Management and Conservation Note

Maned Wolf Density in a Central Brazilian Grassland Reserve

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ABSTRACT The maned wolf (*Chrysocyon brachyurus*) inhabits the savannah-like Cerrado of Brazil. Although 80% of this biome has already been affected by human activity, little is known about maned wolf abundance. Using mark–recapture models, we obtained the first density estimate from central Brazil, the core of maned wolf distribution. With 5.19 individuals/100 km^2, even large reserves support only small maned wolf populations. Therefore, long-term conservation of the maned wolf depends on land management outside of reserves. (JOURNAL OF WILDLIFE MANAGEMENT 73(1):68–71; 2009)

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The maned wolf (*Chrysocyon brachyurus*) is the largest South American canid, with a mean shoulder height of 90 cm and mean weight of 23 kg (Eisenberg and Redford 1999). Maned wolves can be found throughout Paraguay, eastern Bolivia, and northern Argentina but the Brazilian Savannah, or Cerrado, constitutes the largest portion to the species' range (Langguth 1975, Rodden et al. 2004). The Cerrado is Brazil's second largest biome, covering 21% of the country's land area (Klink and Machado 2005). Over the last 35 years >50% of its area has been transformed into agriculture and cattle pasture (Klink and Machado 2005) and 80% is considered to be under some level of human influence (Cavalcanti and Joly 2002). The biome was classified as one of the earth's 25 ecological hotspots (Myers et al. 2000), but only 1.9% of its area is in federal or state reserves (Cavalcanti and Joly 2002).

In spite of its wide distribution and the serious threats of habitat loss the maned wolf is facing, even many basic aspects of its ecology remain unstudied. Although it is classified as Near Threatened by the International Union for Conservation of Nature (IUCN; Sillero-Zubiri and Hoffmann 2004), no abundance estimate is available for the species in Brazil. The 2004 IUCN Canid Action Plan suggested extensive surveys of distribution and abundance, as well as population monitoring of the maned wolf (Rodden et al. 2004).

Maned wolves exhibit a social system characterized by monogamous breeding pairs inhabiting exclusive pair territories (Dietz 1984, Rodrigues 2002). Home range size varies among studies, from 30 km^2 (Dietz 1984) up to 75 km^2 (Carvalho and Vasconcellos 1995). Although members of a pair lead largely solitary lives, sightings of males accompanied by young in the wild suggest that they are involved in cooperative rearing of offspring (Dietz 1984, Carvalho and Vasconcellos 1995, Rodrigues 2002). Feeding mainly on small vertebrates and fruits, the maned wolf plays an important role in its ecosystem, controlling prey abundance and serving as a seed disperser (Santos et al. 2003).

Although the Cerrado of Brazil constitutes the largest part of the maned wolf's distribution (Rodden et al. 2004), until today, only one tentative maned wolf density estimate of 3.64 individuals/100 km^2 is available (Trolle et al. 2007). We used livetrapping data in combination with mark–recapture models to present the first estimate of maned wolf density and abundance in Emas National Park (ENP), one of the country's last grasslands refuges, located in central Brazil. Ours is the first study to estimate these parameters in an area that is of substantial importance for the conservation of this species in Brazil.

STUDY AREA

Emas National Park, with its 1,320 km^2, was one of Brazil's most representative protected Cerrado areas, known for its species richness and the abundance of large mammal species listed as endangered by the Brazilian Institute for the Environment and Renewable Resources (IBAMA; Rodrigues et al. 2002). Located in the southwest of Goiás state (18°19′S; 52°45′W), ENP was not only situated in the core of the maned wolf's range of distribution, but also in one of the most productive agricultural areas of central Brazil

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(Klink and Moreira 2002). Currently, ENP is an island of natural vegetation within agricultural land. The park itself was predominantly covered by open grassland habitat (97%), and the western portion of the park, where we conducted livetrapping, was entirely composed of grassland. Climate of the park was characterized by a wet season from September to May with precipitation of 1,500 mm and a dry season with virtually no rain, when temperatures ranged up to 39° C during the day and could drop to −1.5° C at night (Jácomo et al. 2004).

METHODS

We captured maned wolves with 29 steel cage traps placed at 2-km intervals along an entire park road circuit in the western portion of the park from January to March 2006. We baited traps with live pigeons (*Columba livia*) and checked traps daily. We anaesthetized captured maned wolves with an intramuscular shot of 2.77 mg/kg of a combination of tiletamine and zolazepam (Furtado et al. 2006) and fitted them with a radiocollar. The necessary permits for trapping and subsequent procedures were issued by IBAMA (license no. 241/2006).

