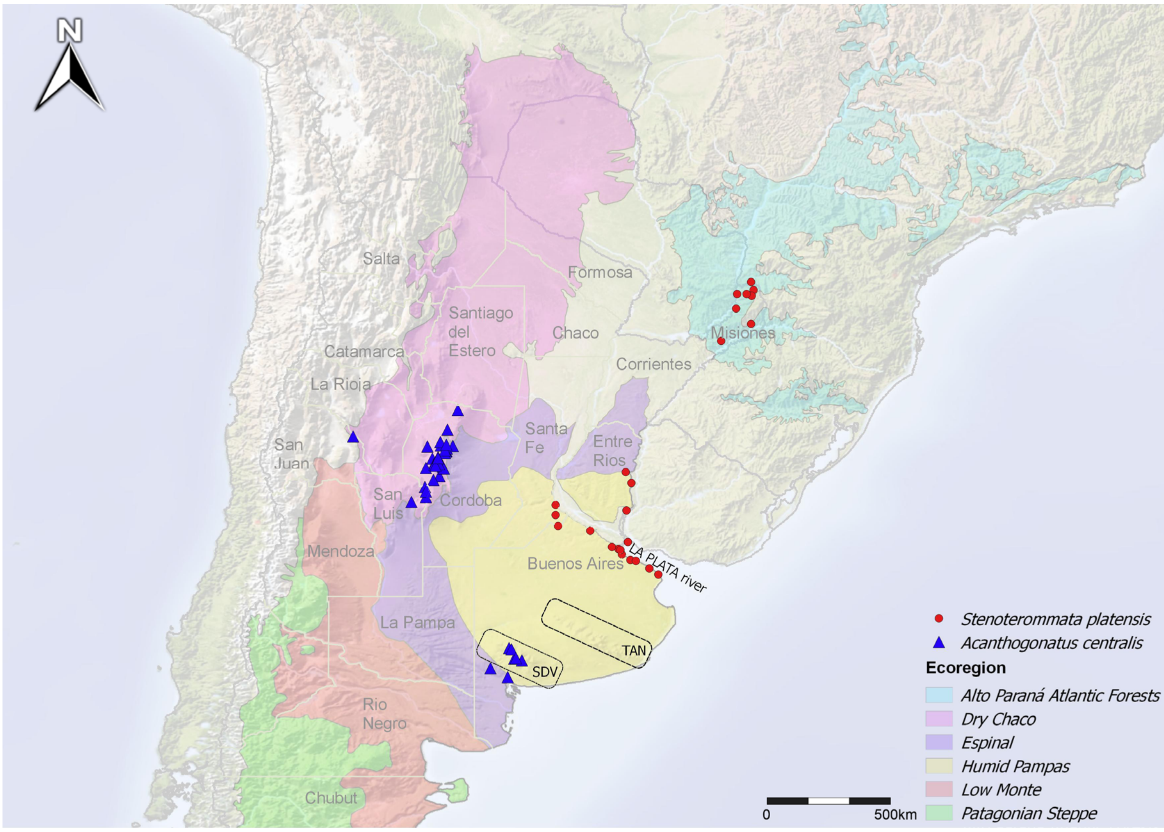


Fig. 1. Distribution map for *Acanthogonatus centralis* (blue triangles) and *Stenoterommata platensis* (red circles) (TAN, Tandilia mountainous system; SDV, Ventania mountainous system).

