

# SEASONAL VARIATION IN FORAGING GROUP SIZE OF CRAB-EATING FOXES AND HOARY FOXES IN THE CERRADO BIOME, CENTRAL BRAZIL

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Frederico Gemesio Lemos<sup>1</sup> and Kátia Gomes Facure<sup>2</sup>

<sup>1</sup> Programa de Conservação Mamíferos do Cerrado, Departamento de Ciências Biológicas, Universidade Federal de Goiás, Campus Catalão, Av. Lamartine P. Avelar, 1120, Setor Universitário, 75704-020, Catalão, Goiás, Brasil. <sup>2</sup> Faculdade de Ciências Integradas do Pontal, Universidade Federal de Uberlândia, Av. José João Dib, 2545, Progresso, 38302-000, Ituiutaba, Minas Gerais, Brasil. Fax: 55-34-32692195 [Correspondence: Kátia Gomes Facure <[katiafacure@pontal.ufu.br](mailto:katiafacure@pontal.ufu.br)>]

**ABSTRACT:** In regions with a pronounced dry season, such as the Cerrado Biome (Brazilian savannah), climate seasonality may affect food availability for canid species and, consequently, their foraging behavior. We investigated seasonal variation in foraging group size of crab-eating foxes (*Cerdocyon thous*) and hoary foxes (*Lycalopex vetulus*) in the Cerrado region for three consecutive years. Data were obtained by direct observations of foraging foxes during spotlight surveys. Both species were sighted foraging individually or in pairs with or without their juvenile offspring. However, crab-eating foxes foraged in pairs more frequently in the wet season and individually more frequently in the dry season whereas hoary foxes foraged mostly individually throughout the year. The higher frequency of solitary foragers in the dry season is possibly a response to the seasonal shortages in the availability of clumped and locally abundant food resources such as fruit and insects, important items in the diet of the crab-eating fox during the wet season. The absence of seasonal variation in foraging group size of the hoary fox may be related to its specialized food habits, since termites predominate in the diet of this species in both seasons.

**RESUMO:** Variação sazonal no tamanho de grupo de forrageio em cachorros-do-mato e raposas-do-campo no bioma Cerrado, Brasil central. Em regiões com uma estação seca pronunciada, como o Bioma Cerrado (savana brasileira), a sazonalidade climática pode afetar a disponibilidade de alimento para as espécies de canídeos e, conseqüentemente, seu comportamento de forrageio. Nós investigamos a variação sazonal no tamanho de grupo de forrageio de cachorros-do-mato (*Cerdocyon thous*) e raposas-do-campo (*Lycalopex vetulus*) na região do Cerrado por três anos consecutivos. Os dados foram obtidos através de observação direta em focagens noturnas dos animais forrageando. Ambas as espécies foram avistadas forrageando individualmente ou em pares com ou sem sua prole juvenil. Entretanto, os cachorros-do-mato foram vistos forrageando em pares mais freqüentemente na estação úmida e individualmente mais freqüentemente na estação seca ao passo que as raposas-do-campo forragearam principalmente individualmente durante todos os meses do ano. A maior freqüência de forrageadores solitários durante a estação seca é possivelmente uma resposta à diminuição sazonal na disponibilidade de recursos alimentares abundantes e com distribuição agregada como frutos e insetos, itens importantes na dieta do cachorro-do-mato durante a estação úmida. A ausência de variação sazonal no tamanho de grupo de forrageio na raposa-do-campo pode estar relacionada ao seu hábito alimentar especializado, uma vez que cupins predominam na dieta desta espécie em ambas as estações.

**Key words.** Crab-eating fox. Direct counts. Hoary fox. Reproduction. Social behavior.

**Palavras-chave.** Cachorro-do-mato. Comportamento Social. Contagens diretas. Raposa-do-campo. Reprodução.

## INTRODUCTION

There is a great variation in group size among canids, ranging from primarily solitary species, such as the red fox (*Vulpes vulpes*), to highly social species as the gray wolf (*Canis lupus*) (Nowak, 1999). According to Moehlman (1989), such variation is related to body weight and sometimes to food type, so that small (<6.0 kg) species feeding mainly on small mammals, insects and fruit, tend to be solitary hunters whereas medium (6.0-13.0 kg) and large (>13.0 kg) species specialized on large prey hunt cooperatively. Group size in canids may also vary intraspecifically as a result of differences in food size and availability (Bekoff et al., 1984), as observed for the bat-eared fox (*Otocyon megalotis*) (Nel, 1990), and the Arctic fox (*Alopex lagopus*) (Angerbjorn et al., 2004). Information about foraging group size and other aspects of social behaviour of South American canids are mostly anecdotal (see Sillero-Zubiri et al., 2004), and more studies are needed to determine where species fit in the pattern of interspecific variation in canid societies (Macdonald and Courtenay, 1996).

