

# Monodelphis domestica.

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## *Monodelphis domestica* (Wagner, 1842)

Gray Short-tailed Opossum

*Didelphys domestica* Wagner, 1842:359. Type locality “Cuyaba,” Matto Grosso, Brazil.

*Microdelphys domestica*: Burmeister, 1856:87. Name combination. *Hemiurus hunteri*: Gervais, 1856:101. Name combination.

*Hemiurus concolor*: Gervais, 1856:plate 16, figure 2. Name combination.

*Peramys domesticus*: Thomas, 1910:502. Name combination using *Peramys* Lesson, 1842:187, with unjustified emendation of *domestica* Wagner.

*Peramys domestica*: Heck, 1912:114. Name combination using *Peramys* Lesson, 1842:187.

*Monodelphis domestica*: Matschie, 1916:272. First use of current name combination.

*Monodelphis domesticus*: Mello, 1977:391. Unjustified emendation.

**CONTEXT AND CONTENT.** Cohort Marsupialia, order Didelphimorphia, family Didelphidae, genus *Monodelphis*. *Monodelphis domestica* is monotypic.

**DIAGNOSIS.** *Monodelphis domestica* differs from *M. maraxina* by having more tail bristles and a more-developed auditory bullae (Pine 1979); it is much larger than *M. kunsii* (total length in adult male *M. kunsii*, 113 mm,  $n = 1$ ) and has a more-developed sagittal crest (Anderson 1982). *M. domestica* lacks the orange color of lateral pelage of *M. dimidiata*; lacks the red on sides of *M. brevicaudata* and *M. henseli*; lacks the rufous color on sides of *M. sorex* (Thomas 1888); lacks the red color of pelage of head, rump, and tail of *M. scalops*; lacks the reddish brown color of dorsal pelage of *M. emiliae* (Peterson and Pine 1982); and lacks the dorsal stripes of *M. americana*, *M. iheringi*, and *M. unistriata*.

**GENERAL CHARACTERS.** Small and volelike in appearance (Hershkovitz 1972), *M. domestica* (Fig. 1) is a pouchless marsupial with a semiprehensile short tail (ca. one-half the body length) that is well furred for the first 1–2 cm near the base and nearly hairless posterior to that (Emmons and Feer 1990). Face and dorsal pelage are a uniform grayish brown; cheeks and sides are paler gray with yellowish tinge; feet are whitish; and chin and ventrum are lighter and gray to buff in color with an orange tinge (Emmons and Feer 1990; Redford and Eisenberg 1992; Thomas 1888).

Captive adult females and males weigh 80–100 g and 90–150 g, respectively (Fadem and Rayve 1985). Length of head and body of captive adults ranges from 170 to 200 mm and length of tail is 60–80 mm (Fadem and Rayve 1985). Compared with captive gray short-tailed opossums, wild-caught adults are lighter (mean body mass, 71.4 g; range, 58–95 g;  $n = 11$ ) and smaller (Redford and Eisenberg 1992); average (ranges in mm) measurements of wild-caught adults are total length, 212.3 (178–270;  $n = 18$ ); length of head and body, 143.2 (123–179;  $n = 18$ ); length of tail, 69.1 (46–91;  $n = 18$ ); length of hind foot, 17.7 (14–22;  $n = 18$ ); and length of ear, 19.8 (14–25;  $n = 17$ ).

Measurements (in mm) from 1 preserved female (Thomas 1888) are length of head and body, 131; length of tail, 75; length of hind foot, 18; distance from muzzle to eye, 17.3; and length of ear, 15. Measurements (in mm) from 1 skull of an adult female *M. domestica* (Fig. 2; Thomas 1888) are basal length, 35.7; greatest breadth of skull, 19.8; length of nasals, 17.8; greatest breadth of nasals, 4.6; least breadth of nasals, 2.3; intertemporal constriction (least breadth between orbitotemporal fossae), 6.0; palate length, 20.3; palate breadth outside M3, 12.1; palate breadth inside M3, 7.1; length of palatal vacuities, 2.9; combined lengths of basisphenoid and basioccipital bones, 12.6; length from basisphenoid–pre-

sphenoid suture to anterior tip of premaxilla, 23.2; ratio of basifacial axis to basicranial axis, multiplied by 100, 184; and combined length of M1–3, 6.6. Additional average skull measurements with range (in mm) of *M. domestica* (Wible 2003) are premaxillary–condylar length, 38.7 (26.7–44.7;  $n = 27$ ); greatest zygomatic breadth, 20.8 (14.3–25.0;  $n = 28$ ); and length of mandible, 28.8 (19.0–34.4;  $n = 29$ ).

