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# Abundance of *Chelonoidis chilensis* (GRAY, 1870) within protected and unprotected areas from the Dry Chaco and Monte Eco-regions (Argentina)

(Reptilia: Testudines: Testudinidae)

## Abundanzen von *Chelonoidis chilensis* (GRAY, 1870) in geschützten und nicht geschützten Gebieten zweier Ökoregionen, des Trockenen Chaco und der Monte-Vegetation (Argentinien)

(Reptilia: Testudines: Testudinidae)

JULIETA SÁNCHEZ & LEANDRO ALCALDE & ALEJANDRO DANIEL BOLZÁN & MARÍA ROCÍO SÁNCHEZ & MARÍA DEL VALLE LAZCÓZ

KURZFASSUNG

Entlang standardisierter Transekte wurde bei fünf Populationen von *Chelonoidis chilensis* (GRAY, 1870) aus dem argentinischen Norden und Süden die Individuendichte während der saisonalen Aktivitätszeit untersucht. Die Studiengebiete umfaßten zwei Ökoregionen, den Trockenen Chaco (Copo Nationalpark und Tío Pozo in der Provinz Santiago del Estero) und die Monte-Vegetation der Steppen und Ebenen (Salinas Grandes, in der Provinz Catamarca sowie den Lihue Calel Nationalpark und die La Amarga Lagune in der Provinz La Pampa). Die Abundanzen reichten von 5 (Copo Nationalpark) über 2 (Salinas Grandes) bis 0 (La Amarga Lagune, Lihue Calel Nationalpark und Tío Pozo) Individuen pro 17.1 ha. Der Wert null in Tío Pozo könnte auf dem hohen Absammeldruck aufgrund des historischen und aktuellen Bedarfs entlang der Nationalstraße 9 in der Nähe der Stadt Loreto beruhen. Der im Lihue Calel Nationalpark erhobene Nullwert ist konsistent zur niedrigen Dichte, die von verschiedenen Autoren für die Verbreitungsgrenze der Art in der Monte-, bzw. Espinal-Ökoregion vermutet wird.

SUMMARY

During the seasonal activity period, abundance data on five populations of *Chelonoidis chilensis* (GRAY, 1870) from the north and south of the species range in Argentina were collected along standardized transects. Studied areas involved the Dry Chaco (Copo National Park and Tío Pozo - Santiago del Estero province) and the Monte of steppes and plains Eco-region (Salinas Grandes - Catamarca province, Lihue Calel National Park and La Amarga lagoon - La Pampa province). The abundance ranged from 5 (Copo NP) to 0 (La Amarga lagoon, Lihue Calel NP and Tío Pozo) tortoises per 17.1 ha. Intermediate values (2 tortoises) characterized Salinas Grandes. Zero values found at Tío Pozo may be due to high harvesting pressure to supply the historic and current demand of tortoises along the National Road 9 near Loreto city. The zero value found at Lihue Calel NP is consistent with the low density suggested by some authors for the border of the species range at the Monte - Espinal Eco-regions.

KEY WORDS

Reptilia: Testudines: Testudinidae; *Chelonoidis chilensis*, Argentine Tortoise, population ecology, abundance, relative frequency, Argentina

## INTRODUCTION

The neotropical testudinid genus *Chelonoidis* includes the species *C. denticulata* (LINNAEUS, 1766), *C. nigra* (QUOY & GAIMARD, 1824), *C. carbonaria* (SPIX, 1824), and *C. chilensis* (GRAY, 1870) (FRITZ & HAVAŠ 2007; FRITZ et al. 2012). Only two of them are present in Argentina. Populations of *C. carbonaria* were confirmed for the province of Formosa whereas the Chaco and Salta records are based on specimens of doubtful origin (CHÉBEZ 2008). Conversely, Argentina covers almost the entire geographical range of *C. chilensis*. This species, the Argentine Tortoise, is present in all provinces, except Tierra del Fuego, the South Atlantic Ocean Islands, Santa Cruz, Entre Ríos, Corrientes and Misiones (CABRERA 1998; GUERREIRO et al. 2005).

