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Abundance and prevalence of plastic twine in nests of Neotropical farmland birds

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ABSTRACT—The materials used for nesting have important structural and nonstructural functions in bird nests. A number of bird species incorporate anthropogenic debris in their nests, but there are few systematic studies about such use by terrestrial birds. Here, we test whether the prevalence and amount of plastic twine differs among nests of Neotropical birds in an orange orchard. We found 78 nests, of which 21 (27%) contained plastic. The nests with plastic belonged to 5 species (*Columbina talpacoti*, *Thamnophilus doliatus*, *Turdus amaurochalinus*, *Coryphospingus cucullatus*, and *Zonotrichia capensis*), which differed by both the prevalence and amount of plastic in their nests. The prevalence of plastic was higher in *T. doliatus* nests than in *Z. capensis* nests, and the amount of plastic was greater in *T. doliatus* nests than in those of *C. cucullatus* and of *Z. capensis*. Our results suggest that the use of anthropogenic material in nest construction may depend on the suitability of its properties to specific nest characteristics.
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Key words: anthropogenic debris, breeding behavior, garbage, monoculture, nesting material.

Abundância e prevalência de fitas de plástico em ninhos de aves Neotropicais em uma monocultura

RESUMO (Portuguese)—Os materiais utilizados na construção dos ninhos das aves têm importantes funções estruturais e não-estruturais. Diversas espécies de aves incorporam resíduos antropogênicos em seus ninhos, mas há poucos estudos sistemáticos sobre tal uso por aves terrestres. Neste estudo, testamos se a prevalência e a quantidade de fitas de plástico difere entre ninhos de aves Neotropicais em uma monocultura de laranjeiras. Encontramos 78 ninhos, dos quais 21 (27%) continham plástico. Os ninhos com plástico pertenceram a 5 espécies (*Columbina talpacoti*, *Thamnophilus doliatus*, *Turdus amaurochalinus*, *Coryphospingus cucullatus*, e *Zonotrichia capensis*), as quais diferiram quanto à prevalência e à quantidade de plástico em seus ninhos. A prevalência de plástico foi maior nos ninhos de *T. doliatus* do que nos ninhos de *Z. capensis*, e a quantidade de plástico foi maior nos ninhos de *T. doliatus* do que naqueles de *C. cucullatus* e *Z. capensis*. Nossos resultados sugerem que o uso de material antropogênico na construção do ninho pode depender da adequabilidade das suas propriedades às características de cada tipo de ninho.

Palavras-chave: comportamento reprodutivo, lixo, material de ninho, monocultura, resíduos antropogênicos.

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Bird nest characteristics are directly linked to the species' life history traits (Lee and Lima 2016, Martin et al. 2016), therefore species developed divergent patterns of selection of nest site and nesting material (Brightsmith 2005, Botero-Delgadillo et al. 2017). The adaptive value of the chosen nesting material is related to structural functions (e.g., insulation; Hilton et al. 2004) and nonstructural roles, such as protection against predators and nestling parasites (Wimberger 1984, Schuetz 2005). Several marine and terrestrial bird species incorporate anthropogenic materials in their nests (Blem et al. 2002, Hartwig et al. 2007, Wang et al. 2009, Votier et al. 2011, Townsend and Barker 2014, Tavares et al. 2016), supposedly in relation to their availability at the breeding site (Igic et al. 2009, Radhamany et al. 2016, Witteveen et al. 2017). Anthropogenic materials can fulfill both structural and nonstructural functions in bird nests (Roda and Carlos 2003, Suárez-Rodriguez et al. 2013), but their use increases nest visibility for predators (Canal et al. 2016) and may cause deaths by entanglement (Blem et al. 2002, Townsend and Barker 2014).