**DISTRIBUTION.** *Monodelphis domestica* ranges along the southern rim of the Amazon Basin in eastern, southern, and central Brazil; eastern Bolivia; northern Paraguay; and northern Argentina (Fig. 3; Eisenberg and Redford 1999; Emmons and Feer 1990; Myers and Wetzel 1979; Redford and Eisenberg 1992; Streilein 1982a). In Argentina, *M. domestica* is known from the Reserva Natural Formosa in the Formosa Province (Heinonen Fortabat and Chebez 1997). *M. domestica* is most common in Brazil and is well known from the Caatinga region (Streilein 1982a, 1982b, 1982c, 1982d). No fossils of *Monodelphis domestica* are known.

**FORM AND FUNCTION.** Pelage of study skins is fluorescent under ultraviolet light; dim reddish purple on dorsum and red orange on ventrum (Pine et al. 1985). A living specimen exhibited a rose orange fluorescence for the entire pelage under ultraviolet light (Pine et al. 1985). Photorepair and excision repair occur in the dermis after exposure of shaved skin to ultraviolet light (VandeBerg 1990). Macroscopic tissue wounds of the skin that occur before postnatal day 9 heal without scarring (Armstrong and Ferguson 1997).

*Monodelphis domestica* has well-developed curved claws and relatively small digital pads (Hamrick 2001). Papillary ridges are present on the volar surface of digital pads running from distal phalangeal joint to tips of digits; these ridges are broader on toes of hind feet than forefeet (Hamrick 2001).

Microvibrissae allow object recognition, whereas macrovibrissae of the mystacial pad allow spatial recognition (Brecht et al. 1997). Mystacial microvibrissae function for distance detection (Brecht et al. 1997).

Dental formula is  $i\ 5/4$ ,  $c\ 1/1$ ,  $p\ 3/3$ ,  $m\ 4/4$ , total 50. Molars are tribosphenic. Labial, occlusal, and lingual views of dentition of *M. domestica* are figured by Reig et al. (1987, figure 24).

Computed tomography scans of skulls of *M. domestica* confirm the presence of a discrete interparietal bone in the adult skull (Macrini 2000). A small, midline ossification occurred on dorsal rim of foramen magnum in 11 of 27 specimens (Wible 2003). Presence of a postorbital process is variable; it is absent in some spec-



FIG. 1. A female *Monodelphis domestica* with litter from the research colony of the Southwest Foundation for Biomedical Research in San Antonio, Texas. Photograph, courtesy of J. VandeBerg, previously published in Robinson et al. (1994, figure 1b) is reprinted with permission from authors and the American Association for Cancer Research.

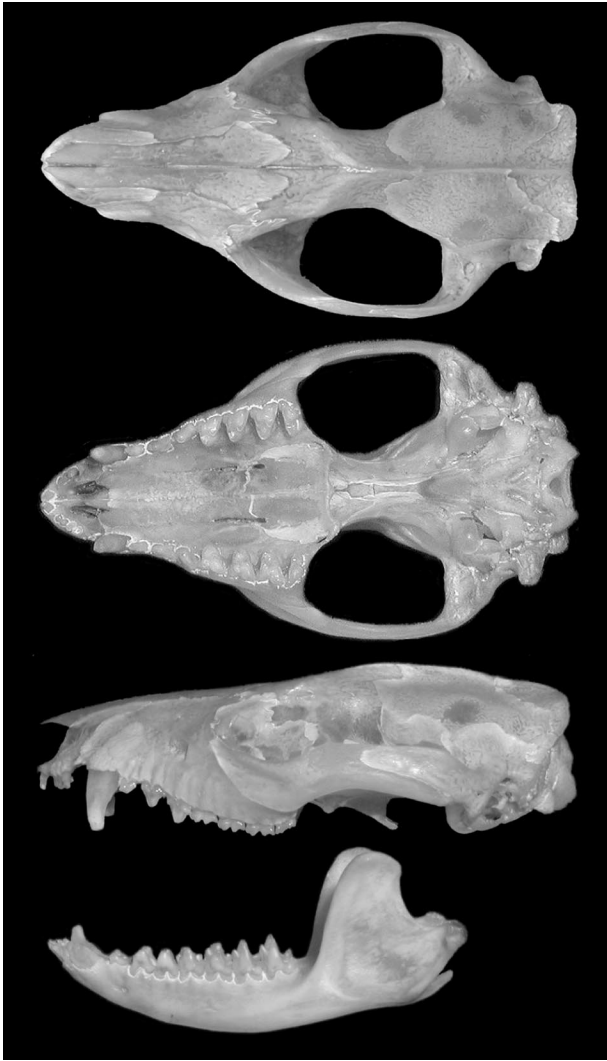


FIG. 2. Dorsal, ventral, and lateral views of cranium and lateral view of mandible of an adult male *Monodelphis domestica* (Vertebrate Paleontology Laboratory, Texas Memorial Museum, TMM M-7546). This specimen was obtained from the research colony of the Southwest Foundation for Biomedical Research in San Antonio, Texas. Total skull length is 41.65 mm. Photographs by T. Macrini.

imens, partially developed in several, and well developed in at least 1 individual (Pine 1979).