Currently, *C. chilensis* is included in Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), and it is considered 'Vulnerable' in the IUCN Red List of Threatened Species (Tortoise & Freshwater Turtle Specialist Group 1996). At country level, the species was recently moved from 'Endangered' (Richard & Waller 2000) to 'Vulnerable' (Prado et al. 2012) although the main factors adversely affecting the species have increased over time. These factors are multipurpose exploitation (mostly for pet trade), local extinction of many populations, and habitat loss by expansion of the agricultural frontier (Richard & Waller 2000). In spite of local and international legal conservation efforts during the last two decades, control acts or law effectiveness remained low, especially with regard to the regulation of the internal pet trade. During the field work, the authors observed the construction of new roads (across all species range) and the areal expansion of petroleum and mining projects (mainly upon southern and western populations), both directly affecting the populations through roadkills and facilitating harvesting of tortoises when they cross either the roads or the numerous industrial driveways of the petroleum fields.

The recently DNA-supported solution for the historic systematic problem of the *C. chilensis* complex (Fritz et al. 2012), suggesting that *C. chilensis* should be considered as a single species, and the identification of the main threats affecting this species (see above) are important advances that impact conservation in a positive manner. On the contrary, there is lack of contemporary field studies assessing the current status of *C. chilensis* populations. In fact, only few works assessed the density, the abundance or merely the presence/absence of this species in certain regions of Argentina (Auffenberg 1969; Waller & Micucci 1997; Richard 1999; Guerreiro et al. 2005; Briguera et al. 2006; Chébez 2008; Sanabria & Quiroga 2009).

Thus, the main objective of the present paper is to provide abundance estimations for *C. chilensis* within two protected and three unprotected areas from three provinces (Catamarca, La Pampa and Santiago del Estero) and two Eco-regions (Monte of Steppes and Plains and Dry Chaco) of Argentina (Burkart et al. 1999) to determine the conservation status of the natural populations of this species.

## METHODS

Listed in Table 1 are the main features relative to the study transects (number, length, width, space between them, covered surface area) of the five geographical sites examined in the present work (Fig. 1).

La Amarga lagoon and Lihue Calel NP have the typical vegetation of the Monte of Steppes and Plains Eco-region. The "Jarilla" (*Larrea* sp.) is the dominant community, other kinds of brush is also common: "Algarrobillo" (*Prosopis flexuosa*), "Piquillín" (*Condalia* sp.), "Chañar" (*Geoffroea decorticans*) and "Chañar-Brea" (*Cercidium australis*). In addition, small patches of grass-covered areas between the brush, and "Jume" (*Suaeda* spp.) were abundant near salinitrous depressions. Cactus diversity and abundance was low with respect to Dry Chaco sites. The Lihue Calel NP has many trees representative of the Espinal Eco-region: "Calden" (*Prosopis caldenia*), "Sombra de Toro" (*Jodina rhombifolia*) and Molle (*Schinus longifolius*).

The Dry Chaco sites, Copo NP and Tío Pozo, have an arboreal community dominated by the "Quebrachos" (*Aspidosperma quebracho-blanco*, *Schinopsis lorentzii*), "Algarrobos" (*Prosopis* spp.), "Itin" (*Prosopis kuntzei*), "Espinillo" (*Acaia caven*), "Vinal" (*Prosopis ruscifolia*) and Chañar (*Geoffroea decorticans*), among others. Cactus diversity is high and many cactuses display an arboreal growth such as the "Cardon Moro" (*Stetsonia corine*), "Ucle" (*Cereus forbesii*) and "Quimil" (*Opuntia quimilo*). Concerning Tio Pozo, this is an unprotected area with scattered rural inhabitants practicing familial agriculture and cattle ranching. Two rivers delimited Tío Pozo in the northeast (Dulce River) and southwest (Saladillo

