Journal of Zoology. Print ISSN 0952-8369

New records and a status assessment of a rare dwarf brocket deer from the montane forests of Bolivia

D. I. Rumiz[1], E. Pardo[2], C. F. Eulert[3], R. Arispe[3], R. B. Wallace[4], H. Gómez[4] & B. Ríos-Uzeda[4]

1 Wildlife Conservation Society and Museo de Historia Natural Noel Kempff Mercado, Santa Cruz, Bolivia
2 Centro de Biodiversidad y Genética, Universidad Mayor San Simón, Cochabamba, Bolivia
3 Museo de Historia Natural Noel Kempff Mercado, Santa Cruz, Bolivia
4 Wildlife Conservation Society – Greater Madidi Landscape Conservation Program, San Miguel, La Paz, Bolivia

Keywords
Mazama chunyi; camera trapping; deer sign; Andean habitats; geographic distribution model.

Correspondence
Damián I. Rumiz, Wildlife Conservation Society and Museo de Historia Natural Noel Kempff Mercado, PO Box 6272, Santa Cruz, Bolivia. Email: confauna@scbbs-bo.com

Received 4 October 2005; accepted 12 June 2006

doi:10.1111/j.1469-7998.2006.00226.x

Abstract

Two skeletons, tracks, faecal pellets, photographs and local reports are described and compared with the few previous records of dwarf Andean deer from Bolivia and Peru. Tarsal bones and incisor teeth were diagnostic traits for *Mazama* and not for *Pudu*, while skull measurements, ear shape, body colour and facial patterns were consistent with descriptions of *Mazama chunyi*. Twenty-five new localities (including more than 60 sites in La Paz and Cochabamba) extended significantly the previously known range for *M. chunyi* in Bolivia. It occurs in Madidi, Apolobamba, Pilón Lajas, Cotapata, Carrasco and probably Isiboro Sécure protected areas, in habitats ranging from grasslands and *Polylepis* elfin forests of the 'ceja de Yungas' at 3600 m to sub-Andean forests at 1000 m. A geographical information system modelled geographic distribution area based on altitude and ecological zone estimates a potential range of about 45 717 km^2 in Bolivia. About 36% of this range (or 41% of the extent of occurrence) is degraded and fragmented, but the rest seems to be in relatively good conservation status. Habitat decline and a limited area of occupancy estimated for Bolivia (and suspected for Peru) suggest that *M. chunyi*'s conservation status should be updated from Data Deficient to Vulnerable VU A4c; B2a + b(iii).

Introduction

Among neotropical deer there is a group of dwarf forms, in the genera *Pudu* and *Mazama*, whose small size and reduced antlers seem to be adaptations for moving through the dense understorey of the mountain forests they mostly inhabit (Redford & Eisenberg, 1992). The genus *Pudu* Gray, 1850 comprises one species from the Patagonian forests of Argentina and Chile (*Pudu puda* Molina, 1782) and another from the Andean forests of Colombia, Ecuador and Peru (*Pudu mephistophiles* De Winton, 1896, cited in Hershkovitz, 1982). This northern species of *Pudu* apparently overlaps its range with *Mazama rufina* Pucheran, 1851 (= *Mazama bricenii* Thomas, 1908) in Colombia and Ecuador, and with *Mazama chunyi* Hershkovitz, 1959 (or *Mazama bricenii chunyi*; Anderson, 1997) in central Peru (Eisenberg & Redford, 1999). *Mazama chunyi* is taller, less stocky and lighter in colour than *Pudu*, but both forms are rare and little studied. According to Hershkovitz (1959, 1982), *M. chunyi* is the only dwarf deer occurring in southern Peru and northern Bolivia since '*Pudu*' specimens from Puno were misidentifications of *M. chunyi* (but see Infonatura, 2004). Recently, another distinct dwarf deer species was photographed in southern Peru (Trolle & Emmons, 2004), and ranges of these three deer are shown in Fig. 1.

Published records of the Bolivian 'venadillo', 'chuñi-taruka' or 'cabrito' (*M. chunyi*) consist of two specimens collected in La Paz department (Cocapunco: Hershkovitz, 1959; Unduavi: Yensen, Tarifa & Anderson, 1994) and signs or sightings from protected areas Apolobamba (Jungius, 1974) and Cotapata (Ríos-Uzeda, 2001; Pacheco, Guerra & Ríos-Uzeda, 2003) also in La Paz, Isiboro Secure (Altamirano, 1992) in La Paz–Beni border, and Carrasco (Rumiz, Eulert & Arispe, 1998) in Cochabamba department (Figs 1 and 2). The limited information on this species' range and the existing threats to Andean forest habitats led one to consider the dwarf brocket as a rare and Vulnerable (VU) species in Bolivia (Tarifa, 1996). At global level, it is categorized as Data Deficient (DD), and the IUCN's deer action plan (Wemmer, 1998) recommends studying its distribution, ecology and threats in Peru and Bolivia. In this paper we describe new specimens and geographic records, present an updated distribution map, and characterize the habitat, tracks and faeces of this little-known species in Bolivia. We also assess its potential distribution range and conservation status.

