



Review of chelid and emydid turtle distributions in southern South America with emphasis on extralimital populations and new records for Argentina

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There are many cases of animals reported in localities away from natural areas of distribution for the species. With respect to native freshwater turtles of Argentina and bordering countries, several populations (and single specimens) were reported for areas that cast doubts about their origin, due to not only the long distance from other known localities but also the geographical barriers that are in between. The present work provides a review of localities of the native turtle species *Hydromedusa tectifera*, *Phrynops hilarii*, *Acanthochelys pallidipectoris*, *A. spixii* and *Trachemys dorbigni* in Argentina, Bolivia, Brasil, Paraguay and Uruguay, and adds new records for some of these species for Argentina. We also employ an analysis to recognise core and extralimital populations, and a methodology based on five criteria that must be taken into account to elucidate if one extralimital turtle record is the result of anthropogenic action or a case of natural occurrence. Finally, we discuss about the origin of extralimital reports of turtles of the mentioned species.

Keywords: freshwater turtles, distribution, Argentina, bordering countries, translocation

INTRODUCTION

Translocation is defined as the intentional release of individuals of a species at a within-range location different from their capture site in order to 'establish, reestablish, or augment a population' (Griffith et al., 1989; Rittenhouse et al., 2007; 2008). This type of planned translocation is a useful conservation tool for population management, particularly when the habitat persists but the species to be translocated is locally extinct (Cook, 2004; Tuberville et al., 2005; Moore et al., 2013).

Officially planned turtle translocations of chelid and emydid turtles have never been performed in Argentina or in the bordering countries where they are distributed (Bolivia, Brasil, Paraguay and Uruguay). However, extralimital populations have been reported for certain freshwater turtle species. Some of these populations are arbitrarily believed to have been introduced by humans (Freiberg, 1938; Cei, 1993). They are (1) the South American snake-necked turtle *Hydromedusa tectifera* (Cope, 1869) recorded extraliminally in Atamisqui (Santiago del Estero province), and in mountain streams from western Córdoba province and southern Buenos Aires province (Cabrera et al., 1986; Cabrera, 1998; Di Pietro et al., 2012); (2) the spotted-bellied toad-headed turtle *Phrynops hilarii* (Duméril & Bibron, 1835), which

has extralimital records in three western provinces (San Juan, Mendoza and Tucumán) and the centre of Argentina (Santiago del Estero province and north-western Córdoba province; Laurent & Teran, 1981; Richard, 1987; Broin & de la Fuente, 1993; Cabrera, 1998; Prado et al., 2012); (3) the chaco side-necked turtle *Acanthochelys pallidipectoris* (Freiberg, 1945) and (4) the black spiny-necked swamp turtle *A. spixii* (Duméril & Bibron, 1835), both with extralimital records in Mendoza province (Richard, 1987; 1991a). Here, we review the distribution of these species and of the black-bellied slider turtle, *Trachemys dorbigni* (Duméril & Bibron, 1835), in South America with a focus on localities from Argentina. We also supply previously unknown core localities for this country and provide new extralimital localities for central and north-western Argentina: two for *H. tectifera*, one for *P. hilarii* and one for *T. dorbigni*. We also determine if the extralimital populations of the five species studied here are a result of anthropogenic action or a case of natural occurrence.

MATERIALS AND METHODS

The distributions of the chelids *H. tectifera*, *P. hilarii*, *A. pallidipectoris*, *A. spixii* and the emydid *T. dorbigni* in Argentina were constructed on the basis of specimens

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housed at the main herpetological collections of the country and from literature reports (Online Appendix). During the review of herpetological collections, we detected localities that were not previously reported in the literature. In addition, we provide other localities based on our field observations. The distribution of these species in other countries of South America were constructed on the basis of an exhaustive revision of literature reports. Localities with several reports were listed using only the first available one in order to avoid excessive references (Online Appendix). Records of water courses that lacked of precise location were mapped on the middle basin.

A Kernel Density Analysis (KDA) was conducted to determine the core of species distribution using ArcGIS software. This spatial analysis identifies one or more central points of distribution and calculates the mean and standard distances from them. This procedure generates concentric areas that correspond to different categories of significant point density. We worked with nine categories: four with the highest concentration of points (core of the species range), four with moderate to low concentration of records (peripheral distribution) and one with the lowest density (extralimital records, independently of their origin, natural or anthropogenic). Ringuelet (1956) listed four key factors to understand the current chorology of a given species. We used these combined with those established by Cabrera et al. (1986) to generate five criteria that a researcher must take into account to decide if a given extralimital turtle record is the result of anthropogenic action or a case of natural occurrence. It is important to note that just one of these criteria may be determinant to choose natural occurrence instead of anthropogenic mediated distribution. These points are (in order of importance according to our view): 1) paleochorology estimated from the fossil record: the

presence of the species (or related species) in the area in past geological times; 2) efficacy of the methods of dispersion associated with the presence of both current and ancient habitat corridors: it is important to know if it is possible that the turtle could have reached the area by its own through a water course; 3) ecological requirements and interactions with other species (e.g., competition among others); 4) current toponymy or place names that indicate the presence of certain fauna there (e.g., the turtles' stream); and 5) the certainty that official species introduction has not occurred in the past.

RESULTS

Hydromedusa tectifera

Our analysis showed that *Hydromedusa tectifera* has a distribution with two principal cores: one in Argentina and Uruguay, along the Uruguay-Río de la Plata river basin, and the other in southern Brazil, surrounding the Iguazú River (Fig. 1). We report 12 previously unknown localities corresponding to the first mentioned core from five departments of the north-east of Buenos Aires province (Río de la Plata and Salado river basins). These reports are based on our field observations, some of them supported with e-voucher specimens (Online Appendix). They are: (1) El Gato stream, (2) Rodriguez stream, (3) Carnaval stream, (4) Martín stream, (5) Pescado stream and (6) Cajaravilla stream (La Plata department); (7) del Petroleo channel (Ensenada department); (8) Tubichamini stream and the associated Cañada Arregui, (9) Zapata stream and (10) Juan Blanco stream (Magdalena department); (11) Juan Gerónimo ranch (Punta Indio department); and (12) Salada de Monasterio lagoon (Lezama department).

