SENTINELS IN *Saltator atricollis* (PASSERIFORMES: EMBERIZIDAE)

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(With 4 figures)

ABSTRACT

I studied the existence of sentinels in *Saltator atricollis* in a 'campo-cerrado' (Brazilian savanna) during the breeding seasons of 1994-95 and 1995-96. Groups of this species consisted of two to seven birds (N = 25). Sentinels were present (mean ± sd) 62% ± 9% of the time, and most sentinel bouts lasted from less than one to six minutes (although in some occasions for more than 30 min.). Overlap of two or more sentinels occurred on average only 3.2% of the time with birds on guard. Sentinels commonly gave contact calls in the beginning and/or at the end of a sentinel bout. The group size had no effect on time with sentinels. However the encounter rate between raptors and groups significantly influenced the time guarded. The results of this study suggests that the ability of sentinels to detect predators may play a central role as an anti-predator device.

Key words: Emberizidae, Brazilian savanna, raptors, alertness, sentinels.

RESUMO

Sentinelas em *Saltator atricollis* (Passeriformes: Emberizidae)

Estudei a existência de sentinelas em *S. atricollis* em campo-cerrado, nas estações reprodutivas de 1994-95 e 1995-96. Os grupos de *S. atricollis* continham de dois a sete indivíduos (N = 25). Os sentinelas vigiaram os grupos (média ± dp) por 62% ± 9% do tempo, sendo que a maioria dos turnos de vigilância durou de menos de um a seis minutos (em alguns casos se extenderam por mais de 30 min.). Dois ou mais sentinelas vigiaram simultaneamente, em média, apenas 3,2% do tempo vigiado. Os sentinelas comumente emitiam chamados de contato quando iniciavam e/ou terminavam um turno de vigilância. O tamanho dos grupos não apresentou relação com o tempo vigiado. Por outro lado, a taxa de encontros entre predadores aéreos e grupos influenciou significativamente o tempo vigiado. A habilidade dos sentinelas em perceber predadores provavelmente apresenta uma função relevante, conferindo vantagens antipredatórias aos grupos dessa espécie.

Palavras-chave: Emberizidae, campo-cerrado, predadores aéreos, vigilância, sentinelas.

INTRODUCTION

Among some advantages of living in groups, birds may benefit from the enhancement of protection from predators mainly due to better surveillance (Pullian, 1973), as verified empirically in some studies (Powell, 1974; Bertram, 1980; Elcavage & Caraco, 1983; McGowan & Woolfenden, 1989).

Sentinels (i.e. individuals that interrupt foraging for extended periods to watch for predators) have been identified in many bird species (Andrews & Naik, 1970; Gaston, 1977; Wickler, 1985; Verbeek & Butler, 1981; Ferguson, 1987; McGowan & Woolfenden, 1989; Alves & Cavalcanti, 1996). Actions such as guarding other individuals, alerting them to danger, and an alternation of guarded periods to avoid vigilance overlapping are pointed as remarkable features to evaluate sentinel behavior as an adaptive device (McGowan & Woolfenden, 1989). Because sentinels improve the group's vigilance, by increasing perception from predators, other group members may decrease personal efforts of

vigilance (McGowan & Woolfenden, 1989; Hailman *et al.*, 1994).

The black-throated saltator (*Saltator atricollis*) is fairly common in Brazilian semi-open habitats such as 'campo-cerrado' (Brazilian scrub savanna; see Eiten, 1994). It is a conspicuous species whose behavior is quite different from other saltators' in which one bird of a group (2-6 birds) may be seen prominently perched on a scrub or a tree presumably watching about, while fellow group members are foraging on or close to the ground (Ridgely & Tudor, 1989; Sick, 1997, pers. obs.). Raptors in the campo-cerrado, such as *Falco femoralis* and *F. sparverius*, among others, threaten foraging birds with low flights or even attacks (Ragusa-Netto, 1999). Thus, *S. atricollis* on exposed perches, presumably watching about, may be related to avoiding predation. In this study I quantified some features from those prominently perched birds in order to verify if their function is vigilance.