Materials and methods

Recent studies of Andean cervids (Pardo, 2001) and other mammals (e.g. Rumiz *et al.*, 1998; Ríos-Uzeda, 2001;

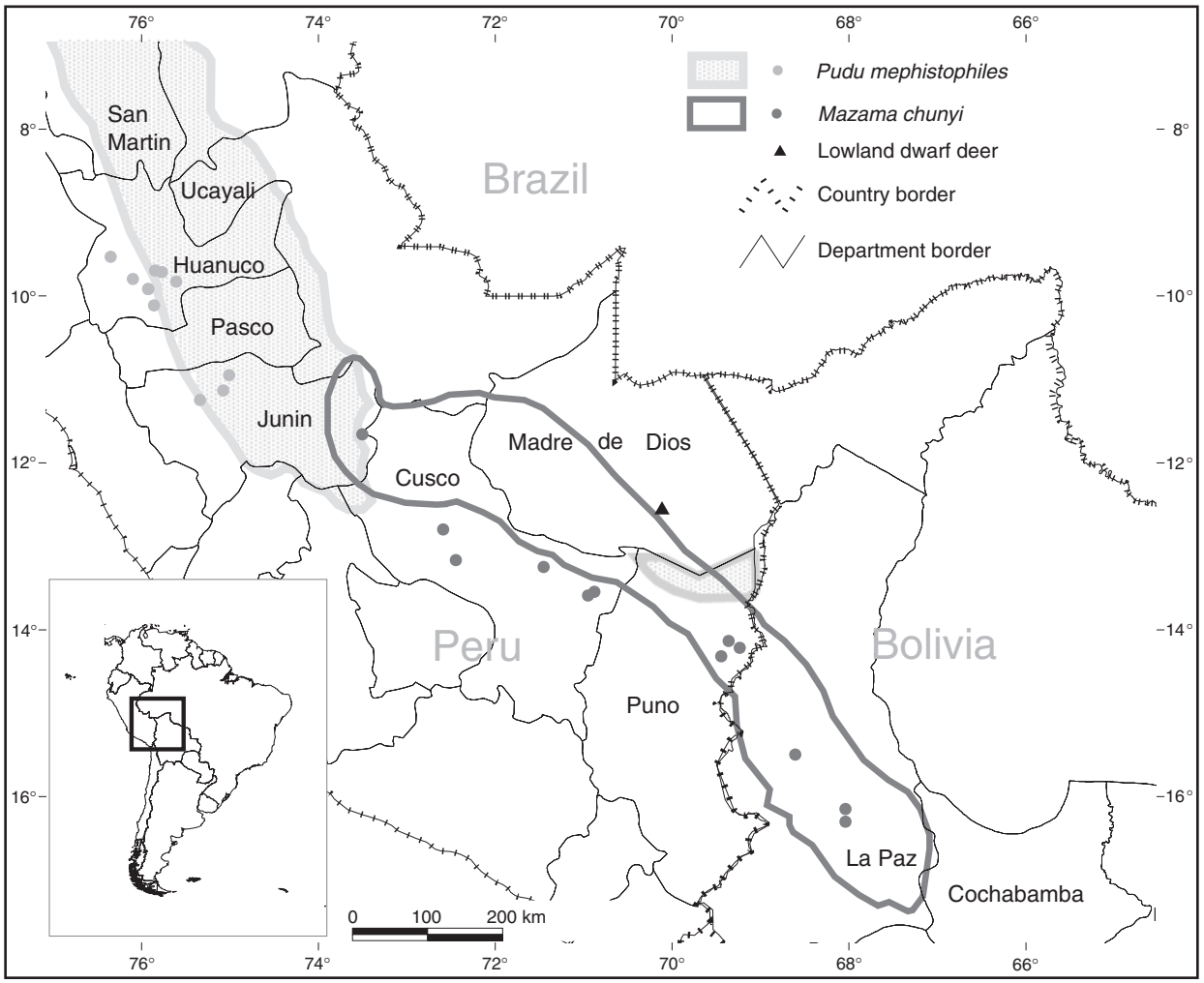

Figure 1 Geographic ranges of dwarf deer species in northern Bolivia and southern Peru (points from Hershkovitz, 1959, 1982, and Trolle & Emmons, 2004; polygons from Infonatura, 2004).

Pacheco *et al*., 2003; WCS La Paz, unpubl. database) rendered new records of this dwarf deer in Bolivia. The above studies lasted several months and involved either transect counts or camera-trapping surveys, plus habitat descriptions, global positioning system (GPS) locations, track and scat measurements, and questionnaires to local people. We compiled 61 new records of dwarf deer from Bolivia and summarized them together with published studies into an annotated list of 25 localities (see Table 1 and Fig. 2). Each locality is numbered from 1 to 25 in the text and map, but may represent multiple sites with different records (e.g. specimen, photographs, animal sign or local reports).

We described these deer based on pictures of at least seven live animals photographed in Carrasco, Apolobamba and Madidi protected areas (~70 from camera traps and five from other sources) and by examining two skeletons obtained in Carrasco. One set of bones belonged to an injured juvenile male that was captured and photographed (Supplementary Material Figure S1a) in 1997 by park guard G. Córdoba at Sehuencas (location #5). The animal died and was buried nearby, but its skeleton was recovered and taken by C. F. E. and R. A. to the Museo de Historia Natural Noel Kempff Mercado in Santa Cruz (MNK 3174, Table 2). The other skeletal remains belonged to an adult female and were collected by E. P. in 2000 from a cave in El Limbo (#11, MNK 3175, Table 2).

New specimens were compared with published descriptions (Hershkovitz, 1959, 1982; Anderson, 1997), with a specimen from the National Museum in La Paz, and with traits of potentially sympatric species *Mazama gouazoubira* and *P. mephistophiles*. The comparison of skull measurements, as defined by DeBlase & Martin (1981), included skull length, condylobasal length, palatal length, zygomatic breadth, interorbital breadth, braincase breadth, mandible length and height, cheek teeth row, condylar width, foramen height and foramen width.

