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Bird nests: An overlooked ecosystem opportunity for specialised nest-dwelling arthropods

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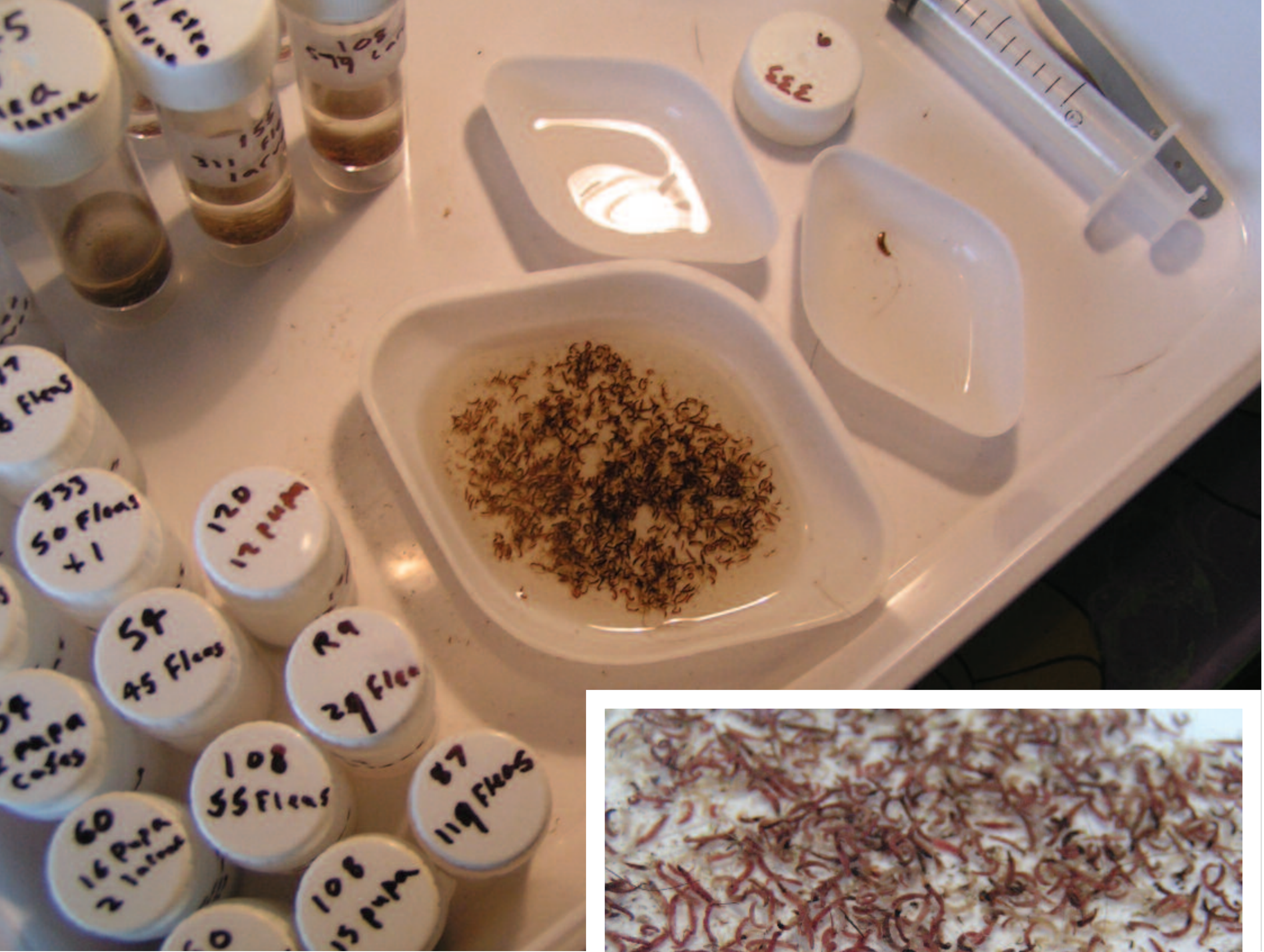
Birds' nests are occupied by more than just birds: they are an important habitat for a diverse invertebrate fauna, with the nest structure effectively becoming a miniature ecosystem of specialised and generalised nest-dwellers. The conditions that favour the rearing of chicks also produce a favourable physical habitat for arthropods as well as providing a plentiful food supply. Food in the nest takes the form of feathers, discarded food, faeces, skin cells and other exuviae for scavengers as well as living and more-or-less helpless chicks for parasites. Studies have shown that intra-nidal arthropods, which include both ectoparasitic and free-living species, are a common component of a breeding bird's environment. Indeed, a large nest, such as that of an American kestrel, can harbour over 26,000 individual invertebrates from nearly 100 different species.

