GREY SHORT-TAILED OPOSSUM
Monodelphis domestica (Wagner, 1842)

FIGURE 1 - Adult, Brazil (Nilton Cáceres undated).

TAXONOMY: Class Mammalia; Subclass Theria; Infraclass Metatheria; Magnorder Ameridelphia; Order Didelphimorphia; Family Didelphidae; Subfamily Marmosinae; Tribe Monodelphini (Myers et al 2006). Twenty-nine species are recognised in this genus, three are present in Paraguay. The scientific name *Monodelphis* is from the Greek meaning "single womb" referring to the lack of a pouch (Palmer 1904), *domestica* is Latin for "domestic" derived from the species habit of entering human dwellings (Braun & Mares 1995).

Assigned to the dryland *brevicaudata* species group within *Monodelphis* by Solari (2010).

The species is monotypic. Wetzel & Lovett (1974) mistakenly regarded *Didelphys brevicaudis* as a senior synonym of this species. Synonyms adapted from Macrini (2004) and Gardner (2007):

Didelphys domestica JA Wagner 1842:359 Type Locality "Cuayaba", Mato Grosso, Brazil.

Hemiurus hunteri P.Gervais 1856:101. Name combination. Not *Didelphys hunteri* Waterhouse (1841).

Hemiurus concolor P.Gervais 1856:pl.16. New name combination.

[*Didelphys* (*|Microdelphys/*)] *domestica* Burmeister 1856:87. Name combination.

Didelphys [(*Peramys*)] *domestica* O.Thomas 1888:358. Name combination.

Hemiurus domesticus Winge 1893:55. Name combination.

P[*eramys*]. *domesticus* O.Thomas 1897:220. Name combination.

Peramys domestica Heck 1912:14 Name combination.

[*Didelphis* (]*Monodelphis*[)] *concolor* Matschie 1916:271. Name combination.

[*Didelphis* (]*Monodelphis*[)] *domestica* Matschie 1916:272. Name combination.

Monodelphis domestica Pohle 1927:240. First use of current name.

Monodelphis domestica domestica Cabrera 1958:8. Name combination.

Monodelphis brevicaudis brevicaudis Wetzel & Lovett 1974:206. Not *Didelphys brevicaudis* Olfers (1818).

Monodelphis domesticus Mello 1977:391 Name combination and incorrect gender.

ENGLISH COMMON NAMES: Grey Short-tailed Opossum (Wilson & Cole 2000), Grey-faced Opossum (Macrini 2004), Short Bare-tailed Opossum (Macrini 2004, Streilein 1982a), Brazilian Bare-tailed Opossum (Unger 1982), Plain Bare Tail (Canevari & Balboa 2003), Gray Opossum (Fadem 1985), South American Opossum (Kusewitt et al 1997), Brazilian Gray Short-tailed Opossum (Kuehl-Kovarik et al 1994).

SPANISH COMMON NAMES: Colicorto gris (Emmons 1999), Colicorto chaqueño (Massoia et al 2000), Catita (Massoia et al 2000, Colicorto domestico (Canevari & Balboa 2003).

GUARANÍ COMMON NAMES: Anguja mykure (Esquivel 2001), Mbicuré-í (Massoia et al 2000).

DESCRIPTION: Pelage short, dense and smooth, somewhat uniformly brownish-grey though paler and more creamy-white towards the cheeks and venter, often with a slight yellowish tinge. Some individuals may show indistinct olive-speckling to the dorsum and/or paler flanks. Pelage is fluorescent under ultra-violet light, that of study skins reddish-purple dorsally and reddish-orange ventrally. Naked nose pinkish, ears are large and greyish. Semi-prehensile tail short and thick-based, dark brown above and paler below and at the tip. It is furred at the basal 25% of its length and naked for the rest. Extremities pinkish. Females lack a pouch and usually possess 13 nipples, though in some the most anterior may be absent and they may have only 11 or 12. Males possess a suprasternal gland.

CRANIAL CHARACTERISTICS: Skull of adult males larger than that of females, but female skull bones grow faster because of a shorter growing period. Well-developed sagittal crest. *Basal Length:* 35.7mm; *Premaxillary-Condylar Length:* 38.7mm (26.7-44.7mm); *Greatest Width*: 19.8; *Greatest Zygomatic Width*: 20.8mm (14.3-25mm); *Mandible Length*: 28.8mm (19-34.4mm); *Length of Nasals*: 17.8mm; *Maximum Nasal Width*: 4.6mm; *Minimum Nasal Width*: 2.3mm; *Inter-temporal Constriction:* 6mm; *Palate Length:* 20.3mm; *Palate Width Inside M3:* 12.1mm: *Palate Width Outside M3:* 7.1mm; *Length of Palatal Vacuities:* 2.9mm; *Basisphenoid + Basioccipital Length*: 12.6mm. (Macrini 2004).