To characterize the potential geographic range of this species, we used altimeter/GPS readings and habitat

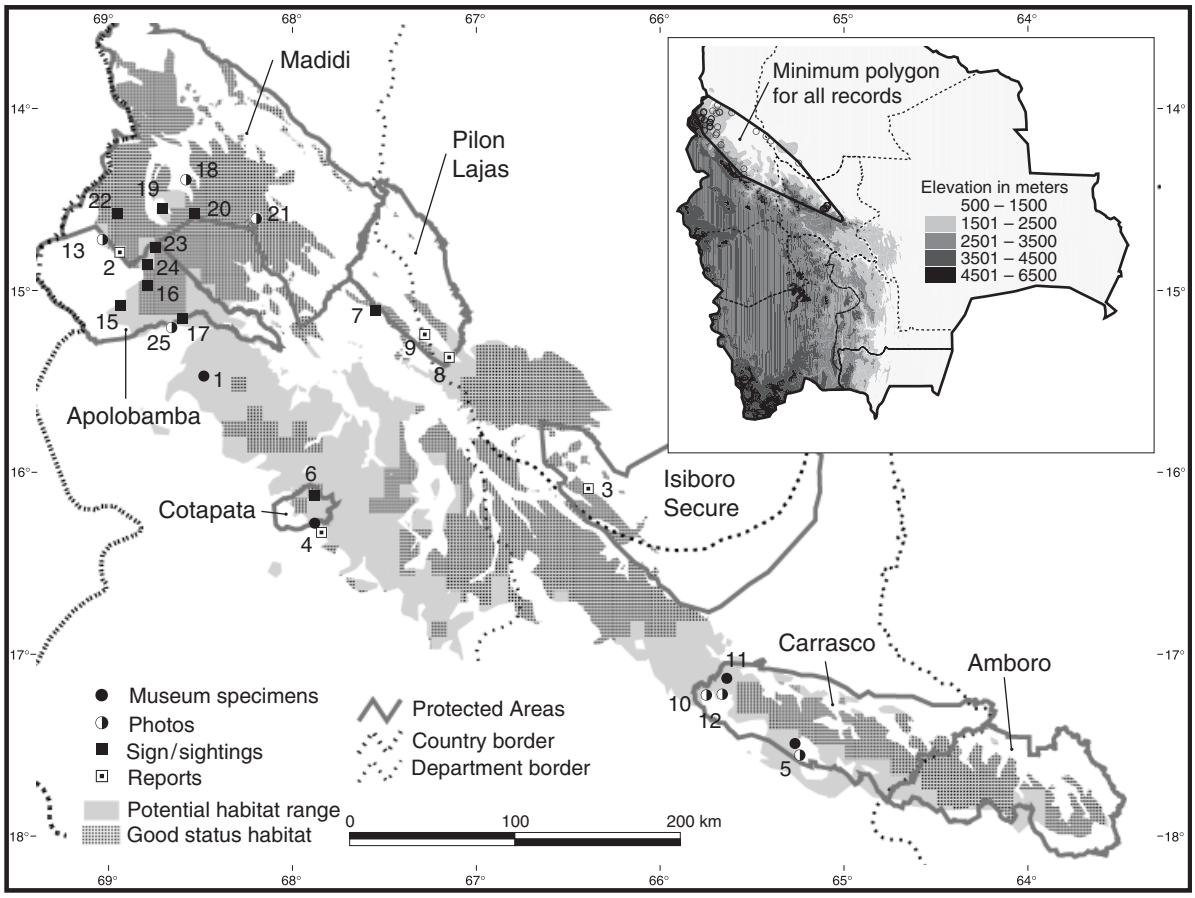

Figure 2 Records of dwarf *Mazama*, protected areas, expected geographic range and good-condition habitats in the Bolivian Andes. Inset: elevation and extent of occurrence (minimum convex polygon; IUCN, 2005) in Bolivia based on 65 record sites.

descriptions made in the field (following Navarro & Maldonado, 2002), as well as data derived from geographic information layers such as elevation (90 m grid, SRTM model), terrestrial ecoregions (Dinerstein *et al*., 1995), mean annual rainfall (~3.6 km grid) and habitat conservation status (~9 km grid) from the Bio-corridor Amboro-Madidi (Araujo & Ibisch, 2000). As described further in the Results, we estimated suitability limits for selected environmental variables and performed exclusionary processes in Arcview v.3.2 to define the potential habitat and geographic range in Bolivia. Then, we examined the ecological variation and threats within this range, and estimated the areas of occurrence and occupancy (IUCN, 2005) to assign a conservation category to this species.

Results

External morphology of dwarf brocket deer

The young male from Sehuencas (MNK 3174) had a head and body length of 60 cm and a height at the rump of about 42 cm (Supplementary Material Figure S1a). Photographs showed that the general body colour was brown, with reddish midback and flanks, and a blackish neck, head and legs. The throat, chest and belly were buff to pale orange, contrasting with the outer surface of the legs and dorsum. The tail was not concealed within the rump, was reddish-brown in colour, and had a prominent white tuft underneath. Ears were blunt at the tip, not pointed as in *M. gouazoubira* nor as round as in *P. mephistophiles*, had a whitish rim and a white spot at the base internally, and dorsally were blackish-brown as the forehead and crown. A black mandibular band crossing the whitish chin and a white but small narial patch were prominent in the facial pattern. Less noticeable were a pale ring around the eye and the whitish opening of the preorbital pouch. Hooves were black, not contrasting with the skin of the foot. The picture of the San Jacinto individual (Supplementary Material Figure S1b) showed the same colour pattern, but was darker than the one from Sehuencas. The throat and the interior of the ears were light and contrasting with the head and the upper surface of the neck in both specimens.