Vertebral formula is 7 C, 14 T, 6 L, 2 S, 19–20 Ca, total 48–49 (T. E. Macrini, in litt.; Pridmore 1992). The walking gait of *M. domestica* is a lateral sequence with extensive lateral bending of the trunk but no sagittal bending (symmetrical gait—Pridmore 1992). Lateral bending of the trunk during slow walking is most prominent in the anterior lumbar region of the vertebral column. Sagittal bending is common during trotting but lateral bending is absent. During locomotion, the pelvis rotates in the yaw plane in sequence with the locomotor cycle of the hind limbs (Pridmore 1992). The epipubic bones in *M. domestica* act as a lever that, when retracted, stiffen the trunk and prevent long-axis torsional bending during symmetrical gaits (Reilly and White 2003).

The primary somatosensory neocortical area is medial along a strip of a middle layer of the cortex running from the rhinal sulcus to the medial wall (Catania et al. 2000; Frost et al. 2000; Huffman et al. 1999). The secondary somatosensory cortex is caudolateral to the primary somatosensory neocortical area (Catania et al. 2000; Frost et al. 2000). The auditory cortex is in the lateral cortex behind the secondary somatosensory cortex and the primary visual cortex is located at the caudal end of the cortex (Catania et al. 2000). The primary visual area of *M. domestica* is relatively large and well



FIG. 3. Geographic distribution of *Monodelphis domestica*. Map compiled from Eisenberg and Redford (1999), Emmons and Feer (1990), Myers and Wetzel (1979), Redford and Eisenberg (1992), and Streilein (1982a).

developed compared to that of *Didelphis virginiana* (Huffman et al. 1999; Kahn et al. 2000). The primary visual area has neural connections with the entorhinal and multimodal cortices in *M. domestica* (Kahn et al. 2000).

The intestine of *M. domestica* lacks macroscopic features that clearly demark different regions (Koch et al. 1990). A cecum is present. The urethra displaces the intestines in the caudal abdomen of males. The falciform ligament provides the only division between the quadrate and left medial lobes of the liver, and the gall bladder separates the quadrate and right medial lobes. The spleen is mostly caudal to the costal arch, extending dorsally between the stomach and left kidney and ventrally to the ventral medial line (Koch et al. 1990). The greater omentum is very thin but may extend to the cranial end of the urinary bladder (Koch et al. 1990). Subperitoneal fat can be extensive in females, occupying a large portion of the caudal–ventral abdomen (Koch et al. 1990). Frontal, suprasternal, sternal, and anal scent glands are present in adult male *M. domestica*, but only frontal and anal scent glands are present in females (Fadem 1986).

Females usually have 13 inguinal mammae, but sometimes the anteriormost nipples are absent so only 11 or 12 nipples are present (Robinson et al. 1991). Striated voluntary muscle derived from the musculus iliomarsupialis inserts on the bases of the teats and allows retraction of mammae (Griffiths and Simms 1993).

Milk of *M. domestica* is comprised of <10% solids during the early stages of lactation (ca. postnatal day 5—Green et al. 1991). This percentage increases to 30% over the next 25–30 days, until weaning (Green et al. 1991). The relative percentages of protein, fat, and carbohydrate of the solid portion of the milk remain constant over the first 50 days of lactation at 36%, 28%, and 34%, respectively (Green et al. 1991). The carbohydrate portion includes a variety of mono- and oligosaccharides, with galactose being the major monosaccharide (Crisp et al. 1989). Sodium and magnesium concentrations of milk are constant throughout lactation, but potassium and calcium proportions vary (Green et al. 1991).

