

## Veredas and their use by birds in the Cerrado, South America: a review

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**Abstract:** In the Cerrado, *veredas* are linear physiognomies that occur on hydromorphic soil usually along narrow water courses. They often grow on flat terrain or near headwaters. They are characterised by the abundance of *buriti* palms (*Mauritia flexuosa*) that grow over other trees, numerous shrubs and a dense herbaceous stratum. Despite being common landscape elements through the Cerrado's extension, the use of *veredas* by birds has not been examined in detail. This study aimed to review studies of birds and *veredas* in the Cerrado. Publications (n = 25) reported the use of *veredas* by 261 bird species. Only 13 of them had aspects of their biology (reproduction and feeding) studied in detail. *Veredas* are poorly used by Cerrado's endemic species, but are the major habitat requirement of several species. The richness of bird species found in *veredas* is increased by their inclusion in the home range of forest, savanna and grassland species. This study also discusses the values of *veredas* to the regional biodiversity, and the major threats to their conservation inside and outside the system of nature reserves. Suggestions for future research on birds and *veredas* in Cerrado also are provided.

**Keywords:** grassland, landscape, *Mauritia*, savanna, wetland.

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**Resumo:** No Cerrado, *veredas* são fisionomias com formato linear que ocorrem em solos hidromórficos geralmente ao longo de estreitos cursos d'água. Crescem usualmente em relevo plano ou próximo a nascentes. São marcadas pela abundância de *buritis* (*Mauritia flexuosa*), que se destacam sobre outras árvores, arbustos, e um denso estrato herbáceo. Apesar de serem comuns elementos de paisagens em toda a extensão do Cerrado, o valor de *veredas* às aves ainda não foi examinado em detalhe. Este trabalho teve como objetivo revisar os estudos envolvendo aves e *veredas* no Cerrado. Publicações (n = 25) mencionaram o uso de *veredas* por 261 espécies de aves no Cerrado. Somente 13 dessas espécies tiveram aspectos de sua biologia (reprodução ou alimentação) estudados em detalhe. *Veredas* são pouco usadas por espécies endêmicas do Cerrado, mas são o principal requerimento de habitat de algumas espécies de aves. A riqueza de espécies de aves encontrada em *veredas* é em grande parte aumentada pela sua inclusão na área de vida de espécies florestais, savânicas e campestres. Este estudo também discute os valores de *veredas* à biodiversidade do Cerrado, e as principais ameaças à sua conservação dentro e fora do sistema de reservas naturais. Também são fornecidas sugestões para pesquisas futuras envolvendo aves e *veredas* no Cerrado.

**Palavras-chave:** área úmida, campo, *Mauritia*, paisagem, savana.

## Introduction

Vegetation physiognomies with numerous palm trees are remarkable landscape elements in several tropical regions. Among them are palm forests in South America, forests of *babaçu* and *buriti* palms in southern Amazon and *veredas* in central Brazil (Eiten 1993, Stotz et al. 1996, Rizzini 1997).

*Veredas* are linear and common landscape elements widely distributed through the naturally patchy environment of Cerrado – the savanna ecosystem that dominates central Brazil (Eiten 1993, Oliveira & Ratter 2002). They are open vegetation physiognomies characterised by the presence of numerous *buriti* palms (*Mauritia flexuosa*), a dense herbaceous stratum and a diverse range of shrubs and trees (Ribeiro et al. 1983, Ribeiro & Walter 1998, Oliveira & Ratter 2002). They occur on hydromorphic soil usually along narrow water courses (Motta et al. 2002, Oliveira & Ratter 2002). *Veredas* harbor a considerable species richness of grasses, shrubs and trees (Silva & Felfili 1998, Filgueiras 2002). Also, *veredas* are among the habitat requirements of a diverse range of wildlife (Villalobos 1994, Marinho et al. 1998, Bonvicino et al. 2005, Gurgel-Gonçalves et al. 2006).

Birds have been investigated in detail in *veredas* since the 1940s. For example, Sick (1948a, b) examined the breeding biology of two swift species in Mato Grosso. In this same region, Sick (1955) examined the distribution of bird species in different vegetation physiognomies, including *veredas*. In his review of Cerrado's wildlife, Sick (1965) provided a list of bird species typical of *veredas* (*buritizais*). More recently, Antas & Cavalcanti (1988) elaborated the first field guide of identification of bird species commonly found in central Brazil. In this book, they provided information on the use of *buriti* palms and *veredas* by birds.

Numerous studies, encompassing a wide range of topics of research, have been conducted in more recent decades. Among them is a detailed research on the feeding ecology of birds in a *vereda* in the Brazilian Federal District (Villalobos 1994). The breeding biology of *Ara ararauna* was investigated in Goiás state (Bianchi 1998). The arthropod fauna associated to the nesting of *Phacellodomus ruber* was examined in the Federal District (Gurgel-Gonçalves et al. 2004, 2006, Gurgel-Gonçalves & Cuba 2007). Further, some studies compared the bird species composition of *veredas* with those of physiognomies such as forests and savannas in northern, central and southeastern Cerrado (Silva et al. 1997, Bagno & Marinho 2001, Santos 2001, Franchin & Marçal 2004, Valadão et al. 2006). Additionally, brief information on the biology of species found in *veredas* has been reported in publications focusing a wide range of aspects of birds in the Cerrado (e.g., Willis & Oniki 1993, Silveira et al. 2001, Blamires et al. 2005).

Despite these numerous studies, the use of *veredas* has received little or no attention in major reviews about the avifauna found in Cerrado (Cavalcanti 1988, Silva 1995, 1997, Macedo 2002, Silva & Bates 2002, Silva & Santos 2005). As they emphasised the use of forests, savannas and grasslands, the use of *veredas* by birds has not been reviewed in detail.

This study aimed to review information on birds and *veredas* in the Cerrado province. First, I compiled and characterised the studies containing this information. Then, I examined the use of *veredas* by species, and reviewed the major results brought by these publications. The information was evaluated to identify ecological patterns and lacunes of knowledge. Also, I present a general overview considering most information on birds and studies concerning aspects of the biodiversity and conservation of *veredas* in the Cerrado. Finally, I provide suggestions for future research on *veredas* and birds in the Cerrado.

