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Animal behaviour

Incorporation of cigarette butts into nests reduces nest ectoparasite load in urban birds: new ingredients for an old recipe?

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Birds are known to respond to nest-dwelling parasites by altering behaviours. Some bird species, for example, bring fresh plants to the nest, which contain volatile compounds that repel parasites. There is evidence that some birds living in cities incorporate cigarette butts into their nests, but the effect (if any) of this behaviour remains unclear. Butts from smoked cigarettes retain substantial amounts of nicotine and other compounds that may also act as arthropod repellents. We provide the first evidence that smoked cigarette butts may function as a parasite repellent in urban bird nests. The amount of cellulose acetate from butts in nests of two widely distributed urban birds was negatively associated with the number of nest-dwelling parasites. Moreover, when parasites were attracted to heat traps containing smoked or non-smoked cigarette butts, fewer parasites reached the former, presumably due to the presence of nicotine. Because urbanization changes the abundance and type of resources upon which birds depend, including nesting materials and plants involved in self-medication, our results are consistent with the view that urbanization imposes new challenges on birds that are dealt with using adaptations evolved elsewhere.

1. Introduction

Urbanization is increasingly interesting to biologists as it causes significant changes to species composition, species interactions, and ecological and evolutionary processes [1,2]. Because organisms residing in cities are exposed to different environmental conditions from those in which they evolved, it is relevant to investigate how populations cope with such differences. Parasites affect most aspects of their hosts' life history and are an important evolutionary force [3,4]. Potential changes in host–parasite interactions as a consequence of urbanization may thus influence which species are most able to exploit urban landscapes.

A variety of parasites cohabit with birds. Of these, ectoparasites are taxonomically widespread, and have severe negative impacts on host condition, reproductive performance and survival [3–5], both because of their direct effects (e.g. blood-sucking) and indirect effects (e.g. transmission of endoparasites) on avian health. These selective pressures have favoured the evolution of defence mechanisms such as complex immune systems or specific antiparasite behaviours [3,4]. Self-medication is an antiparasite behaviour in which substances produced by other organisms are exploited to increase fitness [6]. For example, some bird species incorporate aromatic plants into their nests, and it has been proposed that the volatile secondary compounds contained therein may either have antiparasitic properties [7–10] or stimulate the nestlings' immune system [11].

Urbanization changes the abundance and type of resources available to birds, including nesting materials [12,13]; nest contents of urban birds represent a shift from natural to anthropogenic nesting materials [14]. In nests of some urban birds, cellulose cigarette butts are commonly found [15–17]. Butts from smoked cigarettes retain substantial amounts of nicotine and other compounds that may also act as arthropod repellents [18]. Prominent among these is the alkaloid nicotine. This is an antiherbivore chemical derived from the tobacco plant (*Nicotiana* sp.), and has been used as an arthropod repellent in some crops [19] and for the control of ectoparasites in poultry [20]. Consequently, we hypothesized that cigarette butts may act as an ectoparasite repellent in the nests of urban birds. We conducted field measurements and an experimental field manipulation to evaluate the prediction that the presence of cigarette butts in nests reduces the abundance of nest-dwelling ectoparasites.

2. Material and methods

The study was conducted in an urban population of house sparrows (*Passer domesticus*; HOSP) and house finches (*Carpodacus mexicanus*; HOFI) breeding at the campus of the National University of Mexico (UNAM) in Mexico City during the reproductive season of 2011. Both multi-brooded species are widely distributed in cities and are known to incorporate cigarette butts in their nests [15,16].

A thermal trap was placed to attract ectoparasites in nests of HOSP ($n = 27$) and of HOFI ($n = 28$) during their second breeding events. This consisted of a battery (12 V/17 A), heating two resistors (37°C) that were situated at opposite sides of the nest. Resistors were fitted with adhesive tape so that parasites became stuck as they reached the source of heat. The cellulose fibres from a smoked (experimental) or a non-smoked cigarette filter (control) were attached to the resistors. To standardize the experimental treatment, smoked filters were obtained from a single 400-pack of regular filter cigarettes (Marlboro) consumed by an artificial smoking device. Traps were left for 20 min in each nest, then the adhesive tapes were collected in individually labelled plastic bags and stored at 4°C until any attached ectoparasite was counted under the microscope (Karl Zeiss Stemi DV4). Nest content (empty, eggs, nestlings) was recorded.

Immediately after chicks fledged, 28 nests of HOSP and 29 nests of HOFI were carefully collected in individually labelled sealed plastic bags and stored at room temperature; nests collected during a week were processed the following weekend. We weighed each nest, assessed the nature and quantity of materials it was composed of, and quantified the number of ectoparasites it contained using Berlese funnels for 24 h under constant temperature and illumination (from a 60 W incandescent lamp; [21,22]). Mites were collected in vials containing 70 per cent ethanol and counted under the microscope as above. We quantified the contribution of cigarette butts as the total weight of cellulose fibre per nest. Ectoparasite abundance was the total number of mites collected. To evaluate differences in ectoparasite abundance between treatments, we used variance component analyses, including nest as a random factor and treatment and nest content as fixed factors. To test for an association between ectoparasite abundance and the weight of cellulose in nests, a general linear model was performed including species as categorical predictor. Analyses were performed using STATISTICA software.