Resting metabolic rate and heat production of females during gestation are not significantly different from those of non-reproductively active females when the effects of body mass and body temperature are taken into account (Harder et al. 1996). However,

metabolic rate and heat production are significantly higher in lactating than in nonlactating females (Harder et al. 1996). Energy consumption (mean  $\pm$  SE, 1,261.3  $\pm$  28.0 kcal total consumption) from conception to weaning in gray short-tailed opossums is positively correlated with litter size and mass of young (Hsu et al. 1999). The isolated central nervous system of a newborn *M. domestica* remains electrically excitable for days when maintained in culture, making study of neural activity possible (Zou 1994). The nervous system's rhythm (mean  $\pm$  SE) is 34  $\pm$  1.1 discharges/min in 4-day-old individuals and 47  $\pm$  4.3 discharges/min in 8-day-old individuals (Zou 1994).

The vomeronasal organ in *M. domestica* is a chemosensory detector involved in conspecific communication and pheromonal induction of estrus (Jackson and Harder 1996; Poran 1998; Poran et al. 1993a, 1993b). Lateral grooves on the ventral rhinarium, incisive papillae, and filiform papillae on the tongue increase the ability of solutes to reach the vomeronasal organ (Poran 1998). Contraction and extension of smooth muscles in a transition zone between the vomeronasal organ and a caudal serous gland pump solutes into the lumen of the vomeronasal organ (Poran 1998).

**ONTOGENY AND REPRODUCTION.** Females breed year-round in the wild in the Caatinga region of Brazil (Streilein 1982c). Elsewhere in Brazil, breeding occurs mainly during the wet season (Bergallo and Cerqueira 1994). Under optimal conditions, females in the Caatinga region of Brazil produce 5 or 6 litters a year, with 6–11 young per litter with a mean of 8.4 young (Streilein 1982c). Mean number of embryos per litter is 7.9 (range, 2–16) in northeastern Brazil (Bergallo and Cerqueira 1994). Breeding occurs year-round in captivity and females can produce up to 4 litters per year (Fadem et al. 1982).

The female reproductive tract of *M. domestica* is figured by Harder et al. (1993, figure 1). Loops of the lateral vaginae of *M. domestica* are prominent (Reig et al. 1987). The pseudovaginal canal is not permanent; it is present only during parturition and regresses soon thereafter (Reig et al. 1987).

Female *M. domestica* do not show an estrous cycle; isolated females remain anestrous but are induced to estrus within 4–11 days after exposure to male pheromones (Fadem 1987; Harder et al. 1993). Females do not reach puberty unless exposed to male pheromones (Stonerook and Harder 1992). However, isolated postlactational females exhibit spontaneous estrus in the absence of male pheromones (Jackson and Harder 2000).

Ovulation occurs ca. 18–20 h after mating and is stimulated by physical contact with the male but not necessarily intromission (Harder et al. 1993; Mate et al. 1994). Ovulation rate is 12 ova per cycle on average (Harder et al. 1993) and conception occurs in the oviduct within 2 h of ovulation (Baggott et al. 1987; Zeller and Freyer 2001). Within 24 h, the zygote passes from the oviduct to the uterus, where shell-membrane formation commences from secretory cells in the endometrium (Baggott and Moore 1990). The shell membrane grows for several days until just before blastocyst expansion (Baggott and Moore 1990). The 1st cleavage occurs at right angles to the zygote equator ca. 28–29 h after ovulation (54–55 h after mating) and includes division of a partitioned yolk mass (Baggott and Moore 1990; Mate et al. 1994). The 2nd and 3rd cleavages at 44 and 72–74 h, respectively, result in blastomeres surrounded by yolky vesicles but without cell-to-cell contact (Baggott and Moore 1990; Mate et al. 1994). The 4th cleavage at 96 h results in 2 layers of cells flattened against the inner surface of the zona pellucida; unilateral blastocysts form ca. 5 days after conception (Baggott and Moore 1990).

Primary ectoderm is present on postconception day 6 (Mate et al. 1994), and the mesoderm and embryonic disc develop between days 6 and 10 of gestation (Harder et al. 1993). By postcopulation day 10 (ca. 9 days after conception), the embryo has a neural groove, neural crest, a primitive streak, paraxial mesoderm with 5 or 6 somites, lateral plate mesoderm with pericardium, extraembryonic mesoderm, and a yolk-sac cavity (Zeller and Freyer 2001). Breakdown of the shell membrane occurs ca. 10.5 days after conception and marks the beginning of organogenesis in marsupials (Harder et al. 1993). By postcopulation day 11, the embryo exhibits a strong curvature of head and neck, a dorsally concave lumbar curvature, a foregut with visceral clefts and arches, a brain plate with eye anlagen, ear placodes, a heart anlage, and anlagen of upper extremities (Zeller and Freyer 2001). A choriovitelline pla-

centa is formed and implantation occurs on day 12 of gestation (Harder et al. 1993).