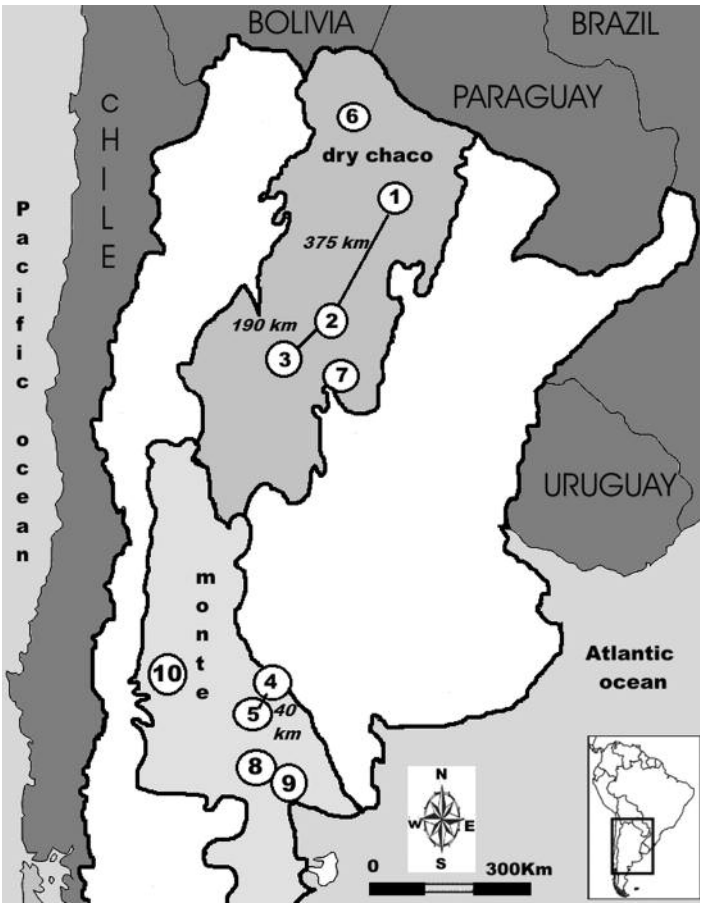


Fig. 1: Map of Argentina with the southern part of the Patagonia not included. Different gray tones indicate the Monte of Steppes and Plains (clear) and the Dry Chaco (dark) Eco-regions. Numbers within circles indicate places at which the present (1-5) or previous authors (6-10) estimated abundance of *Chelonoidis chilensis* (Gray, 1870). 1 - Copo NP; 2 - Tío Pozo; 3 - Salinas Grandes; 4 - Lihue Calel NP; 5 - La Amarga lagoon; 6 - Salta province (Chébez 2008); 7 - La Posta - Córdoba province (Auffenberg 1969); 8 - Salina y Bajo del Gualicho - Río Negro province (Cei 1986); 9 - near San Antonío Oeste - Río Negro province (Waller & Micucci 1997; 10 - región del Nevado - Mendoza province (Richard 1999).

Abb. 1: Karte von Argentinien ohne Südpatagonien. Verschiedene Grautöne bezeichnen die Monte-Vegetation der Steppen und Ebenen (hell) und den Trockenen Chaco (dunkel). Eingekreiste Zahlen bezeichnen Lokalitäten, wo die relative Häufigkeit von *Chelonoidis chilensis* (Gray, 1870) von den Autoren dieser Arbeit (1-5) oder von früheren Autoren (6-10) geschätzt wurde. 1 - Copo Nationalpark; 2 - Tío Pozo; 3 - Salinas Grandes; 4 - Lihue Calel Nationalpark; 5 - La Amarga Lagune; 6 - Provinz Salta (Chébez 2008); 7 - La Posta, Provinz Córdoba (Auffenberg 1969); 8 - Salina y Bajo del Gualicho, Río Negro Provinz (Cei 1986); 9 - in der Nähe von San Antonío Oeste, Río Negro Provinz (Waller & Micucci 1997); 10 - Gebiet des Nevado, Provinz Mendoza (Richard 1999).