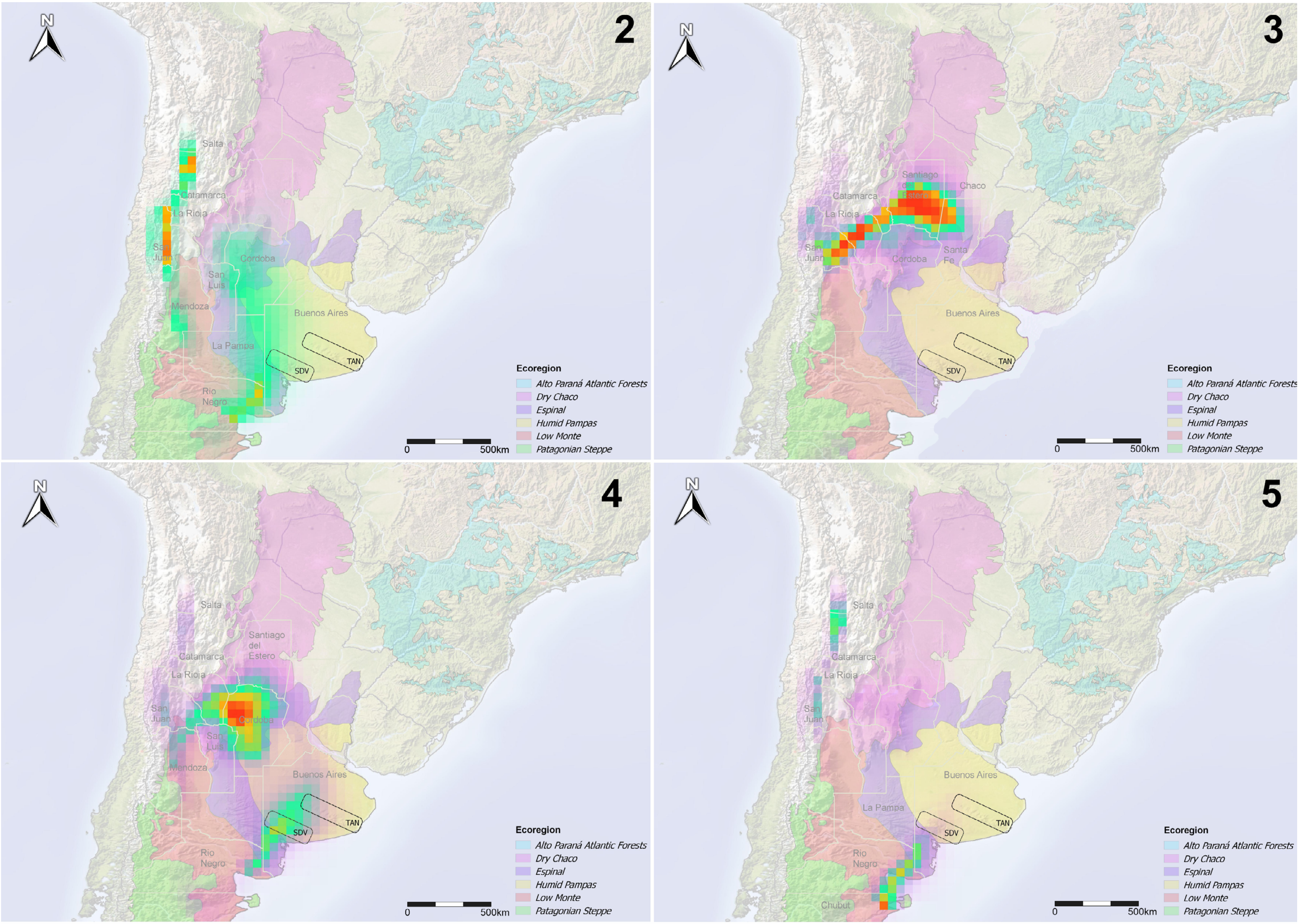
The suitable areas of *A. centralis* under modern climatic conditions (1950-1999) showed the highest areas of suitability along the mountainous systems of central Argentina, mainly at Córdoba province (Fig. 4). Under future climatic conditions (RCP 8.5) projected for 2080-2100, we observed a displacement of the suitable area into the southern coast, extending towards the Patagonian steppe in the provinces of Río Negro and Chubut; in addition, the central mountainous systems are no longer suitable (Fig. 5). Under this climatic scenario, the mountainous system of Tandilia is not suitable for the presence of this species, but a suitable area was found in the western mountainous belt of Ventania. Past conditions (Pliocene and LGM) (Figs 2, 3) showed a similar distributional pattern in central Argentina but with a small displacement into the western region, thus the Tandilia mountainous system remained as a non-suitable area for this species in the past.