STUDY SITE AND METHODS

I studied groups of *S. atricollis* in the campo-cerrado in Brotas (São Paulo State, 22°11'S, 47° 54'W, elevation 750 m). The observations were conducted during the 1994-1995 and 1995-1996 breeding seasons (October to February). The site was approximately 1,500 ha in area. The vegetation consisted of small trees and bushes (heights 1-6 m), interspersed with grassy open areas. Mean annual temperature was 19.7°, and mean annual rain fall approximately 1,430 mm, with 1,200 mm falling from October to March (source: meteorology service of Ripasa [neighbor to the study site]; period: from April 1994 to March 1996). A wet hot season extends from October to March; a cooler dry season occurs from April to September. In order to find birds I walked 11,500 m of trails in the campo-cerrado. Twelve points (1,000 m away from each other) were selected on the trails as starting points to walking. The definition of starting point and direction to be followed were randomized by lot without replacement. Observations were taken during a morning period (7:00 to 12:00 h) and during an afternoon period (13:00-18:00 h). Only one group was studied during each period. If the groups were lost from view within 1 hr, the observation was discarded. Observations were also discarded if groups started confrontations towards conspecifics before 1 hr had passed. In those cases, I abandoned the flock and tried to study another one. If confrontations started after 1 hr had elapsed, I interrupted the observation and took it as a replicate for statistical analysis. This was done to assure the observation of only one group per period since most birds were not color ringed and to avoid any effect of confrontation on time birds spent on exposed perches. Birds were observed through 8 x 30 binoculars, and observations were dictated in a portable recorder for later transcription. When a group of *S. atricollis* was found, I waited 5-10 min. to allow the birds to become habituated to my presence (generally I conducted observations 10-20 m away from birds). For each group I recorded: a) group size, b) time with at least one prominently perched bird, c) calls given by prominently perched bird, d) raptors visible while groups were observed and e) bird reaction to raptors.

I almost continuously observed prominently perched birds to check if they were doing regular rotatory movements of the head holding the bill horizontally positioned, once the performance of those movements suggests the bird is watching about. As a prominently perched bird watching about may be vigilant (Andrews & Naik, 1970; Gaston, 1977; Wickler, 1985; Verbeek & Butler, 1981; Ferguson, 1987; McGowan & Woolfenden, 1989) I assumed that this duty was accomplished by such a bird only if besides watching about it also alerted foraging conspecifics. As both contact and alarm calls may be recorded from prominently perched birds (Wickler, 1985; McGowan & Woolfenden, 1989), in this study the criterion used to distinguish one from the other was bird responses. Commonly alarm calls trigger instantaneous evasive responses while contact calls do not trigger evasive responses. I also attempted to determine the causes of alarm calls, and if the caller was foraging or prominently perched.

All raptors seen (also presumably by birds) while a group was observed were recorded as an encounter between raptors and groups of *S. atricollis*. I used Kruskal-Wallis analysis of variance to test for differences in time birds were on exposed perches and Chi-square test to compare the proportions of contact calls given by prominently perched birds (Sokal & Rohlf, 1981).

RESULTS

I studied a total of 25 groups of *S. atricollis* in two breeding seasons. Group size varied from two to seven birds (mean [± sd] was 4.0 ± 1.3

birds). Groups were directly observed for 2 h 17 min., on average (direct observations totaled 57 hr). At least one prominently perched bird was present from 46% to 76% of the time (mean 62% ± 9%) while group members foraged. Birds were recorded on exposed perches (N = 414) commonly from less than one to six min. (Fig. 1), although in some cases for more than 30 min. The prominently perched birds constantly turn their head, first to one side, then to the other holding the bill horizontally positioned. Some times this conduct was interrupted for short intervals of maintenance activities. All alarm calls recorded when raptors were present were given by prominently perched birds (see results below). The alarm calls caused all fellow group members to head for cover. Two or more prominently perched birds were recorded simultaneously on average only for 3.2% of the time with birds on exposed perches.