The crab-eating fox (*Cerdocyon thous*) and the hoary fox (*Lycalopex vetulus*) are small to medium sized canids occurring in central areas of South America. The crab-eating fox (4.5-8.5 kg) occurs from southern Colombia and Venezuela to northern Argentina, Paraguay, and Uruguay (Berta, 1982; Eisenberg and Redford, 1999; Nowak, 1999) and inhabits a variety of habitats, including marshland, savannah, scrubland, and forests (Courtenay and Maffei, 2004). The smaller hoary fox (3.0-4.0 kg), in contrast, is endemic to the open formations of the Cerrado Biome of Central Brazil (Eisenberg and Redford, 1999; Nowak, 1999; Dalponte and Courtenay, 2004). Both species are opportunistic feeders and shift their diets to utilize seasonally available food items such as fruits, arthropods, and small vertebrates (e.g., Bisbal and Ojasti, 1980; Dalponte, 1995; Facure and Monteiro-Filho, 1996; Dalponte and Lima, 1999; Dalponte, 2003; Facure et al., 2003; Courtenay et al., 2006), although the hoary fox depends heavily on termites (Ferreira-Silva and Lima, 2006).

The Cerrado Biome is a savannah-like ecosystem covering about 2 million km<sup>2</sup>, mostly on the Central Brazil plateau. The climate is typical of the moister savannah regions of the world, with an average precipitation of 800-2000 mm and a very marked dry season from April to September (Oliveira-Filho and Ratter, 2002). Such climate seasonality may affect food availability for canid species and, consequently, their foraging behavior. Considering that foraging group size is primarily influenced by temporal and spatial patterns of resource availability (Caraco and Wolf, 1975), the objective of this work was to investigate seasonal variation in foraging group size of the crab-eating fox and the hoary fox in the Cerrado region. We also present data on reproductive season of both species based on sightings of pregnant females and cubs.

## MATERIALS AND METHODS

This study was conducted in six contiguous cattle ranches (and surrounding areas) located in the Municipality of Cumari (18°22'S, 48°07'W; 600-800 m elevation), southeast of Goiás State, Central Brazil, comprising a total area of 2100 ha, which holds about 4000 oxes (*Bos taurus*). Most of the area (90%) has been covered with exotic pasture (*Brachiaria* sp.) for at least ten years. However, it still contains small patches of original vegetation, such as gallery forest and semideciduous forest. The climate has two well-defined seasons, one wet and warm, from October to March, and other dry and cold, from April to September (Sano and Almeida, 1998). The average annual temperature and rainfall are 22 °C and 1770 mm, respectively.

Field work was carried out monthly from January 2003 to December 2004 and biweekly from January 2005 to January 2006. Group size was quantified by direct observation of foxes in the field. The technique was adapted from Brady (1979) and consists of driving slowly (20 km/h) through the dirt roads crossing the study area (totaling about 80 km) from 18:00 to 24:00 h, coinciding with the expected activity peak for these canids (Juarez and Marinho-Filho, 2002; Maffei et al., 2007), and search for foxes using the pick-up head lights and a portable 40-watt spotlight (spotlight surveys; Geese, 2004). The transect roads were driven just once in the same night to avoid pseudo-replication (observe the same foxes). When a fox was sighted, the vehicle was turned off and the animal was watched with binoculars for at least

ten minutes from a distance that could vary from 10 to 30 m. While watching the animal, the area around it (within 100 m) was searched for other foxes that could belong to the same group of the first one sighted. Foxes were considered from the same group when they were sighted keeping some kind of interaction (e.g., moving, foraging or resting together). For every observation, we recorded the total number of animals and the composition of the group (sex and age category). Individuals were sexed based on their posture when urinating, with males raising one of their hind legs back and slightly outward (Brady, 1979). Although not all the foxes were individualized, it was possible to recognize and accompany families for several weeks due to their behaviour of staying restricted to the same area during the lactation period (pers. obs.; Courtenay et al., 2006) and individual marks. The age of cubs was estimated based on their size and behaviour according to Courtenay et al. (2006) and born dates were estimated based on the sightings of pregnant females.