Regarding the models of *S. platensis*, under present climatic conditions (Fig. 8), the model predicted a suitable area along the La Plata River Basin, mainly in southern Entre Ríos province, northern Buenos Aires province and Misiones province in Argentina, and western coast of Uruguay. The suitable areas for the distribution of *S. platensis* under future climatic scenarios (Fig. 9) denoted a southern displacement towards the mountainous systems (Tandilia and Ventania) and Pampean plains of southern Buenos Aires province. During the Last Glacial Maximum (Fig. 7), the climatic conditions indicated a suitable area in concordance with present conditions, along the La Plata River Basin, particularly in Corrientes and northern Entre Ríos provinces. However, past conditions in Pliocene (Fig. 6) showed a displacement of the suitable areas towards the southeastern region, extending from northern Buenos Aires province, Uruguay and southern Brazil.

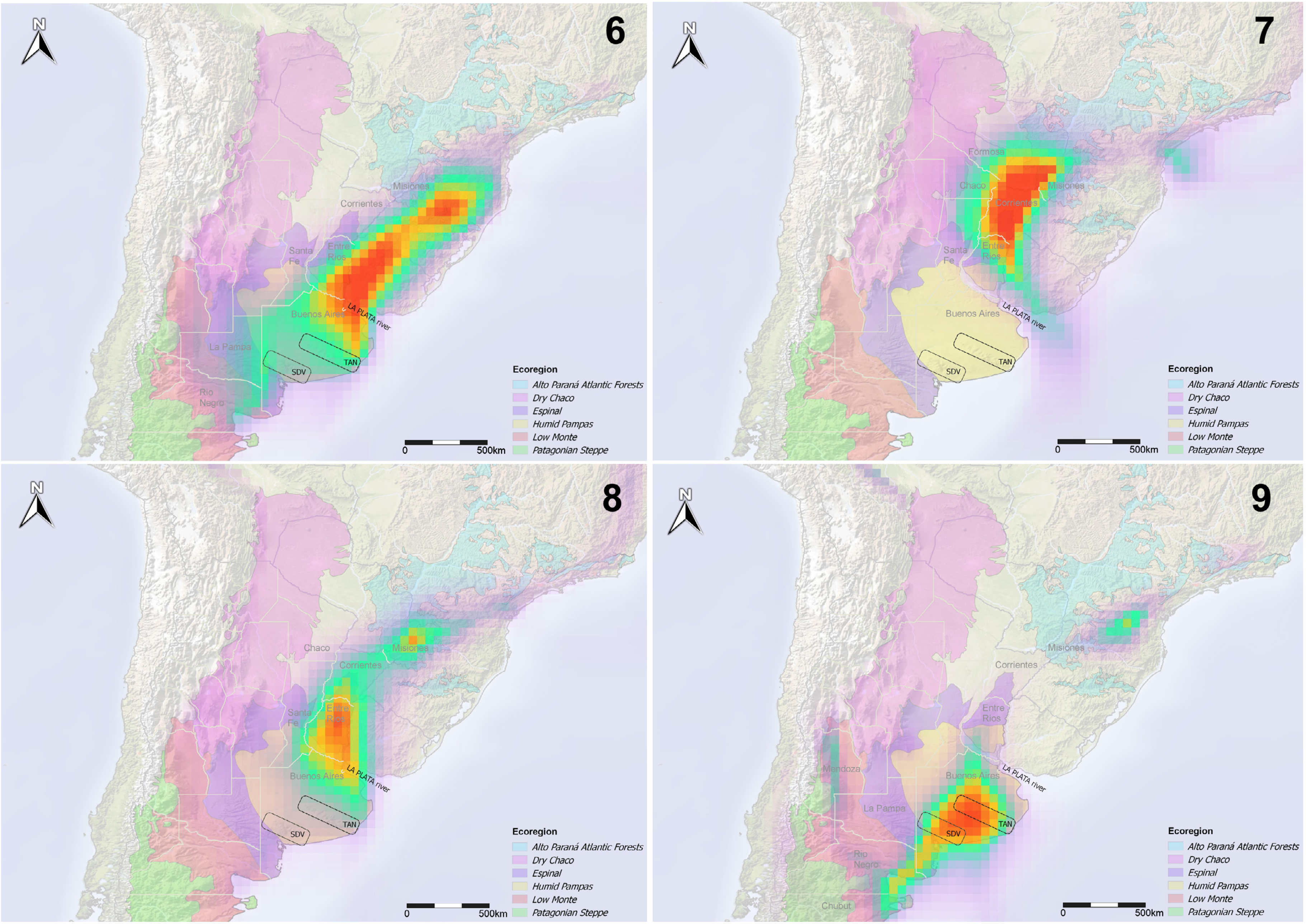
DISCUSSION

Although the two pycnothelids are characterized by similar life-history– they construct silk tubes under stones, rocks or in open environments (Goloboff, 1995; Ferretti *et al*., 2011; Schwerdt & Copperi, 2014) – most predictive models show the Tandilia mountainous grassland as a non-suitable area for the establishment of their populations due to environmental factors.

Niche modeling was performed for *Stenoterommata platensis* to evaluate the effects of climatic change in relation to the future conservation problems and the potential distribution for explaining its geographical distribution (Ferretti *et al*., 2018; Signorotto *et al*., 2023). In this work, the niche modeling was to assess the main environmental



Figs 2–5. Maps showing predicted distributions for *Acanthogonatus centralis*. Colors ranged from green (low suitability) to red (high suitability): 2, Pliocene climatic conditions (3Ma); 3, LGM climatic conditions (21Ka); 4, Present-day climatic conditions (1950-1999); 5, Future climatic conditions (2080-2100) (TAN, Tandilia mountainous system; SDV, Ventania mountainous system).