## Methods

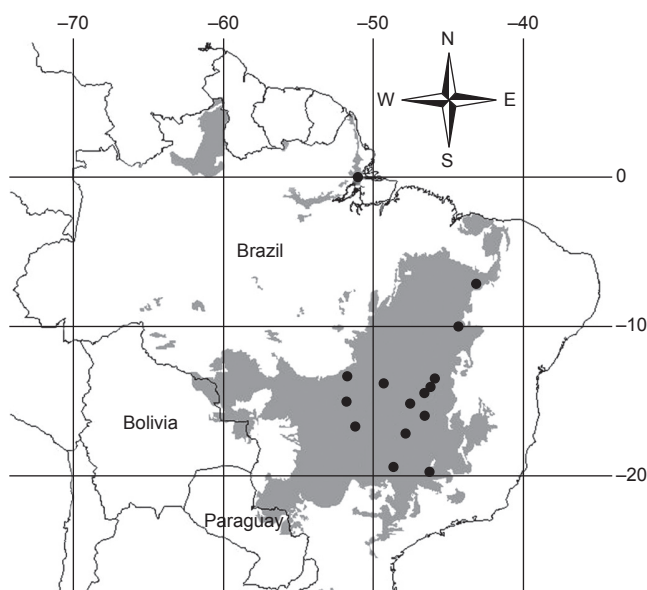
### 1. Cerrado

This vegetation province occupies near 2,000,000 km<sup>2</sup> in Brazil, Paraguay and Bolivia (Figure 1). It dominates the highlands of central Brazil and extends through peninsulas and isolated patches to the Atlantic Forest, the Amazon, the Chaco and Caatinga (Eiten 1972, IBGE 1993, Oliveira & Marquis 2002).

The vegetation cover of landscapes in Cerrado is usually dominated by cerrado *sensu lato*, a gradient of physiognomies ranging from grasslands to woodlands and forests (Eiten 1972, Coutinho 1978, Ribeiro & Walter 1998, Oliveira & Ratter 2002). Cerrado *sensu lato* is the matrix of uplands, where semi-deciduous forests, deciduous forests and rocky grasslands usually cover smaller areas. Gallery forests, marshes, floodplain grasslands and *veredas* occur in valleys (Ribeiro et al. 1983, Eiten 1993, Oliveira & Ratter 2002). Climate is tropical and strongly seasonal, with well defined dry and wet seasons (Assad 1994). The Cerrado is influenced by natural and man-made fire (Coutinho 1994, Miranda et al. 2002, 2004). Additional information on the Cerrado's environment can be found in Oliveira & Marquis (2002) and Scariot et al. (2005).

### 2. Veredas

*Veredas* are linear vegetation physiognomies (Figure 2) that occur commonly and widely through the Cerrado extension (Ribeiro et al. 1983, Eiten 1993, Ribeiro & Walter 1998). They often growth along narrow water courses on flat terrain, in the middle of topographic sequences between gallery forests and cerrado, or near headwaters (Silva & Felfili 1998, Oliveira & Ratter 2002). They grow on hydromorphic soil, where the water table reaches or almost reaches the surface during the rainy season (Motta et al. 2002, Oliveira & Ratter 2002). *Veredas* are open physiognomies characterised by: 1) numerous *buriti* palms (*Mauritia flexuosa*) composing most of the arboreal stratum, 2) the presence of shorter trees and shrubs forming groups



**Figure 1.** Geographical distribution of localities (black spots) where studies on birds and *veredas* have been done in the South American Cerrado.

**Figura 1.** Distribuição geográfica das localidades (pontos negros) onde estudos sobre aves e *veredas* foram conduzidos no Cerrado, América do Sul.



**Figure 2.** Veredas at a) Parque Nacional das Emas; and b) Estação Ecológica de Uruçuí-Una, in the Brazilian states of Goiás and Piauí, respectively. Their linear format, *buriti* palms (*Mauritia flexuosa*) as emergent trees, numerous trees and shrubs and a dense herbaceous layer can be noted.

**Figura 2.** Veredas situadas a) no Parque Nacional das Emas; e b) na Estação Ecológica de Uruçuí-Una, nos estados brasileiros de Goiás e Piauí, respectivamente. Seu formato linear, palmeiras buritis (*Mauritia flexuosa*) como árvores emergentes, numerosas árvores e arbustos, e um denso estrato herbáceo podem ser notados.

or not, 3) a dense herbaceous stratum (Eiten 1993, Ribeiro & Walter 1998, Silva & Felfili 1998, Oliveira & Ratter 2002). A high diversity of plants can be found in *veredas* (Silva & Felfili 1998, Filgueiras 2002, Meirelles et al. 2004).

### 3. Literature review

All studies found that contained information on the use of *veredas* by birds in the Cerrado province (considering its extension in Brazil, Bolivia and Paraguay) were included in this review. The literature review included peer-reviewed articles published in scientific journals until 2007. Their search was mainly based on Oniki & Willis (2002), the Web-of-Science and Google Scholar. PhD and Master theses, scientific books (including identification guides) and their chapters also were considered.

## Results and Discussion

### 1. Types of study

Publications (n = 25) reviewed in this study include articles of scientific journals (n = 17), theses (n = 2), book chapters (n = 3)

and books (n = 3). Both theses and five scientific articles had birds and *veredas* as their major focus of research (Sick 1948a, b, Villalobos 1994, Bianchi 1998, Gurgel-Gonçalves et al. 2004, 2006, Gurgel-Gonçalves & Cuba 2007). On other hand, eight publications compared the occurrence of species in different physiognomies, including *veredas* (e.g., Sick 1955, 1965, Negret et al. 1984, Silva et al. 1997, Bagnó 1998, Santos 2001). Other reviewed publications provided only brief comments on species occurrence or aspects of bird biology in *veredas*. They include books and short communications (e.g., Willis & Oniki 1993, Sick 1997, Silva & Silva 2004).