Camera-trapped individuals from Cochabama (Supplementary Material Figure S1c–f) and La Paz (Supplementary Material Figure S2a–d) also showed a dark crown, neck and dorsum, a contrasting light ventrum, and whitish ear

Table 1 Summary of old and new geographic records (25 localities; including >60 multiple sites = ms) of dwarf brocket deer in Bolivia

#	Locality (protected area)[a]	Source	Evidence and year	Latitude and longitude[b]	Altitude[b] (m)	Rainfall[c] (∼mm year^{-1})	Habitat status[c]
1	Cocapunco	Hershkovitz (1959)	Specimen, 1926	15°30′S, 68°29′W	3100	1700	2
2	Pelechuco, Ulla Ulla (Ap.)	Jungius (1974)	Reports, 1970?	NA	∼3500–2200	NA	[3]
3	Mosetenes (IS)	Altamirano (1992)	Reports, 1991?	∼16°00′S, 66°20′W	∼1500	4000+	5
4	Unduavi, ms	Yensen *et al.* (1994)	Specimen, 1992	16°18′S, 67°52′W	2750	1400	2
5	Sehuencas, ms (Ca.)	C. Eulert and R. Arispe	Specimen, photo, 1997	17°30′S, 65°16′W	2250	NA	[3]
6	Hormuni, ms (Co.)	Ríos-Uzeda (2001)	Signs, 1998	16°09′S, 67°52′W	∼3300–2400	2000	4
7	Serranía Beu (PL)	D. Rumiz	Signs, 1998	15°08′S, 67°33′W	1400	2400	5
8	Cascada (PL)	Guards, hunters	Reports, 1998	∼15°24′S, 67°09′W	∼1000	2000	3
9	Buena Vista (PL)	Park guards	Reports, 1998	∼15°16′S, 67°17′W	∼1000	1800	4
10	San Jacinto (Ca.)	C. Azurduy and X. Velez	Photo, reports, 1998	17°14′S, 65°45′W	3400	2600	[3]
11	Limbo, ms (Ca.)	E. Pardo	Specimen, sighting, 2000	17°09′S, 65°38′W	2440	4000	2
12	Sillar–San Jacinto, ms (Ca.)	E. Pardo	Signs, 2000	17°13′S, 65°40′W	3330–2700	4000?	[3]
13	Pasto Grande, Whata, ms (Ap.)	WCS La Paz	Photos, signs, 2000, 2002	∼14°46′S, 69°02′W	3490–3020	1500	3
14	Condormallku, ms (Ap.)	N. Rocha	Signs, 2001	14°50′S, 68°56′W	2550–2464	1900	3
15	Wairapata, Curva, ms (Ap.)	WCS La Paz	Sighting, signs 2001–2002	15°07′S, 68°56′W	3500–3380	1400	3
16	Sorapata–Kiyali, ms (Ap.)	WCS La Paz	Signs, 2001–2002	15°00′S, 68°47′W	3525–3240	1400	4–3 [5]
17	Majata, Yurilaya/Tuano, ms.	WCS La Paz	Signs, 2001, 2002	15°14′S, 68°36′W	3100–2000	1600	3
18	Pata/Sauce, ms (Ma.)	WCS La Paz	Photo, signs, 2002	14°26′S, 68°42′W	2155–1900	1500–1700	4
19	Virgen del Rosario Cuatro vientos (Ma.)	WCS La Paz	Signs, 2002	14°35′S, 68°42′W	1500	1500	
20	Santa Cruz del Valle Ameno, ms (Ma.)	WCS La Paz	Signs, 2002	14°37′S, 68°32′W	2260–2215	1400	4 [3]
21	Sarayo (Ma.)	WCS La Paz	Photos, 2002	14°38′S, 68°12′W	2300	1600	4
22	Totoake/Chuncani, ms (Ma.)	WCS La Paz	Signs, 2002	14°37′S, 68°57′W	2790–23420	1700	5
23	San Juanito/Core area, ms (Ma.)	WCS La Paz	Signs, 2002	14°48′S, 68°75′W	3445–2300	1500–1900	3–4
24	Laji/Chaca Machay (Ma.)	WCS La Paz	Signs, 2002	14°53′S, 68°47′W	3440–3320	1900	3
25	Road near Charazani	WCS La Paz	Sighting, 2002	∼15°13′S, 68°42′W	∼2500	1600?	3

[a]Protected areas: Ap., Apolobamba; Ca., Carrasco; Co., Cotapata; IS, Isiboro Secure; Ma., Madidi; PL, Pilón Lajas.

[b]Provided by the source, or (∼) estimated from maps.

[c]Estimated from digital models in Araujo & Ibisch (2000). Status: 5, very good; 4, good; 3, regular; 2, critical; 1, very critical; or [×], assigned in the field.

Table 2 Measurements (in mm) of new Bolivian specimens of *Mazama chunyi* from Sehuencas (MNK 3174) and Limbo (MNK 3175) compared with other deer taxa

	Mazama chunyi					*Mazama gouazoubira*	*Pudu mephistophiles*
	Juv. M[a,b] AM 73098	Ad. F[a]	Ad. F[c] CBF 2959	Juv. M MNK 3174	Ad. F MNK 3175	3 Ad. F and 3 Ad. M[b]	9 Ad. F and 10 Ad. M[d]
Head body	706	720		~600		931–1130	600–720
Tail	24					78–130	30–45
Hind foot	124	164				264–322	160–180
Ear	–	63				100–116	65–82
Skull length	117.0	146	141.0	~125	~151		127–142
Condylobasal length	110.2		137.0	~116	~140	142.2–180.5	
Palatal length	69.4		88.3	~73.7	–	90.3–114.5	
Zygomatic breadth	60.0	66.9	72.3	64.3	~72.7	71.2–75.3	62.0–72.4
Interorbital breadth	27.1	–		30.6	36.5	32.7–45.8	
Braincase breadth	43.2	47.7		45.0	48.4		32.0–47.7
Mandible length	90.6	–	117.4	103.8	124.0	116.1–148.0	
Mandible height	46.1	–	56.4	50.5	62.8	59.3–76.5	
Cheek teeth row	dpm^2-m^2 37.8	pm^2-m^3 44.7		dpm^2-m^3 41.3	pm^2-m^3 43.7	pm^2-m^3? 52.4–57.0	39.8–43.5
Condylar width	–		29.0	26.0	30.5		
Foramen height	–		14.0	13.5	16.7		
Foramen width	–		19.3	14.5	16.9		