Mares et al (1989) give the following measurements for 2 adult females from central Brazil: *Greatest Length of Skull* 32.3-33.9mm; *Condylobasal Length* 29.1-31mm; *Interorbital Width* 5.5-5.8mm; *Zygomatic Width* 17.5-17.9mm; *Width of Braincase* 11.7-11.9mm; *Mastoid Width* 12.8mm; *Palate Length* 17.3-18.4mm.

Clark & Smith (1993) give a detailled account of the osteogenesis of cranial bones in this species. The premaxillae, maxillae, palatines, pterygoids, mandibles, and exoccipitals are all present at birth. The neurocranial bones ossify relatively slowly following a long period of brain growth, but the rapid development of the bones of the oral cavity is probably to facilitate suckling.

Sanchez-Villagra (2002) described the development of the subarcuate fossa and the cerebellar paraflocculus. Macrini et al (2007) described the individual and ontogenetic variation in cranial endocasts in this species. Smith (1994) describes the development of the craniofacial musculature of this species.

DENTAL CHARACTERISTICS: I5/4 C1/1 P 3/3 M 4/4 = 50. Molars are tribosphenic. *Length M1-M3*: 6.6mm. (Macrini 2004). Mares et al (1989) give the following measurements for 2 adult females from central Brazil: *Length of Upper Tooth Row* 14mm.

Van Nievelt & Smith (2005) documented tooth eruption in this species as related to ageing, noting that whilst tooth emergence is subject to individual variation, the eruption of the upper molars is not. As a result they defined their class boundaries based on the eruption of the upper molars with the following results for live specimens: *Dental Class 0* (0-31 days) no teeth emerged; *Dental Class 1* (32-48 days) M1 erupts at approximately 35.8 days; *Dental Class 2* (49-81 days); M2 erupts at 49 days; *Dental Class 3a* (82-107 days) M3 erupts at 83 days; *Dental Class 3b* (108-125 days) Sees the eruption of p3 (at 108 days) and P3 (at

111 days); *Dental Class 4* (>125 days). These dental classes varied slightly for preserved or defleshed skulls *Dental Class 0* (<46 days), *Dental Class 1* (46-55 days), *Dental Class 2* (56-97 days), *Dental Class 3* (98-133 days) and *Dental Class 4* (>133 days).

GENETIC CHARACTERISTICS: 2n=18, FN=20. X chromosome smaller than autosomes. Eight pairs of autosomes including one large pair of submetacentrics (pair 1) and six pairs of agrocentrics/subtelocentrics. (Svartman & Vianna-Morgante 1999). Ag-NORs were only present in the telomeric region of the short arm of the X chromosome. (Carvalho et al 2002). Zakharova et al (2011) demonstrated that the inactive X chromosome is hypomethylated at H3K4 and hypoacetylated at H3K9.

The G-band and C-band patterns were described by Merry et al. (1983) and Pathak et al. (1993). Margulies et al (2005) present the sequencing and comparative analysis of a 1.9 megabase (Mb) region from this species, finding that approximately 34% of the marsupial genome is alignable with the human genome (Wakefield & Graves 2005). Gouin et al (2005) isolated and characterized 26 polymorphic microsatellite markers in this species. Belov et al (2007) report the identification of key immune genes, including the highly divergent chemokines, defensins, cathelicidins, and Natural Killer cell receptors.

Although the species diverged from Australian marsupials some 70 million years ago, the karyotype was highly conserved in relation to the comparative study species (*Sminthopsis crassicaudata, Macropus eugenii, Trichosurus vulpecula*). Five chromosomes (pairs 1, 2, 5, 8 and the X) were conserved between this species and the presumed ancestral 2n=14 Australian ancestral karyotype (Rens et al 2001).

This species is becoming an increasingly prominent study subject in genome studies. Comparative analyses using the opossum genome have provided a wealth of new evidence regarding the importance of noncoding elements in the evolution of mammalian genomes, the role of transposable elements in driving genomic innovation, and the relationships between recombination rate, nucleotide composition, and the genomic distributions of repetitive elements. The genome sequence is also beginning to enlarge our understanding of the evolution and function of the vertebrate immune system, and it provides an alternative model for investigating mechanisms of genomic imprinting. The availability of the genome sequence is fostering the development of new research tools for physical and functional genomic analyses of *M. domestica* that are expanding its versatility as an experimental system for a broad range of research applications in basic biology and biomedically oriented research. (Samollow 2008).