To obtain individual capture histories, we divided the trapping period into 16 4-day trapping sessions and noted whether each animal had been caught during each trapping session. To estimate abundance from these data, we used Program CAPTURE (Otis et al. 1978, Rexstad and Burnham 1992). Within CAPTURE, we implemented 6 mark–recapture models, assuming different sources of variation in capture probability (no variation, M_0; time, M_t; behavioral response to capture, M_b; individual heterogeneity, M_h as well as M_{bh} and M_{tb}). Program CAPTURE provides a series of tests to determine which model best fits the data.

CAPTURE assumes populations are closed (i.e., no recruitment or loss of individuals during the trapping period). We believe that our study meets this assumption for 3 reasons. 1) Maned wolves are territorial and from our radiotracking experience, territories remain stable, sometimes over several years. 2) Maned wolves reproduce yearly, with peak birth occurring from June to September (Rodden et al. 2004), thus, chances of recruitment through birth during our sampling period was minimal. 3) During our study, no marked animal died, thus, no vacancy in the system of territories that could potentially trigger permanent immigration was created (Dietz 1984). To control for permanent emigration, we tried to locate collared animals weekly. Further, we used the closure test implemented in CAPTURE to detect violation of the closed population assumption.

We used the radius of the mean home range (assuming home range to be circular) as radius of a buffer circle that we placed over all traps (Soisalo and Cavalcanti 2006), and we used the resulting area formed by all buffer circles as the effective sampled area. For ENP maned wolves, 11 years of radiotelemetry resulted in a mean annual home range size of 30.73 km^2 (SD = 20.83) using the 90% harmonic mean (L. Silveira, Jaguar Conservation Fund, unpublished data), which corresponds to a buffer radius of 3.13 km (SD = 2.12). Buffering traps produced a contiguous sampled area with no internal spaces.

We obtained density by dividing the estimated abundance by the effective sampled area. To determine the standard error of the density estimate, we first calculated the variance of the buffer radius from the variance of home range size and used a delta method approximation, as described by Karanth and Nichols (1998, eq. A.1), to obtain the variance of the sampled area. We obtained the variance of the density estimate, and subsequently the standard error, from the variance of the 2 former parameters, as density is a function of sampled area and abundance (Karanth and Nichols 1998, eq. 3).

RESULTS

Using 29 traps, in 1,621 trap days we captured 12 individual maned wolves 109 times. Model M_h received the strongest support from CAPTURE. Under this model, we estimated N at 16 individuals (SE = 4.27), and average capture probability was 0.199. Sampled area was 308 km^2 (SE = 132), resulting in a density estimate of 5.19 maned wolves/100 km^2 (SE = 2.62).

Radiotelemetry data showed that no animal we caught died or emigrated permanently from the sampled area, because we located all individuals within the area at least once per month during the trapping period. We located all animals except one within the last 2 days of the trapping period. The test for population closure we implemented in CAPTURE did not indicate violation of the closure assumption ($z = 1.531$, $P = 0.937$).

DISCUSSION

We present the first estimate of maned wolf density from central Brazil. Although we are aware that CAPTURE has some drawbacks and limited model alternatives, we refrained from using a more complex approach due to our small sample size. We recognize that reliability of model choice can be weak (Stanley and Burnham 1998) and that MARK (White and Burnham 1999) provides a more reliable procedure for model choice, as well as more flexible analyses. Our choice of model M_h for our data seems reasonable because heterogeneity is generally expected in mark–recapture studies with large territorial mammals (e.g., Karanth and Nichols 1998). Considering that the respective estimator is the most reliable implemented in CAPTURE (Otis et al. 1978, White et al. 1982), we are confident that, within the limitations of the small data set and the analytical method, our density estimate is a reasonable approximation.

Trolle et al. (2007) tentatively estimated 3.64 wolves/100 km^2, from a mosaic of agriculture and native Cerrado vegetation from the northeastern portion of the maned wolf's range, and 1.56/100 km^2 from the Pantanal, based on camera-trapping data. Silveira (1968) estimated 0.3 individuals/100 km^2 for the Cerrado in general, without giving details about methodology. Central Brazil is thought to have

a higher maned wolf abundance than other areas within the species' distribution (Rodden et al. 2004), and although rather preliminary, our density estimate from ENP seems to corroborate that. Emas National Park is one of Brazil's last grassland refuges. Considering that open grassland is the habitat most frequently used by maned wolves (Jácomo et al. 2004) and that ENP is located in the core part of the maned wolf's geographic range, the park is of substantial importance for the conservation of the species in Brazil. The comparatively high maned wolf density estimate confirms this.

