

The Didelphimorphia (Didelphidae) of Reserva Natural Laguna Blanca, Departamento San Pedro, Paraguay

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► **Resumen** — “Los Didelphimorphia (Didelphidae) de la Reserva Natural Laguna Blanca, Departamento San Pedro, Paraguay”. Se reportan los resultados del inventario de los Didelphimorphia de la Reserva Natural Laguna Blanca, Departamento San Pedro, Paraguay. Se registró la presencia de seis especies y se aportan datos ecológicos y morfológicos para los ejemplares colectados. Entre los registros obtenidos, se destacan importantes extensiones de las distribuciones conocidas de *Marmosa (Micoureus) constantiae* Thomas, 1904 y de *Monodelphis kunsii* Pine, 1975, ambas especies recientemente documentadas en Paraguay y anteriormente conocidas a partir de muy pocos ejemplares en el país. Se discute la necesidad de más trabajos de inventario en Paraguay a fin de comprender mejor la distribución del grupo.

Palabras clave: *Monodelphis kunsii*, *Marmosa (Micoureus) constantiae*, inventario, *Gracilinanus*, *Cryptonanus*.

► **Abstract** — The results of the inventory of the Didelphimorphia of Reserva Natural Laguna Blanca, San Pedro Department, Paraguay, are presented. Six species are recorded as present and ecological and morphometric data are provided. Significant new range extensions of *Marmosa (Micoureus) constantiae* Thomas, 1904 and *Monodelphis kunsii* Pine, 1975 are detailed, since both species were recently documented in Paraguay and are known from very few specimens. The urgent need for further inventory work in Paraguay is discussed.

Key words: *Monodelphis kunsii*, *Marmosa (Micoureus) constantiae*, inventory, *Gracilinanus*, *Cryptonanus*.

INTRODUCTION

The Didelphimorphia is the most species-rich order of the Ameridelphia and are distributed from extreme southern Canada (Kays & Wilson, 2009) south to Santa Cruz Province in southern Argentina (Massoia *et al.*, 2000). Members of this family are frequently common in any given habitat, but are generally under-recorded because of their secretive habits, the small size of some species and, in many cases, the need for specialised methods of capture (Voss & Emmons, 1996). Though higher level taxonomy has been the subject of much historical debate, the most recent and complete revision of didelphid phylogeny by Voss & Jansa (2009) splits the single family of the order, Didelphidae, into four subfamilies, with the Di-

delphinae further being divided into four tribes. Representatives of two subfamilies have been documented as occurring in Paraguay, Caluromyinae (1 species) and Didelphinae (16 species), with all four tribes of the latter represented in the national fauna. A total of 17 species in 11 genera are documented as present in Paraguay (Smith, 2010), approximately 18.7 % of the total diversity of the family (Voss & Jansa, 2009).

Despite one of the longest histories of zoological investigation on the continent, dating back to the times of Félix de Azara (1742-1821), very little published data are available on the distribution of didelphids in Paraguay (De la Sancha *et al.*, 2007, 2011; Voss *et al.*, 2009), and very few specimens are available in collections. The most important national collection, that of the Museo Nacional de Historia Natural del Paraguay (MNHNP), contains just 177 didelphid spec-

imens (MNHNP database 2010 data), of which almost half (79 specimens - 44,6 % of the total) belong to just two common and widespread species *Didelphis albiventris* and *Monodelphis domestica*. A search for Paraguayan didelphid specimens in North American museums registered as part of the online MaNIS database project returns just 263 specimens, 129 of which (49 % of the total) represent the same two species. Furthermore, the Cerrado region of northeastern Paraguay has been largely overlooked by fieldworkers and its fauna is much less well-known than those of the country's other major eco-regions, the Atlantic Forest and the Chaco (Smith *et al.*, 2011; Smith *et al.*, 2012ab).

Here we provide a preliminary report on the species composition of a community of didelphids from a small private reserve of Cerrado and transitional subhumid forest in northeastern Paraguay, Reserva Natural Laguna Blanca (RNLB), representing the results of sustained inventory work on small mammals at this single site. Important new distributional information for two poorly known species recently documented as occurring in Paraguay (De la Sancha *et al.*, 2007; Voss *et al.*, 2009) is provided, along with data related to morphometry and, where available, ecological data associated with their capture.