The genome of the gray short-tailed opossum *Monodelphis domestica* is notable for its large size (c3.6 Gb). Gentles et al (2012) characterised nearly 500 families of interspersed repeats from the *Monodelphis*, covering approximately 52% the genome. In comparison to other mammals, *Monodelphis* is significantly rich in non-LTR retrotransposons from the LINE-1, CR1, and RTE families, with >29% of the genome sequence comprised of copies of these elements. *Monodelphis* has at least four families of RTE, and there is support for horizontal transfer of this non-LTR retrotransposon. In addition to short interspersed elements (SINEs) mobilized by L1, several families of SINEs that appear to use RTE elements for mobilization were found. In contrast to L1-mobilized SINEs, the RTE-mobilized SINEs in *Monodelphis* appear to shift from G+C-rich to G+C-low regions with time. Endogenous retroviruses have colonized c10% of the opossum genome and their density was enhanced in centromeric and/or telomeric regions of most chromosomes. A total of 83 new families of ancient repeats that are highly conserved across amniotic lineages were identified, including 14 LINE-derived repeats; and a novel SINE element, MER131, that may have been exapted as a highly conserved functional noncoding RNA, and whose emergence dates back to c300 million years ago. Many of these conserved repeats are also present in human, and are highly over-represented in predicted *cis*-regulatory modules. Seventy-six of the 83 families are present in chicken in addition to mammals.

TRACKS AND SIGNS: Well-developed curved claws and small digital pads (Macrini 2004).

EXTERNAL MEASUREMENTS: Easily the largest of the Paraguayan Short-tailed Opossums. Adult males larger than females. **TL:** 21.23cm (17.8-27cm); **HB:** 14.32cm (12.3-20cm); **TA:** 6.91cm (4.6-10.6cm) approximately 50% of body length; **FT:** 1.77cm (1.4-22cm); **EA:** 1.98cm (1.4-2.8cm); *Distance from Muzzle to Eye* 1.73cm; **WT:** 71.4g (36-93g) As much as 100-150g in captivity where males may be considerably heavier than females. Females stop growing upon reaching sexual maturity though males continue to grow on beyond it. Growth in length is finite but mass increases through life. **WN:** 0.10g. (Massoia et al 2000, Macrini 2004, Eisenberg & Redford 1999, Emmons 1999).

Mares et al (1989) give the following measurements for 2 adult females from central Brazil: **TL:** 17.5-18cm; **TA:** 5.8-6.5cm; **FT:** 1.7-1.8cm; **EA:** 2-2.2cm; **WT:** 32-46.5g.

SIMILAR SPECIES: Much the largest of the Paraguayan Short-tailed Opossums and with the most uniformly brownish-grey colouration. *Monodelphis sorex* is distinctly reddish in colouration, particularly on the head, rump and sides, which immediately separates it. On average it is almost twice the size of *Monodelphis kunsi*, with longer fur and proportionately longer ears. Note also the reddish-brown pelage of the smaller species. Cranially it has a much larger skull with a pronounced sagittal crest, the latter character absent in *M.kunsi*.

DISTRIBTUTION: Widely distributed through the caatinga belt of Brazil south of the Amazon, into eastern Bolivia, across northern Paraguay and into the Chaco of northern Argentina where it is apparently restricted to Provincia Formosa (Barquez et al 2006). Flores (2006) maps the species for the Humid Chaco of Argentina but Chebez (2009) considers this an error.

Brown (2004) notes the species in Bahía, Ceará, Goiás. Mato Grosso, Mato Grosso do Sul. Minas Gerais. In Bolivia there are records from Beni, Chuquisaca, Santa Cruz and Tarija (Anderson 1997). In Paraguay there are specimens from the cerrado and chaco regions of Departamentos Boquerón, Alto Paraguay, Concepción, Amambay, Canindeyú and San Pedro (Smith et al 2012).

HABITAT: Typical of xeric habitats, being found in the cerrado and Paraguayan Chaco where it inhabits cerradón, subhumid forest, cerrado scrub and chaco woodland. In central Brazil it is apparently most numerous in rocky areas in the caatinga (Mares et al 1989) though it is ubiquitous throughout the region, even being trapped in cultivated and abandoned agricultural fields (Streilein 1982d). Also in more open, grassy habitats, including recently-burned areas. (Macrini 2004) and occasionally close to or even inside human habitation (Smith et al 2012).

In the cerrado zone of Goiás, Brazil Bonvicino et al (2002) found the species in gallery forest, hill forest, semi-deciduous forest, cerrado sensu stricto, wet grasslands and rocky cerrado. They considered it to be a common and widespread species occurring in conserved and altered vegetation with no restriction on habitat within the cerrado biome.

ALIMENTATION: Carnivorous. A voracious hunter of invertebrates and small vertebrates including rodents, lizards, frogs and snakes, able to take prey of similar body mass to its own (Streilein 1981a). They may take fruit and carrion when available.

Foraging Behaviour and Diet The sense of smell is used to detect food, the nose often being inserted into the substrate whilst sniffing. Prey is captured with the forefeet after a rapid pounce and vertebrates are killed with a bite to the back of the neck. Prey is often manipulated in the forefeet prior to consumption. Streilein (1981a) notes that flying insects can be taken from the air and that scorpions are first pinned with the forefeet and the last few segments of the tail bitten off prior to consumption, with the head head being eaten first and the appendages removed in the process. There is no direct evidence proving that wild individuals require access to drinking water. Streilein (1982b) gives the maximal urine concentration for this species as 3285 milliosmols per litre.