I recorded birds giving contact calls while on exposed perches. Four patterns were verified: a) the bird gave one contact call as soon as it assumed position on an exposed perch, b) the bird gave one contact call before leaving an exposed perch, c) the bird gave two contact calls; the first when took position on exposed perch and the other before leaving that position and d) the bird gave no contact call while on exposed perch. The absence of contact calls was less frequent than the emission of at least one contact call while on exposed perches (77% of the cases, N = 414; $\chi^2 = 79.62$, $p < 0.0001$, Fig. 2). As group size varied from two to seven birds, I verified if the proportion of time with birds on exposed perches were correlated with group size. For this analysis three classes of group size were considered: small (2-3 birds), medium (4) and large (≥ 5). Group size did not correlate with time birds were on exposed perches (Kruskal-Wallis, H = 2.80, p > 0.29, Fig. 3).

Seven species of raptors were recorded at encounters (N = 34) with *S. atricollis* (Table 1). I recorded the emission of four alarm calls by prominently perched birds with raptor presence (one alarm due to *Falco femoralis*, other due to *Elanus leucurus*, other due to *Milvago chimachima*, and due to *Buteo albicaudatus*). Foraging birds gave no alarm call. The encounter rate between raptors and groups of *S. atricollis* varied from zero to three per hour (average 0.72 encounters/h). Most encounters were with *Falco femoralis* and *F. sparverius* (Table 1). Encounters between raptors and saltator groups varied from distant (± 300 m) to quite close (low flights over groups). Apparently, the degree to which the groups was threatened varied according to raptor species, distance from group, raptor pattern of encounter. As encounters between raptors and groups were not specific and in different ways, encounters of all kinds were grouped in classes according to raptor encounter per hour.

This was done in order to test if the raptor encounter rate was correlated with the proportion of time birds were on exposed perches.

Thus, time with birds on exposed perches was larger for higher encounter rates (Kruskal-Wallis, H = 11.33, p < 0.01, Fig. 4).

DISCUSSION

Vigilance performed by prominently perched birds has been found in some species.

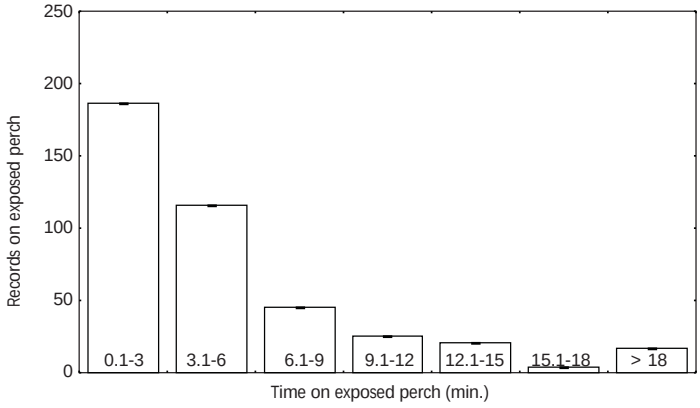

Fig. 1 — Number of times *S. atricollis* was recorded on exposed perches watching about (N = 414) as a function of time (in classes) spent on exposed perches.

Predation avoidance is thought as the main function of this behavior because an advantageous position increases perception from predators (Andrews & Naik, 1970; Gaston, 1977; Wickler, 1985; Verbeek & Butler, 1981; Ferguson, 1987; McGowan & Woolfenden, 1989). McGowan & Woolfenden (1989) showed in Florida scrub jay (*Aphelocoma coerulescens*) the existence of a sentinel system in that birds coordinated the vigilance and were highly efficient to alerting those being protected thorough alarm calls.

In this study, prominently perched birds continuously performed movements of the head in the horizontal plane. This evidenced those birds were watching about.

Furthermore, all alarm calls recorded due to approaching raptors were given by prominently perched birds and the time employed on exposed perches by birds was larger when raptor encounter rate with saltator groups was higher.

Also, two or more birds overlapped time on exposed perches for less than 5% of the time those birds were prominently perched. These behaviors suggested sentinel function to birds recorded on exposed perches.