### 2. Regional distribution of studies

Records of birds in *veredas* are widespread through Cerrado (Figure 1). A relatively high number of studies have been conducted in its central portion: Goiás State and the Federal District (e.g., Antas & Cavalcanti 1988, Bagnó 1998, Bianchi 1998, Bagnó & Marinho 2001, Gurgel-Gonçalves & Cuba 2007, Curcino et al. 2007). Investigations in northern Cerrado were in the states of Amapá (Silva et al. 1997) and Piauí (Santos 2001, Silveira et al. 2001). Studies conducted in western Cerrado were in Mato Grosso (Sick 1948a, b, Sick 1955). Other studies involved records in Minas Gerais state, southeastern Cerrado (Franchin & Marçal 2004, Valadão et al. 2006, Vasconcelos et al. 2006). Other publications have not informed the regions or localities where records were obtained (e.g., Sick 1997, Silva & Silva 2004). No studies examined regional variation in the use of *veredas* by birds.

### 3. Species richness and composition

A total of 261 bird species of 18 orders and 53 families were detected in *veredas* in the Cerrado (Appendix 1). Passeriformes, Falconiformes and Charadriiformes were orders with more species. Families with the highest species richness were Tyrannidae, Emberizidae, Psittacidae, Thraupidae and Accipitridae, with 34, 19, 17, 15 and 12 species, respectively (Appendix 1).

The proportion of bird assemblages that use *veredas* could be assessed at three spatial scales. After discarding those studies conducted outside the Cerrado core area, an evaluation at a macro scale could be done. Of the 846 bird species found in the Cerrado core area (Silva 1995, Silva & Santos 2005), 254 (30%) were recorded in *veredas* (Appendix 1). As this is the first study to compile records of bird species for an only physiognomy in the Cerrado, comparisons with other vegetation are not possible.

The bird species richness recorded until now in *veredas* in the Cerrado (Appendix 1) should be considered as underestimated due to some reasons. First, several studies that greatly contributed to the knowledge of regional or local avifaunas (e.g., Willis & Oniki 1990, 1991, Bagnó & Marinho 2001, Kirwan et al. 2004, Narosky & Yzurieta 2006, Silva et al. 2006, Pacheco & Olmos 2006) have not pointed out those species detected in *veredas*, despite having sampled these physiognomies. Second, field guides of South American birds (e.g., Ridgely 1989, 1994, Sigrist 2006) reported the occurrence of species in palm groves (including those of *Mauritia* trees) but have not informed if records occurred within Cerrado. Third, some books (e.g., Antas & Cavalcanti 1988) have identified species that use *buriti* palms, without informing the physiognomies where records were obtained. As *buriti* palms also occur in gallery forests, savannas and grasslands close to *veredas*, some of their records were not included in Appendix 1. Fourth, studies on *veredas* are not numerous and often involved relatively short sampling periods or a low number of sites (*veredas*).

The proportion of species that use *veredas* also could be assessed at a regional scale. Of 429 species recorded in Brazil's Federal District, 57 (13%) were noted using *veredas* (Negret et al. 1984).

Bagno & Marinho (2001) reviewed information on birds of this same region and reported that 22% of the species use *veredas*. Santos (2001) has reported that 26% of species recorded in the region of Chapada das Mangabeiras were observed in *veredas*.

Assessments at smaller scales could be done considering the species composition of protected portions of landscapes. In the experimental campus of Embrapa, in Amapá, 37 species (14%) were found in *veredas* (Silva et al. 1997). At Estação Ecológica de Águas Emendadas, central Cerrado, 86 (30%) of the 287 recorded species were observed in *veredas* (Bagno 1998). Bird species found in *veredas* comprised 73% and 80% of the avifaunas of two urban parks in southeastern Cerrado (Franchin & Marçal 2004, Valadão et al. 2006).

A comparison of these assessments reveals a substantial variation in the values of representativeness (13-80%) of species that use *veredas* to the composition of local or regional avifaunas. Factors related to this wide range of proportions might be related to characteristics of *veredas*, landscapes and sampling. The number of *veredas* in a given landscape mosaic, variation in the structure and floristics of *veredas* and the juxtaposition to other physiognomies might influence the bird species composition found in *veredas* in different studies. Also, these assessments have not standardized the sample efforts in the different physiognomies. Thus, the contribution of bird species that use *veredas* to the species composition of local or regional assemblages could have been under or overestimated.

#### 4. The use of *veredas* and other physiognomies

All species detected in *veredas* (Appendix 1) also can be found in other vegetation physiognomies or water bodies in the Cerrado (Negret 1983, Silva 1995, Sick 1997, Silva et al. 1997, Bagno 1998, Melo-Junior et al. 2001, Tubelis & Cavalcanti 2000, 2001, Bagno & Marinho 2001, Sigrist 2006). The absence of species restricted to *veredas* might result of four reasons. First, great part of the species richness found in *veredas* is composed of species that inhabit other physiognomies and use *veredas* as additional habitat. For example, *Galbula ruficauda*, *Picumnus albosquamatus*, *Cnemotriccus fuscatus*, *Synallaxis frontalis* and *Turdus* spp are forest species (Negret 1983, Lins 1994, Sick 1997, Tubelis et al. 2004a) that were recorded in *veredas* (Appendix 1). Specimens of these and other forest birds might leave gallery forests occasionally to use nearby *veredas*. Similarly, species that require mainly savanna woodlands (*campo cerrado* and *cerrado sensu stricto*) for survival, such as *Suiriri suiriri*, *Cyanocorax cristatellus*, *Troglodytes musculus* and *Cariama cristata* (Sick 1997, Tubelis & Cavalcanti 2001, Amaral & Macedo 2003, Lopes & Marini 2006) also might include *veredas* in their home ranges (Appendix 1). Also, individuals of species that require mainly grasslands and savannas (Tubelis & Cavalcanti 2001), such as *Rhynchotus rufescens*, *Ammodramus humeralis* and *Emberizoides herbicola* also might use *veredas* if living close to them. Thus, part of the bird species richness found in *veredas* is due to the use of *veredas* as additional habitat by individuals living in forests, savannas and grasslands close or adjacent to *veredas*.