METHODS

Fieldwork was conducted at Para La Tierra Ecological Station (PLT) located at Reserva Natural Laguna Blanca (S 23°48'45.4", W 56°17'41.7") in the Cerrado zone of northeastern Paraguay (Fig. 1). The RNLB is a small 804 ha reserve consisting of over 400 ha of near pristine Cerrado, a patch of degraded Atlantic Forest and some semi-deciduous transitional humid-dry gallery forest. The Reserve has an altitude of 204m above sea level and is based around the Laguna Blanca lake of 157 ha. A basic description of the area and its floral composition is provided in Guyra Paraguay (2008).

Broadly speaking, the Cerrado biome can be split into four categories or «ec-

otopes»: campo limpio (grassy field), campo sucio (grassy and bushy fields with scattered trees), cerrado *sensu stricto* (bushy fields with less grass and trees less scattered) and cerradón (cerrado dry forest/cerradão). These ecotopes represent observable trends in habitat types and are not associated with any specific floral communities, which may vary greatly in any given ecotope from one area to another (Eiten, 1972, 1978). Floral and faunal species diversity within any given patch of Cerrado is associated with the ecotope diversity rather than the total habitat area (Colli *et al.*, 2002; Nogueira *et al.*, 2005). The four main Cerrado ecotopes are present at RNLB and grow on a predominantly sandy substrate.

PLT fieldworkers based permanently at RNLB have been performing a year round small mammal mark-recapture project since February 2011. Pitfall traps with drift fences arranged in linear sequences of ten 20 litre buckets spaced five metres apart and square grids of 100 Sherman traps (7.5 x 9 x 23 cm) baited with peanut butter, biscuits, oats and vanilla essence and spaced 10 metres apart were the primary methods of capture. All habitat types within the reserve are being systematically sampled. Sherman traps are placed principally at ground level with arboreal (1-3 m high) and canopy (>10 m) traps also used occasionally. Sampling effort varies according to the requirements of the mark-recapture project, and although rodents are the main focus of the project, didelphids are occasionally captured. Voucher specimens of all species new to the reserve are collected to contribute towards the cross taxon inventory project at the RNLB and are housed in the registered Colección Zoológica de Para La Tierra (CZPLT) based at the reserve. All specimens were prepared as skin and skull, and a sample of tissue (liver) were collected, unless noted. Specimens were handled and sacrificed humanely following international guidelines on animal care (Romero-Almaraz *et al.*, 2007). Permits were provided by the Secretaría del Ambiente (SEAM, Paraguay).

Taxonomy follows Voss & Jansa (2009)

and the common names follow Gardner (2007). Identification to species level was possible in the majority of cases on external characters alone and confirmed using keys provided by Gardner (2007). External measurements were taken following Voss & Jansa (2009) and cranial measurements following Voss *et al.* (2004). With the exception of *Didelphis albiventris* (for which age classes are provided), all specimens cited are adult.

RESULTS

Twenty-eight specimens of six didelphid species have been collected at RNLB to date. Details of specimens with some ecological

data are provided below. External measurements of the specimens are provided in Table 1 and cranial measurements are provided in Table 2.

Tribe Marmosini,
Hershkovitz 1992

White-bellied woolly mouse-opossum
Marmosa (Micoureus) constantiae
Thomas, 1904 (Fig. 2)

De la Sancha *et al.* (2011) reviewed the distribution of this recently-recorded species in Paraguay with dispersed records from Chaco habitats in the Departments of Alto