River). Overgrazing and tree-cutting produced areas covered by a dense web of brush, locally known as "fachinal". The salinitrous zones of Tío Pozo are dominated by "Jume", although "Jarilla" (*Larrea* spp.) is also present in this locality. These features are practically absent in the protected area of Copo NP (no salinitrous zones, no rivers, near absence of rural inhabitants, cattle and agriculture). The area of Copo NP

Table 1: Characterization and main results of the five areas where *Chelonoidis chilensis* (Gray, 1870) was studied using transects. Asterisks indicate protected areas (National Parks). Number of transects per study area: 57; transect size: 100 m long, 30 m wide; minimum distance between transects: 50 m; covered surface per study area: 171,000 m².

Tab. 1: Charakterisierung von und Hauptresultate zu den fünf Studiengebieten, bei denen das Vorkommen von *Chelonoidis chilensis* (Gray, 1870) mittels der Transekt-Methode untersucht wurde. Anzahl Transekte pro Studiengebiet: 57; Transektgröße: 100 m lang, 30 m breit; Minimalabstand zwischen Transekten: 50 m; Untersuchungsfläche pro Studiengebiet: 171,000 m².

| Province<br>Provinz | La Pampa | | Catamarca | Santiago del Estero | |
|---|---|---|---|---|---|
| Study area<br>Studiengebiet | La Amarga lagoon | Lihue Calel * | Salinas Grandes | Tío Pozo | Copo * |
| Coordinates (elevation)<br>Koordinaten (Seehöhe) | 38°13'52.1"S<br>66°11'35.74"W<br>(253 m a.s.l.) | 37°50'41.95"S<br>65°28'52.89"W<br>(230 m a.s.l.) | 29°30' 37.39"S<br>64°58'37.05"W<br>(185 m a.s.l.) | 28°23'35.31"S<br>63°59'15.37"W<br>(133 m a.s.l.) | 25°39'40.66"S<br>61°59'35.95"W<br>(179 m a.s.l.) |
| Eco-región<br>Ökoregion | Monte of Steppes and Plains | | | Dry Chaco | |
| Date Datum | 10-12/III/2012 | 3-4/III/2012 | 14-15/XI/2011 | 16-17/XI/2011 | 19-20/XI/2011 |
| Horary range<br>Tageszeit | 8.40-18.37 | 9.33 - 20.24 | 9.06 – 16.20 | 8.22 - 20.14 | 6.45 - 20.14 |
| Temperature range (mean) (°C)<br>Temperaturspanne (Mittel) (°C) | 21 - 38.5 (28.39) | 20 - 45 (31.5) | 26 - 41 (35.1) | 25 - 37 (31.56) | 26 - 41 (33.68) |
| Mean survey time per transect<br>Mittlere Begehungszeit pro Transekt | 9.61 min | 11.47 min | 12.7 min | 15.57 min | 16.49 min |
| Total survey time per study area<br>Gesamtbegehungszeit pro Studiengebiet | 8.48 hrs | 11.06 hrs | 12.03 hrs | 14.4 hrs | 15.58 hrs |
| | Number of tortoises found / Anzahl festgestellter Schildkröten | | | | |
| within transects<br>in Transekten | 0 | 0 | 2 | 0 | 5 |
| between transects<br>zwischen Transekten | 1 | 0 | 0 | 0 | 2 |
| in other places within study area<br>an anderen Orten des Studiengebietes | 0 | 0 | 0 | 0 | 7 |
| Total | 1 | 0 | 2 | 0 | 14 |

includes a grass community, locally known as "Aibales" (*Elionurus* sp.), which grows only at the places at which paleorivers crossed the Chaco during earlier geologic times. A more detailed characterization of the soil, climate, geological history and vegetation of the Dry Chaco can be found in the work of Torrella & Adámoli (2006).

