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Implications of nest-site size selection on the nest building strategy in woodpeckers (Picidae: Aves)

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RESUMEN: Utilicé al Carpintero de Hoffmann (*Melanerpes hoffmannii*) como modelo para determinar cómo el tamaño del nido en los carpinteros influye en el tamaño de los sitios elegido para anidar. Analicé la relación existente entre seis medidas del nido de *M. hoffmannii* con el diámetro a la altura de la entrada del nido (DNE), para determinar cómo están influenciadas las dimensiones del nido por el tamaño del sitio elegido para construirlo. Encontré 32 nidos a lo largo de un año en un área de 25 ha en Getsemaní, Costa Rica. Todos los nidos que encontré estuvieron en sitios con DNE ≥ 10 cm. El grosor de la pared frontal y trasera fueron las únicas variables del nido que están influenciadas por las dimensiones del sitio escogido para anidar. Nidos con paredes más delgadas podrían ser menos resistentes al ataque de depredadores. La profundidad de los nidos fue la medida que más varió posiblemente asociada con la dureza del sitio elegido. La entrada de los nidos fue más alta que ancha, y fue la medida más consistente en todos los nidos.

PALABRAS CLAVE: Costa Rica, fitness, *Melanerpes hoffmannii*, árboles muertos en pie.

INTRODUCTION

Woodpeckers are very specific in nest-site selection (Aitken *et al*., 2002; Adkins-Giese and Cuthbert, 2003; Sandoval and Barrantes, 2006). This can be influenced by macro (e.g., canopy cover, canopy height and surrounding vegetation) (Conner and Adkinsson, 1977; Petit *et al*., 1985; Adkins-Giese and Cuthbert, 2003) and micro habitat conditions (e.g., tree species, wood hardness and fungus infection) (Li and Martin, 1991; Schepps *et al*., 1999; Aitken *et al*., 2002), as well as for the energy and the time that will be invested in digging the cavity, favoring sites that are easy to excavate (Martin, 1993; Newton, 1994; Sandoval and Barrantes, 2006). A factor that has not yet been analyzed in terms of site selection in any woodpecker species is nest size. This factor is possibly the most important for selecting the nesting place, since it determines the minimum size where the woodpecker can build a successful nest. I selected the Hoffmann's Woodpecker as a model species, to prove if the nest sizes limit the places select to nest by woodpeckers. I use this species because is a common species in Costa Rica Central Valley (Stiles and Skutch, 1989; Sandoval and Barrantes, 2006), and build nest between 1 to 8 m high, facilitating its measure. My objective is to describe the Hoffmann's Woodpecker (*Melanerpes hoffmannii*) nest cavity dimensions, to explain which nest features are limited by nest-site selection. Also I suggest a model between the wood hardness and nest depth.

MATERIALS AND METHODS

I conducted this research in Getsemani, Costa Rica (10º01' N, 85º06' W), from October 2003 to October 2004, in an area of approximately 25 ha, 60% coffee plantations and 40% pastures land, divided by living fences. I searched for active Hoffmann's Woodpecker nests', walking through all the area along transects, in dead trees (snags) and dead parts of live trees, places used by this species to build nest. When I found a nest, I review if was active (eggs, chicks or adults carrying food) or not. In the active nest, I measured the tree diameter perpendicular at the nest entrance (DNE) wit a ruler, entrance height and width, front wall thickness (front wall), cavity diameter at entrance with a calliper (±0.1 mm), and the thickness of the back wall

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(estimated by substracting the wall thickness and the depth of the nest in relation to the DNE). The cavity depth was determined by measuring the length of the cavity from the bottom to top.

I determined a relationship between the DNE and the other six nest measurements using six simple lineal regressions, one for each pair of comparison. This analysis involved a multiple test in which I adjusted the *P* values for the tests number, applying the Dunn-Sidak method derived from Kipper *et al*. (2006). With this equation the correct *P* value is obtained for the tests. A paired *t*-test was used to compare width and height of the nest entrance, and a Pearson simple correlation for analyzing the relation between them.