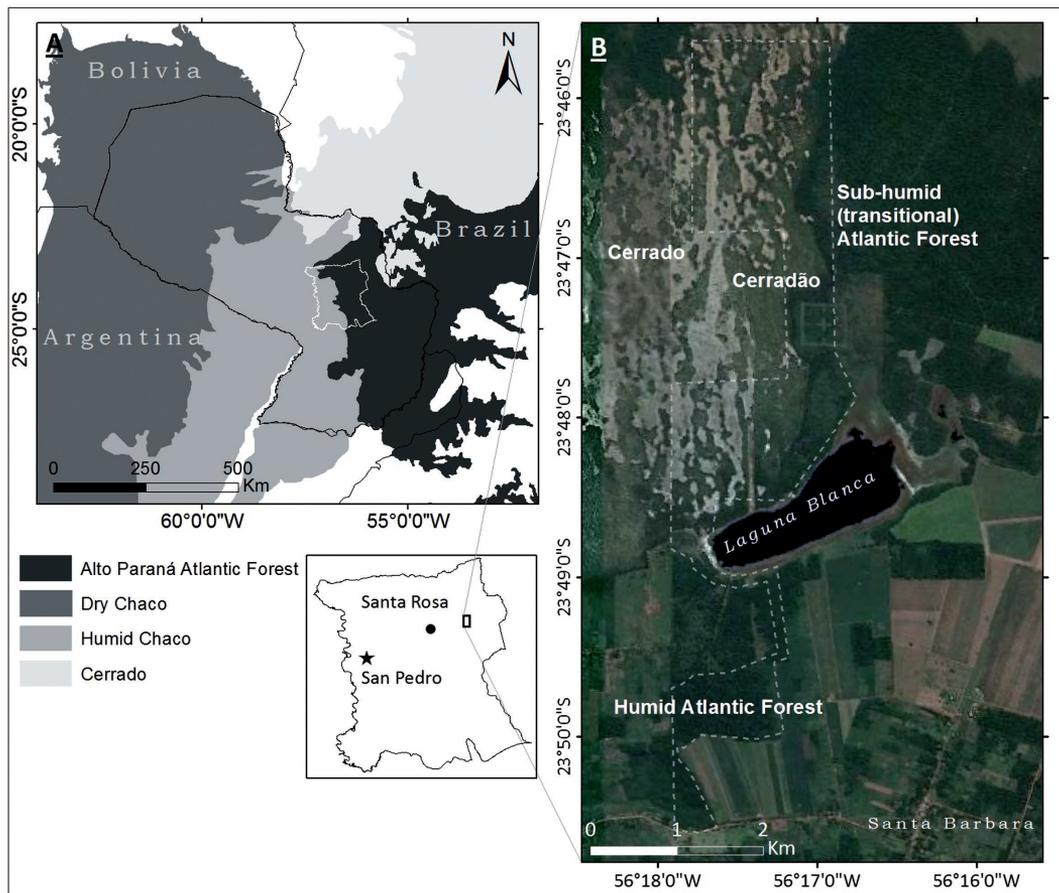


Figure 1. Map of the study area: (A) Major ecoregions of Paraguay and their extent in neighbouring countries; (B) Location of Reserva Natural Laguna Blanca (RNLB) in San Pedro Department, Paraguay, showing major ecotopes occurring there and the reserve boundaries (delineated with a dotted line). Ecoregion spatial data based on Olson *et al.* (2001).

Table 1. Morphometrics of Didelphimorphia specimens from RNLB (Reserva Natural Laguna Blanca). Specimens were deposited in the Colección Zoológica de Para La Tierra (CZPLT). Mean and ranges are provided for each measurement. Total length (TL), tail (TAIL), hind foot (HFL) and ear (EL) lengths are in millimetres, mass in grams. External measurements follow Voss & Jansa (2009).

Species	CZPLT Number	Sex	TL	TAIL	HFL	EL	MASS
<i>Marmosa constantiae</i>	012 (n=1)	Male	382	220	30.0	28.0	92
<i>Marmosa constantiae</i>	013, 014, 015 (n=3)	Female	335 (324-346)	199.3 (193-205)	24 (23-25)	25 (25-25)	53.7 (51-58)
<i>Monodelphis domestica</i>	011, 030 (n=2)	Male	197.5 (170-225)	74.5 (65-85)	19.3 (18.5-20)	23.3 (21-25.5)	55.5 (38.5-72.5)
<i>Monodelphis kunsii</i>	005, 215 (n=2)	Male	116.8 (114.5- 119)	39.8 (39.5-40)	11.3 (11-11.5)	10 (8-12)	7.5 (5-10)
<i>Didelphis albiventris</i>	010 (n=1)	Male (Age class 5)	680	340	54	60	779
<i>Didelphis albiventris</i>	023 (n=1)	Female (juvenile)	313	146	24	35	85
<i>Cryptonanus chacoensis</i>	020, 021, 022, 217 (n=4)	Female	192 (183-201)	111.3 (106-118)	15.8 (15-17)	17 (16.5-18.5)	14.5 (12-17)
<i>Gracilinanus agilis</i>	006, 017, 024, 025, 026, 027, 204, 207, 208, 209 (n=10)	Male	202.1 (164-233)	122 (95-135)	14.8 (13-16)	18.1 (16-20)	13.9 (10-16, n=9)
<i>Gracilinanus agilis</i>	016, 205, 210 (n=3)	Female	201 (164-236)	116.7 (100-135)	14 (13-15)	17.5 (15-21.5)	10.5 (9.5-11.5, n=2)

Table 2. Cranial measurements of selected adult specimens given to the nearest tenth of a millimetre. Measurements were taken following Voss *et al.* (2004). Abbreviations as follows CBL: Condyllo-base Length; NB: Nasal Breadth; LIB: Least Interorbital Breadth; ZB: Zygomatic Breadth; PL: Palatal Length; PB: Palatal Breadth; MTR: Maxillary Tooththrow Length; LM: Length of Molars; M1-3: Length of M1-M3; WM4: Width of M4.