The extralimital populations of *H. tectifera* detected from the KDA are located in Argentina (north-center of Córdoba province, center of Santiago del Estero province

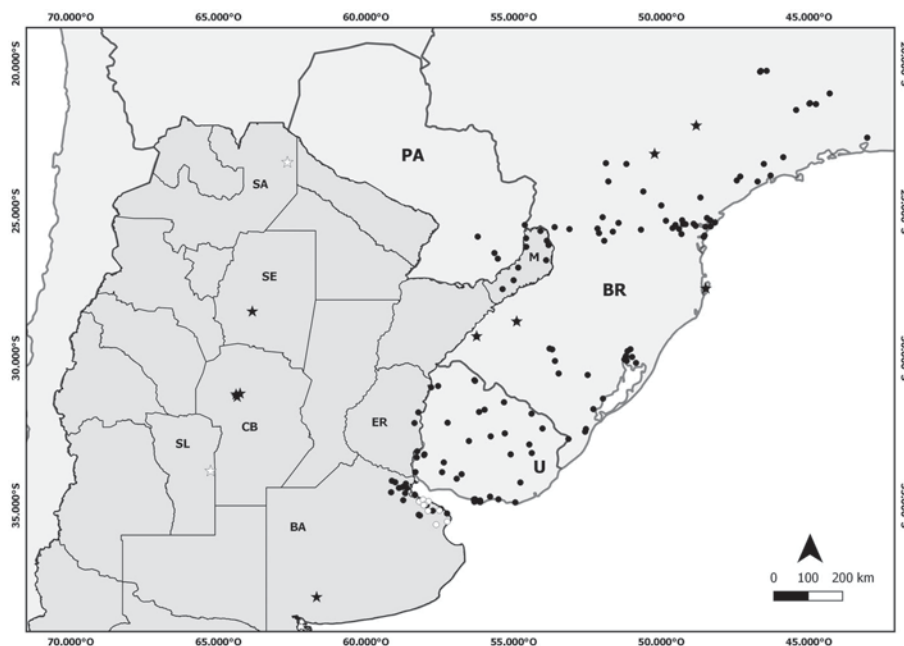


Figure 1. Localities recorded for *H. tectifera* in Argentina and in bordering countries. Spots indicate records corresponding to the core(s) of the species distribution; stars indicate extralimital records. Black colour represents previously known localities; white colour represents new records. Records with no precise locality were not mapped. BA, Buenos Aires; BR, Brazil; CB, Córdoba; ER, Entre Ríos; M, Misiones; PA, Paraguay; SA, Salta; SE, Santiago del Estero; SL, San Luis; U, Uruguay.

and south-west of Buenos Aires province), and in the south of Brazil (Tieté River, Andirá, Itaqui, Bossoroca, and Florianópolis; Online Appendix; Fig. 1).

Here we add two previously unknown and clearly extralimital localities for the species, which constitute the first records for two provinces. One of these is the Popopis River (also known as Quinto River), at Justo Daract, General Pedernera department, in eastern San Luis province (Fig. 1). We visited this river in October 2014 and found four females and two males of the species (the e-voucher of one of them is housed at the herpetological collection of the Universidad Nacional del Nordeste (Online Appendix; Fig. 2A-B). This locality is part of the Espinal Eco-region (Burkart et al., 1999) and the Popopis River flows from north-west of San Luis province to La Picaza lagoon system in the south of Córdoba province. The other extralimital locality we report here is Los Blancos, Rivadavia department, in north-eastern Salta province (Fig. 1). The voucher material is the carapace of an adult male housed at the herpetological collection of the Fundación Miguel Lillo (Online Appendix; Fig. 2C-D). Los Blancos is located in the Dry Chaco Eco-region (Burkart et al., 1999), about 50 km N Bermejo River; this river is a tributary of Paraguay River and belongs to the Paraná-Río de la Plata river basin.

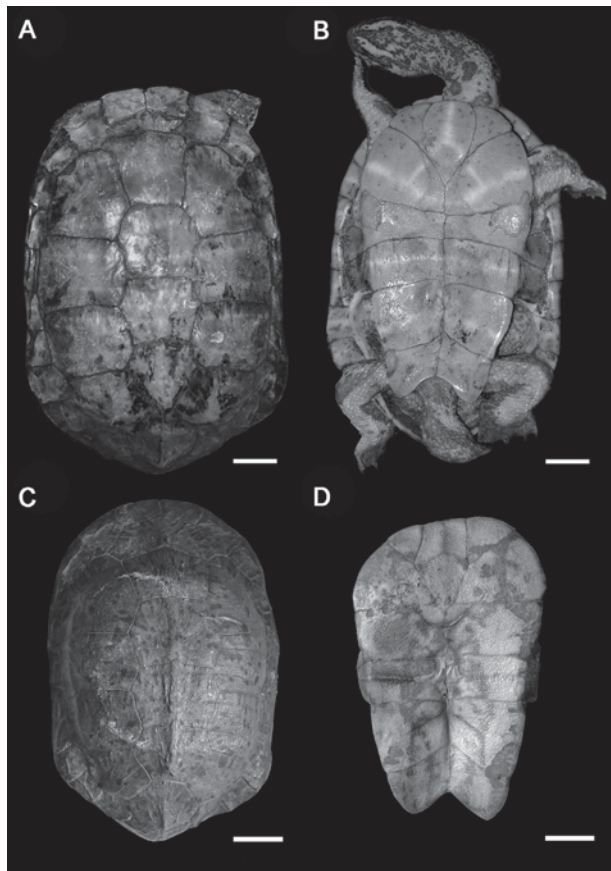


Figure 2. (A) Dorsal and (B) ventral views of a male specimen of *H. tectifera* from Popopis River, San Luis province (UNNEC-A 000010). (C) Dorsal and (D) ventral views of the carapace of a male specimen of *H. tectifera* from Los Blancos, Salta province (FML 13573). Scale bars = 3 cm.

Phrynops hilarii

According to the KDA, the distribution of *Phrynops hilarii* has two main cores: one is located in the Argentine Litoral region, mainly along the Paraná and Uruguay river basins and the Río de la Plata River, where these rivers flow into (Fig. 3). The other core occurs in southern Brazil and in northern Uruguay, mainly in the area drained by the Guaíba river basin and the system of dos Patos and Merin lagoons. We provide 19 previously unreported core localities of the species for five Argentine provinces (Buenos Aires, Santa Fe, Córdoba, Chaco and Corrientes). These records are mainly based on our field observations (some of them with e-voucher support; Online Appendix; Fig. 3) and communications from colleagues. Ten of the records correspond to Buenos Aires province: (1) El Gato stream, (2) Rodríguez stream, (3) Cajaravilla stream and (4) Pescado stream (La Plata department); (5) Aeroclub lagoon (Ensenada department); (6) Los Talas (Berisso department); (7) Juan Blanco stream and (8) Zapata stream (Magdalena department); (9) Cañada de los Peludos (Chacabuco department, M. V. Lazcoz, pers. comm.); and (10) "A" channel on Provincial Road 2, south of Dolores (Dolores department). The core records 11–13 are from Santa Fe province: two near Paraná River in north-eastern Santa Fe province: 11) Aguilar stream, General Obligado department, and 12) a small lagoon between Cayastá and Helvecia, in Garay department; record number 13 is near Salado River in the central-west of Santa Fe (San Cristobal department). The new records number 14 and 15 correspond to Corrientes province: a nameless stream near Paraná River, about 30 km NW Esquina (Esquina department) and Curupicay River at National Road 14 km 377 (Monte Caseros department). Records 16–17 are from Tercero River in south-eastern Córdoba province: Monte Buey (Marcos Juárez department) and Ballesteros Sud (Unión department). Finally, the new records 18 and 19 are from eastern Chaco province, near Paraguay River (El Cachapé farm and surroundings of Resistencia, on National Road 11).