Figs 6–9. Maps showing predicted distributions for *Stenoterommata platensis*. Colors ranged from green (low suitability) to red (high suitability): 6, Pliocene climatic conditions (3Ma); 7, LGM climatic conditions (21Ka); 8, Present-day climatic conditions (1950-1999); 9, Future climatic conditions (2080-2100) (TAN, Tandilia mountainous system; SDV, Ventania mountainous system).

variables affecting its distributional range along the Tandilia mountainous system. Under this context, the variables that are contributing most to the model of *S. platensis* are mean diurnal range (max. temp. – min. temp.) and the precipitation of the driest month. These bioclimatic variables in relation to temperature seasonality and precipitation were the same to that reported by FERRETTI *et al*. (2018) and SIGNOROTTO *et al*. (2023) as the factors that most affect the distribution. We found no suitable areas along the Tandilia mountain belt that could support the presence of *S. platensis* under past and present conditions. Indeed, the distributional range is restricted to the La Plata Basin, congruent with the actual geographical distribution of this species. Although comparable habitats in mountainous ranges of central and southern Uruguay are actually home of *S. platensis* (MONTES DE OCA & PÉREZ-MILES, 2009), this seems to be not the situation for the Argentinean Tandilia mountainous grassland. On the other hand, the predictive model under future climatic conditions shows a displacement of the suitable areas to the southern region of the La Plata Basin. This reduction of suitable areas was reported by FERRETTI *et al*. (2018) and highlights the threat to the persistence of their populations. For this reason, it is imperative to suggest proper conservation actions in the area with the goal of not only preserve this region but also to assure the survival of the species in the future. Under this scenario, the model projected for 2080–2100, identified suitable areas along the Tandilia mountainous grassland. Moreover, the presence of this species in this grassland mountainous system in the future could act as a refuge to mitigate the effects of climate change, as found for another mygalomorph spider from central Argentina (FERRETTI *et al*., 2019b).