Species	CBL	NB	LIB	ZB	PL	PB	MTR	LM	M1-3	WM4
<i>Marmosa</i>	40.5	4.4	6.3	23.7	22.9	13.0	16.2	8.4	6.9	2.8
<i>constantiae</i>	(n=1)	(3.6-5.1, n=2)	(5.8-6.8, n=2)	(n=1)	(n=1)	(12.7-13.3, n=2)	(15.8-16.6, n=2)	(8.2-8.5, n=2)	(6.9-6.9, n=2)	(2.7-2.9, n=2)
<i>Monodelphis domestica</i>	NA	5.1	5.4	NA	18.1	13.1	12.6	8.0	5.9	3.0
		(4.8-5.4, n=2)	(5.3-5.5, n=2)		(n=1)	(13.0-13.2, n=2)	(n=1)	(7.7-8.2, n=2)	(5.4-6.4, n=2)	(2.8-3.1, n=2)
<i>Monodelphis kunsii</i>	23.1	3.2	4.3	12.2	11.2	7.6	9.5	5.7	4.3	1.8
	(n=1)	(2.7-3.7, n=2)	(4.0-4.5, n=2)	(n=1)	(10.2-12.1, n=2)	(n=1)	(n=1)	(n=1)	(4.0-4.5, n=2)	(n=1)
<i>Cryptomys chacoensis</i>	25.8	3.1	4.6	14.0	12.7	7.9	9.5	5.1	4.5	1.9
	(25.7-25.9, n=2)	(2.9-3.4, n=3)	(4.4-4.8, n=2)	(13.1-14.5, n=3)	(11.3-13.5, n=3)	(7.9-8.0, n=3)	(9.5-9.5, n=2)	(4.9-5.3, n=4)	(4.2-4.8, n=4)	(1.8-2.0, n=4)
<i>Gracilinanus agilis</i>	25.5	3.9	4.6	14.2	13.6	8.9	9.9	5.7	4.7	2.1
	(21.6-29.5, n=7)	(2.9-4.8, n=9)	(4.0-5.4, n=10)	(12.5-17.0, n=7)	(11.6-16.1, n=7)	(7.4-10.1, n=9)	(7.9-11.0, n=9)	(5.2-6.7, n=9)	(3.9-5.5, n=10)	(1.9-2.4, n=6)

Paraguay (MNHNP 0481, 1659, 1660, FMNH 54404) and Presidente Hayes (km 155 of Ruta Transchaco, TK 121795), and from Cerrado in Amambay Department (33 km SE of Pedro Juan Caballero, MSB 67000). Though the collector's notes for TK 121795 state that the locality is in Departamento Boquerón, it is in fact well within Presidente Hayes Department. Five specimens have been collected in above ground Sherman traps at heights of 1 to 3m at RNLB, all in the semi-deciduous, transitional gallery for-

est that runs along the shores of the lake. To date it has not been captured in open habitats or in any Cerrado ecotopes.

De la Sancha *et al.* (2011) comment that the specimen MSB 67000 from the Cerrado zone of Amambay Department is somewhat larger than the Chaco specimens they cite, but small sample size prevents further statistical analysis. However, the specimens reported here from this single locality show similar variations in body size to those reported by De la Sancha *et al.* (2011) from



Fig 2. CZPLT 014 *Marmosa constantiae* (Helen Pheasey).

across Paraguay. The RNLB records extend the known distribution of the species in Paraguay by approximately 128 km to the southwest, substantially closing the gap between the known ranges of this species and the congeneric Atlantic Forest endemic *Marmosa (Micoureus) paraguayana* (De la Sancha *et al.*, 2011).

Specimens: CZPLT 012, 013, 014, 015.