Diet in Captivity Domestic individuals fed on commercially-available fox-food pellets performed better than those on a meat diet (Macrini 2004). Unger (1982) maintained captive individuals on a diet of mealworms, orange, banana, evaporated milk, ground beef mixed with egg white and wheatgerm and a vitamin supplement. Astúa de Morães et al. (2003) experimentally tested the proportions of protein, lipid, carbohydrate and fibre in the diet of adults (n=18) and juveniles (n=11) of this species under laboratory condtions. Mean proportions per 100g dry weight of food were: protein ad. 4.37g (+/-1.04), juv. 1.24g (+/-0.94); lipid ad. 0.88g (+/-0.51), juv. 0.15g (+/-0.11); carbohydrate ad. 2.03g (+/-1.31), juv. 1.91g (+/-1.62); fibre ad. 1.03% (+/-0.57), juv. 2.13% (+/-0.75). Santori et al (2004) described and illustrated the gut morphology of this species and associated it with dietary habits.

Halpern et al (2005) experimentally suggested that the vomernasal system was important in food preference in this species. Preoperative individuals showed a strong preference for meat over fruit, but postoperatively they showed no preference for one over the other. Laboratory animals urinate in smaller quantities than similarly-sized rodents (Zuri et al 2007).

Kushwaha et al (2004) noted that laboratory opossums showed considerable variation in their response to dietary lipids and that this variation was due to a single major gene. An experiment was performed in which resistant and susceptible lineages were subjected to diets that were high in cholesterol with or without high saturated fat from lard or coconut oil. It was concluded that the gene affects the response to dietary cholesterol but not to saturated fat.

Smith et al (2012) captured the species in Sherman traps baited with peanut butter, biscuits, oats and vanilla essence.

REPRODUCTIVE BIOLOGY: Captive breeding studies of specimens collected in the Brazilian caatinga make this one of the most well-known small opossums. Captive individuals breed happily in cages 43 x 22 x 13cm with a small nest box 18 x 13 x 10cm, a covering of wood-shavings on the floor and an ambient temperature of between 23.5 and 26.5ºC. Captive populations may produce up to four annual litters. Switching males following mating acts to reduce female violence and males must be removed upon birth of the litter (Trupin & Fadem 1982). Upon reaching sexual maturity the siblings must be separated. Onset of reproductive decline begins earlier in females (18-24 months) than males (24-30 months). (Bergallo & Cerquiera 1994, Macrini 2004).

Seasonality It breeds throughout the year in the Chaco and Brazilian caatinga producing at least two litters and occasionally as many six annually. Streilein (1982c) found lactating females in 8 of the 10 months sampled in the caatinga and considered it a year-round polyestrous breeder. Breeding is seasonal in Bahía, Brazil, and coincides with the wet season, with females becoming reproductively active once they reach Age Class 5. A population peak is reached in July in Pernambuco, Brazil (Bergallo & Cerquiera 1994).

Courtship Trupin & Fadem (1982) described courtship in captive individuals. Initial interactions between male and female consist of genital sniffing and face-to-face contact is avoided. Should it occur the pair may turn away and move apart or else respond antagonistically with open-mouthed threat displays. Males would then reapproach from behind, avoiding eye contact. Typically the female will then walk away with the male following, though aggressive males will restrain the female with the forefoot whilst attempting to sniff her genitals. Nonreceptive females attempt to flee or respond aggressively. Receptive females allow the male to restrain them with the forepaw and turn parallel to them. Genital sniffing follows and the female then begins to move away, inviting the male to follow, still attempting to lick and sniff her genitals. Periodically she stops and faces the male and if the male ceases the chase, the female follows him, again inviting him to pursue her. Females often drag the rump which, though apparently an attempt to conceal the genitals, acts to intensify the male pursuit. Similarly a hunched posture with short, delicate steps had a similar effect on males. Genital investigation continues and eventually leads to biting of the fur on the flanks and rump, occasionally leading to a brief outbreak of fighting after which the female would break away. Biting was accompanied by spitting vocalisations from the female. If the male did not follow, the female again sought to incite pursuit. The whole procedure was repeated four or five times over a period of 5 to 7 minutes.

Copulation occurred at the end of these sequences, the male swinging his hindquarters around and mounting the female. He grasped the midsection anterior to the pelvis with his forepaws and immobilised the ankles of the female with his hindpaws using the opposable hallux. The pair than fall to the side (the right side in 70% of cases) and the male began to thrust, thrusting being more vigorous prior to penetration and shallow and more measured afterwards. Thrusting took place for a period of 4 to 7 minutes with several rest periods, the male kneading the sides of the female who remained immobile with mouth open. Prior to termination the male thrusts with more force, then stopped, dismounted and moved away. A lock of the penis into the vagina was noted, with the male tugging to release himself for 1 to 3 seconds in 60% of observed copulations, whilst in one case the male dragged the female backwards for 5 seconds as he sought to free himself. Following copulation both animals groomed their genital area for 10

to 15 seconds. No further sexual encounters took place and approach of either individual was repelled with open-mouthed threats or retreat to the nest box.