The extralimital records of the species detected from the analysis in Argentina are: north-central Mendoza province, north-central Santiago del Estero province, central Tucumán province, southern San Juan province, northern Formosa province, north and central Córdoba province, and western Santa Fe (Online Appendix; Fig. 3). We incorporate two new extralimital reports (Fig. 3): one from the Cabra Corral dam in Salta province (first provincial record), and the other from a tributary of San Juan River, near San Agustín del Valle Fértil, in eastern San Juan province (E. Sanabria, pers. comm.). Both are supported by the finding of several specimens that were not collected nor photographed: the record from Cabra Corral consists of a group of about six adults detected basking on an emerged trunk on the reservoir margins, and the one from San Agustín del Valle Fértil is supported by nine specimens found during dredging works in streams in the area.

Regarding the bordering countries of Argentina, there are some records that are extralimital according to the analysis: three localities in Paraguay (two on the Paraguay River and one on the Paraná River), two in eastern Uruguay

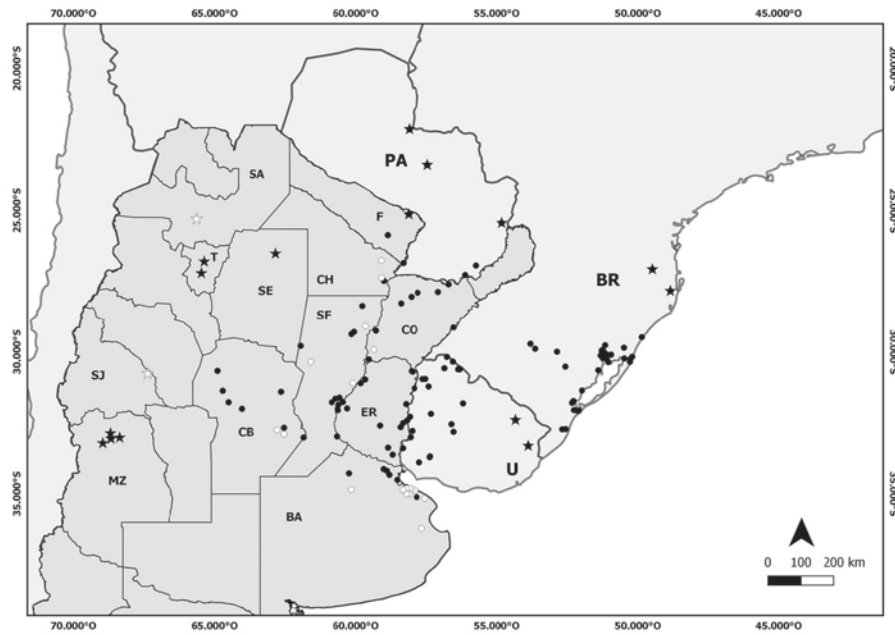


Figure 3. Localities recorded for *P. hilarii* in Argentina and in bordering countries. Spots indicate records corresponding to the core(s) of the species distribution; stars indicate relevant extralimital records (see Discussion). Black colour represents previously known localities; white colour represents new records. BA, Buenos Aires; BR, Brazil; CB, Córdoba; CH, Chaco; CO, Corrientes; ER, Entre Ríos; F, Formosa; MZ, Mendoza; PA, Paraguay; SA, Salta; SE, Santiago del Estero; SF, Santa Fe; SJ, San Juan; T, Tucumán; U, Uruguay.

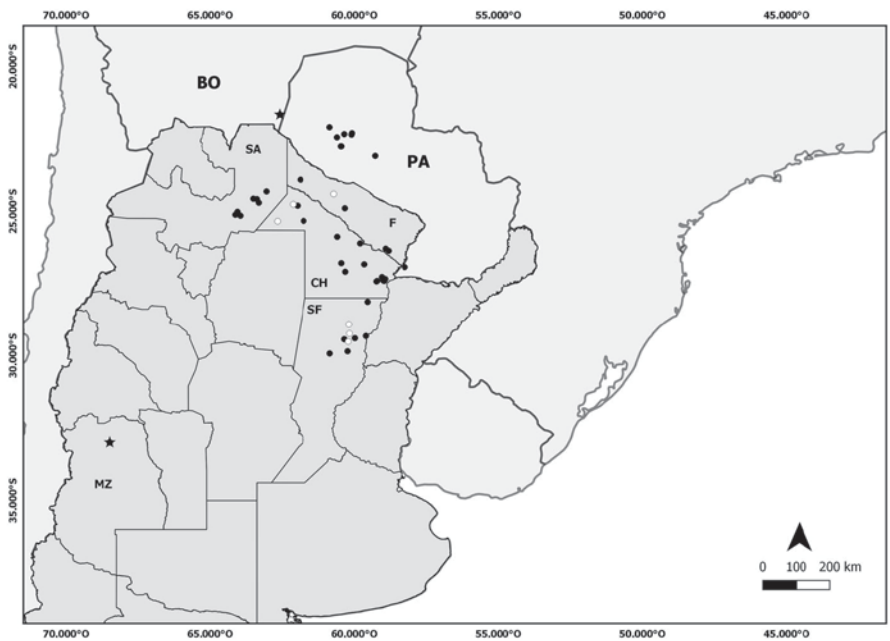


Figure 4. Localities recorded for *A. pallidipectoris* in Argentina and in bordering countries. Spots indicate records corresponding to the core(s) of the species distribution; black ones represent previously known localities; white ones are new records. Black stars indicate extralimital records. BO, Bolivia; CH, Chaco; F, Formosa; MZ, Mendoza; PA, Paraguay; SA, Salta; SF, Santa Fe.

(Cebolatti River and Tacuarí River) and the other two at the northern end of the species range, in Brazil (Ibirama and P.E. Serra do Tabuleiro; Online Appendix; Fig. 3).

Acanthochelys pallidipectoris

The analysis showed that the core of the species distribution is in north of Santa Fe province and Chaco province (Argentina), and continuous to north-west towards the south of Paraguay (Fig. 4). We report six new core localities for three of the four Argentine provinces

where *A. pallidipectoris* occurs: 1) Paraje La Guardia (Almirante Brown, new record for the department), and 2) Don Palomo (General Güemes department), both from Chaco province; 3) Yema Lagoon (Bermejo department, first record for the department), from Formosa province; 4) National Road 11 near Espin, 5) Ogilvie and 6) Campo Garabato Natural Reserve, from Vera department, Santa Fe province (Online Appendix; Fig. 4).