We found that during Pliocene, the predicted niche modeling for *Acanthogonatus centralis* mostly align with its present geographic distribution, showing a continuous connection among the Pampean ranges and the Ventania mountainous grassland together with suitable areas along the pre Andean ranges. During past climate conditions at the Last Glacial Maximum, the suitable areas are restricted mostly to central-north Argentina, at the Dry Chaco region. Arguably, this pattern could be the result of the contractions of the areas occupied by subtropical and tropical biomes during cold-dry climates producing an expansion and interconnections of the open biomes (KALIN-ARROYO *et al*., 1988; ORTIZ-JAUREGUIZAR & CLADERA, 2006), justifying this modeling observed to the present day. Moreover, along the eastern flank of the Andes, a savanna corridor was formed during periods of cold-dry climates, providing a north–south corridor for animals and plants (WEBB & RANCY, 1996; ORTIZ-JAUREGUIZAR & CLADERA, 2006). Under future climatic conditions, the geographic distribution of *A. centralis* will be drastically reduced and displaced towards southeast Argentina at the Patagonic steppe region. This can be due to the increase in temperature projected for future scenarios of global climate change (JIANG *et al*., 2016) in relation to the environmental variables that are relevant in shaping the suitable areas to this species, which are directly related to temperature.

The mountainous grasslands of Argentina usually comprise habitats where more than one species of Pycnothelidae can be easily found, because of the microhabitat characteristics of these particular environments. After many years of sampling and examining Argentinean scientific collections, we were aware that no species of pycnothelid is present at the Tandilia mountainous system. Even this belt is geographically close to the Ventania mountainous grassland and they share most of the mygalomorph fauna among each other. From the present work, we were able to evaluate the influence of the climatic variables in shaping the distribution of these species and corroborate that niche-modelling approaches are good to unveil the suitable or non-suitable areas that could explain some unexpected and observed absences.

REFERENCES

ARANA, M. D.; NATALE, E.; FERRETTI, N.; ROMANO, G.; OGGERO, A.; MARTÍNEZ, G.; POSADAS, P. & MORRONE, J. J. 2021. Esquema biogeográfico de la República Argentina. **Opera lilloana 56**.

BALDWING, R. A. 2009. Use of maximum entropy modeling in wildlife research. **Entropy 11**:854-866.

CATÁLOGO DE ARAÑAS DE ARGENTINA. 2024. **Catálogo de Arañas de Argentina.** Museo Argentino de Ciencias Naturales "Bernardino Rivadavia". Available at <https://sites.google.com/site/catalogodearanasdeargentina/>. Accessed on 5 May 2024.

CANTOR, S. B.; SUN, C. C.; TORTOLERO-LUNA, G.; RICHARDS-KORTUM, R. & FOLLEN, M. 1999. A comparison of C/B ratios from studies using receiver operating characteristic curve analysis. **Journal of Clinical Epidemiology 52**:885-892.

DALLA SALDA, L. H. 1999. Craton del Rio de la Plata, basamento granítico metamorfico de Tandilia y Martín García. **Instituto de Geología y Recursos Naturales Anales 29**:97-99.

ELITH, J.; PHILLIPS, S. J.; HASTIE, T.; DUDÍK, M; CHEE, Y. E. & YATES, C. J. 2011. A statistical explanation of MaxEnt for ecologists. **Diversity and Distributions 17**(1):43-57.

FERRETTI, N.; PÉREZ-MILES, F. & GONZÁLEZ, A. 2010. Mygalomorph spiders of the Natural and Historical Reserve of Martín García Island, Río de La Plata River, Argentina. **Zoological Studies 49**:481-491.

FERRETTI, N.; POMPOZZI, G. & PÉREZ-MILES, F. 2011. The species of *Grammostola* (Araneae: Theraphosidae) from central Argentina: taxonomy, distribution, and surface ultrastructure of coxal setae. **Zootaxa 2828**:1-18.