Based on capture and radio telemetry data from a project the authors are carrying out at the same area with the same species, it was possible to raise an estimative on how many animals live in the area. During three years, analyzing each year separately, our team captured or monitored six hoary foxes and 15 crab-eating foxes simultaneously, which apparently shows a high intra and interspecific home-range overlapping (Lemos et al., in preparation). However, according to Lemos et al. (2011), mortality tax at the area is high, so these individuals are not all the same every year or two. Also based on the monitoring data, both foxes use pastures and may be found close to human habitations, even when denning. Indeed, the high intra and interspecific home-range overlapping mentioned before shows that different individuals of both species may be observed on each drive. Based on these data, at least six hoary foxes and 15 crab-eating foxes were sighted and observed during the present work.

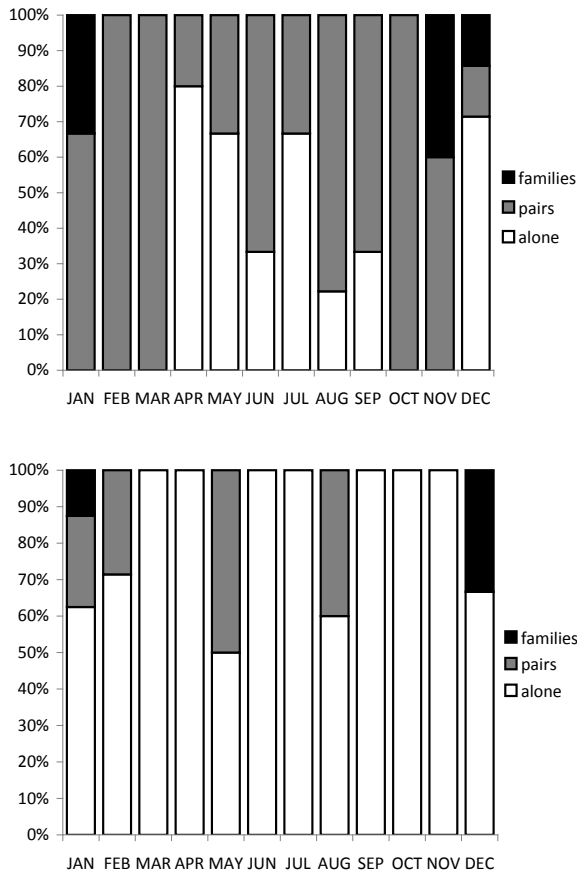
Intra-specific variation in the number of animals sighted per survey and in group size were evaluated using Mann-Whitney U tests (Zar, 1999). The proportion of surveys in which each species was sighted and the proportion of encounters in which crab-eating foxes were sighted alone in the dry and wet season were compared using chi-square (Zar, 1999). We assumed all observations to be independent because no more than one observation of the same individual or group was made on any given day. The influence of the distance travelled by survey on the number of foxes sighted and the

probability of sighting a fox was tested, respectively, through Spearman correlation and logistic regression (Zar, 1999).

## RESULTS

From January 2003 to January 2006 we conducted 53 surveys to the six cattle ranches in Cumari. In a total searching time of 234.3 h (mean =  $4.4 \pm 1.7$  h/survey,  $N = 53$  surveys) we travelled 2044.6 km (mean =  $38.6 \pm 13.1$  km/survey,  $N = 53$  surveys) and recorded 127 encounters with foxes. The distance travelled in each survey varied from 25 to 79 km (mean = 43.5 km/survey) in the dry season and from 15 to 60 km (mean = 35.1 km/survey) in the wet season and was not correlated to neither the number of animals sighted (Spearman rank correlation coefficient,  $P > 0.10$  in all cases) nor the probability of sighting a fox (logistic regression,  $P > 0.10$  in all cases), independently of species and season. Crab-eating foxes and hoary foxes were sighted respectively in 37 (69.8%) and 43 (81.1%) of the 53 surveys. The number of animals sighted per survey varied from zero to seven with mode two for the crab-eating fox and from zero to six with mode one for the hoary fox, and did not differ between species (Mann-Whitney U test = 1555,  $P = 0.327$ ,  $N = 53$  surveys for both species) nor between seasons, both for the crab-eating fox (Mann-Whitney U test = 273.5,  $P = 0.205$ ) and for the hoary fox (Mann-Whitney U test = 356,  $P = 0.778$ ) ( $N = 22$  surveys in dry season and 31 surveys in the wet season for both species).