3. Results

HOSP nests were heavier (43.70 ± 24.34 g) than HOFI nests (26.22 ± 12.53; $F_{1,55} = 11.74$, $p = 0.001$). Cellulose from cigarette butts was present in 89.29 per cent of HOSP and 86.21 per cent of HOFI nests, and weighted on average 2.45 ± 3.34 g (range 0–11.75) and 3.06 ± 4.15 g (range 0–14.86) in HOSP and HOFI nests, respectively. On average, HOSP nests included eight (range 0–38) and HOFI nests 10 (0–48) used cigarette butts [23]. Neither the presence nor the amount of cellulose per nest differed between species (all $p > 0.55$). The number of mites was not different between HOSP and HOFI nests ($F_{1,54} = 0.22$ $p = 0.64$). In both species, parasite abundance was negatively associated with cellulose weight ($F_{1,54} = 17.31$, $p = 0.0001$; figure 1). Traps containing cellulose from smoked butts attracted significantly fewer ectoparasites than traps with non-smoked cellulose ($F_{1,54} = 43.13$, $p < 0.0001$; figure 2). Also, control traps in nests containing eggs gathered more parasites than those in empty nests or in nests with nestlings ($F_{2,52} = 3.74$, $p = 0.03$; see electronic supplementary material).

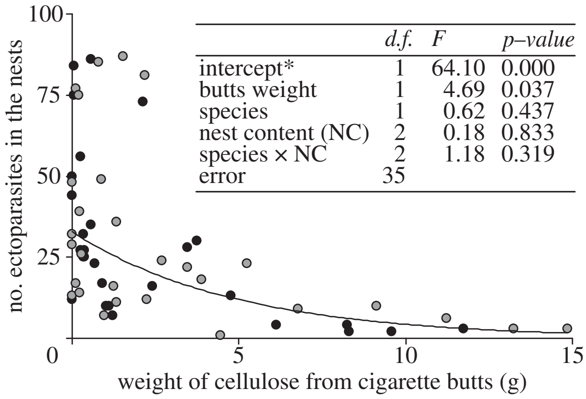

Figure 1. Number of parasites, *C. mexicanus* (grey circles) and *P. domesticus* (black circles), was a negative function of the amount of cigarette butt material contained in the nest. Asterisk (*) represents regression line from an exponential model fitted to the data from both species.

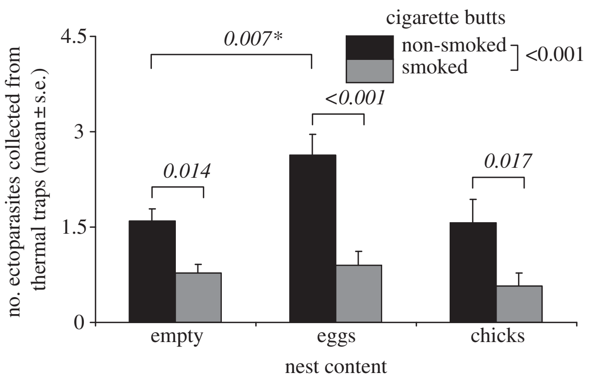

Figure 2. Thermal traps with smoked butts attracted fewer mites than traps with non-smoked butts, regardless of the nest content. Non-smoked butts gathered more parasites from nests assayed during incubation than from empty nests or (non-significantly) than after hatching, presumably as some parasites remained attached to the chicks. Probability values from a variance component analysis (global) and from post hoc Bonferroni-corrected comparisons between treatments and nest contents. Probabilities in *italics* from Bonferroni-corrected individual comparison.

4. Discussion

We provide evidence that urban birds incorporate cellulose from smoked cigarette butts into the nest and that this behaviour entails a reduction in the number of nest-dwelling ectoparasites. It appears that this effect may be due to the fact that mites are repelled by the nicotine, perhaps in conjunction with other substances, because thermal traps laced with cellulose from smoked butts attracted fewer ectoparasites than traps laced with non-smoked cellulose.

This novel behaviour observed in urban birds fulfils one of the three conditions necessary to be regarded as self-medication: it is detrimental to parasites [6]. However, to determine that this behaviour amounts to self-medication, it would be necessary to demonstrate that cigarette butts are deliberately collected and incorporated into nests because of their detrimental effect on parasites, and that such detrimental effect on parasites leads to an increase in host fitness.

The similarity between butt cellulose nest-lining and the use of green plant material in the nests of several species [7–11] suggests that the former may indeed be an urban manifestation of pre-existing behaviour, and it would be interesting to investigate whether HOSP and HOFI use green plant material in their nests (outside or within the cities). Alternatively, the use of cellulose from cigarette butts may be due to other properties of the cellulose (e.g. as a thermal insulator) unrelated to the effect of nicotine on ectoparasites. Presumably, both new and smoked butts can provide thermal insulation, but only the latter would protect against ectoparasites, thus a choice test under controlled conditions could be used to disentangle which is the primary function of this behaviour. Birds could distinguish smoked and non-smoked butts from their scent, just as some birds that use the chemical compounds of plants as defence against parasites appear to rely on olfaction to collect those with effective chemicals [24]. Thus, we propose that olfaction must be involved if the collection of cigarette butts by urban birds is a translation to the urban medium of a pre-existing adaptation against nest parasites.

Smoked cigarette butts contain a large number of toxic substances, including traces of pesticides [25]. Such pesticides, however, cannot explain why fewer mites were attracted to the thermal traps containing smoked butts, an effect that is consistent with nicotine being an arthropod repellent (figure 2). Nonetheless, those chemicals are in contact with the birds at the nest, and their toxicity could potentially counterbalance any benefits that may result from the reduction of ectoparasites occasioned by lining the nest with cigarette butts.

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