Second, some bird species found in *veredas* also have other elements of Cerrado's landscapes as their major habitat requirements. For example, aquatic bird species such those of the families Ardeidae, Anatidae, Rallidae, Scolopacidae and Alcedinidae also live in marshes, streams, rivers and other wet physiognomies. Similarly, species such as *Orthopsittaca manilata*, *Ara ararauna*, *Phacellodomus ruber* and *Schistochlamis melanopsis* also are found in other vegetation physiognomies, such as forests, *babaçuais* and savannas (Sick 1955, 1965, Ridgely 1989, 1994, Sick 1997, Erize et al. 2006, Sigrist 2006).

The third reason for the absence of species restricted to *veredas* is related to their linear format. As *veredas* are usually narrow landscape elements, birds might find difficulties in establishing long and narrow home ranges or territories within their limits, as suggested by the central place foraging theory (Pyke et al. 1977, Tubelis et al. 2004b). Related to this, is the fact that physiognomies adjacent to *veredas* might provide food and other resources for birds whose home ranges are centered in *veredas*. The seasonal occurrence of trees or shrubs with numerous flowers or fruits is common in gallery forests and savannas (pers. observ.). Also, termite swarms are frequent in grasslands and woodlands during the rainy season in the Cerrado. So, it is expected that birds occasionally leave *veredas* to adventure in adjacent physiognomies to search for food resources not found in *veredas*, as reported for forest birds in central Cerrado (Negret 1983, Lins 1994). Several aquatic species as well as *Ara ararauna*, *Orthopsittaca manilata*, *Chaetura meridionalis*, *Tachornis squamata*, *Phacellodomus ruber* and *Berlepschia rickeri* can be considered as examples of these species.

#### 5. *Vereda* use by species endemic to Cerrado

Of the 36 bird species considered as endemic to the Cerrado region, most are forest species while others are species of open physiognomies of *cerrado sensu lato* (Silva 1995, Cavalcanti 1999, Macedo 2002, Silva & Bates 2002, Silva & Santos 2005). Only four (11%) of these species were observed using *veredas* (Appendix 1). Two forest species (*Herpsilochmus longirostris* and *Hylocryptus rectirostris*) were observed in *veredas* of urban parks in southeastern Cerrado (Franchin & Marçal 2004, Valadão et al. 2006). *Cyanocorax cristatellus* and *Saltator atricollis*, two species that require mainly savanna woodlands for survival (Sick 1997, Tubelis & Cavalcanti 2001, Amaral & Macedo 2003) also were detected in *veredas* in central and southeastern Cerrado (Appendix 1). These low numbers of species, records and studies suggest that *veredas* are not among the major habitat requirements of most bird species endemic to Cerrado. One exception appears to occur with *Conothraupis mesoleuca*, a poorly known species occasionally found in *veredas* at Parque Nacional das Emas (pers. com.).

#### 6. Aspects of bird biology investigated in detail in *veredas*

Detailed investigations on the natural history of bird species in *veredas* involved their breeding and feeding activities. The breeding biology of four species has been studied in detail in *veredas*. In September 1946, a *Tachornis squamata* was observed building a nest in a *vereda* in the Rio das Mortes region (Sick 1948a). The nest – an elongated clump of feathers glued with mucus – was constructed in a dry *buriti* leaf and contained three eggs. In a *vereda* of this same region of Mato Grosso, three nests of *Chaetura meridionalis* were found in October and November (Sick 1948b). They were open cups fixed to internal walls of trunks of dead *buritis* and contained four or five eggs.

Five decades later, a more detailed study examined the breeding biology of *Ara ararauna* at Parque Nacional das Emas (Bianchi 1998). Eighteen nests found in dead *buriti* palms were monitored. Macaws nested near the top of trunks, where one to five eggs were found. Macaws started the courtship activities and the selection of nest cavities in the beginning of the dry season (May). Egg laying occurred in September and October, and were followed by incubation periods of about 26 days. As consequence, young macaws were able to fly in the early rainy season. About 72% of nesting attempts were successful, and factors involved in nest predation could not be clarified. This study also provided detailed information on the nest cavities used by macaws and on their behavior, courtship, nesting care and eggs (Bianchi 1998).

The nesting of *Phacellodomus ruber* was examined to verify its association with the occurrence of Hemiptera species in central Cerrado (Gurgel-Gonçalves et al. 2004, 2006, Gurgel-Gonçalves & Cuba 2007). It was found that larger and active nests contained more arthropods than smaller and inactive nests. Authors argued that characteristics such as several incubation cameras per nest, nest re-occupation and life in groups contribute for the abundance of arthropods in *buriti* palms with nests of *P. ruber*. Also, the hemipteras found in *P. ruber* nests were not infected with *Tripanossoma cruzi*. Gurgel-Gonçalves et al. (2004) also reported the nesting of *Caracara plancus* and *Gnorimopsar chopi* in *veredas*, but details were not provided.

Feeding ecology was other aspect of bird biology researched in detail. In a *vereda* at Brazil's Federal District, nine frugivorous bird species had their foraging activities examined during a 11-month period (Villalobos 1994). This study has shown that three parrot species (*Orthopsittaca manilata*, *Ara ararauna* and *Amazona aestiva*) are key species in the ecology of trophic guilds of bird and mammal species associated with *buriti* fruits in *veredas*. Although these three species tended to exploit fruits in the *buriti* canopies, they also had a major role in seed dispersion and fruit dropping. As result of their feeding activities, open fruits became available in canopies and were eaten by four bird species (*Thraupis sayaca*, *Schistochlamis melanopsis*, *Gnorimopsar chopi* and *Cyanocorax cristatellus*). Fruits open by parrots also had parts eaten while on the ground. One specimen of *Porzana albicollis* collected with a trap had its stomach full of *buriti* pulp. *Caracara plancus* was seen with whole fruits in adjacent woodlands, and then considered as a species able to gather fruits from *buritis* (Villalobos 1994). This was the only study to examine *vereda* use by birds in different periods of the day. *Buritis* were visited with similar frequencies in mornings and afternoons by *Orthopsittaca manilata* and *A. ararauna*, while *A. aestiva* was detected only in mornings (Villalobos 1994).