Interactions between birds and nest dwelling arthropods are highly variable. Some species are ectoparasites, and should therefore, by definition, have a negative impact on their hosts, while others are commensuals, taking advantage of a favourable habitat without affecting the birds in any way. Still others have a weak mutalistic relationship with their avian co-inhabitants, for example, by assisting in the decomposition process when chicks die. Most nest-arthropod research has focused more-or-less exclusively on ectoparasites. However, whilst these may be more ecologically "glamorous", and by definition have an impact on fitness, productivity, and population dynamics, they are only a small part of the story. With this in mind, we decided



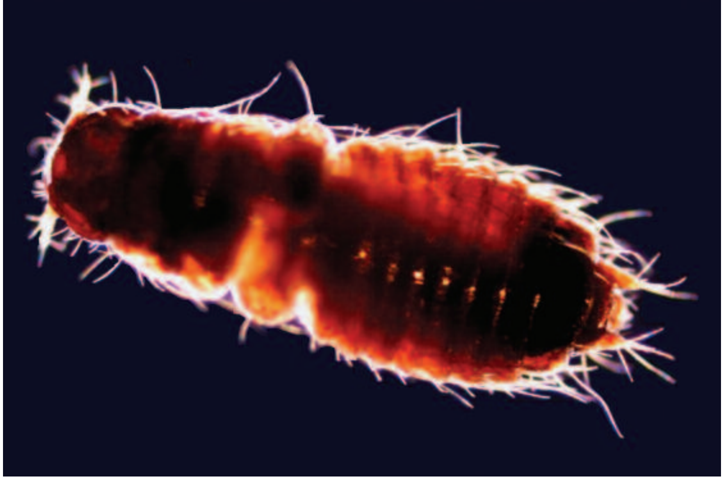
Extracting hen flea larvae from a nest

to take a more holistic look at the arthropods of the bird nest ecosystem.

We collected 20 great tit nests from wooden nestboxes at Nagshead Nature Reserve (Forest of Dean, Gloucestershire, UK) for analysis under licence by English Nature. The nest structure was removed from the nestbox within 24 hours of the final chick fledging and before nest dwelling arthropods began to desert the nest. Nests were sealed in a 'zip-lock' air-tight polythene bag and any feather dust and parasites remaining in the nestbox were collected using a pooter (with suction provided by a battery-powered miniature vacuum to avoid inhalation of fine feather dust) or soft forceps. Once in the laboratory, nests were deep frozen to kill and preserve the arthropod assemblages. The nest material was then thoroughly searched for arthropods under a dissection microscope using tweezers and mounted needles to pull apart the nesting material and soft-tipped paint bushes to search the feather dust. Arthropods were extracted, identified as far as possible, and counted.