[a]Hershkovitz (1959, p. 46).
[b]Anderson (1997, p. 604).
[c]Yensen *et al.* (1994), specimen measured at the CBF, Natural History Museum, La Paz.
[d]Hershkovitz (1982, p. 52).
Juv., juvenile; Ad., adult; F, female; M, male; dpm, deciduous premolar; pm, premolar; m, molar.

rims and narial patches. Although automatic photos are sometimes blurry or poorly lighted, they were very valuable for confirming the presence of this species and examining more individuals. Colour balance and saturation in these pictures may vary widely, depending on flash illumination [e.g. the dark and the light deer pictures (Supplementary Material Figure S2a and b) are actually from the same individual], but in all we saw the diagnostic patterns described by Hershkovitz (1959, 1982) for *M. chunyi*.

New specimens

The skeleton from Sehuencas (MNK 3174, juv. M in Supplementary Material Figure S1a) was nearly complete, except for broken premaxillae and a few missing bones (caudal vertebrae, some teeth and vestigial metacarpals or metapodials). It was reported as a male by the park guards, which was in agreement with the small antler pedicels (but not antlers) present in the skull. Measurements of this specimen are listed in Table 2. The jaws had six uppers and six lower molariforms. The three anterior ones (deciduous premolars) were very worn and had non-erupted teeth beneath. The three posterior (permanent) molars had sharp crests and the last ones (third molars) were not yet in occlusion. Several lower incisors were lost, but one remaining first incisor had a large, spatulated crown, a characteristic for *Mazama* (unlike *Pudu*'s small and rectangular ones). The tarsal bones gave another diagnostic character for *Mazama*, because the cuneiform was separated from the cuboid navicular and did not form a single bone as in *Pudu*.

The skeleton from El Limbo (MNK 3175) belonged to an adult female *Mazama,* with permanent molars, noticeably worn premolars, and a well-fused suture between the basi occipital and the basi sphenoid. The skull was partially broken and some appendicular bones were missing, but it was still possible to take several comparative measurements (Table 2). Although larger than other *M. chunyi* specimens, this adult female was smaller than adults of *M. gouazoubira* and *Mazama americana*.

Apart from the size, *M. chunyi* skulls from Bolivia showed apparent differences with *M. gouazoubira* skulls examined at the Museo NKM, such as the presence of a depression in the occipital lamboid crest, only one postzygomatic process noticeable in ventral view and a scarcely expanded infraorbital margin. Also, *M. chunyi* females showed a very pronounced postorbital groove, not noticeable in *M. gouazoubira*.

Dwarf deer signs in Carrasco protected area

Tracks and faeces of dwarf deer were found around sites of specimen collection and associated with reliable sightings and reports by local people in Carrasco National Park. In the area of Sehuencas, tracks measured between 23–28 mm × 18–19 mm and were not associated with larger deer tracks, which would have suggested they belonged to

fawns of a larger species such as *M. gouazoubira* or *M. americana*. A series of tracks of an individual walking on a wet road showed steps of about 350 mm and strides of about 600 mm.

Dung piles made of distinctly small pellets were collected in different latrines at Sehuencas. Pellets were ovoid to pyramidal in shape and slightly compressed or concave in their contact surface with other pellets. All presented a pointed tip in contrast with a wider base. The pellets' length and width ($n = 52$, from three piles) averaged 7.6 mm (range 6.2–10.0, SD 0.98) by 5.1 mm (range 4.5–5.9, SD 0.34), respectively. Measured pellets from El Limbo were slightly larger (mean 8.5 mm long, range 6.8–11.4, SD 1.10, by 5.4 mm wide, range 3.9–7.7, SD 1.01, $n = 59$).

Dwarf deer habitats and ecology

Habitats showing signs of this deer in four sites around Sehuencas (south-west Carrasco, #5) ranged from *Polylepis* woodlands and anthropogenic grasslands at 3100 m in Cerro Astilla ('ceja de monte' Yungas vegetation, according to Navarro & Maldonado, 2002) to *Prumnopitys* 'pine' forest and *Alnus* riverine forest at 2300 m in Río Fuerte (lower montane Yungas forest). Habitats with deer signs in three sites of north-west Carrasco (#11) ranged from grasslands and elfin forest of the 'ceja' vegetation at 3400 m (*Polylepis racemosa*, *Symplocos nana*, Ericaceae) to humid lower montane forests at 2000 m (*Nectandra* and *Podocarpus* forests with *Cyathea* tree ferns). Some sites were devoid of human use but others experienced timber extraction, or were currently under use for cattle pasture, small-scale agriculture and tourism. Near Sehuencas, park guards reported sights of solitary adults or adults with fawns despite human activities in the surrounding area.

About 400 km north–north-west of Carrasco Park, similar small tracks were recorded in Serranía Beu in Pilón Lajas Reserve, La Paz Department (#7). They occurred at 1400 m of altitude, in a humid, upper sub-Andean forest dominated by *Dictyocaryum* palms. From the same reserve, reliable hunter and park guard accounts described a small deer at lower elevations (around 800–1000 m, or lower sub-Andean forest) in Buena Vista and Cascada about 50 km south-east of Beu, near the La Paz–Beni border (#8 and 9).