The Salinas Grandes (Province of Catamarca) may be considered as an ingression of the Monte Eco-Region into the Dry Chaco. Consequently, the vegetation which covers the Salinas Grandes is mainly composed of typical Monte brush mixed with arboreal cactuses and some Dry Chaco trees ("Quebracho Blanco" and "Algarrobo").

The data on abundance was obtained employing a standardized methodology across the studied places, based on transects of uniform width and length. The sampling

method was adapted from transect methods developed by other authors (see references in BUCKLAND et al. 2001). Transects were made using a string on a reel with the purpose of covering 100 m of transect length and 30 m of transect width (15 m to the right and left of the middle line). The string was unrolled by one person (W1) walking along an almost straight line and, after 100 m were unreeled, the string was reeled up by the second person (W2). W1 began searching tortoises along both sides near the string, whereas W2 covered the 15 m strip at the left side only. Once the string was completely unrolled, the roles changed: W2 returned rolling the string and searching tortoises near it whereas W1 returned covering the 15 m strip at the right side of transect. Within the 30 m width of the transect, all types of refuges (caves, crevices under trunks or brush, etc) were carefully revisited to ensure that all tortoises were detected. In addition, tortoises sighted when walking between transects were also counted for descriptive purposes but not included in the statistical analysis. A series of 57 transects covering an area of 171,000 m² (minimum distance between transects = 50 m) were assessed at each study area. To avoid overcounts, each tortoise was marked applying paint to a small area of the plastral scute sutures. Temperature was taken periodically at the soil level covering almost all of the horary range at which transects were conducted. Sex, weight, straight carapace length (SCL), sanitary status (presence of carapace and plastral injuries, other signs of disease, etc.), and the activity grade (1 - active, 2 - semi-active, 3 - inactive) of each sampled tortoise were registered. Animals were (1) active, when found moving, (2) semi-active, when found quiet but with signs of recent activity, and (3) inactive, when found resting with the head and legs entirely retracted into the carapace.

The different values of tortoise abundance across the five study areas were globally compared using the non-parametric Cochran *Q* Test (ZAR 2010). Once significant differences were detected in the global analysis, pairwise comparisons of the locations were performed. Comparisons of sexual size dimorphism, temperature values (°C) and time effort (minutes) employed at each transect were made among sample sites using the *t*-Test. Statistical analysis and graphs were conducted using the software Statistica 6.0 (StatSoft Inc. 2001, Tulsa, USA).

## RESULTS

There were two Monte (Lihue Calel NP, La Amarga lagoon), and one Dry Chaco (Tío Pozo) study areas at which no tortoises were found within transects. Within transects two tortoises were found at Salinas Grandes and five at Copo NP; between transects one in La Amarga lagoon and two at Copo NP. Thus, the global values of tortoise abundance found within transects differ significantly among sites ($X^2_{p0.05;\ v4}$ = 9.48 < $Q$ = 13.71). The analysis was also executed excluding zero tortoise localities (Tío Pozo, Lihue Calel NP, and La Amarga lagoon) in order to avoid the putative effect of blocks containing all zero values. The output value of the analysis excluding these localities did not show differences in tortoise abundance within transects between Copo NP and Salinas Grandes ($X^2_{p0.05;\ v2}$ = 3.841 < $Q$ = 1.28).

All tortoises found within and between transects were adult specimens, most of them males (Fig. 2A). When detected, they were either active or semi-active (Fig. 2B) and none of them showed carapacial injuries. Ticks were found on tortoises from Copo NP (Dry Chaco Eco-region - Santiago del Estero) and Salinas Grandes (Monte ingression into the Dry Chaco - Catamarca).

Although the same time effort was employed per transect at each study area, tortoise abundance varied significantly between Copo NP and Tío Pozo. However, the time effort per transects was different for Dry Chaco and Monte Eco-regions places (Table 2; Fig. 3 A). Temperature values were more constant across study sites. They showed significant differences only when La Amarga lagoon is compared with Salinas Grandes and Copo NP (Table 2; Fig. 3B).

