Climate and nest opening orientation in *Furnarius rufus* (Furnariidae)

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ABSTRACT. The Rufous Hornero (*Furnarius rufus*) is one of the most common bird species in Brazil. Anecdotal information indicates that nest opening orientation in this species is contrary to wind or rainfall direction. To check for the existence of such a pattern, *F. rufus* nests were randomly sampled within an urban area in central Brazil to assess whether factors such as wind and vegetation cover influence nest opening orientation. Using circular statistics, no evidence was found that nest-opening orientation was important for the species. These results refuse the expected pattern for tree hollow or enclosed nests. The results suggest that factors such as nesting architecture, nest material, nest microclimate or a combination of these, instead of local climate, must be conditioning nesting behavior in this species.

KEYWORDS. Circular statistics, *Furnarius rufus*, nest orientation, nesting behavior, Rufous Hornero.

RESUMO. Clima e orientação da abertura dos ninhos de joão-de-barro, *Furnarius rufus* (Furnariidae). O joão-de-barro (*Furnarius rufus*) é uma das espécies de aves mais comuns do Brasil. Informações sugerem que a orientação da abertura dos ninhos desse furnarídeo seria direcionada em posição contrária das direções de incidência dos ventos e das chuvas. Para averiguar tal padrão de nidificação, ninhos de *F. rufus* foram aleatoriamente amostrados em uma área urbana da região Centro-Oeste do Brasil para verificar se fatores como vento e cobertura vegetal exerciam influência sobre a orientação de suas aberturas. Testes envolvendo estatística circular revelaram que a abertura dos ninhos refletiu um padrão aleatório de orientação, algo não esperado para aquelas espécies que nidificam em ocos de árvores ou que constroem seus ninhos de maneira a proteger a câmara de incubação. Ao invés do clima da região, os resultados sugerem que a arquitetura e o material de construção do ninho, o microclima dentro do ninho ou uma combinação desses fatores possam estar condicionando o comportamento de nidificação dessa espécie.

PALAVRAS-CHAVE. Estatística circular, *Furnarius rufus*, joão-de-barro, orientação da entrada do ninho, nidificação.

Species must have a skill to select nest sites suitable in relation to reproductive efforts (Alcock, 2001). In spite of the fact that nest architecture is an important feature for systematics and phylogenetic studies in Furnariidae (Whitney *et al*., 1996; Zyskowski & Prum, 1999), which in turn can provide interesting insights into nesting behavior among species, studies on this subject are scarce. Particularly for those bird species nesting in rifts, tree hollows or chambers, such as evidenced for South American Psittacidae (parrots, macaws, parakeets), Picidae (woodpeckers), and Furnariidae (ovenbirds), nest opening orientation usually is related to local environmental conditions. In such cases, the factors determining the pattern of nest opening orientation are wind and rainfall (Conner, 1975; Inouye, 1976; Raphael, 1985; Mezquida, 2004). Also, habitat characteristics around nest such as a matrix of distinct physiognomies or tree branch arrangement (e. g. inclination) can influence the direction in which birds will positionate the nest entrance (Viñuela & Sunyer, 1992; Zwartjes & Nordell, 1998; Thogmartin, 1999). This relationship between nesting behavior and environmental characteristics is often observed for species from regions with stressing seasonal climatic changes, such as temperate species. While this relationship may be true for such species, this may not be the case for organisms in tropical areas, where climate is usually less severe (Towsend *et al*., 2003).

The Rufous Hornero, *Furnarius rufus* (Gmelin, 1788) is one of the most common bird species in Brazil. It is common in farms, orchards, gardens, and even in the urban areas, usually occupying open areas with scattered trees and short grass vegetation. One remarkable characteristic of the species is its nest. With a mixture of clay, leaves and grass, the couple builds an oven-like nest every year in lampposts, trees, and houses. Eventually, an old nest is repaired instead a new one is built (Fraga, 1980; Sick, 1988).