Even then it is worth to consider others possible factors which may cause birds to use advantageous observation points. Birds might use exposed perches to enhance the detection of a prey below or a prey flushed by other group members.

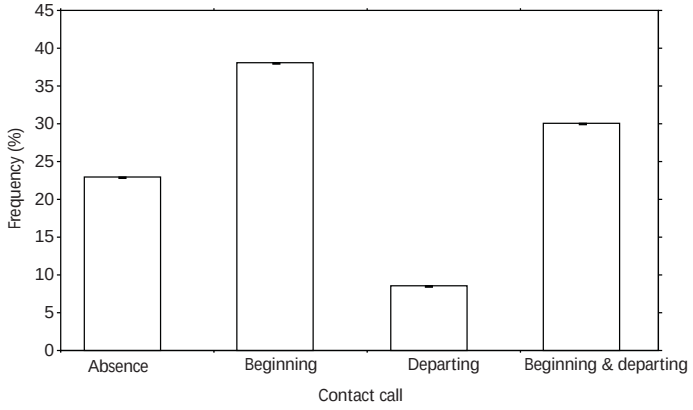

Fig. 2 — Contact calls given by *S. atricollis* while on exposed perches (N = 414). Absence: no contact call given; beginning: one contact call was given as soon as the bird assumed position on an exposed perch; departing: one contact call was given before the bird to left an exposed perch; beginning & departing: two contact calls were given on arrival and on departure (χ^2 = 79.62, p = 0.0001).

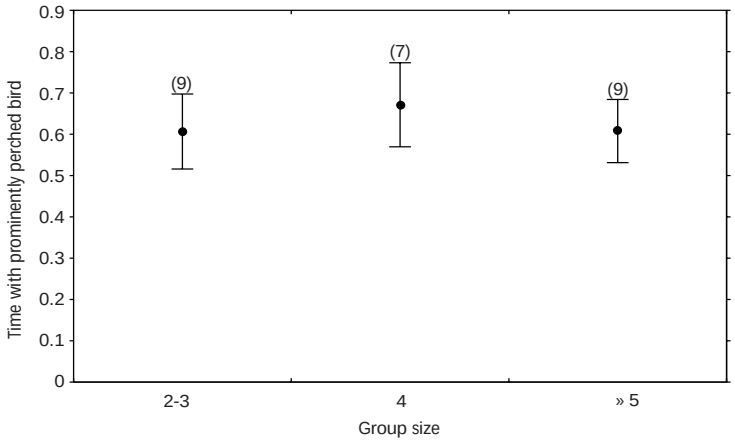

Fig. 3 — Relationship between group size and mean (± sd, lines) proportion of time with prominently perched bird. The sample size are in brackets (Kruskal-Wallis test, H = 2.80, p = 0.29).

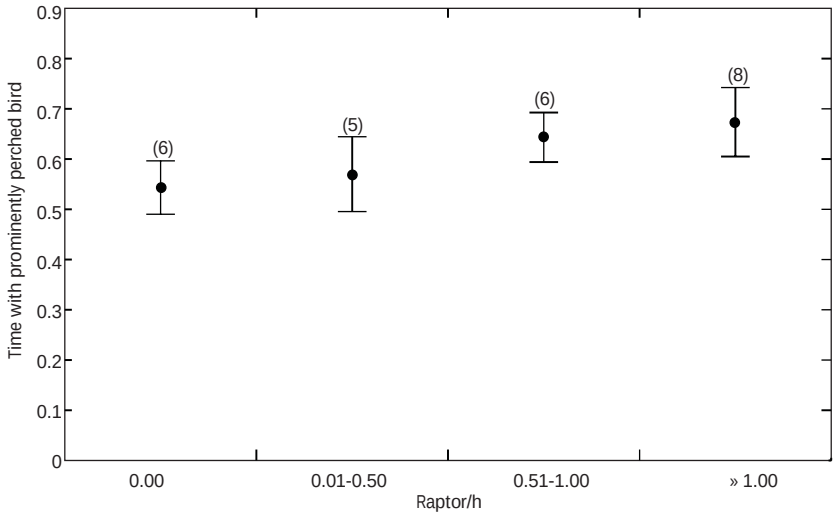

Fig. 4 — Relationship between encounter rate with raptors (in classes) and mean (± sd, lines) proportion of time with prominently perched bird. The sample size are in brackets (Kruskal-Wallis test, H = 11.33, p = 0.01).