Plastic is one of the most common anthropogenic materials found in bird nests (e.g., Cristofoli and Sander 2007, Cristofoli et al. 2008, Tomaz et al. 2009). The prevalence of plastic has been investigated mainly in seabird nests (Hartwig et al. 2007, Votier et al. 2011, Lavers et al. 2013), whereas systematic studies addressing the abundance and prevalence of plastic in nests of terrestrial birds are scarce (e.g., Wang et al. 2009, Townsend and Barker 2014, Møller 2017). In addition, few studies have investigated the response of sympatric bird species to the availability of anthropogenic nesting materials. Here, we report the use of plastic twine in nest construction by Neotropical birds in an orange orchard (*Citrus* sp.), and test whether the species that use plastic as nesting material differ in (1) the prevalence (percentage of nests containing plastic) and (2) the abundance of plastic in their nests. We hypothesized that both the prevalence and abun-

Table 1. Total number of nests and number of nests with plastic twine found in the study area and the amount of plastic (standardized score) in the nests (mean, SE) per species.

Species	Number of nests: Total	Number of nests: With plastic	Amount of plastic: standardized score
Columbidae			
Columbina talpacoti	8	5 (62.5%)	0.34 (0.17)
Apodidae			
Amazilia lactea	1	0 (0.0%)	—
Thamnophilidae			
Thamnophilus doliatus	5	5 (100.0%)	0.60 (0.06)
Furnariidae			
Synallaxis albescens	1	0 (0.0%)	—
Synallaxis frontalis	4	0 (0.0%)	—
Turdidae			
Turdus amaurochalinus	12	5 (41.7%)	0.23 (0.09)
Thraupidae			
Volatinia jacarina	2	0 (0.0%)	—
Coryphospingus cucullatus	9	2 (22.2%)	0.08 (0.06)
Sporophila caerulescens	6	0 (0.0%)	—
Emberizidae			
Zonotrichia capensis	30	4 (13.3%)	0.08 (0.05)
Total	78	21 (26.92%)	0.18 (0.04)

dance of plastic in the nests differ among species because they should select nesting material according to the suitability of its properties.

Methods

We carried out this study in an orange orchard in Ibitinga (48°54′50″W, 21°42′23″S), São Paulo state, Brazil. The climate is tropical with hot, wet summers and dry winters, with mean monthly temperatures between 17.9 °C and 24.1 °C and annual rainfall ~1,270 mm (Alvares et al. 2013). The study area (~4.0 ha) ranges from 475 to 489 m a.s.l. and had ~1,450 12-year-old orange trees planted in 7 × 4 m spacing. Birds took the plastic twine from abandoned harvest bags regularly found throughout the orchard area.

We actively searched for nests every week from November 2013 to January 2014, checking all the orange trees. We also located nests on the ground when females were accidentally flushed. For all nests, we recorded the species and plastic presence, and we estimated visually the amount of plastic from a general overview of the external and inner lining, using the scores 0 (no plastic), 1 (1–25%), 2 (26–50%), 3 (51–75%), or 4 (76–100%) (Schuetz 2005). We attributed a score of 4 to 4 nests built directly over plastic bags (see Results). For each bird species that had at least one nest with plastic, we calculated the prevalence (percentage of nests with plastic) and the mean plastic score, which was standardized between 0 and 1. The plastic score had a non-normal distribution (Shapiro–Wilk test, $P = 0.624$). Thus, we tested whether the prevalence and the amount of plastic in nest construction differed between species using pairwise comparisons of the Fisher exact test with Bonferroni correction and the Kruskal–Wallis test with pairwise comparisons, respectively. We conducted the analyses in the software SPSS Statistics 20 (IBM 2011).

Results

We registered 78 nests of 10 bird species. The nests of 5 bird species had no plastic and were excluded from statistical analyses (Table 1). We found plastic in 21 of 64 (33%) nests spread among the other 5 bird species: Ruddy Ground Dove (*Columbina talpacoti*), Barred Antshrike (*Thamnophilus doliatus*), Creamy-bellied Thrush (*Turdus amaurochalinus*), Red-crested Finch (*Coryphospingus cucullatus*), and Rufous-collared Sparrow (*Zonotrichia capensis*) (Table 1). Only one pairwise comparison of the prevalence of plastic twine in nests (*T. doliatus* vs. *Z. capensis*) was statistically significant (Table 2). The amount of plastic in the nests differed among species (Kruskal–Wallis; Wald $= 13.045$, df $= 4$, $P = 0.011$). The nests of *T. doliatus* had significantly more plastic than those of *Z. capensis* and of *C. cucullatus* (Table 2). The other pairwise comparisons about the amount of plastic were not statistically significant. Two nests of *C. talpacoti* and two of *Zonotrichia capensis* were built directly over plastic harvest bags (Fig. 1). No other anthropogenic material was found in bird nests during this study.