The KDA recognised two extralimital records for the species: one in Argentina and one in Bolivia. The former

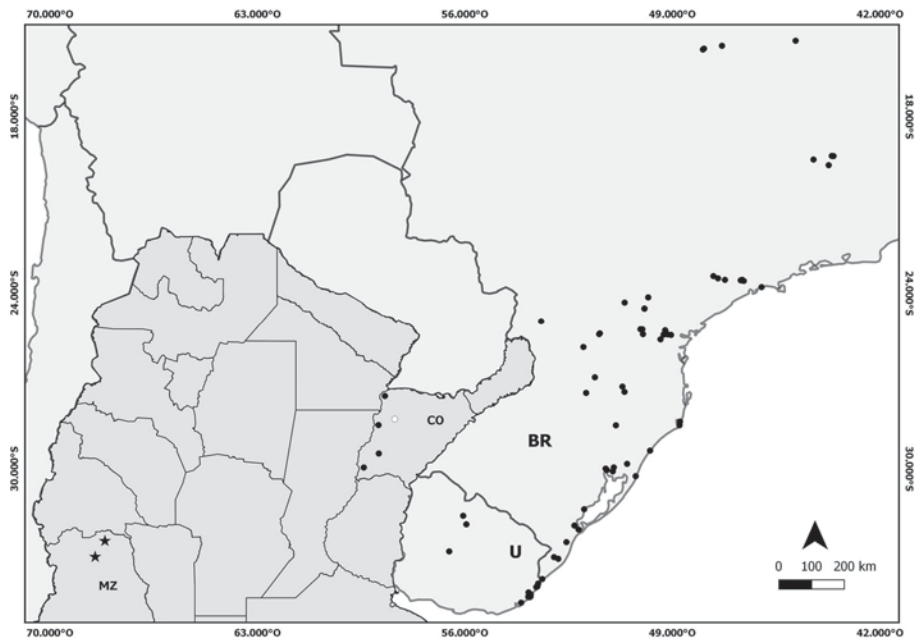


Figure 5. Localities recorded for *A. spixii* in Argentina and in bordering countries. Spots indicate records corresponding to the core(s) of the species distribution; black ones represent previously known localities, white one represents the new record. Black stars indicate extralimital records. BR, Brazil; CO, Corrientes; MZ, Mendoza; U, Uruguay.

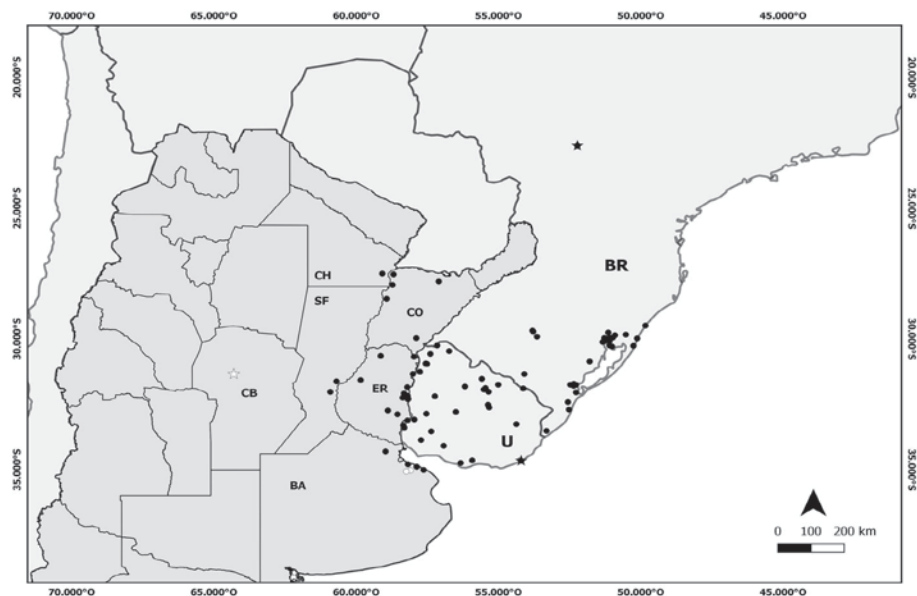


Figure 6. Localities recorded for *T. dorbigni* in Argentina and in bordering countries. Spots indicate records corresponding to the core(s) of the species distribution; stars indicate relevant extralimital records (see Discussion). Black colour represents previously known localities; white colour represents new records. BA, Buenos Aires; BR, Brazil; CB, Córdoba; CH, Chaco; CO, Corrientes; ER, Entre Ríos; SF, Santa Fe; U, Uruguay.

is in the north Mendoza province in Alto Verde lagoons (San Martín department; Online Appendix; Fig. 4). In October 2014 we visited this site, located in the farm of Figueroa family, at Las Violetas street, following the indications provided by Richard (1987). These “lagoons” are in fact artificial ponds and the area was completely modified for grape and olive cultivation. We interviewed local people and searched for turtles in the surroundings with no success. The new owners of the farm told us that the lagoons dried-up in 2000 with no signs of turtles there since (this is also valid for *A. spixii*).

Acanthochelys spixii

The species core is mainly along the Atlantic coastal area from northern Uruguay to southern Brazil into the Paraná State, with isolated populations corresponding to the peripheral distribution, in Corrientes province, Argentina, and the states of Minas Gerais and Distrito Federal, in Brazil (Online Appendix, Fig. 5). We provide one new locality for Corrientes province on National Road 12 near San Roque (Saladas department; Online Appendix; Fig. 5).

The analysis showed two extralimital reports in north of Mendoza province, Argentina: Alto Verde lagoons in San Martín department (as in the case of *A. pallidipectoris*) and

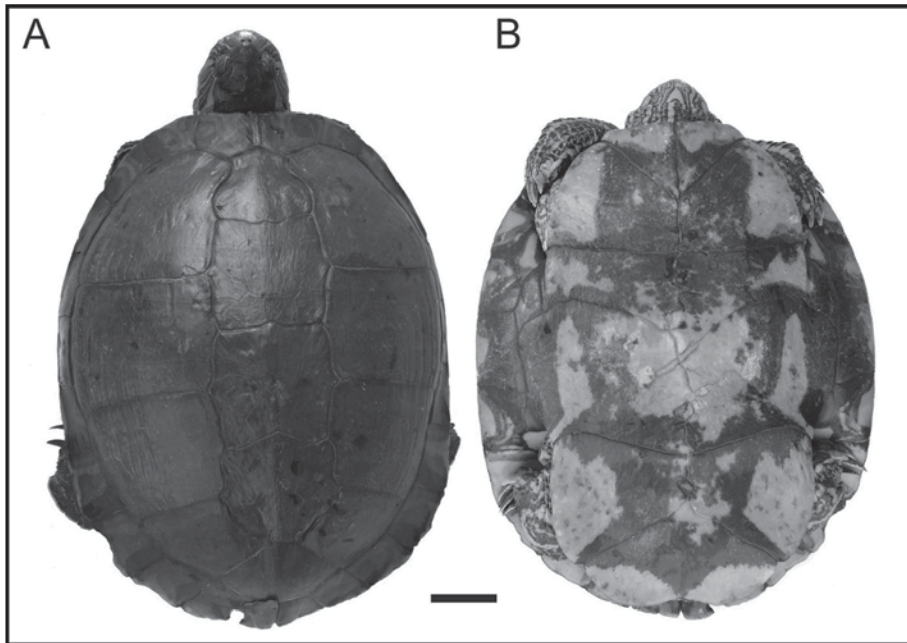


Figure 7. (A) Dorsal and (B) ventral views of a female specimen of *T. dorbigni* from Toro Muerto stream, Córdoba province (UNNEC-A 000009). Scale bar = 3 cm.

on Road 142 (Lavalle department, Online Appendix; Fig. 5).

Trachemys dorbigni

The core of *Trachemys dorbigni* distribution is from eastern Argentina, on the region drained by the Uruguay River and Río de la Plata River, almost Uruguay, to southern Brazil, into the area of influence of Guaíba River, Lagoa dos Patos and Grande River (Fig. 6). There are some isolated records associated to the Paraná River (Chaco, Corrientes, Santa Fe and Entre Ríos provinces), which suggests that the species has a peripheral distribution around this river basin. We add two new core localities for the species in Argentina: El Pescado stream (La Plata department, Buenos Aires province) and its tributary, Cajaravilla stream, both part of the Río de la Plata river basin (Online Appendix; Fig. 6).