Foraging group size ranged from one to three for the crab-eating fox and from one to four for the hoary fox. For both species groups larger than two individuals were observed only during the wet season, from November to January (**Fig. 1**), and were represented by families (parents with their cubs). Solitary individuals were adults ( $N = 15$  encounters for the crab-eating fox and 56 for the hoary fox) or sub adults ( $N = 4$  encounters for the crab-eating fox and 3 for the hoary fox). Crab-eating foxes were sighted foraging mainly in pairs (58.6% of 58 encounters), consisting of an adult male and an adult female, whereas hoary foxes



**Fig. 1.** Foraging group size of the crab-eating fox (upper) and the hoary fox (below) in Cumari, Goiás, Brazil. The numbers below month names correspond to sample sizes (number of independent observations).

ing predominantly alone both in the dry season (87.1% of 31 encounters) and in the wet season (84.2% of 38 encounters) (**Fig. 2**). One family of crab-eating foxes (a cub with its parents) was observed on five occasions from November 2005 to January 2006. The female was pregnant in August-September and probably gave birth in October, when she was not found. Two families of hoary foxes were found each one once, the first one (two adults and a cub aged c. four months old) in January 2003 and the second one (an adult and three cubs aged c. three months old) in December 2003.

## DISCUSSION

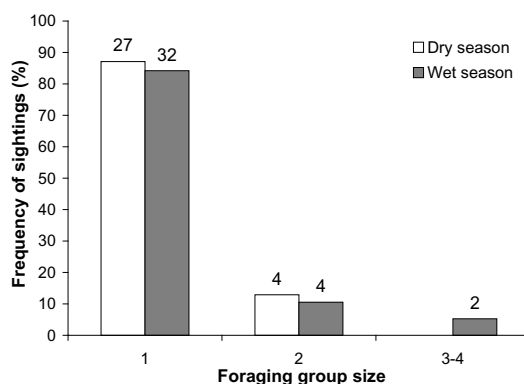
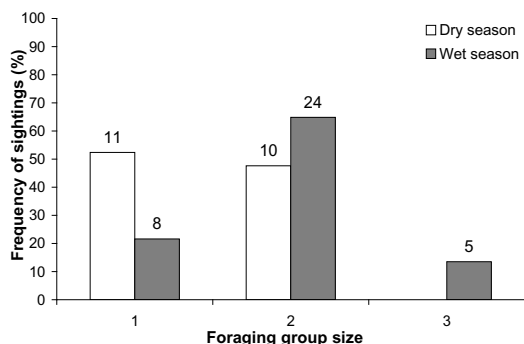
Spotlight surveys at our study area indicated that the crab-eating fox and the hoary fox may forage individually or in pairs with or without their juvenile offspring. Similar results were also reported based on other methods

were found foraging mostly alone (85.5% of 69 encounters). Acoustic communication was recorded once for the crab-eating fox, when a couple was separated by the pick-up. The male was c. 100 m from the female and continued calling her until she joined him.

Seasonal variation in foraging group size was verified for the crab-eating fox (Mann-Whitney U test = 244,  $P = 0.007$ ,  $N = 21$  encounters in the dry season and 37 encounters in the wet season) but not for the hoary fox (Mann-Whitney U test = 568,  $P = 0.678$ ,  $N = 31$  encounters in the dry season and 38 encounters in the wet season). Crab-eating foxes were observed foraging individually more frequently (Yates corrected  $\chi^2 = 4.442$ ,  $df = 1$ ,  $P = 0.035$ ) in the dry season (52.4% of 21 encounters) than in the wet season (21.6% of 37 encounters) whereas hoary foxes were observed forag-

and for other areas (Montgomery and Lubin, 1978; Brady, 1979; Macdonald and Courtenay, 1996; Dalponte, 2003; Courtenay et al., 2006). Our most important finding was that climatic seasonality in the Cerrado Biome apparently affects the foraging behavior of the two fox species in different ways. Crab-eating foxes were sighted foraging in pairs or family groups more frequently in the wet season and individually in the dry season whereas hoary foxes foraged mostly alone throughout the year.