Extrapolating the estimate of 5.19 maned wolves/100 km^2 to the 97% of ENP that is covered with open vegetation, the park holds a population of 60 to 70 adult individuals. Following a genetically explicit population viability analysis for the maned wolf in the region of ENP (Rodrigues and Diniz-Filho 2007), the population may not be viable over the long term (200 yr). However, in our study area, maned wolves make extensive use of the surrounding farmlands and the actual population should therefore be larger. Adaptability of the maned wolf to a mixture of natural habitat and agriculture has been shown throughout the species' range (e.g., Dietz 1984, Trolle et al. 2007), making its future much more promising than that of many other large carnivores. Nevertheless, as a Cerrado species it deserves special attention; conversion of the Cerrado biome, which constitutes the major part of the species geographic range (Rodden et al. 2004), continues at rates higher than those of the Amazon Rainforest (Klink and Moreira 2002, Machado et al. 2004). Additionally, open grasslands preferred by the maned wolf (Jácomo et al. 2004) are the first to disappear, which is reflected in the fact that today, of the remaining area covered by natural Cerrado vegetation, only 7% are constituted by this habitat type (Sano et al. 2008). Maintaining a stable population at a strategic location like ENP therefore becomes even more important, and maintaining this stable population requires a conservation strategy that includes not only the park itself, but also the surrounding areas.

Management Implications

Occurring at low densities, even in what is thought to be optimal habitat, the maned wolf faces conservation problems similar to those of other large carnivores (Schonewald-Cox 1983); even large reserves like ENP do not alone hold populations that can guarantee the species' survival. Therefore, some type of land management outside of reserves is needed. Density and abundance estimates should be obtained from other strategic areas important for the range-wide conservation of the species so the actual status of the maned wolf can be assessed with more accuracy.

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LITERATURE CITED

Carvalho, C. T., and L. E. M. Vasconcellos. 1995. Disease, food and reproduction of the maned wolf—*Chrysocyon brachyurus* (Illiger) (Carnivora, Canidae) in southeast Brazil. Revista Brasileira de Zoologia 12:627–640.

Cavalcanti, R. B., and C. A. Joly. 2002. Biodiversity and conservation priorities in the Cerrado region. Pages 351–367 *in* P. S. Oliveira and R. J. Marquis, editors. The Cerrados of Brazil. Ecology and natural history of a neotropical savannah. Columbia University Press, New York, New York, USA.

Dietz, J. M. 1984. Ecology and social organization of the maned wolf (*Chrysocyon brachyurus*). Smithsonian Contributions to Zoology 392:1–51.

Eisenberg, J. F., and K. H. Redford. 1999. Mammals of the neotropics. Volume 3. The central neotropics: Ecuador, Peru, Bolivia, Brazil. University of Chicago Press, Chicago, Illinois, USA.

Furtado, M. M., C. K. Kashivakura, C. Ferro, A. T. A. Jácomo, L. Silveira, and S. P. Astete. 2006. Immobilization of free-ranging maned wolf (*Chrysocyon brachyurus*) with tiletamine and zolazepam in central Brazil. Journal of Zoo and Wildlife Medicine 37:68–70.

Jácomo, A. T. A., L. Silveira, and J. A. F. Diniz-Filho. 2004. Niche separation between the maned wolf (*Chrysocyon brachyurus*), the crab-eating fox (*Dusicyon thous*) and the hoary fox (*Dusicyon vetulus*) in central Brazil. Journal of Zoology, London 262:99–106.

Karanth, U., and J. D. Nichols. 1998. Estimations of tiger densities in India using photographic captures and recaptures. Ecology 79:2852–2862.

Klink, C. A., and R. B. Machado. 2005. Conservation of the Brazilian Cerrado. Conservation Biology 19:707–713.

Klink, C. A., and A. G. Moreira. 2002. Past and current human occupation, and land use. Pages 69–88 *in* P. S. Oliveira and R. J. Marquis, editors. The Cerrados of Brazil. Ecology and natural history of a neotropical savannah. Columbia University Press, New York, New York, USA.

Langguth, A. 1975. Ecology and evolution in the South American canids. Pages 192–206 *in* M. W. Fox, editor. The wild canids. Their systematics and behaviour. Litton Educational, New York, New York, USA.