Here we present the first extralimital report for central Argentina (Online Appendix). During field work in Córdoba province in March 2017, we found an adult female in the vegetated margins of Toro Muerto stream (Punilla department; Fig. 7A-B). This stream runs across a mountain range area where there is no important urbanisation but there are some houses near the water course.

With regard to bordering countries, our analysis identified two extralimital records for the species in Brazil: Morro do Diabo State Park and Santa Vitoria do Palmar; and two in Uruguay: one in the Atlantic coast and the other in a lagoon near Olimar River (Online Appendix; Fig. 6).

DISCUSSION

Hydromedusa tectifera

In Argentina, *H. tectifera* is mostly distributed in ponds, lagoons, streams and rivers that are part of the Río de la Plata and Uruguay river basins across three provinces (Misiones, Entre Ríos and Buenos Aires; Fig. 1). The species

was also generically mentioned for Chaco, Corrientes, Formosa and Santa Fe provinces, but with no specific localities and, except that of Corrientes, without voucher specimens (Freiberg, 1938; Ernst & Barbour, 1989; Richard & de la Fuente, 1992; Cei, 1993; Cabrera, 1998; Prado et al., 2012). The only precise locality mentioned for Corrientes province was published in a guide of the fauna and flora of Iberá Natural Reserve (Petraglia de Bolzón & Bolzón, 2003), but the referred specimen clearly corresponds to *Phrynops* (probably *P. williamsi*). In the third edition of this guide (Petraglia de Bolzón & Bolzón, 2009), the authors removed *H. tectifera* from the species list.

The extralimital and presumably isolated populations of the species are treated separately in the following paragraphs, since each case represents a different situation that deserves specific attention. *A priori*, the presence of *H. tectifera* in areas far away from the core of its range suggests anthropogenic origin, but a detailed examination of water courses of these regions does not necessarily favour this hypothesis. The records from Los Blancos (Salta province), Villa Atamisqui (Santiago del Estero province) and Popopis River (San Luis province) (Fig. 1) are clear examples of extralimital populations of *H. tectifera* connected with the core of the species distribution by rivers. Except for the significant absence of precise localities for Corrientes province, the species seems to be distributed along the large rivers that run from north to south in eastern Argentina. Los Blancos locality (Salta province) is about 50 km north from Bermejo River and about 500 km west from Paraguay River, a northern tributary of Paraná River. The species was also recorded in Asunción, Central department, Paraguay, east of Paraguay River (Bertoni, 1939; Cacciali et al., 2016). Therefore, the reported specimen of *H. tectifera* from Los Blancos should be considered within the natural range of the species distribution. In any case, since the record consists of a dried carapace collected in 1934, we consider that new

studies are needed to confirm the species there and its abundance in the area.

Regarding the populations from the western mountain chain of Córdoba province, first mentioned by Cabrera et al. (1986), we agree with the authors that they could be a relict population of a wider ancient distribution.

The record of Villa Atamisqui (Santiago del Estero province) is near Dulce River, which flows into Mar Chiquita Lake, on south-eastern Santiago del Estero and north-eastern Córdoba provinces. This lake also receives water from the Suquía River, which in turn is connected with the system of mountain streams and rivers where *H. tectifera* inhabits (Cabrera et al., 1986). Although currently isolated from the species distribution core, the populations of Córdoba and Santiago del Estero provinces are connected by the mentioned water courses.

The extralimital San Luis province record is from Popopis River. This river flows into south Córdoba province and forms an important wetland (La Amarga wetland). In the rainy season, this area overflows, connecting with Salado River in Buenos Aires province, which is part of the Río de la Plata river basin. Thus, based on 1) presence of certain Parano-Platense fish species (Bistoni et al., 1996; Garelis & Bistoni, 2010), 2) connection of water courses and 3) no official translocation; we consider the population of *H. tectifera* from Popopis River has a natural origin.

Finally, with respect to the presence of the species in the Sauce Grande River on south of Buenos Aires province, there are early-middle Pliocene fossils of *H. tectifera* (or a related species) from Quequén Salado River and Sauce Grande River (de la Fuente, 1992). Moreover, Ringuélet (1971; 1975) determined the south-west limit of the Parano-Platense biogeographic province in this area based on fish fauna, although the south of the province belongs to a different hydrogeological basin. Hence, we consider that the presence of *H. tectifera* in the Sauce Grande River might be part of the species ancestral distribution (Fig. 1). With regard to the Brazilian records, one corresponding to Florianópolis (Fig.1) occurs in an area that connects with the southern core of distribution through an Atlantic coast saline lagoon system. Hence, we think this record might be a case of natural occurrence because the presence of hydrological connection. The records of Tiete River and Andirá (Fig.1), although detected by the analysis as extralimital, are clearly part of the natural distribution of the species since both are situated in the Upper Paraná River basin. The other Brazilian records (Itaqui and Bossoroca) correspond to localities situated in the proximity of the Uruguay River, where the species is present. So, following the same criteria, they should be considered as natural occurrence.

In comparison with the maps published by Iverson (1992) and Rhodin et al. (2017), the most remarkable differences are: (1) we present three times more records than the Iverson's map and at least 50 more records than the map of Rhodin et al. (2017), mainly from the extreme south and the west of the distribution but also filling gaps in the south of Brazil; (2) there are currently several records for Paraguay (also reflected in the map of Rhodin et al., 2017), a country for which Iverson (1992) had

recognised the species as probably present; (3) contrary to previous maps we decided to exclude the species from two provinces (Corrientes and Santa Fe, Argentina) since no precise localities have been provided; and finally (4) the map of Rhodin et al. (2017) mentioned but had not mapped the species from Santiago del Estero province (Argentina). We included the species in this province based on the record from Atamisqui.

Phrynops hilarii

In Argentina, *P. hilarii* was mostly recorded for Corrientes, Entre Ríos, Santa Fe and Buenos Aires provinces. The species was generically mentioned for Misiones province by Freiberg (1938), without a precise locality. The single specific locality documented for this province was provided by Cabrera (1998). However, this report refers to San Juan Pirahui ranch, which in fact corresponds to Corrientes province. During the revision of material we found an unassigned record of *Phrynops* from Iguazú National Park, Misiones (FML 07764). It consists of a set of bones of a juvenile specimen regurgitated by a South American raccoon (*Procyon cancrivorus*). Thus, due to the state of the material, it is not possible to assign these remains to the species.