By postcopulation day 12, heart is large and able to support yolk-sac circulation, lumbar curvature flattens, caudal amnion is expanded, and embryo is completely sunk into yolk sac (Zeller and Freyer 2001). By postcopulation day 13, neural tube is closed; peripheral nerves and ganglia are present; and the following structures are present: eye cups, labyrinth vesicle, epithelial nasal sac, muscular tongue, chondrified endoskeleton with occipital pillar, axial skeleton, Meckel's cartilage, gut canal, liver, well-developed heart, lung, and differentiated mesonephros. Amniotic fluid travels between yolk sac and amnion by postcopulation day 14 (Zeller and Freyer 2001).

Early stages of embryonic development of *M. domestica* were cultured in vitro (Moore and Taggart 1993; Selwood et al. 1997). Stages of cleavage and unilaminar blastocyst formation proceed at similar rates in vivo and in vitro (Selwood et al. 1997).

In captivity, implantation typically lasts only 3 days and neonates are born 14 days after conception (15 days after copulation) and immediately attach to a nipple. Neonates of *M. domestica* are altricial at birth; total length is ca. 1 cm and mass is ca. 100 mg (VandeBerg 1983).

Young do not detach from the nipple until ca. 2 weeks after birth and they are weaned at ca. 8 weeks (Kraus and Fadem 1987; VandeBerg 1990). Hair growth begins at ca. days 18–21 after birth and opening of the eyes occurs at ca. days 28–35 (Kraus and Fadem 1987). Sexual maturity occurs at 5–6 months, and the onset of reproductive decline occurs at 18–24 months in females and 24–30 months in males. Individuals that die of natural causes have a lifespan of 36–42 months in captivity (VandeBerg 1990). One captive individual lived 49 months (Nowak 1999).

Females invest more energy in reproduction than do males, and consequently, growth rates are sharply reduced in females in conjunction with birth of their 1st litter, but males continually grow throughout their 1st reproductive season (Bergallo and Cerqueira 1994). Growth in length of head and body in both sexes is finite, but increase in mass is continuous throughout life (Bergallo and Cerqueira 1994).

Dermal bones of skull begin to ossify before endochondral bones, with only a few bones of the face and exoccipitals beginning to ossify at birth (Clark and Smith 1993). Viscerocranial bones (mainly dermal in origin) grow at a faster rate than neurocranial bones (mainly endochondral in origin), which grow for a longer period of time (Maunz and German 1996). Overall rates of growth of skull bones are faster in females but because males are larger than females at weaning age and grow for longer periods of time, skulls of adult males are larger (Maunz and German 1996).

At birth, the jaw joint of *M. domestica* is between the malleus and incus (Maier 1990) and jaw movement is possible by flexure along Meckel's cartilage (Filan 1991). Incus and malleus anchor tongue musculature, which aids in suckling (Filan 1991), and do not have an auditory function until later. The gray short-tailed opossum can hear at ca. days 28–30 after birth (Aitkin et al. 1997; Reimer 1996), when the external auditory meatus is partially open and the middle ear ossicles are immature (Sánchez-Villagra et al. 2002). After eruption of the 1st teeth, the dentary angular process contacts a rectangular fenestra of the tympanic bulla, which is covered by a membrane of loose connective tissue (Maier 1987). This relationship is maintained to a lesser extent throughout life.

Neonates of *M. domestica* have the adult number and arrangement of carpal elements (Prochel and Sánchez-Villagra 2003). Cell condensation for the centrale is present at postconception day 13 but the element is absent at birth. Ossification of most of the carpal elements begins 12–30 days after birth. The trapezium and trapezoid commence ossification relatively late, and the pisiform and prepollex begin ossifying last. The pisiform is larger and more robust in adult males than in females (Prochel and Sánchez-Villagra 2003).

Stages of dental eruption in *M. domestica* follow the pattern of *Didelphis* except for the relative timing of appearance of P3 and M4 (Tribe 1990). In *M. domestica*, P3 may erupt either before, after, or simultaneously with M4 (Tribe 1990).

Craniofacial muscles of *M. domestica* develop postnatally, and differentiate rapidly and simultaneously (Smith 1994). Contrahentes muscles of the hand develop on the palm and split into 4 muscles that insert on digits I, II, IV, and V without reduction or disappearance of parts of these muscles during ontogeny (Trnková-Her-

getová and Dylevský 1996). Microscopic study of the shoulder musculature of 2 individuals revealed 113 and 131 muscle spindles in the 4 rotator cuff muscles and 76 and 40 Golgi tendon organs in muscle-tendon junctions of these muscles near the humeral head insertion (Maass et al. 2001). Large numbers of muscle spindles and Golgi tendon organs also are found in surrounding shoulder muscles, but the Golgi to spindle ratio is smaller, ca. 0.2 (Maass et al. 2001).