As consequence of these studies, 13 species had their biology investigated in detail in *veredas*. This number corresponds to only 5% of the bird species richness found in this physiognomy (Appendix 1). With the exception of *P. albicollis*, these species are land birds. Thus, although numerous aquatic bird species occur in *veredas* (Appendix 1), research on them is lacking.

### 7. Overview and conservation issues.

This review highlighted some roles that *veredas* play for bird assemblages in the Cerrado. First, they are used by a high number of bird species - 28% of the species richness found in the Cerrado core area. Second, *veredas* function as additional habitat for part of the populations of numerous species that have forests, savannas and grasslands as their core habitats. This could be considered as one more component of the biodiversity found in Cerrado, as home ranges with and without *veredas* might be ecologically or evolutionary distinct. Third, the compiled information indicates that *veredas* are poorly used by Cerrado's endemic species. Fourth, no bird species are restricted to *veredas*. This fact does not imply in absence of habitat specialization. Knowledge brought in the last two decades suggests that habitat specialization in the Cerrado region should not be thought considering a unique physiognomy. Instead, the existence of a core habitat and the use of adjacent physiognomies should be considered, as shown for forest and savanna birds (Cavalcanti 1992, Lins 1994, Silva 1995, Tubelis et al. 2004a). Thus, *veredas* are the main habitat requirements of several bird species, as argued by scientists with long experience in the Cerrado (e.g., Sick 1955, 1965, 1997).

Besides birds, a wide range of fauna and flora elements can be found in *veredas* (Villalobos 1994, Marinho et al. 1998, Silva & Felfili 1998, Meirelles et al. 2004). Further, *veredas* play an important role

in the protection of watersheds (Filgueiras 2002). To exemplify this fact, the Estação Ecológica de Águas Emendadas was created with the purpose of protecting the headwaters of two major hydrographic basins in central Brazil (Marinho et al. 1998). *Veredas* also give an outstanding contribution to the beauty of landscapes in the Cerrado region (pers. observ.). Further, *veredas* are potential sites for recreation and leisure in protected and non-protected landscapes. This because they provide suitable conditions for pleasant walkings and excellent opportunities for swimming or drinking. *Veredas* also have the potential for the sustainable exploitation of parts of *buriti* palms, that are widely used in some Cerrado regions. More importantly, *veredas* are a unique ecosystem in the Cerrado province, harboring particular species, interactions and ecological processes. Further, *veredas* are traditionally considered as sites of great importance by rural populations inhabiting Cerrado's landscapes (Rosa 2006). Therefore, numerous aspects of the biotic and abiotic environment of *veredas*, including their biodiversity and ecosystem services, make them major targets for conservation actions inside and outside the system of nature reserves in the Cerrado.

Despite their values, *veredas* have been severely modified by human activities. For example, the establishment of agribusiness is a major threat to the Cerrado's biodiversity (Ratter et al. 1997, Klink & Moreira 2002). Only *veredas* with few meters in width are usually immersed in agricultural landscapes (pers. observ.). Besides being narrow, these *vereda* remnants might be substantially contaminated with agrochemicals used in exotic plantations, such as those of soyabean and cotton.

Other potential conservation problem concerning *veredas* is the intense and unsustainable exploitation of *buriti* resources in some regions, such as Piauí and Maranhão. *Buritis* have a great economical value, as their parts can have a wide range of use (Almeida et al. 1998, Felfili et al. 2004). For example, in Teresina and other municipalities of northern Cerrado, markets often sell numerous products made with dead and alive parts of *buritis* (pers. observ.). Although *buriti* palms are abundant and widely distributed through the Cerrado extension, overexploitation might lead to dramatic negative impacts on wildlife in some regions or localities. Dams are other threat to *veredas* outside nature reserves. Hydroelectric dams can occasion the complete inundation of *veredas*. On other hand, small dams made by rural people to store water for drinking or planting (e.g., rice fields) often interrupts the water flow and cover part of the grass layer in *veredas* (pers. observ.).

Other major threat to the health of *veredas* is burning by local population. Negative impacts of burning and cattle trampling on the grass layer have been shown by a study in a non-protected landscape in central Cerrado (Meirelles et al. 2004). Unfortunately, burning of *veredas* has been occurring for decades within the Cerrado's reserve system. Between 2005 and 2007, I visited some nature reserves in northern Cerrado (Maranhão and Piauí states) and found numerous *veredas* modified by man-made fire. For example, numerous inhabitants of Parque Nacional da Chapada das Mesas and Estação Ecológica Uruçuí-Una burn the grass layer of *veredas* located in the proximities of their houses. Some of them informed that numerous *veredas* are drying, and argued that this process occurs due to the frequent burning and logging of their vegetation. At Parque Nacional das Nascentes do Rio Parnaíba, problems appear to be worse. There, great extensions of *veredas* have their grass layer burned during the dry season to stimulate the regrowth of grasses (Figure 3). After rebouting, numerous cattle are illegally brought to the park by ranchers to feed on *vereda* grasses. Despite great effort by park managers, this *invernada* activity and other illegal actions involving *veredas* still occur in some Cerrado's reserves.



**Figure 3.** A *vereda* modified by burning targeting regrowth of grasses at Parque Nacional das Nascentes do Rio Parnaíba, in northern Cerrado (Piauí state), Brazil.

**Figura 3.** Uma *vereda* modificada por queimada visando a rebrota de gramíneas no Parque Nacional das Nascentes do Rio Parnaíba, na região norte do Cerrado (estado do Piauí), Brasil.