On the other hand, extralimital reports from Tucumán, San Juan (without a precise locality) and Mendoza provinces (Laurent & Teran, 1981; Richard, 1987; Broin & de la Fuente, 1993; Prado et al., 2012) are treated in the literature as translocation cases of the species, whereas the populations of Córdoba and Santiago del Estero provinces are considered isolated but part of the natural distribution of the species (Cabrera, 1998; Prado et al., 2012). The presence of *P. hilarii* in Tucumán province was first recorded by Laurent and Teran (1981), who determined it was introduced by humans without providing further explanations. The upwaters of Dulce River are in the north-west of the country. It then flows across Tucumán (where is called Salí River) and Santiago del Estero provinces, and ends into Mar Chiquita lagoon (south-eastern Santiago del Estero and north-eastern Córdoba province), where the species is present (Cabrera, 1998; Leynaud et al., 2006; Fig. 3). Although it is far from the species core of distribution, we think the extralimital records from Tucumán could be considered of the natural distribution of *P. hilarii* because there is a river system that connects with the Mar Chiquita Lake population. Moreover, there are fossil records of *Phrynops* sp. in Tiopunco, Tucumán province, dated to the Upper Tertiary (de la Fuente, 1992).

We present here the first report for Salta province in Cabra Corral water reservoir. This dams the Juramento River (also called Salado del Norte River), flows to the east across north of Santiago del Estero and north of Santa Fe provinces, and finally flows into Paraná River. The species is known in localities associated with Juramento River: Campo Gallo (Santiago del Estero), Villa Ana and San Cristóbal (Santa Fe). On the other hand, there is a fossil record from Angastaco, Salta province, presumably of *Phrynops* sp., dated to the Upper Tertiary (de la Fuente, 1992). This locality is about 75 km west from Cabra Corral reservoir. Thus, we consider that the Cabra Corral record

might be part of the natural distribution of the species, although extralimital. The reports from the east of the country (Mendoza and San Juan provinces) present a different situation: there are no water courses that currently connect this region with other populations of the species (Fig. 3). Therefore, and according to Richard (1999), the Mendoza population could have anthropogenic origin. Nevertheless, there are some reasons to be cautious about this: 1) certain fish fauna are mostly the Paraná-Río de la Plata Rivers species (Acosta et al., 2013; Fernandez et al., 2015); 2) an unassigned chelid was reported for the Upper Tertiary of Mendoza province (25 de Mayo, San Rafael department; de la Fuente, 1992; Broin & de la Fuente, 1993); and 3) although isolated and probably with a particular biology, there are recent records which confirm that the species is settled in the area (Valle Fértil, San Juan). Thus, with the available information, we cannot confirm if these populations have been introduced by humans or are a relict population of a wider ancient distribution. Further studies (e.g. genetic) are needed to elucidate this issue.

The rest of the records that the KDA considered as extralimital (two in Córdoba province and two in Santa Fe province) are not relevant, since these are too close to the peripheral distribution of the species.

Regarding the extralimital records of Paraguay River and Pilcomayo River (Formosa province) and Upper Paraná River in Paraguay (Fig. 3), we think they have a natural origin since these rivers flow directly towards the Argentine core of the species distribution. The extralimital localities of Uruguay (Cebolatti River and Tacuarí River, Fig. 3) are hydrographically connected to the Brazilian core of the species distribution (both rivers flow into the Merin lagoon), so we consider these to be of natural origin. The lack of records in between is surely related to a lack of sampling in the area, as also occurs for the records of Paraguay. Finally, the extralimital records of Brazil are situated on the north of the Brazilian core of distribution, near the Atlantic coast of Santa Catarina State (Fig. 3). Following the same criteria, although there is a significant distance in between, this area is connected by a system of rivers and coastal lagoons, suggesting these records are cases of natural occurrence.

Comparing our map and the one presented by Rhodin et al. (2017), these are mostly in agreement, but we enriched the distribution adding at least a quarter more records. The distribution of the species has greatly increased since Iverson (1992), with quadruple more records than in his map, particularly the localities from the Argentine Chaco and South of Brazil. The main differences with the map of Rhodin et al. (2017) are that we excluded the species from Misiones (since the single record for this province actually corresponds to a locality from Corrientes, Argentina) and the recognition of the species for Salta (Argentina).

Acanthochelys pallidipectoris and *A. spixii*

Acanthochelys pallidipectoris inhabits temporary fresh water ponds in the Chaco region: Chaco, Formosa, Salta and Santa Fe Argentine provinces, eastern Paraguay, and western Bolivia; and Monte (Mendoza province)

Eco-region (Burkart et al., 1999; Fig 4). The ability of *A. pallidipectoris* to perform terrestrial incursions is revealed from direct observations of specimens walking on land, in general during night, and also from the presence of ticks attached on the soft parts of the turtles (Vinke et al., 2011; MJC and LA personal observations). In fact, most freshwater turtles display to some degree the ability to do terrestrial displacements. In the case of *A. pallidipectoris*, we think such ability is restricted to movements between the temporary ponds the species inhabits, but it is weak to explain connections among isolated populations of the species along the Chaco region. The record of Bolivia, despite being isolated and distant from the area with the major concentration of localities for the species, belongs to the Chaco region, so it should not be unusual to find the species there. We believe that exhaustive searches in the area are necessary in order to complete the lack of data there.

The distribution pattern of *A. pallidipectoris* remains almost equal to that displayed in the map of Iverson (1992). There are many new records that fill gaps but that do not expand the distribution area (except by the presence of the species in Bolivia that had been suggested as probable by Iverson, 1992). Although supported by two times more localities, the distribution pattern of our map coincides in general with that published by Rhodin et al. (2017).

The other species, *A. spixii*, occurs more in permanent environments, such as lagoons and streams associated with big rivers. In Argentina, it is recorded for the tributaries of Paraná River in the province of Corrientes (Cabrera, 1998), and in temporary ponds in northern Mendoza province (Richard, 1999; Fig 5). The records from Mendoza (Alto Verde Lagoons, and Provincial Road 142 on Lavalle department) are clearly extralimital for both species. Richard (1999) established the anthropogenic origin of the Alto Verde populations of both species based on statements of local people who said that the owners of the farm (Figueroa family) had introduced them into the lagoons during the 1970s. As we related in the Results section, we visited the area and we can affirm that the populations of *A. pallidipectoris* and *A. spixii* from the Alto Verde Lagoons are extinct.

Regarding the record of the specimen of *A. spixii* found crossing the Provincial Road 142, the situation seems to be different from the case of Alto Verde lagoons, since it was found in a natural area with no human settlements nearby. Richard (1999) provided a series of arguments that support that the specimen may correspond to a natural population: (1) presence of fossil turtles in the area (de la Fuente, 1992; Broin & de la Fuente, 1993); (2) certain fish species are the same as those in the Paraná river basin. The presence of this fish fauna correlates with data from geological and palinological studies (see compilation in Ringuélet, 1956) that demonstrates the presence of a Late Pleistocen and Early Holocen extense waterbodies and laggons net, which has hydrologically connected the arid west with the humid east of the country; and (3) *A. spixii* usually has a distribution pattern based on isolated populations. Therefore, we agree with the author that it could be part of an extralimital natural population, but we

consider that exhaustive searches in the area are needed to find new specimens inhabiting there.

The main differences between our work and the maps of this species published by early authors are: (1) Rhodin et al. (2017) recognised the species for the Brazilian states of Bahia and Goiás (we are not sure of precise localities supporting that) and excluded the species (with no justification) from Corrientes province, Argentina; (2) Iverson's map showed a very similar pattern to the one known at present but based on very few localities (we present two times more records than in Iverson's map, filling many gaps for the extreme south of the distribution); and (3) the presence of the species for Paraguay was suggested by Iverson (1992) but, until now, there are no records supporting the presence of the species in this country.