Results

Of the 39 Hoffmann's Woodpecker nests I found, 32 were accessible for measuring. I was able to do all the measurements in 23 nests (Table 1); in the other nine nests its location limited the nest measures. Twenty five nests was built in *Erithryna* sp., three in *Lonchocarpus* sp., two in *Bursera simaruba*, one in *Zanthoxilum caribeum* and one was in an unknown tree species. I found nest in both snags or dead tree parts and had a DNE ≥ 10 cm. Snags with large DNE had thicker front ($F_{1,29}$ = 9.8, P = 0.024, Fig. 1A) and back ($F_{1,27}$ = 727.2, P = 0.006, Fig. 1B) walls. The DNE size did not influence the cavity diameter ($F_{1,28}$ = 3.47, P = 0.38), or cavity depth ($F_{1,22}$ = 0.6, P = 0.98), wide entrances ($F_{1,30}$ = 0.02, P = 1.00) or higher nest entrances ($F_{1,30}$ = 0.05, P = 1.00). The nest depth varied the most with a minimum of 28 mm and maximum of 85 mm (Table 1); and both measurements of the entrance showed the least variance, entrance height varied from 44 to 75 mm and the entrance width from 36 to 61 mm (Table 1). The height of the nest entrance is larger than the width of the entrance (t_{31} = 4.7, P < 0.001, Table 1) and both measurements are correlated (r = 0.46, x^2 =7.062, P < 0.01).

Discussion

Hoffmann's Woodpecker nest had low variation in the cavity diameter (Table 1). This low variability influences the relationship found between the DNE and the walls thicker of the nest, because places with big DNE had more wood in the walls than trees with small diameters, with nests of similar sizes. For this reason build nest in places with smaller DNE values reduced the front and back wall thickness, and thus can reduce the structural resistance of the nest for predator attacks decreasing nesting success and/or woodpecker survival. This could be important because in the dry forest and Central Valley where inhabit this woodpecker in Costa Rica (Stiles and Skutch, 1989; Barrantes and Sánchez, 2003; Sandoval and Barrantes, 2006), nest predators are common, especially mammals such as coatis (*Nassua narica*), racoons (*Procyon lotor*) and opossums (*Didelphis marsupialis*), that are capable of digging into the wood in search of food (Kilham, 1971; Rendell and Robertson, 1989; Cáceres and Monteiro-Filho, 2001). This predation pressure could cause the Hoffmann's Woodpeckers to avoid building nests in places with DNE ≤ 10cm (although they could build nest in places with DNE smaller than I found, according to my results *e.g*., 8 cm), to trait to increase his fitness.

Variation of the conditions of heartwood that are infected by fungi (Ligon, 1970; Jackson, 1977; Conner and Locke, 1982), or attacked by arthropods (Schaefer *et al*., 2004), are possibly responsible for the high variability found in the Hoffmann's Woodpecker cavity depth. Tree infections occur before nest cavity construction (Kilham, 1971; Conner *et al*., 1976) and wood hardness is inversely proportional to the degree of infection. For analysis the relation among hardness and depth of cavity is necessary to take into account the bird energy allocated to nest construction. The energy invested could affect the bird fitness so I propose a linear model with the three variables to explain the cavity depth (Fig. 2). This model is based on an ideal snag with two infection degrees, not infected and highly infected, and takes into account that the bird has a limited energy reserve for nest construction.

Places for nesting with little or no infection are more resistant to excavation and the woodpecker expends more energy in nest construction, and result in shallower cavities than the highly infected places (Fig. 2). In these cavities the wood hardness may be a good defence mechanism against nest predation (e.g., especially avoid digging predators) (Kilham, 1971). Trees and snags with high infection have softer wood (Kilham, 1971; Conner *et al*., 1976; Rudolph and Conner, 1991) and less energy are allocate to digging a nest (Fig. 2). However, since this wood is weak, digging a cavity the same depth as in a non-infected site may make the nest more vulnerable to predator attacks.