The olfactory mucosa lining the internal surfaces of the nasal capsule and associated turbinates mainly develops postnatally in *M. domestica* in association with a growing nasal cavity and increasing complexity of the turbinates (Leo and Brunjes 1999). The nasopalatine duct of the vomeronasal complex connects the nasal and oral cavities by postnatal day 13; the vomeronasal organ 1st opens into a vertically oriented nasopalatine duct on postnatal day 40 (Sánchez-Villagra 2001). The paraseptal cartilage forms a circle around the vomeronasal organ early in ontogeny (postnatal day 11), but this condition is absent in later stages including the adult (Sánchez-Villagra 2001). Vomeronasal receptor neurons in the middle and deep sensory epithelium project to the accessory olfactory bulb early in ontogeny (Jia et al. 1997). These neurons segregate into 2 adult fiber types by postnatal day 21; 1 is connected to the middle layer of the vomeronasal organ and the other to the deep layer (Jia et al. 1997).

Few postmitotic cells are present in the forebrain at birth (Brunjes et al. 1992). The olfactory bulbs assume adult form by postnatal day 30 (Brunjes et al. 1992). The neurohypophysis and adenohypophysis do not fuse until after postnatal day 12 (Gasse and Koch 1991). The cerebellum consists of a loose accumulation of cells at birth; differentiation of cerebellar cortical layers occurs over the next 75 days (Sánchez-Villagra and Sultan 2002). The most advanced stage of development (separation of the granular layer from the white matter) occurs at ca. postnatal day 35 in association with opening of the eyes (Sánchez-Villagra and Sultan 2002).

Neither the petrosal lobe of the parafoveolus of the cerebellum nor the subarcuate fossa of *M. domestica* is distinguishable at birth (Sánchez-Villagra 2002). The fossa 1st appears by postnatal day 6 and is completely filled by the parafoveolus at ca. postnatal day 18. However, in the adult (a condition seen from day 35 onward), the subarcuate fossa is only one-half filled by the parafoveolus and ca. one-half of the volume of the parafoveolus is outside the fossa. Sizes of the adult parafoveolus and the subarcuate fossa are poorly correlated in *M. domestica* (Sánchez-Villagra 2002).

Enzymes capable of synthesizing androgens are present 1 day before birth, before the appearance of the scrotal anlage, which appears 1 day after birth (Russell et al. 2003). Prenatal transport of antibodies from mother to embryo is not evident but antibodies travel from mother to the gut of the pouch young through suckling (Wild 1997). Tight junctions in epithelial cell membranes of the choroid plexus are present early in postnatal development as part of the blood-cerebrospinal fluid barrier in the brain (Ek et al. 2003).

**ECOLOGY.** *Monodelphis domestica* frequents human dwellings in Brazil (Nowak 1999). In the Caatinga region of Brazil, *M. domestica* uses rainforest, low thorn scrub, high thorn scrub, cultivated and abandoned fields, and granitic outcrops (Streilein 1982a, 1982c, 1982d). Outcrops are preferred because this habitat retains water better than other areas in the region (Streilein 1982a, 1982c, 1982d); however, direct evidence that *M. domestica* requires free drinking water in the wild is lacking.

Home range size (mean  $\pm$  SD) in the Caatinga region of Brazil is 1,209.4  $\pm$  1,050.4 m<sup>2</sup> for adult males ( $n = 6$ ) and 1,788.8  $\pm$  487.8 m<sup>2</sup> for females ( $n = 5$ —Streilein 1982c). Population densities for *M. domestica* in the Caatinga region range from 0 to 4.0 adults/ha (Streilein 1982a).

Captive and wild *M. domestica* consume living or dead rodents, lizards, frogs, snakes, insects, other invertebrates, and fruits (Streilein 1982a). They can take prey similar in size to their own body mass (Streilein 1982b). Published data on natural predators of *M. domestica* do not exist.

Endoparasites of *M. domestica* include the coccidian *Eimeria* (Heckscher et al. 1999), the tapeworm *Linstowia schmidtii* (Gardner and Campbell 1992) in Bolivia, the trematode *Rhopalium dobini* (Prod'hon 1968), the nematode *Viannia monodelphisi* (Durante-Desset 1968), and flagellate protozoans of the taxon *Trypanosoma* (Mello 1977) from Brazil. Ectoparasites, such as the tick

*Amblyomma dissimile* (Acari, Ixodidae), occur on *M. domestica* from Pernambuco State of northeastern Brazil (Botelho et al. 2002).