Table 2: Mean values of both temperature (°C) and time (min.) spent per transect survey for each transect-sampled study area. Asterisks above (time) and below (temperature) the diagonal represent significant ($p < 0.05$) differences between study areas. C - Copo NP; LA - La Amarga lagoon; LC - Lihue Calel NP; SG - Salinas Grandes; TP - Tío Pozo.

Tab. 2: Durchschnittswerte von Temperatur (°C) und Zeit (min.), die je Transektbegehung aufgewendet wurde, von allen mittels der Transekt-Methode untersuchten Studiengebieten. Sternchen über (Zeit) und unter (Temperatur) der Diagonale bezeichnen signifikante ($p < 0.05$) Unterschiede zwischen den Studiengebieten. C - Copo Nationalpark; LA - La Amarga Lagune; LC - Lihue Calel Nationalpark; SG - Salinas Grandes; TP - Tío Pozo.

| | LA | LC | SG | TP | C |
|---|---|---|---|---|---|
| LA | 38.39 °C<br>9.61 min | * | * | * | * |
| LC | - | 31.5 °C<br>11.47 min. | * | * | * |
| SG | * | - | 35.1 °C<br>12.7 min. | * | * |
| TP | - | - | - | 31.56 °C<br>15.57 min. | - |
| C | * | - | - | - | 33.68 °C<br>16.49 min. |

## DISCUSSION

Few works assessed population density or abundance of *Chelonoidis chilensis* in Argentina and there is no data available for the populations of this species living in the Dry Chaco from Paraguay and Bolivia. In Argentina, abundance estimations of *C. chilensis* are only available for two localities of the Monte Eco-region (Richard 1999; Waller & Micucci 1997) and one locality of the Dry Chaco (Auffenberg 1969). In addition, some minor comments about the abundance of this species in Salina del Gualicho (Río Negro province) and Salta province were published by Cei (1986) and Chébez (2008), respectively. The present results and observations cannot be compared with estimates by Cei (1986), Chébez (2008) and Auffenberg (1969) because these authors did not provide any information about how tortoise abundance was assessed. On the contrary, although not statistically supported, the estimations of Waller & Miccuci (1997) and Richard (1999) were obtained using a replicable methodology that contextualized their results. Estimations of these authors vary from 1 tortoise per hectare to 11 tortoises / ha (Richard 1999), including intermediate values (3-4 tortoises / ha; Waller & Micucci 1997). If the number of tortoises found in the present work is expressed in relation to the total surface covered by the transects at each study area (17.1 ha), the results were 0.117 tortoises per ha in the Salinas Grandes locality and 0.292 tortoises per ha in the Copo NP locality. Both results differ drastically from those published by Waller & Micucci (1997) and Richard (1999) for the southern populations of *C. chilensis*. Nevertheless, the same methodological conditions must be used to properly compare different places. Thus, an interesting result of the current data is the presence of significant differences between the abundance of tortoises in Tío Pozo (0 tortoises) and Copo NP (5 tortoises) using the same methods at a time interval of only two days and no temperature or rainfall variations between locations (Tables 1 and 2). As previously summarized in the Materials and Methods section, Tío Pozo may be characterized as a degraded Dry Chaco forest (livestock, historical selective forest extraction) mixed with mosaic areas, a product of the influence of the Dulce River at the northeast and the influence of the Salinas de Ambargasta, and the Saladillo River at the south and southwest. These factors (salinitrous environments, wet zones influenced by the river, and overgrazing by livestock) are absent in the locality of Copo NP. The Copo NP is a