Female receptivity lasted about 36 hours. By 48 hours after the initiation of receptivity females showed increased aggressive responses and would attack males after 2 to 3 minutes of genital sniffing.

Fadem & Rayve (1985) document in detail the oestrous cycle of this species based on vaginal smears. Oestrous was identified by a sudden proliferation of epithelial cells that lasted 3 to 12 days and was then followed by leucocytic infiltration. Mean length of the period of oestrous was 5.9 days (+/- 2.1 days) and mean oestrous cycle length was 26.3 days (+/- 9.2 days). However variability in the oestrous cycle length was attributed to a bimodal distribution of 14.4 days (+/.2.8 days, range 11-17 days, n=5) and 32.3 days (+/.3.4 days, range 28-39 days, n=10). Length of the period of oestrous however did not vary regardless of the cycle length. Oestrous periods occurred in synchrony and were induced by the presence of a male.

Oestrous period following the introduction of a male was 4 to 8 days, though one female already in oestrous when a male was introduced showed an oestrous period of 12 days. Under captive conditions 75% of matings occurred within 9 days of the introduction of a male and 91.6% within 13 days. Females also came into reproductive condition 3 to 7 days after they were permitted to have sensory contact with a male, even if mating was subsequently prevented. As a result the presence of males affects oestrus, ovulation and pregnancy in this species. Animals housed alone for long periods become reproductively inactive. However not all females are physiologically responsive to males, and 54% of the females in one group failed to produce litters whilst 43% of females in a second group failed to enter oestrus despite being paired with males. (Fadem 1985).

Fadem (1987) experimentally demonstrated that pheromonal cues from intact males induced oestrous in 75-100% of females, whilst cues from females and castrated males resulted in just 25% of females entering oestrous. The females were not exposed to the other animals themselves, but to the cages which they had recently inhabited. This mechanism allows females to rapidly enter into reproductive condition in the presence of a male. Though the identity of the pheromone was unknown, it was identified as at least partially androgen-dependent and possibly related to secretions from the suprasternal gland of males, as the gland disappears following castration.

Pregnancy No females weighing less than 50g exhibited signs of reproduction in the Brazilian caatinga (Streilein 1982c). Fadem (1985) noted that 75% of litters were born 19 to 24 after pairing and 16.6% were born 26 to 28 days after pairing. The remaining 8.4% were born 36 to 39 days after pairing.

In the laboratory c86% of matings occurred in the dark phase of the laboratory-controlled mating cycle. Ovulation occurs 18-20 hours after mating, stimulated by contact with the male, and conception 2 hours later. (Macrini 2004). The gestation is 14 to 15 days, new-borns being c1cm long, altricial and immediately attaching to a nipple. Litters in wild populations in the Brazilian caatinga contain 6 to 11 offspring, with an average of 8.4 (Streilein 1982c). In captivity litters of 3 to 14 have been reported with an average of 7. The juveniles are attached to the nipple for 2 weeks before being transferred to the nest or carried on the mother´s back. (Macrini 2004). Periods as short as 7 to 8 weeks have been recorded between pregnancies in the Brazilian caatinga (Streilein 1982c).

Development Neonates that fall from the nipple are not retrieved by the mother, but older young which fall from her back are retrieved. Hair growth begins at 18-21 days and the eyes open at 28-35 days. Once hair has begun to grow the mother grooms her offspring using her tongue, teeth and forefeet. Wounds incurred prior to postnatal day 9 heal without scarring. Juveniles are capable of taking solid food at 4 to 5 weeks and captive juveniles can be successfully separated from the mother at 7 weeks. Typically weaning occurs at 8 weeks. The parent recognises her own young by their scent. A minimum of 7 to 8 weeks passes between litters. Sexual maturity is reached at 5 to 7 months, and captive individuals were able to reproduce at 15 months. (Redford & Eisenberg 1999, Macrini 2004).

Harder & Jackson (2003) demonstrated the young females come into oestrous earlier if they have been exposed to male pheromones. Females that were exposed to male pheromones at 90 days were larger on average by 130 days (63.5g +/-1.1g) than those that had not been exposed (56.6g +/- 1.1g), and four out of five exposed females had entered oestrous by this time. Uterine mass was higher (129.8mg +/- 28.8mg) in exposed than unexposed (25.4mg +/- 6.7mg) females. None of the unexposed females had

expressed oestrous by 150 days. Pheromonal induction of first estrus was associated with an increased rate of body growth and follicular development.

GENERAL BEHAVIOUR: Terrestrial and solitary in habits.

Activity Levels Though frequently described as diurnal (Redford & Eisenberg 1999, Massoia et al 2000), Macrini (2004) states that the greatest period of activity is for the first 1 to 3 hours after dusk and that activity continues periodically through the night.

