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ORIGINAL PAPER

A new material for old solutions—the case of plastic string used in Great Grey Shrike nests

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Abstract Innovative behaviours are defined as new behaviour patterns derived by the modification of pre-existing ones. To date, studies of animal innovation have focussed mainly on foraging activity. In this paper, we focussed on the innovative use of a new material—man-made plastic (polypropylene) string—in nest construction by a solitary nesting, territorial species, the Great Grey Shrike *Lanius excubitor*. An analysis of field data collected during the years 1999–2006 during intensive shrike research in Poland, as well as of nest record cards since 1964, suggests that plastic string has been a very popular nest material since the 1980s. Recently, plastic string was used significantly more often by shrikes living in intensive farmland habitats than by those in more natural meadows. We discuss the possible benefits of the use of plastic string, such as strengthening the nest structure and therefore helping to protect eggs and nestlings from inclement weather conditions, such as strong winds. On the other hand, the use of plastic string has a real cost for breeding Great Grey Shrikes because both adult birds and nestlings may get tangled in it.

Keywords Nest material · Animal innovation · Costs of innovation · Farmland · *Lanius excubitor* · Conservation

Introduction

Innovative behaviours are defined as new behaviour patterns derived by the modification of pre-existing ones (Reader and Laland 2003). Greenberg (2003) emphasised that innovation can involve behaviour associated with any aspect of an animal's life, from foraging to social interactions; some of these comprise new techniques for exploiting either existing or new resources. To date, most studies of animal innovation have focussed on foraging,

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simply because they are easy to detect (Reader and Laland 2003). Foraging represents one of the "hot spots" of an animal's behavioural repertoire, where innovations take place most frequently (Reader and Laland 2001; Reader and Laland 2003; Lefebvre et al. 1997). In birds, the best example of this was given by Nicolakakis and Lefebvre (2000) who summarised the ornithological literature for studies of innovative behaviour.

In nesting behaviour, it is especially important to look at changes in nest construction because, to date, this has been considered a conservative evolutionary trait in birds (Hansell and Deeming 2002). However, it is well known that birds accept new materials as ornaments under strong sexual selection, e.g. bowers constructed by bowerbirds (e.g. Borgia 1985). Furthermore, numerous bird species use man-made materials during nest building. Therefore, nesting innovations are classified as the use of an unusual material or nesting site (for examples, see Nicolakakis and Lefebvre 2000). Breeding birds in the process of searching for nest materials encounter several man-made materials. Some of them are similar to those they would use naturally, but some striking differences may arise in colour and shape as well as structural characteristics. There is a large variation between species in the use of man-made materials in nest construction. However, no systematic review has been done, and most information is dispersed in papers considering various aspects of the breeding biology of a particular species (Collias and Collias 1984). After the choice of nest site and the species-typical nest shape, the selection of materials with which to build a nest is the third level at which parent birds can influence the incubation environment (Hansell and Deeming 2002). The right selection of both nest site and nest materials have a significant effect on nest structure and nest environment and thus have a significant effect on breeding success (Hansell 1995, 2000; Hansell and Ruxton 2002). Errors in nesting may have more severe consequences than do foraging errors, leaving little room for significant innovation (Reader and MacDonald 2003). The use of new materials in nest building especially "modern man-made" items might be an example of innovation in the context of the exploitation of new resources or problem solving.

Another striking feature of innovative behaviour is the fact that most have been recorded amongst socially living animals. The next important question concerns the potential costs and benefits of being innovative at the individual, population and species level (Sol et al. 2002). In this paper, we present data on the use of a new material—man-made plastic (polypropylene) string—for nest construction by a solitary nesting, territorial species, the Great Grey Shrike *Lanius excubitor*. We investigate the frequency of use of man-made materials, especially plastic string, both in a historical context as well as in different habitats. We briefly discuss the potential benefits and costs of this novel behaviour and relate this to the conservation issues of shrikes as a rapidly declining species.

Study species

The Great Grey Shrike is a medium-sized passerine inhabiting a broad spectrum of semi-open habitats in Poland especially farmland (Tryjanowski et al. 1999; Antczak et al. 2004). This species builds open cup nests on various trees and bushes including thorn trees, other deciduous species and conifers—mainly pines (Harris and Franklin 2000; Antczak et al. 2004). The nests are bulky structures made of sticks and twigs, rather untidy and sometimes containing man-made materials. The cup is lined with small roots, wool, hair, lichen and feathers (Harris and Franklin 2000; Yosef 1992; Olborska and Kosicki 2004). This species is a highly territorial, socially monogamous bird and does not display flocking behaviour (Lefranc and Worflok 1997). Several populations of the Great Grey Shrike have experienced widespread decline both in numbers and range; however, the Polish populations are stable (Lefranc 1997; Tryjanowski et al. 1999; Antczak et al. 2004). Plastic string has been suggested as an important cause of nestling failures (Slack 1992; Antczak et al. 2004).