### 8. Suggestions for future studies

My suggestions for future research on birds and *veredas* in the Cerrado can be divided in two major categories. First, are those more related to the biology of birds, the environment of *veredas* and aspects of Cerrado's landscapes. Other suggestions comprise investigations that consider *veredas* and their species as indicators of the ecology of birds in naturally patchy environments. They are: (1) identification of species that have *veredas* as core areas of their home ranges or territories, for detailed investigation of aspects of their natural history still poorly known; (2) the study of the biology of aquatic species, including the examination of their responses and adaptations to the seasonal water availability typical of *veredas*. This because most detailed studies on the biology of particular species involved forest, savanna or grassland birds; (3) investigations of modification of *veredas* by agricultural activities (such as reduction of their cover and contamination by agrochemicals) and those involving cattle ranching (such as vegetation burning). The negative impacts of collects of dead and alive parts of *buriti* palms also could be evaluated; (4) examination of the natural variation in the vegetation structure and floristics of *veredas* on their use by birds; (5) *veredas* use as sites for studies of the ecology of patch-matrix movements, landscape supplementation and landscape complementation by birds (Dunning et al. 1992). These studies could include the use of *veredas* by birds of adjacent forests, woodlands and grasslands, as well as the use of adjacent physiognomies by species of *veredas*; (6) examination of how birds inhabit these linear and naturally fragmented elements of Cerrado's mosaics, considering the extensive literature on birds in landscapes modified by human activities; (7) use *veredas* as sites for the study of natal and reproductive dispersal of birds. This aspect of avian biology has rarely been studied in South America and might be successfully conducted in *veredas*. This because the linear format of *veredas* and their relatively simple vegetation structure might facilitate the finding of nests and banded birds in consecutive years.

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## Appendix

**Appendix 1.** Bird species recorded in *veredas* in the Cerrado, with the source of information. The sequence and nomenclature of species follow CBRO (2008).

**Apêndice 1.** Espécies de aves registradas em *veredas* no Cerrado, com as fontes de informação. A sequência e a nomenclatura das espécies seguem CBRO (2008).

Families/Species	Reference codes
<b>TINAMIDAE</b>	
<i>Crypturellus undulatus</i>	25
<i>Crypturellus parvirostris</i>	25
<i>Rhynchotus rufescens</i>	3,5,15,25
<b>ANATIDAE</b>	
<i>Dendrocygna viduata</i>	15,18
<i>Dendrocygna autumnalis</i>	15
<i>Sarkidiornis sylvicola</i>	15
<i>Amazonetta brasiliensis</i>	5,15,18
<i>Netta erythrophthalma</i>	15
<i>Nomonyx dominica</i>	15
<b>CRACIDAE</b>	
<i>Penelope superciliaris</i>	15
<i>Penelope jacucaca</i>	15
<i>Crax fasciolata</i>	25
<b>PHALACROCORACIDAE</b>	
<i>Phalacrocorax brasilianus</i>	18
<b>ARDEIDAE</b>	
<i>Tigrisoma lineatum</i>	3,10,15,18
<i>Cochlearius cochlearius</i>	15
<i>Ixobrychus exilis</i>	15
<i>Butorides striata</i>	5,10,18,21
<i>Bubulcus ibis</i>	21
<i>Ardea alba</i>	10,18
<i>Syrigma sibilatrix</i>	5,12,18,20,21
<i>Pilhedorius pileatus</i>	18,21
<i>Egretta thula</i>	10,18,21
<b>THRESKIORNITHIDAE</b>	
<i>Mesembrinibis cayennensis</i>	5,18,21
<i>Phimosus infuscatus</i>	5,15
<i>Theristicus caudatus</i>	5,12,15,18,21
<b>CATHARTIDAE</b>	
<i>Cathartes aura</i>	12,25
<i>Coragyps atratus</i>	10,12,18,21
<i>Sarcoramphus papa</i>	12
<b>ACCIPITRIDAE</b>	
<i>Chondrohierax uncinatus</i>	10
<i>Elanoides forficatus</i>	15
<i>Elanus leucurus</i>	12
<i>Rostrhamus sociabilis</i>	5
<i>Circus buffoni</i>	5
<i>Geranospiza caerulescens</i>	5
<i>Heterospizias meridionalis</i>	10,12
<i>Harpyhaliaetus coronatus</i>	12
<i>Busarellus nigricollis</i>	5,10

## Appendix 1. Continued...

Families/Species	Reference codes
<i>Rupornis magnirostris</i>	5,10,12,18,21,25
<i>Buteo albicaudatus</i>	12
<i>Buteo melanoleucus</i>	15
<b>FALCONIDAE</b>	
<i>Caracara plancus</i>	5,8,10,12,16,18,19,21,25
<i>Milvago chimachima</i>	5,10,12,18,21
<i>Herpetotheres cachinnans</i>	12
<i>Falco sparverius</i>	12,18
<i>Falco femoralis</i>	12,18
<b>ARAMIDAE</b>	
<i>Aramus guarauna</i>	5
<b>RALLIDAE</b>	
<i>Micropygia schomburgkii</i>	5
<i>Aramides cajanea</i>	5,18,21
<i>Laterallus viridis</i>	5,10,21
<i>Laterallus xenopterus</i>	5
<i>Porzana albicollis</i>	5,8,16
<i>Pardirallus nigricans</i>	5
<i>Gallinula chloropus</i>	5
<i>Gallinula melanops</i>	5
<i>Porphyrio martinica</i>	5
<b>CARIAMIDAE</b>	
<i>Cariama cristata</i>	18,25
<b>CHARADRIIDAE</b>	
<i>Vanellus cayanus</i>	15
<i>Vanellus chilensis</i>	5,10,15,18,21
<b>RECURVIROSTRIDAE</b>	
<i>Himantopus melanurus</i>	15
<b>SCOLOPACIDAE</b>	
<i>Gallinago paraguaiiae</i>	5,15,18
<i>Gallinago undulata</i>	5
<i>Actitis macularius</i>	15
<i>Tringa solitaria</i>	5
<b>JACANIDAE</b>	
<i>Jacana jacana</i>	5,10,15
<b>COLUMBIDAE</b>	
<i>Columbina minuta</i>	3
<i>Columbina talpacoti</i>	3,10,12,18,21,25
<i>Columbina squammata</i>	3,12,18,21
<i>Uropelia campestris</i>	3
<i>Columba livia</i>	18,21
<i>Patagioenas picazuro</i>	12,18,21,25
<i>Patagioenas cayennensis</i>	12,18,21,25
<i>Zenaida auriculata</i>	18,21
<i>Leptotila verreauxi</i>	18,21,25
<i>Leptotila rufaxilla</i>	25
<b>PSITTACIDAE</b>	
<i>Anodorhynchus hyacinthinus</i>	3,4,9,15,17
<i>Ara ararauna</i>	3,4,5,8,9,11,12,15,16,17,18,25
<i>Ara macao</i>	9
<i>Ara chloropterus</i>	9,15,17

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## Appendix 1. Continued...