Home Range Home range in the Brazilian caatinga was estimated at $1209.4m^2$ ($+/-1050.4m^2$) for males and $1788.8m^2$ ($+/-487.8m^2$) for females, with a combined sex total of 1427.7 ($+/-859.3m^2$) (Streilein 1982c). Population densities in the same area varied from 0 to 4/ha. (Macrini 2004). Territories are marked by rubbing the chin, side of the head and then flanks against a substrate. Additionally males may rub the venter and drag the scrotum across the surface. In the wild scent-marking is used to mark "personal space" such as the area immediately around the nest entrance. Population sizes increase in the caatinga during dry months (Streilein 1982c).

Under laboratory conditions animals scent mark their cage shortly after introduction. Head marking is the most frequently used technique, whilst flank marking is seen more often in females (Fadem & Cole 1985). Head marking is done by rubbing the body against a substrate in a series of short, sharp, repeated motions. Occasionally the marking animal sniffs, bites or licks the object being marked whilst holding onto it with the front paws. Flank marking involves pressing the flank against the substrate and sliding forward so that the entire flank rubs against it, and this often follows head marking. In chest marking the animal slides the slightly outstretched paws forwards and upwards to press the chest against the substrate, this often also being followed by head marking. Following flank or chest marking the animal often sniffed the marked area, or groomed itself. The fourth type of scent marking, hip marking, is less common and involves one hip being pressed against the substrate and dragged for 8 to 10cm. This type of marking appeared frantic and usually occurred after a considerable bout of other marking. It has also been observed in oestrous females.

Scent marking behaviour is more common in males, with 11 of 12 males scent marking in a trial compared to just 2 of 10 females. Marking becomes more frequent with age. Older males mark rapidly on being introduced to a new environment. Males up to 5 months marked a mean of 6.1 times in 30 minutes, males aged 8 to 10 months marked 14.2 times and males aged 18 to 34 months marked a mean of 16.6 times per 30 minutes. There were also differences in the type of marking that was observed. Males in the youngest group used the chest 82% of the time and the flank (12%) and head (6%) less often. By 8 to 10 months the head (53%) was used most often followed by the chest 26% and flank (21%) and in the oldest group the three were used fairly evenly head 37%, chest 35% and flank 28%.

Females did not mark with the chest due to the lack of a suprasternal gland. It appears to be related to increased androgen levels and is first seen at 14 weeks. Preference is given to scent-marking areas that had previously been marked by other males. (Trupin & Fadem 1982).

Zuri et al (2007) demonstrate that males investigate scents left by both sexes significantly more than they do distilled water and female odours more than male odours. When comparing the body part from which the scent came they found that males investigate the odours of strange males more than they investigate their own odours. When female odours were paired they showed a significant preference for investigating flank odours more than urine odours, but no preferences were observed when other odour pairs were experimentally tested. Males were able to discriminate between the urine of males and females, though females were not. The authors hypothesised that male odours provide information about the presence of other males and hence aid in avoidance of conflicts, while urine from diestrous females signal the presence of an unmated animal in the area. The animals also investigated distilled water more than they did a blank control, possibly because the scarcity of water in their semiarid natural habitat means that a water-seeking behaviour is a strong component of their behavioural repertoire.

Refuges Nests are built by both sexes. In Brazil nests were built in crevices in rocky outcrops made of leaves, bark, snake skins, grasses, plastic, paper and cloth. Material is collected using the mouth but manipulated between the forelegs, hindlegs and semi prehensile tail. In the nest the animal sleeps on its side, curling into a ball during colder weather. They leave the nest cautiously, sniffing the air and frequently pausing motionless when disturbed. (Macrini 2004). Nests built by captive individuals consisted

of an ovoid chamber 12 x 12 x 5cm connected by a narrow tunnel 8-14cm long and small entrance 3-4cm in diameter. The entry tunnel was slightly curved so that the main chamber was concealed. (Trupin & Fadem 1982).

Unger (1982) noted that captive individuals built various types of nests, some being tighly woven, some unwoven and occasionally they slept directly on the cage floor and dispensed with nest building altogether. It was hypothesised that woven nests were built to protect the animal from daytime heat, with the proportion of woven nests when compared to unwoven being significantly higher on sunny mornings when compared to cloudy mornings. The paper strips provided for nest-building were grabbed with the mouth and transferred to the forefeet then, with the animal posed on its hindlegs, pushed along the ventral surface to the tail where it was gripped in a loop at the tail tip. It was hypothesised that this acted to "odour mark" the paper by rubbing it across the sternal gland.

Grooming Behaviour Following feeding the animal frequently grooms, sitting semi-erect and licking the soles of the forefeet before moving them in a circular motion over the head and snout. The chest and abdomen may then be licked and the incisors used as a sort of "comb". The hindfeet are used primarily for scratching with the animal leaning to one side and scratching the dorsum, back of the head, abdomen, shoulders and sides for a period of 2 to 10 seconds. After scratching the feet are licked. Periods of grooming may last 2 minutes or more. Nuzzling is a behaviour associated with odour uptake from dry surfaces. It involves the repeated rubbing and moistening of dry surfaces with the underside of the nose, followed by licking of the nose to promote oral uptake of odours. (Macrini 2004). A specimen collected in Central Brazil in May was in full dorsal moult and moulting along the midline of the venter. (Mares et al 1989).