Material and methods

We used two sources of information about the use of man-made materials in Great Grey Shrike nests: (1) the nest card scheme and (2) study plots where several aspects of breeding biology (including the occurrence of man-made material in the nests) were studied in detail.

Nest record scheme

We analysed 83 nest card records from the Polish National Nest Card Scheme database (for details, see Olborska and Kosicki 2004). Most data were recorded between 1982 and 2002, with a small percentage (9.8%) from the years 1964–1982. The majority of the data (68.7%) were collected in southwestern and western Poland. Information on nest structure, as well as nest material, was obtained directly from the nest record cards and binary coded for further analysis (0—natural nest material only, 1—contained man-made material (plastic string)).

Field research

We used information on nest structure gathered during regular studies of the Great Grey Shrike's breeding biology and ecology in five local populations in Poland. Data were collected in the years 1999–2006 and details on plot locations, study areas, densities and breeding biology parameters were published elsewhere (Antczak et al. 2004; Tabor 2006). In short, the study areas were in an agricultural landscape, with arable fields, meadows, large fallow areas, small woodlots, mid-field copses and shelter belts. The study plots were located in medium (e.g. Odolanów) to large (e.g. Zielona Góra) river valleys which are optimal habitats for the Great Grey Shrike and where breeding densities reach their highest values (Tryjanowski et al. 1999; Antczak et al. 2004). Nests were inspected for the presence of man-made materials both by direct inspection and, in cases where this was not possible, by careful observation from the ground with binoculars and telescopes. On the Odolanów plot, we noted partial losses including those caused by the entanglement of nestlings in the plastic string.

Nest location was classified either as arable land, when a 500-m radius around the nest comprised arable fields or a mixture of arable fields and small meadow patches, or as meadows—nests mainly located in broad river valleys with traditional meadows and pasture. Some of the nest locations were impossible to fit into one category and were therefore excluded from analyses.

Statistical analyses

All basic statistical analyses were performed according to Zar (1999).

Results

Occurrence of plastic string in nests in the study plots

In all of the study plots, the Great Grey Shrikes almost always used plastic string as a nest material. Across all of the study plots, amongst 317 nests, 294(98%) used plastic string. Only 20 nests were built using only natural materials such as twigs, grass, wool and feathers. A similar pattern was noted across Poland. The majority of plastic string was white, although in two nests shrikes used blue string.

Other man-made materials recorded in Great Grey Shrike nests were pieces of nylon sacks/bags and paper. However, these two categories were used not as common as plastic string. It is interesting that the nest record cards lack information about the use of plastic bags.

Differences between habitats

Plastic string was used more often by shrikes living in intensive farmland habitats (99.5%; 199 out of 200) than in more natural meadows (87.2%; 102 out of 117), and the differences were statistically significant (χ^2=36.49, df=1, P<0.0001).

Historical context—the spread of the use of man-made materials in the Great Grey Shrike population

According to the Polish nest record scheme, the first Great Grey Shrike nest containing this novel material was recorded in 1985. The probability of the use of plastic string increased significantly in the period 1982–2002 (logistic regression ($y = -45.49 + 0.023x$), R^2=0.123, F= 8.98, df=1, 64, P=0.004).

Cost of using new materials

The most important cause of partial losses in the studied population of the Great Grey Shrike was the entanglement of nestlings in the plastic string. However, systematic data were only collected at one study plot, although similar cases of nesting mortality were noted in other surveyed areas. In total, amongst 153 nestlings, 14 (9.1%) died due to plastic string. In all cases, the legs of the nestlings were tangled in the string. The plastic string might also be harmful to the adults—at least four females died due to becoming tangled in the string. All cases occurred during nest building and during the manipulation of nest material at the nest site.

Discussion

If we assume that innovation is the use of new material/environmental resources for problem solving (sensu Reader and Laland 2003) our study shows that using man-made materials in the nest structure should be categorised as innovative behaviour. Nicolakakis and Lefebvre (2000) classified the use of unusual, new, man-made materials for nest construction as nesting innovation. Breeding Great Grey Shrikes from the studied areas used plastic string as nest material, indeed in some cases as a major nest component. This behaviour is currently widespread in all studied populations in Poland. The number of nests containing plastic string increased over time as the use of plastic string in agriculture increased. Plastic (polypropylene) string was commonly used in agriculture from 1982 in Poland (Ptaszyk 1994). What factors influenced shrikes to accept or “discover” plastic string soon after it came into common use? Our presented findings indicate that shrikes started to use this new material after approximately 3 years of its common use in farming. Therefore, it seems that shrikes probably switched to this new source of nest material as soon as it appeared in farmland.