Trachemys dorbigni

In Argentina, the species is distributed along the Paraná and Uruguay river basins, from Corrientes province to Río de la Plata River, as far as Buñirigo and Zapata streams in Buenos Aires province (Fig. 6). The record from Toro Muerto stream in Córdoba province is the first outside the species range. The documented *Trachemys* fossil from Mar Chiquita Lake (Cabrera & Luna, 2011), the accompanying fish fauna, mostly Parano-Platense, and the past water connections with the Paraná-Río de la Plata river basins, are reasons to believe that this locality is, although isolated, part of the natural distribution (as claimed for *H. tectifera*). However, the species has never been reported for the area, although several turtle studies were conducted there (Lescano et al., 2007; 2008; Bonino et al., 2009), the water is transparent, and it is a conspicuous, not secretive species. Thus, we consider that this record is a case of translocation, presumably due to the pet trade, given that *T. dorbigni* is the second most commercialised native reptile in the country (Prado et al., 2012).

The extralimital record for the species in Morro do Diabo State Park (Brazil) seems to be a case of natural occurrence since the turtle was found near the Paranapanema River, an affluent area of the Paraná River, where the species is present (Santos et al., 2009). Nonetheless *T. dorbigni* is a species usually sold as pets in this country, and is common that people release specimens in natural areas. With regard to the extralimital record of the Atlantic coast of Uruguay (surroundings of La Paloma), it is situated in a region that is hydrologically connected with the southern core of distribution, so it may well be part of the natural range of the species. Other extralimital records are not relevant since they are very close to the peripheral range.

Although our map of the species coincides with that presented by Rhodin et al. (2017), these authors excluded the species (with no justification) from two provinces (Chaco and Santa Fe) and presented very few localities for Corrientes. The main difference between our map and that of Iverson (1992) is a marked increase in the localities for Argentina and Brazil (we present four times more records than Iverson's map).

CONCLUSION

In the present work, we provide an updated revision of the geographic distribution of the South American turtles *Hydromedusa tectifera*, *Phrynops hilarii*, *Acanthochelys pallidipectoris*, *A. spixii* and *Trachemys dorbigni*, presenting the first provincial records of some of these species for Argentina, and formally excluding them from other provinces. Moreover, we exposed our position about the origin of all cases of extralimital populations of these species following a methodology that can be replicated in future work.

We would like to remark that contributions we make here tend to solve a relevant conservation issue about extralimital turtle populations. These types of population may be adapted to different habitats, or be genetically isolated and could represent distinct evolutionary units. In that sense, the possible origin about certain turtle populations should be the starting point for making conservation decisions by fauna agencies.

ACKNOWLEDGEMENTS

We thank the Dirección de Recursos Naturales Renovables de Mendoza (Res. N° 442/2014), Dirección de Flora y Fauna de Buenos Aires (Disp. N° 69/2016), Programa de Biodiversidad del Ministerio de Medio Ambiente de San Luis (Res. N° 491/2013) and Secretaría de Ambiente y Cambio Climático de la Provincia de Córdoba, which authorised field works in these provinces. We are grateful to the curators of the Herpetological Collections, who gently provided particular information: Gustavo Scrocchi and Sonia Kretzsmarch (FML), Soledad Palomas (UNNE) and Diego Baldo (LGE); or selflessly aided us during the revision of the material under their care: Jorge D. Williams (MLP) and Julian Faivovich and Santiago Nenda (MACN). To the Turtle Conservation Fund Grants that provided (2014-2015) economical support to develop part of the present work. We thank Jimena Grosso (FML), who kindly took photos of the material and Andres Jakel for the photo editing. The present work is the N° 1005 Scientific Contribution of the Instituto de Limnología Dr. Raul Ringuelet (CCT- La Plata CONICET, UNLP). Three anonymous reviewers clearly improved the first version of the manuscript, we thank them.

REFERENCES

- Acosta, J.C., Laspiu, A., Blanco, G., Protogino, L.C. & Nadalin, D.O. (2013). Lista de los peces de la provincia de San Juan. *Probiota. Serie Técnica y Didáctica* 19, 1–10.
- Bertoni, A. de W. (1939). Catálogos sistemáticos de los vertebrados de Paraguay. *Revista de la Sociedad Científica del Paraguay* 4, 3–60.
- Bistoni, M., Haro, G.H. & Gutiérrez, M. (1996). Ictiofauna del Río Quinto (Popopis) en la provincia de Córdoba (Argentina). *Revista de la Asociación de Ciencias Naturales del Litoral* 27, 43–48.
- Bonino, M.F., Lescano, J.N., Haro, J.G. & Leynaud, G.C. (2009). Diet of *Hydromedusa tectifera* (Testudines-Chelidae) in a mountain stream of Córdoba province, Argentina.