Aggressive Behaviour Streilein (1982e) documents the agnostic behaviour of this species as follows. This species is intolerant of conspecifics responding aggressively, growling and hissing and threatening with open mouth. At low levels the mandibles are only slightly opened so that the canines are visible, whilst at higher levels the lips are drawn back and all teeth are exposed. Some level of open-mouthed threat accompanies all aggressive encounters. Typically open-mouth threats are sufficient to inhibit approaching animals, of ignored aggressive interactions ensue.

Animals that are being approached by a conspecific frequently raise a single paw, holding it parallel to the ground but close to the chest. This posture is generally seen in animals preparing to mount an active defence rather than to flee. Continued approach of an intruder incites the defensive animal to adopt a semi-erect posture, usually preceding a defensive strike. A similar pose in approaching animals typically indicates an imminent attack. The posture provides a favourable angle of attack and protects the animal from the canines of its opponent. Prior to attack the posture is modified to a near erect stance that precedes a lunge at the opponent. The forefeet are used to grab the intruder, bites are administered and the claws of the hindfeet are used to scratch.

Aggressive encounters are rarely prolonged and though open-mouth threats are performed by both sexes, physical conflict occurs only between males. Males do not behave aggressively towards females, though females frequently do towards males. Females however react less aggressively to males when they are familiar with their scent (Fadem & Cole 1985). Juveniles may engage in play-fighting, though adults rarely or never do so. (Macrini 2004). Feeding individuals are oblivious to external disturbances and do not react to agonistic threats by other individuals (Streilein 1981a).

Defensive Behaviour Trapped individuals are docile and rarely attempt to bite, and individuals released after handling frequently foraged as they moved away rather than making a rapid retreat (Streilein 1981a).

Parasites For Brazil Limardi (2006) notes the following ectoparasites of this species: Siphanoptera *Adoratopsylla antiquorum* (Ctenophthalmidae). Acari: Metastigmata *Ixodes amarali, Amblyomma* sp., *Ornithodoros talaje* (Ixodidae). Acari: Mesostigmata *Ornithonyssus bursa* and *O.lutzi, Lepronyssoides perierai* (Macronyssidae); *Eubrachylaelaps rotundus, Mysolaelaps heteronychus* and *M.parvispinosus, Gigantolaelaps butantanensis, G.oudemansi, G.goyanensis* and *G.vitzthumi, Laelaps castroi, L.lateventralis* and *L.paulistanensis* (Laelapidae). Acari: Prostigmata *Parasecia aitkeni* and *Trombewingi bakeri* (Trombiculidae).

Thatcher (2006) gives the following endoparasites from Brazil: Cestoda *Linstowia schmidti* (Anoplocephalidae). This species was described with *M.domestica* as the type host by Gardner & Campbell

(1992). Vicente et al (1997) listed the following nematodes in this species from Brazil: *Aspidodera scoleciformis* (Diesling, 1851) Railliet & Henry, 1912; *Viannaia monodelphis* Durette-Desset, 1968.

Heckscher et al (1999) describe the coccidian *Eimeria cochabambensis* from this species in Bolivia.

Physiology Fadem & Schwartz (1986) described the histology of the suprasternal gland. The gland was present in all adult males aged 30 to 122 weeks, but absent in females and present in just three of 22 juvenile males. Externally the gland is situated medially between the neck and sternum, is ovaloid and devoid of fur. Mean length of the gland was 13.8mm (+/- 2.8mm, range 9-18mm) and width 6.4mm (+/- 1.8mm, range 3-10mm). The gland and surrounding fur were amber-tinted, presumably from glandular sectretions. Under magnification, small, pale hairs were visible on the gland. Sections of the glandular area in males showed an intact epidermis, 2 to 4 nucleated keratinocytes in thickness. Prominent sebaceous units were seen in the upper to mid-dermis and apocrine elements complete with decapitation secretions were seen in the lower dermis. Dermal papillae were evident and the epidermis appeared uniform in depth. The stratum corneum was orthokeratotic with flat layers of anuclear cells. Sebaceous units, composed of lobules, emptied into short sebaceous ducts leading to pilosebaceous follicles not directly onto the skin surface. In sections taken from the entire excised area in females and from the skin surrounding the gland in males, the sebaceous glands were fewer and smaller and pilar structures, typical of normal fur-bearing areas, were identified.

Liddelow et al (2010) describe the development of the lateral ventricular choroid plexus.

Longevity Captive individuals have a natural lifespan of 36 to 42 months, with one individual living 49 months. (Macrini 2004).