In conclusion Hoffmann's Woodpecker varied the nest wall sizes in relation of nest place selected to build the nest. However the nest entrances, cavity deep and diameter was not influence but snag size.

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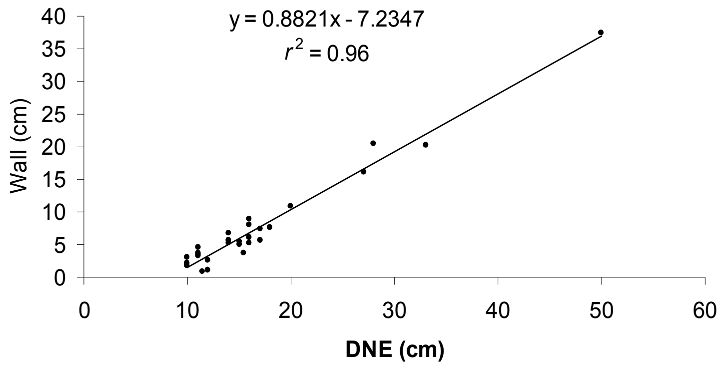
A.



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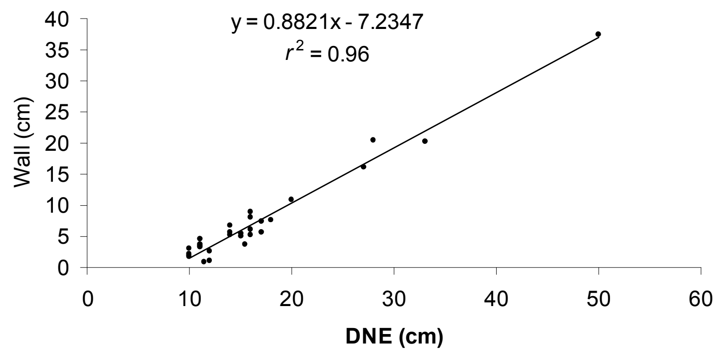

Figure 1. Relation of front (A) and back wall (B) in the Hoffmann's Woodpecker nest with the Diameter at Nest Entrances (DNE).

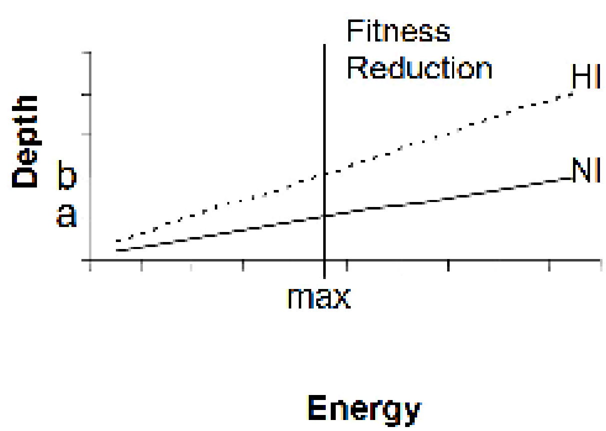

Figure 2. Hypothetical model on relationship between energy expenditure in building cavities by woodpeckers with the cavity depth depending on the hardness of the wood and fitness of the bird. NI = places without infestation (softer wood). HI = wood highly infested. max = maximum value of energy available to construct a cavity, on this point the woodpecker fitness has a reduction. a = maximum cavity depth without fitness reduction for NI conditions. b = maximum protection without fitness reduction for HI conditions. Information on wood hardness implication in woodpecker nest building is from: Kilham, 1971; Conner *et al.*, 1976; Rudolph and Conner, 1991; Sandoval and Barrantes, 2006. Information on energy investment in woodpecker nest building is from: Martin, 1993; Newton, 1994.