Families/Species	Reference codes
<i>Ara severus</i>	9
<i>Orthopsittaca manilata</i>	3,7,8,9,10,12,13,16,17,18,21
<i>Primolius maracana</i>	9
<i>Diopsittaca nobilis</i>	5,9,10,12,15,18,21,25
<i>Aratinga acuticaudata</i>	15
<i>Aratinga leucophthalma</i>	18,21
<i>Aratinga aurea</i>	12,18,21,25
<i>Forpus passerinus</i>	10
<i>Forpus xanthopterygius</i>	12,18,21
<i>Brotogeris chiriri</i>	12,18,21
<i>Brotogeris sanctithomae</i>	10
<i>Amazona aestiva</i>	8,12,15,16
<i>Amazona amazonica</i>	15
CUCULIDAE	
<i>Piaya cayana</i>	15,18,25
<i>Crotophaga major</i>	15
<i>Crotophaga ani</i>	5,10,18,21
<i>Guira guira</i>	5,10,18,21
<i>Tapera naevia</i>	25
TYTONIDAE	
<i>Tyto alba</i>	12
STRIGIDAE	
<i>Megascops choliba</i>	12
<i>Bubo virginianus</i>	12
<i>Strix huhula</i>	15
<i>Glaucidium brasilianum</i>	12
<i>Athene cucularia</i>	18
<i>Rhinoptynx clamator</i>	12
<i>Asio stygius</i>	14
NYCTIBIIDAE	
<i>Nyctibius griseus</i>	12
CAPRIMULGIDAE	
<i>Caprimulgus parvulus</i>	5
<i>Hydropsalis climacocerca</i>	10
APODIDAE	
<i>Chaetura meridionalis</i>	2,3,6,9,12,18
<i>Tachornis squamata</i>	1,3,4,5,6,7,9,10,12,18,21
TROCHILIDAE	
<i>Phaethornis pretrei</i>	21,25
<i>Eupetomena macroura</i>	12,18,21
<i>Colibri serrirostris</i>	5,12,15,18,21,25
<i>Anthracothorax nigricollis</i>	21
<i>Chlorostilbon lucidus</i>	12,18,21
<i>Thalurania furcata</i>	18
<i>Polytmus guainumbi</i>	10
<i>Amazilia fimbriata</i>	10,12,15,18,21
<i>Heliactin bilophus</i>	3
TROGONIDAE	
<i>Trogon curucui</i>	15
<i>Trogon sp.</i>	25
ALCEDINIDAE	

## Appendix 1. Continued...

Families/Species	Reference codes
<i>Megaceryle torquata</i>	10,18,21
<i>Chloroceryle amazona</i>	18
<i>Chloroceryle americana</i>	10
GALBULIDAE	
<i>Galbula ruficauda</i>	15,21
BUCCONIDAE	
<i>Nystalus chacuru</i>	12,25
<i>Monasa nigrifrons</i>	25
RAMPHASTIDAE	
<i>Ramphastos toco</i>	12,21,25
PICIDAE	
<i>Picumnus albosquamatus</i>	12,18,21
<i>Melanerpes candidus</i>	12,18,21
<i>Veniliornis passerinus</i>	12,21
<i>Colaptes melanochloros</i>	12,15,18,21
<i>Colaptes campestris</i>	12,18,21
<i>Celeus flavescens</i>	12
<i>Dryocopus lineatus</i>	12,15
<i>Campephilus melanoleucos</i>	12
THAMNOPHILIDAE	
<i>Taraba major</i>	15,21,25
<i>Thamnophilus doliatus</i>	18,21,25
<i>Thamnophilus torquatus</i>	25
<i>Thamnophilus punctatus</i>	15,25
<i>Herpsilochmus atricapillus</i>	25
<i>Herpsilochmus longirostris</i>	18,21
<i>Formicivora rufa</i>	25
DENDROCOLAPTIDAE	
<i>Sittasomus griseicapillus</i>	12,15
<i>Lepidocolaptes angustirostris</i>	12,15,18,25
FURNARIIDAE	
<i>Furnarius rufus</i>	12,18,21
<i>Synallaxis frontalis</i>	18,21,25
<i>Cranioleuca vulpina</i>	15
<i>Phacellodomus ruber</i>	3,4,5,9,12,18,19,21,22,24
<i>Berlepschia rikeri</i>	4,9,12,13,17, 23
<i>Hylocryptus rectirostris</i>	21
<i>Lochmias nematura</i>	21
TYRANNIDAE	
<i>Leptopogon amaurocephalus</i>	15
<i>Hemitriccus margaritaceiventer</i>	25
<i>Todirostrum cinereum</i>	10,18,21
<i>Elaenia flavogaster</i>	12,18,21,25
<i>Elaenia spectabilis</i>	18,21
<i>Camptostoma obsoletum</i>	12,18,21
<i>Suiriri suiriri</i>	12
<i>Sublegatus modestus</i>	15
<i>Myiophobus fasciatus</i>	18,21
<i>Myiobius barbatus</i>	15
<i>Hirundinea ferruginea</i>	5