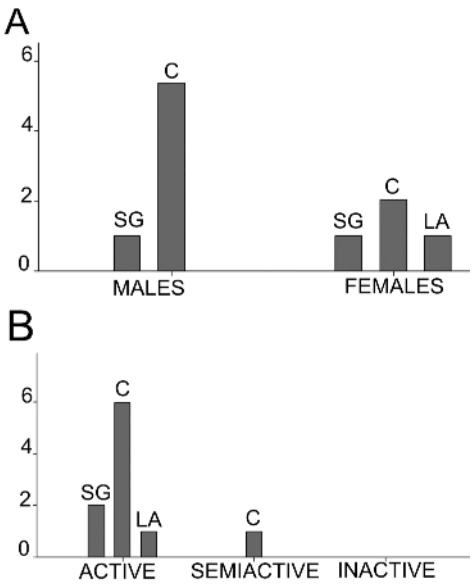


Fig. 2: (A) Proportion of males / females, and (B) proportion of active / inactive specimens of *Chelonoidis chilensis* (GRAY, 1870) found within and between transects. C - Copo NP; LA - La Amarga lagoon; SG - Salinas Grandes.

Abb. 2: (A) Verhältnis von Männchen zu Weibchen und (B) von aktiven zu inaktiven Exemplaren von *Chelonoidis chilensis* (GRAY, 1870), die innerhalb und zwischen den Transekten gefunden wurden. C - Copo Nationalpark; LA - La Amarga Lagune; SG - Salinas Grandes.

typical and very well conserved Arid Dry Chaco forest, dominated by xerophytic trees, with savannahs of "Aibe" herbs (*Elionurus* spp.) the last naturally absent at Tío Pozo. Human population density, roads, train rails and other ways are smaller or absent within Copo NP and surrounding areas when compared to Tío Pozo. In addition, the zone of Tío Pozo is one of the few remaining places at which tortoises are offered and sold by local people at the sides of the National Road 9 south of Loreto. This area is also part of the region from which wild tortoises were extracted at least since the 1960s (WALLER 1997) to satisfy the internal pet trade. Thus, forest degradation by livestock (but fortunately absence of large scale agriculture), presence of rural human populations, presence of domestic animals and formation of peridomestic "peladares" (i. e., family-run restaurants) (MORELLO et al. 2006) together with presence of an important net of roads and ways, and some urban centers (Loreto, Villa Atamísqui), increased the impact of the historical extraction of tortoises to satisfy pet trade. All these factors may explain the zero abundance value found at Tío Pozo when compared to the relatively high value of Copo NP.

Although not studied in the present work, the situation of tortoises from the Dry Chaco northern Córdoba localities may be similar to what was detected at Tío Pozo. These areas of northern Córdoba are highly impacted by transformation of forest into large scale agricultural landscapes mainly for soy production (MONTENEGRO et al. 2004), a situation that is not perceived at the zone of Tío Pozo due to the influence of salinitrous and low soils that make possible familiar cultivation of melons, watermelons and pumpkins, but prevents high scale agriculture. The small forests that remain at the north of Córdoba are highly fragmented and mainly unprotected, except by the Reserva Provincial Chancaní and Reserva Natural Laguna de Mar Chiquita. Fortunately, tortoise populations were recently reported for the Reserva Natural Laguna de Mar Chiquita and surrounding unprotected areas (BRIGUERA et al. 2006), whereas such records are not available for the Reserva Provincial Chancaní.

Finally, the authors wish to highlight a conservation issue related to the road access to the Copo NP at Paraje Río Muerto. At this point, seven tortoises were found on the road (four males, three females), three of which (two females, one male) had died recently, presumably by overheating, because tortoises were literally "caught by the road" due to the height (approximately 40 cm) and vertical inclination of the ditches' walls at some segments of the ways (500 m or more). Since tortoises that cross the road are caught by the ditches, they may die either by overheating (45 °C at midday near the soil) or become victims of opportunistic predators and, occasionally, human collectors.