Machado, R. B., M. B. Ramos Neto, P. Pereira, E. Caldas, D. Gonçalves, N. Santos, K. Tabor, and M. Steininger. 2004. Estimativas de perda da área do Cerrado brasileiro. Conservation International do Brasil, Brasília, Brazil. [In Portuguese.]

Myers, N., R. A. Mittermeier, C. G. Mittermeier, G. A. B. da Fonseca, and J. Kent. 2000. Biodiversity hotspots for conservation priorities. Nature 403:853–858.

Otis, D. L., K. P. Burnham, G. C. White, and D. R. Anderson. 1978. Statistical inference from capture data on closed animal populations. Wildlife Monographs 62.

Rexstad, E., and K. P. Burnham. 1992. User's guide for interactive program CAPTURE. Colorado Cooperative Fish and Wildlife Research Unit, Fort Collins, Colorado, USA.

Rodden, M., F. Rodrigues, and S. Bestelmeyer. 2004. Maned wolf *Chrysocyon brachyurus* (Illiger 1815). *In* C. Zillero-Zubiri, M. Hoffmann, and D. W. Macdonald, editors. Status survey and conservation action plan. Canids: foxes, wolves, jackals and dogs. <http://www.canids.org/cap/index.htm>. Accessed 30 Jun 2006.

Rodrigues, F. H. G. 2002. Biologia e conservação do lobo-guará na Estação Ecológica de Águas Emendadas, DF. Dissertation, Universidade Estadual de Campinas, Campinas, Brazil. [In Portuguese.]

Rodrigues, F. H. G., and J. A. F. Diniz-Filho. 2007. Extinction of canid

populations by inbreeding depression under stochastic environments in Southwestern Goiás State: a simulation study. Genetics and Molecular Biology 30:121–126.

Rodrigues, F. H. G., L. Silveira, A. T. A. Jácomo, A. P. Bezerra, A. M. R. Coelho, D. C. Santos, H. G. Pagnozzi, and A. Hass. 2002. Composição e caracterização da fauna de mamíferos do Parque Nacional das Emas, Goiás. Revista Brasileira de Zoologia 19:589–600. [In Portuguese.]

Sano, E. E., R. Rosa, J. L. Brito, and L. G. Ferreira, Jr. 2008. Mapeamento semidetalhado do uso da terra do Bioma Cerrado. Pesquisa Agropecuária Brasileira 43:153–156. [In Portuguese.]

Santos, E. F., E. Z. F. Setz, and N. Gobbi. 2003. Diet of the maned wolf *Chrysocyon brachyurus* and its role in seed dispersal on a cattle ranch in Brazil. Journal of Zoology, London 260:203–208.

Schonewald-Cox, C. M. 1983. Conclusions: Guidelines to management: a beginning attempt. Pages 414–444 *in* C. M. Schonewald-Cox, S. M. Chambers, B. MacBryde, and L. Thomas, editors. Genetics and conservation. A reference for managing wild animal and plant populations. Benjamin/Cummings, Menlo Park, California, USA.

Sillero-Zubiri, C., and M. Hoffmann. 2004. *Chrysocyon brachyurus*. 2004 IUCN Red List of Threatened Species. <http://www.redlist.org>. Accessed 23 Aug 2005.

Silveira, E. K. P da. 1968. Notes on the care and breeding of the maned wolf *Chrysocyon brachyurus* at Brasilia Zoo. The International Zoo Yearbook 8:21–23.

Soisalo, M. K., and S. M. C. Cavalcanti. 2006. Estimating the density of a jaguar population in the Brazilian Pantanal using camera-traps and capture-recapture sampling in combination with GPS radio-telemetry. Biological Conservation 129:487–496.

Stanley, T. R., and K. P. Burnham. 1998. Estimator selection for closed-population capture–recapture. Journal of Agricultural, Biological, and Environmental Statistics 3:131–150.

Trolle, M., A. J. Noss, E. S. Lima, and J. Dalponte. 2007. Camera-trap studies of maned wolf density in the Cerrado and the Pantanal of Brazil. Biodiversity and Conservation 16:1197–1204.

White, G. C., D. R. Anderson, K. P. Burnham, and D. L. Otis. 1982. Capture-recapture and removal methods for sampling closed populations. Los Alamos National Laboratory, LA 8787-NERP, Los Alamos, New Mexico, USA.

White, G. C., and K. P. Burnham. 1999. Program MARK: survival estimation from populations of marked animals. Bird Study 46: Supplement, 120–138.

Associate Editor: Clark.