## Appendix 1. Continued...

Families/Species	Reference codes
<i>Cnemotriccus fuscatus</i>	21
<i>Pyrocephalus rubinus</i>	15,18,21
<i>Knipolegus lophotes</i>	18
<i>Satrapa icterophrys</i>	18
<i>Xolmis cinereus</i>	18,21
<i>Gubernetes yetapa</i>	3,5,12,18
<i>Fluvicola nengeta</i>	15
<i>Arundinicola leucocephala</i>	18
<i>Alectrurus tricolor</i>	5
<i>Colonia colonus</i>	15
<i>Machetornis rixosa</i>	18,21
<i>Myiozetetes cayanensis</i>	15,21,25
<i>Myiozetetes similis</i>	18,21
<i>Pitangus sulphuratus</i>	5,10,12,15,18,21,25
<i>Myiodynastes maculatus</i>	18,21,25
<i>Megarynchus pitangua</i>	12,15,18,21,25
<i>Empidonomus varius</i>	12,18
<i>Griseotyrannus aurantioatrocristatus</i>	18,21,25
<i>Tyrannus albogularis</i>	12,18,21,25
<i>Tyrannus melancholicus</i>	3,12,18,21,25
<i>Tyrannus savana</i>	12,18,21,25
<i>Myiarchus ferox</i>	18,21
<i>Myiarchus tyrannulus</i>	21,25
PIPRIDAE	
<i>Antilophia galeata</i>	15
VIREONIDAE	
<i>Cyclarhis gujanensis</i>	12,18,21,25
<i>Vireo olivaceus</i>	15,25
CORVIDAE	
<i>Cyanocorax cristatellus</i>	8,12,16,21
<i>Cyanocorax cyanopogon</i>	25
HIRUNDINIDAE	
<i>Pygochelidon cyanoleuca</i>	18,21
<i>Stelgidopteryx ruficollis</i>	18,21,25
<i>Progne tapera</i>	18,21
<i>Tachycineta albiventer</i>	18,21
<i>Tachycineta leucorrhoa</i>	18
TROGLODYTIDAE	
<i>Troglodytes musculus</i>	12,18,25
<i>Pheugopedius genibarbis</i>	15
<i>Cantorchilus leucotis</i>	18,21,25
DONACOBIIIDAE	
<i>Donacobius atricapilla</i>	5,10,15
POLIOPTILIDAE	
<i>Polioptila dumicola</i>	12,18,21
TURDIDAE	
<i>Turdus rufiventris</i>	12,15,18,21
<i>Turdus leucomelas</i>	12,15,18,21,25
<i>Turdus amaurochalinus</i>	12,18,21,25
MIMIDAE	

## Appendix 1. Continued...

Families/Species	Reference codes
<i>Mimus saturninus</i>	3,12,18,21
COEREBIDAE	
<i>Coereba flaveola</i>	12,18,21
THRAUPIDAE	
<i>Schistochlamys melanopsis</i>	3,5,8,9,12,16,18
<i>Thlypopsis sordida</i>	5,15
<i>Piranga flava</i>	25
<i>Eucometis penicillata</i>	18
<i>Tachyphonus rufus</i>	15,25
<i>Eucometis penicillata</i>	18
<i>Ramphocelus carbo</i>	15
<i>Thraupis sayaca</i>	12,18,21,25
<i>Thraupis palmarum</i>	5,8,10,12,16,18,21,25
<i>Tangara cayana</i>	12,15,18,21,25
<i>Tersina viridis</i>	12,18,21
<i>Dacnis cayana</i>	15,18,21,25
<i>Cyanerpes cyaneus</i>	25
<i>Hemithraupis guira</i>	25
<i>Conirostrum speciosum</i>	15
EMBERIZIDAE	
<i>Zonotrichia capensis</i>	12,18,21,25
<i>Ammodramus humeralis</i>	5
<i>Sicalis citrina</i>	12
<i>Sicalis flaveola</i>	18
<i>Emberizoides herbicola</i>	3,12,15
<i>Volatinia jacarina</i>	3,15,18,21,25
<i>Sporophila plumbea</i>	10,12
<i>Sporophila collaris</i>	5
<i>Sporophila lineola</i>	18,21
<i>Sporophila nigricollis</i>	3,5,12,15,18,21,25
<i>Sporophila caerulescens</i>	18,21,25
<i>Sporophila leucoptera</i>	5
<i>Sporophila bouvreuil</i>	5
<i>Sporophila minuta</i>	5
<i>Sporophila angolensis</i>	3,5,25
<i>Sporophila crassirostris</i>	5
<i>Arremon taciturnus</i>	15
<i>Coryphospingus pileatus</i>	12,25
<i>Coryphospingus cucullatus</i>	18,21
CARDINALIDAE	
<i>Saltator coerulescens</i>	15
<i>Saltator similis</i>	18,21,25
<i>Saltator atricollis</i>	3,25
<i>Cyanoloxia brissonii</i>	5,25
PARULIDAE	
<i>Parula pitiayumi</i>	25
<i>Geothlypis aequinoctialis</i>	3,5,10
<i>Basileuterus culicivorus</i>	25
<i>Basileuterus hypoleucus</i>	5
<i>Basileuterus flaveolus</i>	25
ICTERIDAE	

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## Appendix 1. Continued...

Families/Species	Reference codes
<i>Psarocolius decumanus</i>	15
<i>Cacicus cela</i>	15
<i>Icterus cayanensis</i>	10,15,18,21
<i>Icterus jamaicai</i>	15
<i>Gnorimopsar chopi</i>	8,12,16,18,19,21,25
<i>Agelasticus cyanopus</i>	10
<i>Pseudoleistes guirahuro</i>	5,21
<i>Molothrus bonariensis</i>	10,12,18,21
<i>Sturnella militaris</i>	10
FRINGILLIDAE	
<i>Carduelis magellanica</i>	25
<i>Euphonia chlorotica</i>	12,18,21,25
ESTRILDIDAE	
<i>Estrilda astrild</i>	21
PASSERIDAE	
<i>Passer domesticus</i>	18,21

Reference codes: 1, Sick (1948a); 2, Sick (1948b); 3, Sick (1955); 4, Sick (1965); 5, Negret et al. (1984); 6, Antas & Cavalcanti (1988); 7, Willis & Oniki (1993); 8, Villalobos (1994); 9, Sick (1997); 10, Silva et al. (1997); 11, Bianchi (1998); 12, Bagno (1998); 13, Bagno & Marinho (2001); 14, Silveira et al. (2001); 15, Santos (2001); 16, Macedo (2002); 17, Silva e Silva (2004); 18, Franchin & Marçal (2004); 19, Gurgel-Gonçalves et al. (2004); 20, Blamires et al. (2005); 21, Valadão et al. (2006); 22, Gurgel-Gonçalves et al. (2006); 23, Vasconcelos et al. (2006); 24, Gurgel-Gonçalves & Cuba (2007); 25, Curcino et al. (2007).