Dwarf deer signs recorded in Cerro Hormuni, Cotapata (#6; Ríos-Uzeda, 2001; Pacheco *et al*., 2003), were abundant in the upper montane Yungas forests sampled between 2400 and 2600 m (the most frequently encountered mammal sign in tracks plots) and also occurred in the adjacent grassland–woodland of the 'ceja' vegetation, above the tree line (3200–3300 m). However, they were not registered in the lower montane Yungas forest sampled between 1800 and 2000 m. Reports from nearby Unduavi (#4; Yensen *et al*., 1994) described this species surviving in fragmented upper montane forests parsed between fields and second growth.

In Apolobamba, northern La Paz, dwarf deer records ranged from elfin forest and grasslands at the 'ceja' (3600–3500 m) in Sorapata–Kiyalli (#16), Wairapata (#15) and Pasto Grande (#13) to montane forests (2300–2500 m) in Condor Mallku (#14; N. Rocha, pers. comm.) and San Juanito (#23). In Madidi, the highest record came from the upper montane Yungas forest (2790 m) in Chuncani (#22); others came from lower montane forest (2200–2300 m) in Sarayo (#21) and Santa Cruz del Valle Ameno (#20), while lowest sites belonged to the upper sub-Andean forest (1500 m) in Cuatro Vientos (#19). Four intensive mammal surveys carried out at lower altitudes (150–400 m) in these protected areas were negative for dwarf deer.

The altitude of the best substantiated records in Bolivia varies between 1400 and 3600 m, while local reports extend from 1000 m in Pilón Lajas to 4000 m in Unduavi (Yensen *et al.,* 1994). According to Dinerstein *et al*.'s (1995) Latin American ecoregions, most sites correspond to the montane forests of the Bolivian Yungas, although a few belong to the grassland–shrublands of the adjacent Andean Puna or to the lowland forests of the south-west Amazon ecoregions. According to Navarro's biogeographic scheme for Bolivia (Navarro & Maldonado, 2002), most sites belong to the Yungas province of the Andean region (including 'ceja' vegetation, montane forests and sub-Andean forests), although a few may fall in the provinces of the Puna (Andean region) or Acre–Madre de Dios (south-west Amazon region). The vegetation of the well-described sites (~30) represented the more humid variants of 'ceja' and forests, suggesting that dwarf deer avoid xeric and sub-humid variants of montane or sub-Andean forests. Based on a digital model of rainfall (Araujo & Ibisch, 2000), the values for the 65 record sites ranged from 1400 to 4000+ mm year^{-1}.

Preliminary camera trapping with automatically recorded times shows that this species is active day and night, but seems mostly crepuscular (in La Paz: one picture after midnight, two at sunset, one in midmorning; in Carrasco: 63 pictures in five series, all between sunset and 1 AM). Three out of 12 camera stations in Carrasco (set at 1–2 km apart, during 13 days) rendered deer pictures (1, 2 and 60 pictures) from a single individual by station as inferred by the recorded time (mostly sequential photos) and the appearance of the animals. This suggests that dwarf deer live at very low densities and/or that individuals are solitary and do not overlap much in their ranges.

Discussion

Dwarf deer identification

Skeletal characteristics of the new specimens (e.g. spatulated first incisors, a discrete cuneiform bone) as well as facial patterns, body colour, ear shape and tail shown in photographs were consistent with descriptions of *M. chunyi* and not of *P. mephistophiles* (Hershkovitz, 1959, 1982). The size of dwarf deer was smaller than that of other potentially sympatric brocket deer species, and skulls showed morphological differences with *M. gouazoubira*. Currently, we find no reason to believe that these new specimens differ from the previously described ones of *M. chunyi*. However, genetic analyses as well as more in-depth morphological comparisons are needed to confirm the taxonomic status of this

form and the northern taxa of dwarf brocket deer (e.g. *M. rufina*, *M. bricenni* and the form just found in lowland Peru by Trolle & Emmons, 2004).

Their tracks and faecal pellets seemed the smallest of all deer in Bolivia. Sign measurements from Sehuencas were smaller than those of *M. gouazoubira* from lowland Santa Cruz (tracks: 32.4 ± 2.47 SD $\times$ 24.5 ± 3.05 SD; pellets: 10.3 ± 1.3 SD $\times$ 5.4 ± 0.51 SD; Rivero, Rumiz, & Taber, 2005), but those from Limbo seemed more variable and partially overlapped those of this larger species. However, misidentification of dwarf deer signs seems unlikely in sites where *M. gouazoubira* is absent. *Mazama americana* occurs in the montane forests of Cotapata together with *M. chunyi* (Ríos-Uzeda, 2001), as well as in Apolobamba (WCS La Paz, unpubl. data), but its tracks and faeces are noticeably larger. *Hippocamelus antisensis* and *Odocoileus peruvianus* are sympatric with *M. chunyi* at the upper border of the 'ceja' in Carrasco and Apolobamba, but they are much larger.

Estimated geographic range

The currently accepted geographic range of *M. chunyi* (Infonatura, 2004; Fig. 1) extends as a strip of about 127 000 km^2 along the Central Andes, covering 80 000 km^2 in Peru and 47 000 in Bolivia. The new Bolivian specimens of El Limbo and Sehuencas expanded this range about 300 km to the east–south-east, and together with the rest of the points allowed us to generate a minimum convex polygon that extends for 51 000 km^2 from La Paz to Cochabamba (Fig. 2, inset). By selecting areas within the altitude (1000–3600 m) and broad ecological zones of the recorded localities, we adjusted this extent of occurrence (EOO; IUCN, 2005) to an expected range of suitable and nearly connected habitats for dwarf deer in Bolivia (Fig. 2, main map). This expected range consisted of one large polygon and 156 small ones totalling 45 717 km^2 and extending further east from the EOO into Amboró Park in Santa Cruz. Within this range, 77% of the area represented the Yungas montane forest and 13% the sub-Andean forest sub-ecoregions (of Dinerstein's Bolivian Yungas ecoregion). Smaller areas represented the more mesic border of the Puna (9%) to the west of the Andean slopes and the lowland forest (1%) to the east.