However those birds were not looking down and I never observed them to capture a prey immediately after to leave an exposed perch as well as they never chased a flushed prey. If birds were prominently perched mainly for foraging I would expect observing regularly birds going back to an exposed perch after an attempt or successful capture of a prey (as in the case of many Tyrannidae, Fitzpatrick, 1980). Also, simultaneous prominent perching by two or more birds, presumably would be more common.

If *S. atricollis* is territorial, as other bird species from 'cerrado' (Alves, 1990), birds on exposed perches might be monitoring the approach of conspecifics in order to chase them. Nevertheless, I never observed a bird leaving an exposed perch to chase conspecifics as well as fights which suggested territorial defense. *S. atricollis* present collective singing (Ridgely & Tudor, 1989; Sick, 1997) presumably to avoid neighbor groups (pers. obs.).

The sentinel behavior in *S. atricollis* as an important predator defense was also observed in the same area in the course of a study on mixed flocks. *Falco femoralis* and *F. sparverius* attacked 14 times those mixed flocks. In all 14 cases alarm calls given by sentinels of *S. atricollis* avoid predation since all birds escaped into cover (Ragusa-Netto, 1999). As I was the observer in both studies and adopt the same field procedures, the absence of attacks towards unispecific groups of *S. atricollis* probably was the result of differences in sample size (mixed flocks were directly observed by > 420 h) and/or conspicuousness of mixed flocks to raptors (Powell, 1985).

Besides to giving alarm calls, sentinels have been recorded giving contact calls. The function of those calls presumably is to make fellow group members aware about being covered avoiding interruption of foraging for a visual scan of the area to determine the presence of a guard (Wickler, 1985; Rasa, 1986; McGowan & Woolfenden, 1989). As saltators regularly gave contact calls immediately after to take an exposed perch and/or before leaving those perches, this also may be the case for *S. atricollis*. If the function of contact calls was only cohesion maintenance, I would expect foraging birds to emit contact calls regularly, rather than birds on exposed perches which spend substantial periods without foraging.

As verified in other studies, group size and time with a sentinel were unrelated (Ferguson, 1987; Hailman *et al.*, 1994). Hailman *et al.* (1994) pointed out that the presence of extra pairs of eyes and ears of other foraging group members constitute sufficiently increased predator protection, which makes formal sentinel duty unnecessary. In larger groups individual efforts in vigilance were reduced and birds increased foraging time. In the present study as most birds were not color ringed, time individually employed in vigilance was not accessed.

TABLE 1

Number of encounters (N = 34) of raptors with groups of *S. atricollis* and raptor species that stimulated sentinel alarm calls (+ = alarm call was stimulated; – = absence of alarm call).

Species	Encounters	Alarm atimulation
Falco sparverius	11	–
F. femoralis	7	+
Elanus leucurus	7	+
Milvago chimachima	5	+
Herpetotheres cachinnans	2	–
Buteo albicaudatus	1	+
B. magnirostris	1	–

However the similarities in time with sentinel among groups with different size suggested the same pattern found in the above studies.

Groups of *S. atricollis* are probably families, as verified for *Neothraupis fasciata* (Alves, 1990), also common in the cerrado (Ridgely & Tudor, 1989; Sick, 1997). I color ringed only one group of *S. atricollis*. This group had helpers at the nest (pers. obs.). If further studies confirm this observation, the occurrence of cooperative breeding may explain the nature of sociality in this species. In this way, sentinel behavior in *S. atricollis* may have arisen both for parents protecting their offsprings and/or for mate protection as pointed out for *Aphelocoma coerulescens* (McGowan & Woolfenden, 1989). In this respect predator avoidance may be interpreted as one of the main advantages for living in groups (Pullian, 1973) in *S. atricollis*, in which sentinel alertness plays a central role.

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