**ANIMAL HUSBANDRY.** Laboratory breeding colonies of *Monodelphis domestica* were founded in the United States from 7 introductions of 28 wild-caught individuals obtained between 1978 and 1993 from 4 localities in Brazil and 1 locality in Bolivia (VandeBerg and Robinson 1997). Colonies are maintained in Australia, Brazil, Britain, and Germany (VandeBerg and Robinson 1997). Breeding pairs are placed in cages (43 by 22 by 13 cm) constructed from polypropylene or polycarbonate, each with a small (18 by 13 by 10 cm) aluminum nest box (VandeBerg 1990). The cage floor is covered with wood shavings (cedar or hardwood), and paper shavings are provided for nesting material (VandeBerg 1990). Switching males in a female-male breeding pair during courtship tends to facilitate mating by reducing female violence (Fadem et al. 1982).

The male is removed from the cage soon after birth of pups. Siblings are caged together from weaning to sexual maturity, at which time each animal is isolated. Fluorescent lighting on a 10L:14D cycle is provided year-round; temperature is maintained between 23.5 and 26.5°C; and humidity is unregulated (VandeBerg 1990). Food and water are provided ad libitum (VandeBerg 1990). Captive specimens are fed commercially available fox-food pellets, a diet superior to meat-based diets in terms of growth and reproductive performance (Cothran et al. 1985).

**BEHAVIOR.** *Monodelphis domestica* is mainly active during the first 1–3 h after dusk, with additional briefer periods of activity throughout the night (Streilein 1982a). *M. domestica* rapidly shifts its activity pattern to match an artificially altered L:D cycle. In addition, *M. domestica* shifts its activity period over several days when put on a consistent feeding schedule.

*Monodelphis domestica* often takes refuge in crevices in rock outcrops in the Caatinga region of Brazil (Streilein 1982a). Substantial nests are constructed in crevices by using leaves, grasses, bark, snake skins, paper, plastic, and cloth. Nesting material is collected by mouth and manipulated by using the fore- and hind feet and the semiprehensile tail. Both sexes build nests, but females construct more complex and tightly interwoven structures. In its nest, *M. domestica* sleeps on its side and curls into a ball during rainy or cold weather. The sleeping posture is more open during warmer weather.

*Monodelphis domestica* uses caution when exiting its refuge, elevating its snout and sniffing the air continuously while proceeding forward slowly (Streilein 1982a). Stops are frequent and disturbances may cause the animal to freeze for several s. Olfaction plays a major role during foraging, as *M. domestica* thrusts its nose through the substrate when searching for food.

The gray short-tailed opossum lunges forward to pin its prey to the ground with its forefeet before biting it. Vertebrate prey is often bitten on the neck or near the base of the skull and small prey items are manipulated with the forepaws during consumption. Scorpions are handled with caution; the tail is often removed before consumption (Streilein 1982b).

Grooming efforts concentrate on the head, especially the snout, around the eyes, and the ears (Streilein 1982a). In a semi-erect posture, *M. domestica* licks the palmar surface of the forefeet and then rubs its paws in a circular motion on the head. This type of grooming often occurs during or immediately after feeding and may be followed by licking the chest and abdomen, combing with incisors, and use of the forefeet. The sides, flanks, tail, and lower back also are groomed in the semi-erect posture. Hind feet are used mainly for short, rapid scratch strokes when the gray short-tailed opossum is half-reclined to the side. These efforts concentrate behind the ears, beneath the eyes, along the snout, on top of the head, and on the shoulders, sides, upper back, and abdomen. Foot licking often follows each foot-scratching bout. Each scratching bout may last 2–10 s and each grooming session of this type lasts  $\geq 2$  min.

Female *M. domestica* do not pick up young neonates that have detached from the nipples but they will retrieve older young (Streilein 1982a). Females groom fully furred young via licking and combing with the incisors and forefeet until they are weaned. Young are identified by the mother solely by olfaction.

*Monodelphis domestica* is solitary in the wild, only coming together to mate, and consequently is highly intolerant of conspecifics (Streilein 1982a). Hisses, growls, and screeches signal ago-

nistic behavior, with hissing and screeching being the most prominent vocalizations. Open-mouth displays are a prominent component of threat behavior in both sexes. If an intruder approaches too closely, the defender may take a semierect posture; full-erect postures are taken only before a defensive strike using the forepaws and jaws. Extended physical contact between conspecifics is uncommon.