Because record sites coincided only with the more humid habitats ($>$1400–1800 mm year^{-1}, depending on the altitude), we expect dwarf deer to be absent in the xeric and subhumid variants of Yungas montane forests and Puna woodlands described for the region (Bach, Kessler & Gonzales, 1999; Navarro & Maldonado, 2002). These drier spots occur at least in the southern borders of Carrasco and Amboro, in the western range near Cocapunco and in the upper Madidi area, but they have not been reliably mapped yet.

Other gaps in the distribution range result from human activities. Fragmentation and degradation of upper montane forest and woodlands for pastures and agriculture reduce food resources and concealment for deer, which combined with hunting could deplete local populations (e.g. Yensen *et al.,* 1994). A 9×9 km grid analysis of this region's current conservation status (based on human density and immigration, road and river access, mining and oil activities; Araujo & Ibisch, 2000) suggests that 64% of the expected range is in good status (darker shade in Fig. 2), 22% in regular status and 14% in bad status. Good-status cells included most of our records within protected areas, but also showed two blocks of potentially good habitat in the centre of the range and outside protected areas. Bad-status cells occurred south of Apolobamba (including Cocapunco), east and south of Cotapata (including Unduavi), and north-west of Carrasco (near Limbo). The next field surveys should verify the presence of dwarf deer in the good habitat blocks of north-west Cochabamba, south-west Beni and Amboro Park in Santa Cruz, as well as in the dry spots and degraded areas so that they could be appropriately incorporated into distribution models.

Assessment of the conservation status

We examined the criteria proposed by the IUCN (2005) to assess the conservation status of *M. chunyi* and found enough data on extent of occurrence, range decline and area of occupancy to update its current DD status as summarized below:

- *Declining population* (past, present and/or projected). A2–A4: threat not ceased and not reversible (decline threshold $>$30% for VU). A4: decline occurred in the past and is projected for the future. Habitat destruction has occurred for decades in the range of the dwarf deer, its area of occupancy (AOO) has declined in Bolivia (41% degraded), degradation and hunting continue at an unmeasured rate, probably enough to grant the category of VU A4c.
- *Geographic range size* (and fragmentation, decline or fluctuations). B1: extent of occurrence estimated at 51 000 km^2 in Bolivia (Fig. 2, inset), expecting the same or more from Peru (EOO threshold for VU $<$ 20000 km^2), not threatened. B2: area of occupancy based on 60+ sites, with 2×2 km quadrats = 224 km^2 and with 4×4 km quadrats = 656 km^2 (AOO threshold for VU $<$ 2000 km^2). In Bolivia there is a small number of locations and a decline in EOO, presumed similar in Peru, VU B2a + b(iii).
- *Small population size* (and fragmentation, decline or fluctuations). It is not possible to estimate number of individuals or population fluctuations now (DD), but preliminary data suggest a very low abundance at the few known places.
- *Very small populations or very restricted distribution*. There are $>$5 locations and probably $>$1000 individuals (assuming a low density but a relatively large range) not threatened.

Record sites in Peru are also few and the species has been considered as Vulnerable in this country (Emmons, Luna & Romo, 2001; Pacheco, 2002). On the basis of the new data from Bolivia, we propose to update the global category of *M. chunyi* from DD to Vulnerable [VU A4c; B2a + b(iii)]. This status could be considered only as a regional assessment for Bolivia (UICN, 2003), but probably it would not

change significantly if a similar assessment is completed soon for Peru. Nevertheless, we want to stress the need to gather more field information in Peru as well as in Bolivia on geographic distribution (rapid surveys, interviews) at unknown habitat blocks, and on abundance and ecology (camera trapping and sign surveys) at key conservation places. We also recommend initiating genetic studies of this and neighbouring forms of dwarf brocket deer to confirm its taxonomic status and the degree of relationships among populations.

Acknowledgements

Surveys were possible thanks to the institutional support of the Wildlife Conservation Society (WCS) and funding from Phoenix Zoo, Darwin Initiative, Veterinarios Sin Fronteras, IUCN Deer Specialist Group, and the Claiborne-Ortenberg, Moore and MacArthur Foundations. P. Ibisch and N. Araujo kindly shared their geographic files with us, which we analysed with Arcview thanks to a grant from ESRI to WCS. We are indebted to the Bolivian National Park Service, park guards and authorities of Carrasco (Juan Dávalos and José Vega), Pilón Lajas (Luis Marcus), Madidi and Apolobamba (Ciro Oliver, Oscar Loayza and Juan Carlos Gómez). We also thank Gregorio Córdoba, Carola Azurduy and Ximena Vélez for sharing the Sehuencas and San Jacinto photographs, and Norka Rocha, Hugo Araníbar and Charles Veitch for additional field records. Huáscar Azurduy helped us to examine the skeletons, while Louise Emmons, Nick Acheson and two anonymous reviewers contributed with comments that improved the paper.

References

Altamirano, R. (1992). *Inventario de Flora y Fauna, Territorio Indígena Parque Nacional Isiboro Secure*. La Paz, Bolivia: CIDDEBENI-GTZ-Instituto de Ecología.

Anderson, S. (1997). Mammals of Bolivia, taxonomy and distribution. *Bull. Am. Mus. Nat. Hist.* **231**, 1–652.

Araujo, N. & Ibisch, P.L. (Eds) (2000). *Hacia un plan de Conservación para el Bio-Corredor Amboró-Madidi*. Santa Cruz, Bolivia: Editorial FAN.