- Amphibia-Reptilia* 30, 545–554.
- Broin, F. & de la Fuente, M. (1993). Les tortues fossiles d'Argentine: synthese. *Annales de Paleontologie* (Invert.-Vert.) 79, 169–232.
- Burkart, R., Bárbaro, N.O., Sánchez, R.O. & Gómez, D.A. (1999). *Ecorregiones de la Argentina*. Buenos Aires: Secretaría de Recursos Naturales y Desarrollo Sustentable y Administración de Parques Nacionales.
- Cabrera, M.R. (1998). *Las Tortugas Continentales de Sudamérica Austral*. Córdoba: Publisher Cabrera M.
- Cabrera, M.R., Haro, J.G. & Monguillot, J.C. (1986). Presencia de *Hydromedusa tectifera* y *Phrynops hilarii* (Testudines: Chelidae) en la provincia de Córdoba, Argentina. *Academia Nacional de Ciencias* 73, 1–10.
- Cabrera, M.R. & Luna, C.A. (2011). Presencia de *Trachemys Agassiz*, 1875 (Testudines, Emydidae) en el Pleistoceno tardío del centro de la Argentina. *Cuadernos de Herpetología* 25, 37–42.
- Cacciali, P., Scott, N.J., Aquino Ortíz, A.L., Fitzgerald, L.A. & Smith, P. (2016). The reptiles of Paraguay: literature, distribution, and an annotated taxonomic checklist. *Special Publication of the Museum of Southwestern Biology* 11, 1–373.
- Cei, J.M. (1993). *Reptiles del Noroeste, Nordeste y Este de la Argentina: Herpetofauna de las Selvas Subtropicales, Puna y Pampas*. Torino: Museo Regionale di Scienze Naturali.
- Cook, R.P. (2004). Dispersal, home range establishment, survival, and reproduction of translocated eastern box turtles, *Terrapene c. carolina*. *Applied Herpetology* 1, 197–228.
- Cope, E.D. (1869). Seventh contribution to the herpetology of Tropical America. *Proceedings of the American Philosophical Society* 11, 147–169.
- de la Fuente, M.S. (1992). Las tortugas Chelidae del Terciario superior y Cuaternario del territorio argentino. *Ameghiniana* 29, 211–229.
- Di Pietro, D.O., Alcalde, L., Williams, J.W. & Cabrera, M.O. (2012). *Hydromedusa tectifera* (South American snake-necked turtle). *Herpetological Review* 43, 303.
- Duméril, A.M.C. & Bibron, G. (1835). *Erpétologie Générale ou Histoire Naturelle Complète des Reptiles*, 2. Paris: Librairie Encyclopédique de Roret.
- Ernst, C.H. & Barbour, R.W. (1989). *Turtles of the World*. Washington D.C.: Smithsonian Institution Press.
- Fernández, L., Marín, B., Nadalin, D.O. & López, H.L. (2015). Lista de peces de la provincia de Mendoza. *ProBiota. Serie Técnica y Didáctica* 29, 1–10.
- Freiberg, M.A. (1938). Catálogo sistemático y descriptivo de las tortugas argentinas. *Memorias del Museo de Entre Ríos, Zoología* 9, 1–25.
- Freiberg, M.A. (1945). Una nueva especie de tortuga del género *Platemys* Wagler. *Physis* 20, 112–114.
- Garelis, P.A. & Bistoni, M. (2010). Ictiofauna de la Cuenca endorreica del Rio Quinto (San Luis, Argentina). *Natura Neotropicalis* 41, 19–30.
- Griffith, B., Scott, J.M., Carpenter, J.W. & Reed, C. (1989). Translocation as a species conservation tool: status and strategy. *Science* 245, 477–80.
- Iverson, J.B. (1992). *A revised checklist with distribution maps of the turtles of the world*. Richmond: Privately printed.
- Laurent, R.F. & Teran, E.M. (1981). Lista de los anfibios y reptiles de la provincia de Tucumán. *Miscelánea, Fundación Miguel Lillo* 71, 1–15.
- Lescano, J.N., Bonino, M.F. & Leynaud, G.C. (2007). *Hydromedusa tectifera* (South American snake-necked turtle). Copulation. *Herpetological Review* 38, 332.
- Lescano, J.N., Bonino, M.F. & Leynaud, G.C. (2008). Density, population structure and activity pattern of *Hydromedusa tectifera* (Testudines: Chelidae) in a mountain stream of Córdoba province, Argentina. *Amphibia-Reptilia* 29, 505–512.
- Leynaud, G.C., Pelegrin, N. & Lescano, J.N. (2006). Anfibios y reptiles. In *Bañados del Río Dulce y Laguna Mar Chiquita (Córdoba, Argentina)*, 219–235. Bucher E.H. (Ed.). Córdoba: Academia Nacional de Ciencias.
- Moore, D.B., Ligon, D.B., Fillmore, B.M. & Fox, S.F. (2013). Growth and viability of a translocated population of alligator snapping turtles (*Macrochelys temminckii*). *Herpetological Conservation and Biology* 8, 141–148.
- Petraglia de Bolzón, M.L. & Bolzón, N.D. (2003). *Iberá. Vida y Color. Guía de Flora y Fauna*. Buenos Aires: MLPB.
- Petraglia de Bolzón, M.L. & Bolzón, N.D. (2009). *Iberá. Vida y Color. Guía de Flora y Fauna*. Buenos Aires: MLPB.
- Prado, W.S., Waller, T., Albareda, D.A., Cabrera, M.R., et al (2012). Categorización del estado de conservación de las tortugas de la República Argentina. *Cuadernos de Herpetología* 26, 375–387.
- Rhodin, A.G.J., Iverson, J.B., Bour, R., Fritz U., Georges, A., Shaffer, H.B. & van Dijk, P.P. (2017). Turtles of the world: Annotated checklist and atlas of taxonomy, synonymy, distribution, and conservation status (8th Ed.). In *Conservation Biology of Freshwater Turtles and Tortoises: A Compilation Project of the IUCN/SSC Tortoise and Freshwater Turtle Specialist Group, Chelonian Research Monographs* 7, 1–292. Rhodin A.G.J., Iverson J.B., van Dijk P.P., Saumure R.A., Buhlmann K.A., Pritchard P.C.H. & Mittermeier R.A. (Eds.). New York: Chelonian Research Foundation.
- Richard, E. (1987). Sobre la presencia de tortugas dulceacuícolas (Testudines:Chelidae) en la Provincia de Mendoza (Argentina). *Boletín de la Asociación Herpetológica Argentina* 3, 7–8.
- Richard, E. (1991a). Oviposition of *Acanthochelys pallidipectoris* (Freiberg) in captivity (Chelonii: Chelidae). *Bulletin of the Maryland Herpetological Society* 27, 107–109.
- Richard, E. (1999). *Tortugas de las Regiones Áridas de Argentina*. Buenos Aires: L.O.L.A.
- Richard, E. & de la Fuente, M.S. (1992). Lista sistemática y distribución de las tortugas argentinas (Reptilia: Chelonii). *Acta Zoológica Lilloana* 41, 357–364.
- Ringuelet, R.A. (1956). Los factores históricos o geológicos en la Zoogeografía de la Argentina. *Holmbergia* 5, 125–140.
- Ringuelet, R.A. (1971). Zoogeografía de los peces pampásicos. *Boletín Dirección de Recursos Pesqueros* 12, 23–27.
- Ringuelet, R.A. (1975). Zoogeografía y ecología de los peces de aguas continentales de la Argentina y consideraciones sobre las áreas ictiológicas de América del Sur. *Ecosur* 2, 1–122.
- Rittenhouse, C.D., Millspaugh, J.J., Hubbard, M.W. & Sheriff, S.L. (2007). Movements of translocated and resident three-toed box turtles. *Journal of Herpetology* 41, 115–121.
- Rittenhouse, C.D., Millspaugh, J.J., Hubbard, M.W., Sheriff, S.L. & Dijk, W.D. (2008). Resource selection by translocated three-toed box turtles in Missouri. *The Journal of Wildlife Management* 72, 268–275.
- Santos, T., Vasconcelos, T., Molina, F.B. & Zaher, H. (2009). First record of *Trachemys dorbignii* (Duméril & Bibron, 1835) (Testudines, Emydidae) in a remnant of mesophytic semideciduous forest of São Paulo State, southeastern Brazil. *Herpetological Bulletin* 108, 27–30.

- Tuberville, T.D., Clark, E.E., Buhlmann, K.A. & Gibbons, J.W. (2005). Translocation as a conservation tool: site fidelity and movement of repatriated gopher tortoises (*Gopherus polyphemus*). *Animal Conservation* 8, 349–358.
- Vinke, T., Vinke, S., Richard, E., Cabrera, M.R., Paszko, L., Marano, P. & Métrailler, S. (2011). *Acanthochelys pallidipectoris* (Freiberg, 1945)–ChacoSide-Necked Turtle. In *Conservation biology of freshwater turtles and tortoises: A compilation project of the IUCN/SSC tortoise and freshwater turtle specialist group, Chelonian Research Monographs* 5, 65.1–65.7. Rhodin A.G.J., Pritchard P.P., van Dijk P.P., Saumure R.A., Buhlmann K.A., Iverson J.B. & Mittermeier R.A. (Eds.). New York: Chelonian Research Foundation.

Accepted: 22 May 2019

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