The hoary fox is known to adapt to livestock pasture exploiting insects such as termites and dung beetles, which increase abundance in these areas (Dalponte and Courtenay, 2004). Differently from the hoary fox, the crab-eating fox is frequently seen and it even prefers more closed habitats, such as wooded savannah and gallery forests (Macdonald and



**Fig. 2.** Seasonal variation in foraging group sizes of the crab-eating fox (upper) and the hoary fox (below) in Cumari, Goiás, Brazil. Wet season lasts from October to March and dry season from April to September.

is in accordance with the expected for these species (Courtenay and Maffei, 2004; Dalponte and Courtenay, 2004).

Although crab-eating foxes were frequently sighted foraging in pairs, we never observed cooperative hunting. Montgomery and Lubin (1978) suggested that an advantage of foraging in couples is that both individuals are benefited when one of them finds abundant food resources (e.g. fruits, carcasses, eggs). In this way, the seasonal variation in foraging group size may be related to food resource availability and distribution and to the use of different food items in each season. Crab-eating foxes foraged mostly in pairs during the wet season, when they eat mostly fruits and insects, which are resources that tend to be clumped and locally abundant, changing to solitary foragers in the dry season, when they prey mainly on small mammals (e.g., Motta-Junior

Courtenay, 1996; Juarez and Marinho-Filho, 2002; Maffei and Taber, 2003; Courtenay and Maffei, 2004; Vieira and Port, 2006; Maffei et al., 2007). The permanence of this species in areas of the Cerrado Biome converted to pastures may be dependent on the remaining of some forest fragments which are probably important to these species as shelter and to obtain food resources.

Both species were sighted foraging in couples, but pairs were more frequent for crab-eating foxes than for hoary foxes. The call recorded in one opportunity was the typical "siren howl" used after individuals of a pair are separated from each other (Brady, 1981), and may serve to maintain pair contact during foraging activities. For the hoary fox, mated pairs were sighted foraging together very infrequently and with no evident seasonal pattern. The tendency of crab-eating fox to forage mostly in pairs and hoary fox alone

et al., 1994; Facure and Monteiro-Filho, 1996; Juarez and Marinho-Filho, 2002; Facure et al., 2003; Jácomo et al., 2004). The absence of seasonal variation in foraging group size of the hoary fox may be related to its specialized food habits, because termites predominate in the diet of this species in both seasons (see Dalponte, 1995; Juarez and Marinho-Filho, 2002; Dalponte, 2003; Jácomo et al., 2004; Courtenay et al., 2006; Ferreira-Silva and Lima, 2006). Although the climatic seasonality affects differently the foraging group size of the crab-eating fox and hoary fox, both species appeared to have a similar seasonal pattern of reproduction, with mating occurring probably in July-August and births coinciding with the beginning of the wet season.

Courtenay et al. (2006) observed hoary foxes and crab-eating foxes foraging together and MacDonald and Courtenay (1996) reported groups of crab-eating foxes of up to five adult

individuals in Amazon, formed by parents and their offspring. According to these authors, interspecific groups and larger groups for crab-eating foxes are probably related to food availability, with foxes being more tolerant to the presence of other individuals when food resources are abundant and more concentrated. We did not find interspecific groups in our study area and groups larger than two individuals were composed of adults and their juvenile offspring for both crab-eating fox and hoary fox. Indeed, on one occasion, we observed a crab-eating fox aggressively displacing a hoary fox from its feeding site (Lemos et al., 2007). In the diet of crab-eating foxes in Amazon vertebrates were rare and during the dry season the most frequent food items were fruit and insects (Macdonald and Courtenay, 1996). Spotlight surveys of crab-eating foxes in areas where they consume a higher proportion of small vertebrates and a lower proportion of fruit, such as in southern Brazil (see Pedó et al., 2006; Vieira and Port, 2006), may help to clarify the relation between foraging group size and diet in this species and competition with hoary fox.

## ACKNOWLEDGEMENTS

We are grateful to A.A. Giaretta, F.C. Azevedo, F.H.G. Rodrigues, G. Machado, H.L. Vasconcelos, L. Maffei, and two anonymous referees for their valuable comments on the manuscript. We also thank Nilson Floriano Lemos and Eomar Sebastião de Sousa for the permission to work in their ranches and provide logistical support to our team. The Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) provided a graduate scholarship to F.G. Lemos and financial support to K.G. Facure.

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