Bach, K., Kessler, M. & Gonzales, J. (1999). Caracterización preliminar de los bosques deciduos andinos de Bolivia en base a grupos indicadores botánicos. *Ecol. Bolivia* **32**, 7–22.

DeBlase, A.F. & Martin, R.E. (1981). *A manual of mammalogy with keys to families of the world*. Dubuque, IA: Wm. C. Brown Company.

Dinerstein, E., Olson, D.M., Webster, A.L., Primm, S.A., Bookbinder, M.P. & Ledec, G. (1995). *A conservation assessment of the terrestrial ecoregions of Latin America and the Caribbean*. Washington, DC: World Wildlife Fund and The World Bank.

Eisenberg, J.F. & Redford, K.H. (1999). *Mammals of the neotropics: the central neotropics*. Chicago: University of Chicago Press.

Emmons, L.H., Luna, L.W. & Romo, M.R. (2001). Mammals of the northern Vilcabamba Mountain Range, Peru. In *RAP working paper # 12, biological and social assessments of the Cordillera de Vilcabamba, Peru*: 105–109. Alonso, L.E., Alonso, A., Shulenberg, T.S. & Dallmeier, F. (Eds). Washington, DC: Conservation International.

Hershkovitz, P. (1959). A new species of South American brocket, genus *Mazama* (Cervidae). *Proc. Biol. Soc. Wash.* **72**, 45–54.

Hershkovitz, P. (1982). Neotropical deer (Cervide) part I. Pudus, genus *Pudu* Gray. *Field. Zool.* **11**, 1–86.

InfoNatura (2004). *Birds, mammals, and amphibians of Latin America [web application]. Version 4.1*. Arlington, VA, USA: NatureServe. http://www.natureserve.org/infonatura. (Accessed: 18 August 2005.)

IUCN (2005). *Guidelines for using the IUCN Red List categories and criteria*. Gland, Switzerland: Standards and Petitions Subcommittee of the IUCN SSC Red List Programme Committee.

Jungius, H. (1974). Beobachtungen am Weisswedelhirsch und an anderen Cerviden in Bolivien. *Z. Säugetierkd.* **39**, 373–383.

Navarro, G. & Maldonado, M. (2002). *Geografía ecológica de Bolivia: Vegetación y ambientes acuáticos*. Cochabamba, Bolivia: Centro de Ecología Simón I. Patiño.

Pacheco, L.F., Guerra, J.F. & Ríos-Uzeda, R. (2003). Eficiencia de atrayentes para carnívoros en bosques yungueños y praderas altoandinas en Bolivia. *J. Neotrop. Mammal.* **10**, 167–176.

Pacheco, V. (2002). Diversidad y conservación de los mamíferos peruanos. In *Ecología y conservación de los mamíferos de Latino-América*: 503–550. Cevallos, G. & Simonneti, J. (Eds). México, D.F.: Fondo de Cultura Económica.

Pardo, E. (2001). *Distribución y abundancia de la familia Cervidae en la zona oeste del Parque Nacional Carrasco*. Licenciatura thesis, UMSS. Cochabamba, Bolivia.

Redford, K.H. & Eisenberg, J.F. (1992). *Mammals of the neotropics: the southern cone*. Chicago: University of Chicago Press.

Ríos-Uzeda, B. (2001). Presencia de mamíferos terrestres medianos y grandes en el Parque Nacional y Area Natural de Manejo Integrado Cotapata a través del uso de métodos indirectos. *Ecol. Bolivia* **35**, 3–16.

Rivero, K., Rumiz, D.I. & Taber, A.B. (2005). Differential habitat use by two sympatric brocket deer species (*Mazama americana* and *M. gouazoubira*) in a seasonal Chiquitano forest of Bolivia. *Mammalia* **69**, 169–183.

Rumiz, D.I., Eulert, C.F. & Arispe, R. (1998). Evaluación de la diversidad de mamíferos medianos y grandes en el Parque Nacional Carrasco (Cochabamba, Bolivia). *Rev. Boliviana Ecol. Conserv. Ambiental* **4**, 77–90.

Tarifa, T. (1996). Mamíferos. In *Libro rojo de los vertebrados de Bolivia*: 165–264. Ergueta, P. & de Morales, C. (Eds). La Paz, Bolivia: Centro de Datos para la Conservación.

Trolle, M. & Emmons, L.H. (2004). A record of dwarf brocket from lowland Madre de Dios, Peru. *Deer Specialist Group News* **19**, 2–5.

UICN (2003). *Directrices para emplear los criterios de la lista roja de la UICN a nivel nacional y regional. Versión 3.0*. Gland, Suiza y Cambridge, Reino Unido: Comisión de Supervivencia de Especies UICN.

Wemmer, C. (Ed.) (1998). *Deer: status survey and conservation action plan*. Gland, Switzerland and Cambridge, UK: IUCN.

Yensen, E., Tarifa, T. & Anderson, S. (1994). New distributional records of some Bolivian mammals. *Mammalia* **58**, 405–413.

Supplementary material

The following material is available for this article online:

Figure S1 (a) Specimen from Sehuencas, juvenile male saved from dogs by park guards (photo G. Córdoba). (b) Adult female? Captured and released by workers in San Jacinto (photo C. Azurduy). (c) Adult female El Limbo. (d) Adult female Sehuencas 1. (e) and (f) Adult female Sehuencas 2.

Figure S2 (a) and (b) Adult female of Sarayo. (c) Adult female Pasto. (d) Adult male Pata.

This material is available as part of the online article from http://www.blackwell-synergy.com/doi/abs/10.1111/j.1469-7998.2006.00226.x

Please note: Blackwell Publishing are not responsible for the content or functionality of any supplementary materials supplied by the authors. Any queries (other than missing material) should be directed to the corresponding author for the article.