Initial interaction between same-sex or mixed-sex pairs of gray short-tailed opossums in the laboratory involves genital sniffing (Fadem 1989). Open-mouth postures and screeches dominate same-sex interactions, but contact fighting only occurs between males (Fadem 1989). Males show little aggression when encountering females but females are more aggressive. Males attempt to appease females with clicking vocalizations and scent markings (Fadem 1989). Play fighting (e.g., climbing over the back and boxing) is common between prepubescent gray short-tailed opossums but rare between adults (Fadem and Corbett 1997).

Intact females interact more with intact than castrated males in laboratory experiments, whereas ovariectomized females do not prefer intact males. Ovariectomized females with estradiol implants spend less time with castrated males (Fadem et al. 2000). Intact females aggressively repulse precopulatory advances by males even while displaying proceptive behaviors such as rump dragging (Baggott et al. 1987; Fadem et al. 2000). Females continue to be aggressive and may attempt to bite the male during copulation (Fadem et al. 1996, 2000). Ca. 86% of copulations occur during the dark phase in laboratory-induced mating (Harder et al. 1993).

*Monodelphis domestica* commonly marks territory in the wild by rubbing a surface with the chin or side of the head and then that entire side of the body, especially the flank (Streilein 1982a). Sometimes the chest also is rubbed on the same area. Males also may rub their ventrum against the surface and drag their scrotum and hind limbs.

In the wild, scent marking personalizes the immediate area occupied by *M. domestica*, such as the entrance to the nest, and wards away intruders (Fadem 1986). Males scent mark when 1st introduced into a chamber in the laboratory, but marking frequency declines with time spent in that chamber.

Head marking is common in the laboratory and involves rubbing the side of the head and snout repeatedly against an object (Fadem 1986). Hip marking is most common by estrous females but also does occur by males. Males mark more often, mainly by using the head, flank, and chest, whereas females mark with the head and flank only. Scent-marking behavior 1st begins at 14 weeks in males and apparently is associated with increased levels of androgen. This behavior correlates with age in males; 8- to 10-month-old and 18- to 34-month-old individuals marked frequently but individuals between 10 and 18 months old marked infrequently or not at all (Fadem 1986).

Nuzzling is a behavior that allows *M. domestica* to deliver dry odor deposits to the vomeronasal organ (Poran et al. 1993a, 1993b). Nuzzling involves repeated rubbing and moistening of dry deposits with the anteroventral portion of the rhinarium (Poran 1998; Poran et al. 1993b). The tongue is used to lick the snout after nuzzling, promoting the oral uptake of odors (Poran 1998; Poran et al. 1993b).

**GENETICS.** *Monodelphis domestica* has  $2n = 18$  (VandeBerg 1990). As of May 2004, 247 nucleotide and 224 protein sequences were archived in GenBank ([www.ncbi.nlm.nih.org/Genbank/index.html](http://www.ncbi.nlm.nih.org/Genbank/index.html)). The X chromosome of *M. domestica* is distinguished from autosomes by its small size (VandeBerg 1990). C-band material is restricted to the centromeres of the autosomes and X chromosome and to 1 entire arm of the Y chromosome (VandeBerg 1990:239). Nucleolar organizer regions are on the end of the short arm of the X chromosome and the end of the chromosome 5 (VandeBerg 1990). The nucleolar organizer regions on both X chromosomes in females are active but those on chromosome 5 are rarely active (VandeBerg 1990). Males commonly express nucleolar organizer regions on the X chromosome and on at least 1 of the chromosomes 5 (VandeBerg 1990).

Immunoglobulin sequences ( $\kappa$  light chain,  $\gamma$  heavy chain, and E heavy chain) of *M. domestica* and *Trichosurus vulpecula* are 70% or more identical at the amino-acid level (Belov et al. 1999a, 1999b, 2001). Female *M. domestica* show significantly less recombination than males across the genome (Samollow et al. 2004). A

single recessive gene controls dietary-induced hypercholesterolemia (Kushwaha et al. 2001; VandeBerg 1990).

**REMARKS.** A phylogenetic analysis among 15 species of *Monodelphis* based on morphological characters found *M. domestica* as sister taxon to all other species (Gomes 1991). The specific epithet derives from the fact that *M. domestica* frequents human dwellings (Nowak 1999). Additional vernacular names for *M. domestica* are grey-faced opossum (Lydekker 1896), short bare-tailed opossum (Streilein 1982b), catita (Brazil—Streilein 1982b), colicorto gris (Argentina—Emmons and Feer 1990), and mbicuré-i (Paraguay—Emmons and Feer 1990).

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