VOCALISATIONS: Aggressive interactions are accompanied by growls and hisses. Captive males gave soft clicking sounds on seeing a female, and these continued during copulation. The sound is produced by the lips, cheeks and palate and is delivered at a rate of 6 to 7 clicks per second. (Trupin & Fadem 1982). Males may try to appease aggressive females with clicking vocalisations (Macrini 2004). A chirping noise was given when exploring a new cage (Trupin & Fadem 1982).

HUMAN IMPACT: In Brazil this species occasionally enters human dwellings (hence the epithet *domestica*) where it may be confused with a mouse or rat. This behaviour has not so far been reported in Argentina, but in Paraguay a specimen was taken inside a house at Reserva Natural Laguna Blanca, Departamento San Pedro (Smith et al 2012). The species may have benefitted from deforestation opening up new areas of potential habitat and enabling them to colonise secondary habitats (Emmons 1999).

The causative agent of Chaga´s disease is *Trypanosoma cruzi*, a digenetic kinetoplastid and enzootic parasite of almost 100 mammal species, including humans. Though typically transmitted to humans via the Reduviid bug *Triatoma infestans*, oral infection with the disease does occur and is often associated with acute forms of the disease. Roque et al (2008) found that all 6 of 10 specimens that they captured tested serologically positive for *Trypanosoma cruzi* in an area of Ceará State, Brazil that had recently suffered an outbreak of Chagas disease. Parasites were recovered from four of the animals and were of the TC I strain. The tendency for the animals to approach human dwellings is thought to increase the likelihood of them acting as vectors for infection.

The species suitability as a laboratory animal has led to it being utilised in a number of medical and veterinary trials. Several features make the species a good experimental animal for studying the effects of ultraviolet radiation (UVR) as chronic UVR exposure leads to the development of both benign and malignant melanomas. The species resembles human beings in its ability to repair UVR-induced pyrimidine dimers by efficient excision repair and is the only laboratory animal in which UVR serves as a complete carcinogen for melanoma induction. Kusewitt et al (1990) detected naturally occurring malignant melanomas in this species and Kusewitt et al (1997) determined S-100 immunoreactivity in metastatic melanoma lesions in this species. Kuehl-Kovarik et al (1994) morphologically and immunohistochemically characterised spontaneous pituitary adenomas in this species.

CONSERVATION STATUS: Globally considered to be of Low Risk Least Concern by the IUCN, see http://www.iucnredlist.org/search/details.php/40514/all for the latest assessment of the species. The species is apparently common in its Brazilian range and though little data is available for Paraguayan populations it is the most frequently encountered member of its genus and given the isolated nature of its preferred habitat it is not likely to be under any direct threat. Flores (2006) considers the species vulnerable

in Argentina given its limited range, but Chebez (2009) notes that is locally common and occurs within the Reserva Natural de Formosa.

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FIGURE 2 - (FPMAM438PH)
Grey Short-tailed Opossum
Monodelphis domestica.
Lateral view of adult male specimen. Laguna Blanca, Departamento San Pedro, July 2010.
Photo Karina Atkinson.

FIGURE 3 - (FPMAM439PH)
Grey Short-tailed Opossum
Monodelphis domestica.
Dorsal view of adult male specimen. Laguna Blanca, Departamento San Pedro, July 2010.
Photo Karina Atkinson.

FIGURE 4 - (FPMAM440PH)
Grey Short-tailed Opossum
Monodelphis domestica.
Ventral view of adult male specimen. Laguna Blanca, Departamento San Pedro, July 2010.
Photo Karina Atkinson.

FIGURE 5 - (FPMAM441PH)
Grey Short-tailed Opossum
Monodelphis domestica.
Head detail of adult male specimen. Laguna Blanca, Departamento San Pedro, July 2010.
Photo Karina Atkinson.

FIGURE 6 - (FPMAM445PH)
Grey Short-tailed Opossum
Monodelphis domestica.
Tail detail of adult male specimen. Laguna Blanca, Departamento San Pedro, July 2010.
Photo Karina Atkinson.

FIGURE 7 -
Grey Short-tailed Opossum
Monodelphis domestica.
Juvenile. Mbaracayú Biosphere Reserve, Departamento Canindeyú, undated.
Photo Alberto Esquivel.

FIGURE 8 - (FPMAM324PH)
Grey Short-tailed Opossum
Monodelphis domestica.
Adult skull lateral. Paraguay.
Photo Ulf Drechsel www.pybio.org.

FIGURE 9 - (FPMAM322PH)
Grey Short-tailed Opossum
Monodelphis domestica.
Adult skull dorsal. Paraguay.
Photo Ulf Drechsel www.pybio.org.

FIGURE 10 - (FPMAM323PH)
Grey Short-tailed Opossum
Monodelphis domestica.
Adult skull ventral. Paraguay.
Photo Ulf Drechsel www.pybio.org.

FIGURE 11 -
Grey Short-tailed Opossum
Monodelphis domestica.
Adult mandible. Paraguay.
Photo Ulf Drechsel www.pybio.org.