Furnarius rufus nest opening orientation is said to be positioned contrary to wind or rainfall direction. However, few detailed studies were conducted to date to assess specific relationships between these parameters. According to anecdotal information for Argentinean populations of *F. rufus*, nest opening has a south-southwestern orientation and such pattern is in accordance with local wind direction (Herman & Meise, 1965; Fraga, 1980; Sick, 1988). In this paper we report the results of a study dealing with nesting behavior of *F. rufus*. Our main goal was to determine which factors drive nest-opening orientation in this species.

MATERIAL AND METHODS

From May to December 2002, nests of *F. rufus* were randomly sampled in streets, avenues, and parks of Campo Grande City, Mato Grosso do Sul, central Brazil. Two well-defined climate seasons can be distinguished in this region, a wet summer from November to March and a dry winter from April to October. Due to these distinct seasons a first hypothesis related to *F. rufus* nesting behavior can be addressed: if *F. rufus* nest opening is orientated according to local climate, then a non-random opening orientation would be expected in this population. We sampled active and non-active nests. Because nests can ruin after reproductive periods due to rainfall, we sampled only those non-active nests that exhibited a well-defined opening. For each sampled nest we recorded the nest substrate (tree or lamppost, for instance) and percentage of vegetation cover (according to BRAUN-BLANQUET, 1979) above it. From this information, a second hypothesis can be addressed. Vegetation cover, here assumed as a habitat factor, could provide extra-protection for nests in addition to nest opening itself. Thus, well protected nests (≥50% of vegetation cover, defined here as protected sites) could have a random opening orientation due to the extra protection against rain and wind. On the other hand, for those nests fixed in places with scarce (<50%) or none (e. g. lampposts) vegetation cover (defined here as unprotected sites), nest opening orientation should be non-random. Because birds must rely only on their skill to place their nests, nest opening should be turned to the more favorable direction. Opening directions were taken with GPS. All angles were measured with respect to magnetic north and subsequently corrected to true north using a magnetic declination of 15^o East. Meteorological records from the last five years were obtained from Empresa Brasileira de Pesquisa Agropecuária (Embrapa) at Campo Grande.

We conducted circular statistics analyses to examine the distributions of sampled nests (ZAR, 1984; CAIN, 1989). Nest opening orientation were tested for non-random distribution using Rayleigh's *z*-test while pairwise Watson's *F*-test was used to compare samples from protected and unprotected sites and from natural and artificial sites to determine if their mean angles differed significantly. Significant level was set at p<0.05. Both Rayleigh's *z*-test and Watson's *F*-test were performed according to algorithms implemented in software package Oriana™ for Windows, version 1.06 (KOVACH, 1994).

RESULTS

A total of 105 *F. rufus* nests were sampled in the study area. No record on rainfall direction was obtained for the region. Hence, only wind direction was tested for relationship with bird nesting behavior. If directions are grouped, climate data show that winds blew mostly from the northwest, north, northeast and east (around 77%; χ^2 =397.76; p<0.0001; n = 1,035). Although nest opening had a southeastern orientation (mean angle =146.30^o ± 125.11^o; mean ± SD), in fact nest opening orientation followed a random pattern (*r*=0.09; *z*=0.85; p=0.41). By this way, the first hypothesis (i.e., nest-opening orientation being predicted by local climate) is rejected.

Nests were frequently fixed in trees instead of artificial sites. The main tree species used was the "jatobá", *Hymenaea coubaril*, a large-crowned Leguminosae. Mean vegetation cover above nests was 30% ± 27.6%, ranging from zero (lampposts) to 80% (for instance, on *H. coubaril*). Hence, most nests were fixed in poorly covered sites (<50% of vegetation cover). Nests under dense cover exhibited a random pattern (*r*=0.12; *z* =0.48; p=0.64) of opening orientation, as predicted by hypothesis two (nest-opening orientation being predicted by vegetation cover). Openings of these nests exhibited a southwestern orientation (mean angle=204.09^o ± 118.90^o). However, nests under scarce cover (including artificial sites) also exhibited a random opening orientation (*r*=0.11; *z*=0.42; p=0.67) and a southeastern orientation (mean angle =123.30^o ± 119.11^o). Mean angles of nests from protected and unprotected sites did not differ significantly ($F_{1, 103}$= 2.72, p=0.10). However, a significant difference was detected between mean angles of nests constructed in natural (mean angle=167.34^o ± 111.64^o, n=70, southern) and artificial (mean angle=54.63^o ± 120.97^o, n=35, northeastern) sites ($F_{1.103}$=5.20, p=0.02).