Grey short-tailed opossum
Monodelphis domestica
(Wagner, 1842) (Fig. 3)

Specimen CZPLT 011 is a large male captured on the ground in a Sherman trap on 17 July 2011, in humid, Atlantic-type Forest. Though this is one of the most common didelphids in Paraguayan collections and apparently widely distributed throughout the arid Chaco and Cerrado regions of Paraguay (Boquerón, Alto Paraguay, Concepción,

Amambay and Canindeyú Departments), this is the first specimen recorded from Departamento San Pedro. A second specimen CZPLT 030 was captured by hand inside a human dwelling on 30 December 2011. This commensal behaviour has previously been reported in Brazil (Macrini, 2004) and is the origin of the specific epithet «domestica», but we are unaware of previous reports of this behaviour in Paraguay. Additional specimens have been captured and released.

Specimens: CZPLT 011, 030.

Pygmy short-tailed opossum
Monodelphis kunyi
Pine, 1975 (Fig. 4)

Specimen CZPLT 005 is a male captured in a pitfall trap on 24 November 2011 in semi-deciduous transitional humid to dry gallery forest in an area of sandy soil Cerrado habitat. A second specimen CZPLT 215



Fig 3. CZPLT 030 *Monodelphis domestica* (Helen Pheasey).

was captured in a pitfall trap located in Cerrado *sensu stricto* within 1 km of CZPLT 005. These represent the fourth and fifth records of the species in Paraguay and the first for San Pedro Department. De la Sancha *et al.* (2007) documented the previous Paraguayan specimens, one from Filadelfia, Boquerón Department in Dry Chaco habitat (FMNH 164094), and two from Aguara Ñu, Mbaracayú Biosphere Reserve, Canindeyú Department (TK 67127 and TK 121105) captured in dwarf palm Cerrado. The species is rare in collections and despite a generalist habitat preference, it apparently occurs at low densities throughout its wide geographic range, leading to the suspicion that a species complex is in fact involved (De la Sancha *et al.*, 2007; Solari, 2010; Gettinger *et al.*, 2011). Pine & Handley (2007) noted the variation in ventral colouration between specimens. The RNLB specimens differ from previous Paraguayan specimens in having the pale ventral colouration reduced to a thin, whitish longitudinal mid-ventral stripe extending from the chest to the mid belly, su-

perificially more similar in fact to the ventral pattern shown by the specimen reported by Gettinger *et al.* (2011) from Amazonia. The RNLB specimens lie geographically between the previously reported localities for the species in Paraguay.

Specimens: CZPLT 005, 215.

Tribe Didelphini,
Gray 1821

White-eared opossum
Didelphis albiventris
Lund, 1840 (Fig. 5)

The largest and most widespread of the Paraguayan Didelphidae, *D. albiventris* is a habitat generalist that is able to tolerate a wide degree of habitat disturbance (Smith, 2007). Mares *et al.* (1989) recorded them in all major Cerrado ecotypes in Brazil, and at RNLB the species is commonly observed at night in the anthropomorphic areas around the PLT Ecological Station. Specimen CZPLT 010 is a male manually collected on 29 June



Fig 4. CZPLT 005 *Monodelphis kunsii* (Helen Pheasey).

2010, in a cleared area close to PLT headquarters. According to the morphometric data provided by Cáceres & Monteiro-Filho (1999) it corresponds to a young adult 9 to 16 months old, equivalent to dental class 5 of Tyndale-Biscoe & MacKenzie (1976). CZPLT 023 is a recently-independent infant female (younger than the age classes of Cáceres & Monteiro-Filho, 1999), collected on 14 October 2011, in a Sherman trap. Additional individuals captured in Sherman traps in Cerradón were not collected.

Specimens: CZPLT 010, 023.

Tribe Thylamyini, Hershkovitz 1992

Chacoan mouse opossum
Cryptonanus chacoensis
(Tate, 1931) (Fig. 6)

Specimens were identified as *Cryptonanus* on the basis of the P2 being smaller than the P3, presence of accessory cusps on the canines, self-coloured bases to ventral fur, tail scales ordered in annular rows and cranial

characters (Voss *et al.*, 2005; Gardner, 2007). Images of the skull of CZPLT 020 are online in the Fauna Paraguay database (FPMAM1044-1046PH), clearly showing the dental characteristics of the genus (Fauna Paraguay, 2012a). Three female specimens were taken in pitfall traps set in semi-open scrub at the edge of degraded Atlantic Forest, with a covering of ground bromeliads and patches of open sandy soil. A fourth specimen, a lactating female CZPLT 217 (14 March, 2011), was captured in a pitfall trap located in a reed bed on the edge of dry transitional forest. Female specimen CZPLT 022 (9 September, 2011) had an open vagina, other specimens showed no signs of reproductive activity.