FERRETTI, N.; POMPOZZI, G.; COPPERI, S.; PÉREZ-MILES, F. & GONZÁLEZ, A. 2012a. Mygalomorph spider community of a natural reserve in a hilly system in central Argentina. **Journal of Insect Science 12**:31.

FERRETTI, N.; GONZÁLEZ, A. & PÉREZ-MILES, F. 2012b. Historical biogeography of mygalomorph spiders from the peripampasic orogenic arc based on track analysis and PAE as a panbiogeographical tool. **Systematics and Biodiversity 10**(2):179-193.

FERRETTI N.; POMPOZZI, G.; COPPERI, S.; SCHWERDT, L.; GONZÁLEZ, A. & PÉREZ-MILES, F. 2014. Mygalomorphae spider community of the Natural Reserve Sierra del Tigre, Tandilia, Buenos Aires, Argentina. **Revista Mexicana de Biodiversidad 85**:308-314.

FERRETTI, N. E.; ARNEDO, M. & GONZÁLEZ, A. 2018. Impact of climate change on spider species distribution along the La Plata River Basin, southern South America: projecting future range shifts for the genus *Stenoterommata* (Araneae, Mygalomorphae, Nemesiidae). **Annales Zoologici Fennici 55**(1/3):123-133.

Ferretti, N. E.; Soresi, D. S.; González, A. & Arnedo, M. A. 2019a. An integrative approach unveils speciation within the threatened spider *Calathotarsus simoni* (Araneae: Mygalomorphae: Migidae). **Systematics and Biodiversity 17**(5):439-457.

Ferretti, N.; Copperi, S. & Pompozzi, G. 2019b. Discovery of an isolated population of the dwarf tarantula *Homoeomma uruguayense* (Araneae, Theraphosidae) in central Argentina. **Caldasia 41**(2):436-441.

Goloboff, P. A. 1995. A revision of the South American spiders of the family Nemesiidae (Araneae, Mygalomorphae). Part I: species from Peru, Chile, Argentina, and Uruguay. **Bulletin of the American Museum of Natural History 224**:1-189.

Holmberg, E. L. 1882. Observations à propos du sous-ordre des araignées territélaires (Territelariae), spécialement du genre nordaméricain Catadysas Hentz et de la sous-famille Mecicobothrioidae, Holmberg. **Boletin de la Academia Nacional de Ciencias en Córdoba 4**:153-174.

Jiang, H.; Liu, T.; Li, L.; Zhao, Y.; Pei, L. & Zhao, J. 2016. Predicting the potential distribution of *Polygala tenuifolia* Willd. under climate change in China. **PLoS ONE 11**(9):e0163718.

Kalin-Arroyo, M. T.; Squeo, F. A.; Armesto, J. J. & Villagrán, C. 1988. Effects of aridity on plant diversity in the northern Chilean Andes: results of a natural experiment. **Annals of the Missouri Botanical Garden 75**:55-78.

Kristensen, M. J.; Lavornia, J.; Leber, V. A.; Pose, M. P.; Dellapé, P.; Salle, A.; Braccalente, L.; Giarratano, M. & Higuera, M. 2014. Estudios para la conservación de la Pampa austral. I. Diagnóstico de la biodiversidad local. **Revista Estudios Ambientales 2**(1):105-118.

Lima-Ribeiro, M. S.; Varela, S.; González-Hernández, J.; Oliveira, G.; Diniz-Filho, J. A. F. & Terribile, L. C. 2015. EcoClimate: a database of climate data from multiple models for past, present, and future for Macroecologists and Biogeographers. **Biodiversity Informatics 10**:1-21.

Montes de Oca, L. & Pérez-Miles, F. 2009. Las arañas Mygalomorphae del Uruguay: clave para familias, géneros y especies. **Revista del Laboratorio Tecnológico del Uruguay 4**:1-9.

Montes de Oca, L.; Indicatti R. P.; Opatova, V.; Almeida, M.; Pérez-Miles, F. & Bond J. 2022. Phylogenomic analysis, reclassification, and evolution of South American nemesioid burrowing mygalomorph spiders. **Molecular Phylogenetics and Evolution 168**:107377.