One of main reasons for so great use of plastic string is the fact that the availability of long hair, traditionally available from farm animals (especially horses) and used as a nesting material, is decreasing rapidly due to changes in farming practices (Olborska and Kosicki 2004). This idea is supported by the strong differences in the extent of plastic string use by breeding shrikes between intensive and extensive farmland habitats revealed by the present study. Also, Henriksen (2000) noted much more man-made material in the nests of Blackbirds (*Turdus merula*) in urban than farmland areas.

Is there any adaptive value in the use of plastic string as a nest material? No doubt plastic string is an important material for strengthening the nest structure—one of the nest characteristics affecting the protection of eggs and nestlings from inclement weather conditions, such as wind (Hansell and Deeming 2002). In the case of the Great Grey Shrike, this might be particularly important as this species is one of the earliest passerine breeders and often experiences harsh weather in early spring (Hromada et al. 2002; Antczak et al. 2004). The use of plastic string might be advantageous for at least two other reasons. Firstly, the manipulation of such material during nest building might be much easier than natural equivalents. Shrikes are known to manipulate various kinds of objects by impaling them—this is not restricted to prey and includes leaves, nest material and fruits. During recorded observations, some females from the studied populations "impaled" large pieces of nylon string and in this way dismembered and transported the nest material to the nest (MA, MH and PT unpublished observations). This might be one of the expatiations of impaling behaviour (Yosef and Whitman 1992). Secondly, the great availability of man-made materials in the field might reduce search costs for nesting material and increase nest building speed. With the exception of two nests, all plastic string used was white, so the detection of such highly visible material might be easier. Although plastic string differs in many ways from natural materials, shrikes have readily accepted it and use it on a large scale. It is important to note that birds from all surveyed populations used novel materials for nest construction. Therefore, adaptation has a general rather than only a local character, which differs from feeding innovations. Because of the propensity of several feeding innovations in birds to only be local, indicating a low spread speed of innovation (Thompson et al. 1996; Reader et al. 2002; Gajdon et al. 2006), several authors emphasise the role of social transmission of novel behaviour (Lefebvre 1995; Reader and Laland 2003). Great Grey Shrikes are, however, strongly territorial and non-flocking, so the mechanism of spread in use of novel materials might be of a social or coping character. Both sexes are engaged in nest building and re-mating after one breeding season is extremely rare. Given the high dispersal of females, it is possible that particular "new users" meet innovative birds in the next breeding season and disperse behaviour to new areas. Therefore, the spatial spread in the use of new materials might be very quick.

Our presented results show that innovative behaviour incurs real costs. In the case of the studied population of the Great Grey Shrike, plastic string affected both nestlings and adult birds. Entanglement of nestlings was the main reason for partial losses in the studied population (Antczak et al. 2004). Other species which incorporate plastic string in the nest suffer similar losses, the best example being the White Stork (*Ciconia ciconia*; Ptaszyk 1994). Another possible cost for shrike nestlings are infections in healthy nestlings caught from entangled ones. Such situations have been recorded in the White Stork (Ptaszyk 1994).

Our findings prompt us to speculate whether shrikes are innovative birds or not. Shrikes are predators, hunting for a broad spectrum of prey and moreover using several hunting techniques (Lefranc and Worflok 1997). In some shrike species including the Great Grey Shrike, feeding innovations take place. For example, toad skinning as a method of food preparation (Antczak et al. 2005), impaling toxic prey for later consumption after the toxic compounds have degraded (Yosef and Whitman 1992), hunting for unusual prey such as fish or crabs or even feeding on cooked food (Harris and Franklin 2000). Furthermore, the presented paper shows that nesting innovations are also part of a shrike's behavioural repertoire. Shrikes are closely related to corvids, a group known to be very innovative in general. However, the number of recorded innovations in shrikes seems to be low.

Most shrikes are secretive in behaviour and biology and although popular amongst ornithologists are a rare and declining species. In the context of nesting innovations, the best example of the shrike's quick reaction to a new nest material is the story given by Zdeněk Veselovský (personal communication). During World War II, RAF Bomber Command used thousands of small, very thin aluminium strips called "Window" which were dropped from night bombers to neutralise German radar and radiolocation stations during missions. After the RAF raid on Pilzen, Great Grey Shrikes in the vicinity of this town were amongst the first birds which used these strips as nest material, and at least a few pairs incorporated several such strips in their nests.

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