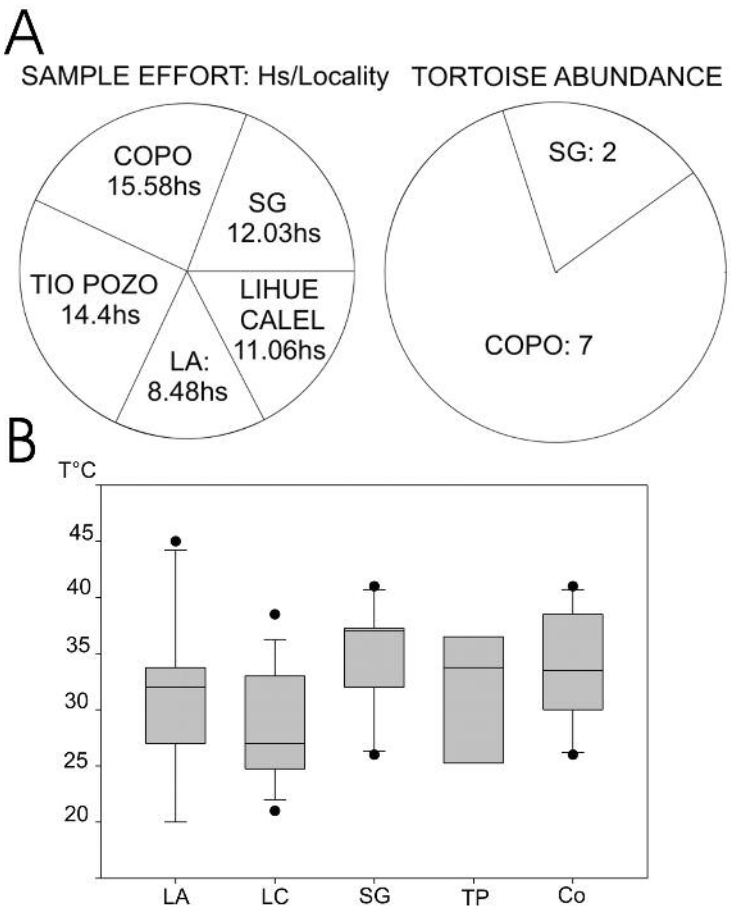


Fig. 3: (A) - Left pie chart represents the time effort spent at each study area and the right one shows the number of specimens of *Chelonoidis chilensis* (Gray, 1870) found in two of the five areas studied by transects. (B) - Temperature variations across the five areas sampled using transects. C - Copo NP; LA - La Amarga lagoon; LC - Lihue Calel NP; SG - Salinas Grandes; TP - Tío Pozo.

Abb. 3: (A) - Das linke Kuchendiagramm beschreibt die aufgewendete Zeit für jedes Studiengebiet und das rechte die Anzahl an Exemplaren von *Chelonoidis chilensis* (Gray, 1870), die in zwei der fünf mit der Transekt-Methode untersuchten Gebiete gefunden wurden. (B) - Temperaturschwankungen an den fünf mit der Transekt-Methode besammelten Studiengebieten. C - Copo Nationalpark; LA - La Amarga Lagune; LC - Lihue Calel Nationalpark; SG - Salinas Grandes; TP - Tío Pozo.

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AUTHORS: Julieta Sánchez < jsanchez@imbice.org.ar >[1], Leandro Alcalde < Corresponding author; alcalde@ilpla.edu.ar >[2], Alejandro Daniel Bolzán < abolzan@imbice.org.ar >[1], María Rocío Sánchez < rociomariasanchez@gmail.com >[2] & María del Valle Lazcóz < vallelazcoz@yahoo.com.ar >[3]

[1] Instituto Multidisciplinario de Biología Celular (IMBICE- CCT CONICET La Plata - CICPBA) CC 403 (1900) - La Plata, Argentina. [2] Instituto de Limnología "Dr. Raúl A. Ringuelet" (ILPLA-CCT CONICET La Plata) CC 712 (1900) - La Plata, Argentina. [3] Universidad Nacional de Lujan, Estudiante de Ciencias Biológicas.