Olson, D. M.; Dinerstein, E.; Wikramanayake, E. D.; Burgess, N. D.; Powell, G. V. N.; Underwood, E. C.; D'Amico, J. A.; Itoua, I.; Strand, H. E.; Morrison, J. C.; Loucks, C. J.; Allnutt, T. F.; Ricketts, T. H.; Kura, Y.; Lamoreux, J. F.; Wettengel, W. W.; Hedao, P. & Kassem, K. R. 2001. Terrestrial ecoregions of the world: a new map of life on Earth**. Bioscience 51**(11):933-938.

Ortiz-Jaureguizar, E. & Cladera, G. A. 2006. Paleoenvironmental evolution of Southern South America during the Cenozoic. **Journal of Arid Environments 66**:498-532.

Pankhurst, R. J.; Ramos, A. & Linares, E. 2003. Antiquity and evolution of the Rio de la Plata craton in Tandilia, southern Buenos Aires province, Argentina. **Journal of South American Earth Sciences 16**:5-13.

Peterson, A. T.; Soberón, J.; Pearson, R. G.; Anderson, R. P.; Martínez-Meyer, E.; Nakamura, M. & Araújo, M. B. 2011. **Ecological niches and geographic distributions**. Princeton University Press, Princeton and Oxford. 260p.

Phillips, S. J.; Anderson, R. P. & Schapire, R. E. 2006. Maximum entropy modeling of species geographic distributions. **Ecological Modelling 19**:231-259.

Ríos-Tamayo, D. & Goloboff, P. A. 2018. Taxonomic revision and morphology of the trapdoor spider genus *Actinopus* (Mygalomorphae: Actinopodidae) in Argentina. **Bulletin of the American Museum of Natural History 419**:1-83.

Schwerdt, L. V. & Copperi, M. S. 2014. A contribution to the knowledge of burrows and reproductive biology of *Stenoterommata platensis* Holmberg (Mygalomorphae: Nemesiidae). **Munis Entomology & Zoology 9**(1):84-88

Schiapelli, R. D. & Gerschman de P., B. S. 1961. Las especies del género *Grammostola* Simon 1892, en la República Argentina (Araneae, Theraphosidae). **Actas y Trabajos del Congreso Sudamericano de Zoologia, La Plata I 3**:199-208.

Signorotto, F.; Mancini, M. & Ferretti, N. 2023. A new small *Acanthogonatus* Karsch, 1880 (Mygalomorphae, Pycnothelidae) species from Argentinean Patagonia: description of *A. messii* Signorotto & Ferretti n. sp. and its phylogenetic placement. **Zoosystema 45**(17):499-512.

Teruggi, M. & Kilmurray, J. 1975. Tandilia. Relatorio de la geología de la Provincia de Buenos Aires. **VI Congreso Geológico Argentino 1975**, 55-77.

Warren, D. L.; Glor, R. E. & Turelli, M. 2008. Environmental niche equivalency versus conservatism. Quantitative approaches to niche evolution. **Evolution 62**:2868-2883.

Webb, S. D. & Rancy, A. 1996. Late Cenozoic evolution of the Neotropical mammal fauna. *In*: Jackson, J. B. C.; Budd, A. F. & Coates, A. G. eds. **Evolution and Environments in Tropical Americas.** Chicago, The University of Chicago, Chicago Press, p. 335-358.

World Spider Catalog. 2024. **World Spider Catalog. Version 25.0**. Natural History Museum Bern. Available at <http://wsc.nmbe.ch>. Accessed on 5 May 2024. doi: 10.24436/2

Zank, C.; Becker, F. G.; Abadie, M.; Baldo, D.; Maneyro, R. M. & Borges-Martins, M. 2014. Climate change and the distribution of Neotropical red-bellied toads (*Melanophryniscus*, Anura, Amphibia): How to prioritize species and populations? **PLoS ONE 9**(4):e94625