Discussion

We registered the use of plastic twine for nest construction by 5 Neotropical bird species in an orange orchard. Of these, plastic was previously

Table 2. Pairwise comparisons between studied species *Zonotrichia capensis* (*Z. cap*), *Coryphospingus cucullatus* (*C. cuc*), *Turdus amaurochalinus* (*T. ama*), *Columbina talpacoti* (*C. tal*), and *Thamnophilus doliatus* (*T. dol*) in relation to the prevalence and amount of plastic twine in the nests (plastic score).

	Prevalence of plastic		Plastic score				
Pairwise comparison	*P*	Adj. *P*	*P*	Adj. *P*	Test statistic	Std. error	Std. test statistic
Z. cap × *C. cuc*	0.607	1.000	0.761	1.000	−1.733	5.708	−0.304
Z. cap × *T. ama*	0.090	0.899	0.097	0.966	−8.525	5.13	−1.662
Z. cap × *C. tal*	0.010	0.101	0.095	0.948	−9.983	5.977	−1.67
Z. cap × *T. dol*	<0.001	0.003*	<0.001	0.002*	−27.433	7.255	−3.781
C. cuc × *T. ama*	0.642	1.000	0.305	1.000	−6.792	6.623	−1.025
C. cuc × *C. tal*	0.153	1.000	0.258	1.000	−8.25	7.298	−1.13
C. cuc × *T. dol*	0.021	0.209	0.002	0.022*	−25.7	8.378	−3.068
T. ama × *C. tal*	0.650	1.000	0.832	1.000	−1.458	6.856	−0.213
T. ama × *T. dol*	0.044	0.441	0.018	0.18	−18.908	7.995	−2.365
C. tal × *T. dol*	0.231	1.000	0.042	0.416	−17.45	8.563	−2.038

* Significant results after Bonferroni correction ($\alpha = 0.005$).

Figure 1. Nests of *Thamnophilus doliatus* (a) and *Turdus amaurochalinus* (b, c) with plastic twine and a nest of *Zonotrichia capensis* (d) over a plastic harvest bag.

documented only in *T. amaurochalinus* nests (Miller and Miller 1968, Cintra 1988, Sick 2001, Borges and Marini 2010, Zima and Francisco 2016). In accordance with our expectation, we found interspecific differences in the prevalence and abundance of plastic twine in the nests, which may be related to the suitability of this material for different nest types. Contrary to the other studied species that use grass pieces, roots, or sticks to build their nests, the natural nesting materials of *T. doliatus* in the study area are thin, flexible vegetal fibers, which are similar to plastic twine in flexibility and resistance. Similarly, some birds will use pieces of wire as nesting material instead of wooden sticks (Roda and Carlos 2003, Costa and Mäder 2011, Pereira 2011, Chaves et al. 2013) and fishing gear items rather than elongated marine vegetation (Votier et al. 2011). Thus, the use of anthropogenic nesting material in certain contexts may be purposeful instead of a selection error. This could explain the high prevalence and amount of plastic in *T. doliatus* nests at the study orchard.

The prevalence of anthropogenic material in bird nests can be used as a bioindicator of environmental pollution (Tavares et al. 2016), but our results suggest that it must be taken with caution, because species can vary in the acceptance of anthropogenic nesting materials. The use of debris in nest construction may depend on several factors beyond its abundance in nest surroundings, such as its mechanical, physical, or chemical attributes (Bailey et al. 2016). Most research to date suggests that the use of anthropogenic nesting material is maladaptive, enhancing nest detection by predators (Hartwig et al. 2007, Borges and Marini 2010) and causing deaths of juveniles and breeding adults by entanglement (Blem et al. 2002, Parker and Blomme 2007, Votier et al. 2011). Future research should focus on the spatial and temporal patterns of anthropogenic debris as nesting material (Hartwig et al. 2007, Lavers et al. 2013, Møller 2017) and its impact on individual fitness and population levels (Blem et al. 2002, Votier et al. 2011, Suárez-Rodriguez et al. 2017) to clarify the effects of environmental pollution on bird nesting behavior.

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