DISCUSSION

Furnarius rufus nest opening did not show a non-random orientation in this study, as would be expected for bird species that nest in rifts, tree hollows or chambers. Usually, local climate conditions, mainly wind and rainfall, are the selective factors that could lead species to build their nests in a specific direction (CONNER, 1975; INOUYE, 1976; RAPHAEL, 1985). Although the findings reported here are indicative of a case where nesting behavior is not determined by environmental conditions, some interesting approaches concerning nesting behavior of the Furnariidae in general and of *F. rufus* in particular should now be investigated.

A first interpretation about a random pattern of nest opening orientation in *F. rufus* could be related to the random pattern of wind direction. Data collected in the region over the last five years showed that around 77% of the wind blew from between northwest and east. Then, wind may not be an important selective force to shape nesting behavior in *F. rufus*. Even if rainfall exhibited a non-random pattern of direction (rainfall data was not collected in this study), its influence on nesting behavior would have been weak, judging from the observed random pattern of nest opening orientation. Therefore, factors other than local climate must be investigated to explain *F. rufus* nesting behavior.

Nest architecture in Furnariidae is both diverse and elaborated (ZYSKOWSKI & PRUM, 1999). For *F. rufus*, the enclosed nest is U-shaped, with a wall separating the nest chamber from the outside. Due to this pattern the incubation chamber is safe from inclement weather, particularly storms and winds. Thermoregulatory constraint is often mentioned as a factor shaping the nest pattern in birds, since a determined nest opening orientation could favor a microclimate inside nest cavity (HARTMAN & ORING, 2003). Here, no attempt was made to compare inside and outside temperature of *F. rufus* nests. However, birds heavily used clay to build the nest, a good thermal isolating material (FIGUEIREDO, 1995). Thus, nest architecture together with nest material may result in nest opening position being unrelated to weather conditions. This may explain the absence of vegetation cover effect on nest opening orientation. One can argue that during reproductive season birds could make use of a non-random nesting orientation in order to maximize reproductive success (MURPHY, 1983; RENDELL & ROBERTSON, 1994; THOGMARTIN, 1999). Then, the random pattern of nest opening reported here for *F. rufus* was biased because the sample included active and non-active nests. To diminish this bias, 14 active nests were sampled during reproductive season (October). Again, a random pattern was detected (*r*=0.34; *z*=1.62; p=0.21; mean angle =154.77° ± 132.21°; southeastern).

For those species that have a wide geographical distribution, and whose populations experience climatic gradients throughout their range, a geographical component in nesting behavior is expected (Murphy, 1983; Thogmartin, 1999). Therefore, a geographical component on nesting behavior could be found throughout *F. rufus* geographical distribution. Sampling populations under different climate conditions could evidence a variation in nesting behavior. Since material used to built nests can change according to the locality (F. L. Souza, not publicated data) and such materials may eventually not be as good a thermal isolating as clay (sand, for instance), maybe in these cases a different pattern of nest opening orientation could be evidenced. Also, birds eventually occupy old nests as sleeping sites during the non-breeding season (Skutch, 2001), a behavior observed for *F. rufus*. Thus, nests can be used for protection throughout the non-breeding season, given the unsuitable climate during this period, characterized by extreme cold and hot temperatures and heavy rainfall. Although it was detected difference between mean angles of nests constructed in natural and artificial sites, these results must be viewed with caution due to the low concentration (i. e. uniform distribution) of the data.

The results found here provided no evidence that nest opening orientation is important for *F. rufus*. Factors such as nest architecture, nest material, nest microclimate or a combination of these may be conditioning nesting behavior in this species.

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