Specimens: CZPLT 020, 021, 022, 217.

Agile gracile opossum
Gracilinanus agilis
(Burmeister, 1854) (Fig. 7)

Specimens were identified as *Gracilinanus agilis* on the basis of P2 and P3 being of equal height, no accessory cusps on the canines,



Fig 5. CZPLT 023 *Didelphis albiventris* (Helen Pheasey).

grey-based belly fur with self-based fur on the chin, throat and chest, a tail to head and body ratio of between 1.3 and 1.5, tail scales ordered in annular rows and cranial characters (Voss *et al.*, 2005; Gardner, 2007). Images of the skull of CZPLT 205 are online in the Fauna Paraguay database (FPMAM1068-1070PH) clearly showing the dental and cranial characteristics of the genus (Fauna Paraguay, 2012b). This species is typical of the Cerrado biome (Geise & Astúa, 2009) and all specimens ($n = 13$) were captured in arboreal Sherman traps at heights of 1.5 - 2 m in the semi-deciduous transitional forest where it appears to be common. Female specimen CZPLT 016 (3 February, 2011) had an open vagina and CZPLT 205 (9 January, 2011) was lactating. Other specimens showed no signs of reproductive activity.

Specimens: CZPLT 006, 016, 017, 024, 025, 026, 027, 204, 205, 207, 208, 209, 210.

DISCUSSION

The species composition reported here for RNLB is typical of Cerrado assemblages from neighbouring Brazil (*e. g.* Mares *et al.*, 1989; Bonvicino *et al.*, 2002, 2005). However, the species recorded to date are unlikely to represent a complete inventory of the family at the site. Hannibal & Cáceres (2010) have previously stressed the importance of thoroughly sampling the vertical strata in order to fully record small mammal communities within the Cerrado biome. As the field work was not specifically designed for the capture of didelphids, sampling methods are biased towards the recording of small or conspicuous species, and with considerably more terrestrial than arboreal trapping effort, the true diversity is likely underestimated. Medium-sized terrestrial and arboreal genera that are potentially present in the reserve, such as *Caluromys*, *Chironectes*,



Fig 6. CZPLT 021 *Cryptonanus chacoensis* (Helen Pheasey).

Lutreolina, *Metachirus* and *Philander* would be unlikely to be detected using these sampling methods, while the presence of *Thylamys macrurus* might be expected as the reserve lies within the presumed Paraguayan range of the species (Smith, 2009) and contains habitat similar to that of Brazilian localities where the species has been recorded (Carmignotto & Monfort, 2006; Cáceres *et al.*, 2007).

Regardless of this, chronic undersampling of didelphids in Paraguay means that the species list for the RNLB is one of the most complete single site lists for any reserve in Paraguay. By means of comparison, the largest Cerrado National Park in the country, Cerro Corrá (12.038 ha), boasts a species list half the size of that published here for the much smaller RNLB (Voss *et al.*, 2009). The two most biodiverse reserves in the country, PN San Rafael (74.800 ha) and Mbaracayú Biosphere Reserve (77.644 ha) have comparable length lists of 6 and 7 species respec-

tively, that without doubt greatly underestimate the true diversity present in those areas (Guyra Paraguay Biodiversity Database, unpublished data). Faunal inventories are still in their initial stages in Paraguay, and our understanding of didelphid distribution and the effectiveness of proposed conservation strategies for these and other taxa are chronically hampered by a lack of data.

ACKNOWLEDGEMENTS

Thanks to all the Para La Tierra volunteers and interns who have worked on the mark recapture project during which the specimens cited here were collected. Robert Owen and Texas Tech University provided academic assistance and very kindly arranged the loan of scientific equipment used in the mark recapture project. Without this agreement such work would not have been possible. Many thanks to Malvina Duarte the owner of Reserva Natural Laguna Blanca for



Fig. 7. CZPLT 209 *Gracilinanus agilis* (Helen Pheasey).

her continued backing of Para La Tierra and their field work. Particular thanks to the Secretaria del Ambiente del Paraguay for granting permissions allowing Para La Tierra to carry out its mission to make RNLB a model reserve in Paraguay.

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