It was immediately clear that nests contained a rich and diverse arthropod fauna. In terms of free-living species, most abundant were herbivorous or scavenging Coleoptera, present as both adults and larvae, including Staphylinidae and Elateridae as well as the occasional *Clytus arietis* (wasp beetle; Cerambycidae) and a single specimen of *Trox scaber* (Trogidae). Parasitoid ichneumon wasps were found in low numbers in 15% of nests, possibly attracted by the presence of beetle larvae in the nest structures. Perhaps the most exciting free-living nest-dwelling arthropod species we found was an uncommon beetle, initially identified as *Gnathoncus buyssoni* (Histeridae), an identification subsequently verified by the Gloucestershire county Coleoptera recorder and by experts at the Natural History Museum. This is a nationally scarce species, being the rarest *Gnathoncus* species, and the second rarest (after *Teretrius fabricii*) in the Histeridae. The species was recorded in 90% of investigated nests, with a total of 101 individuals being found. This suggests either that the study site is nationally important for *G. buyssoni,* or, perhaps more likely, that the species is under-recorded. Bird nests are not commonly hand searched for arthropods and this is seemingly the first time that this species has been recorded as a nest resident, indicating that "hidden" habitats like nests may harbour further "rare" or "obscure" species in large numbers.

We also found several etcoparasitic arthropod species. These included, in order of prevalence, adult and larval *Ceratophyllus gallinae* (hen fleas; Siphonaptera: Ceratophyllidae) in 95% of nests, biting lice (Mallophaga:



Left: Avian biting louse (Mallophaga: Ischnocera), Right: Haematophagous blowfly larvae (*Protocalliphora* spp.)

Ischnocera) in 55% of nests, and *Protocalliphora* (haematophagous blowflies; Diptera: Calliphoridae) larvae and pupae in 45% of nests, together with ticks and mites in 15% and 5% of nests, respectively. With the exception of hen flea larvae, these are all parasitic, living within the nest structure and feeding off blood from the avian hosts (normally the young; rarely the adults).

Probably the most interesting of these avian parasites is *Protocalliphora*. *Protocalliphora* is one of two genera (along with *Trypocalliphora*) of so-called bird blowflies within the Calliphoridae family. Whereas most blowflies have a scavenger larval form, with adults laying eggs on carcasses so that the maggots can consume the dead flesh, bird blowflies have a parasitic larval form. Adult flies enter the nestbox only to lay eggs, usually when young birds are a quarter to a third grown (5-7 days in the case of great tits). After hatching, the larvae live in the nest material, generally only attaching to the chicks at night to feed. It is worth noting that there is some evidence that young are not equally parasitized by blowflies, with some chicks being preferentially selected over others (the so-called "tasty chick" hypothesis). Once the larvae pupate, the parasitic stage of their life cycle is complete and adults emerge from nestboxes as free-living individuals.

Hen fleas, meanwhile, undertake the most important part of their life-cycle, reproduction, during the bird nesting period. Adult fleas live on adult birds, and descend into the relative safety of the nesting environment to mate, after which the females lay their eggs. Once these eggs hatch, the white larvae live in the nest material and feed on feather dust and other organic material. They also feed on undigested blood excreted by adult morphs, after which they become blood engorged. The larvae then pupate in the nestbox over the winter and hatch into adult fleas the following spring. Note that in terms of bird conservation, the presence of overwintering hen fleas as pupae means that it is often recommended to remove nesting material from nestboxes during the winter in order to reduce parasite burdens for subsequent occupants. This action is probably one of the reasons that the breeding success of birds in nestboxes is often higher than birds using natural sites.

Left: Adult hen flea (*Ceratophyllus gallinae*),

Below: Larval hen flea (*Ceratophyllus gallinae*)
Left: typical presentation, Right: blood engorged

Adult hen flea (*Ceratophyllus gallinae*).

Order	Family/Sub-order	Scientific Name	Common Name	Taxonomic Authority
Coleoptera	Cerambycidae	*Clytus arietis*	Wasp beetle	(Linnaeus, 1758)
Coleoptera	Elateridae		Click beetles	Leach, 1815
Coleoptera	Histeridae	*Gnathoncus buyssoni*		Auzat, 1917
Coleoptera	Staphylinidae		Rove beetles	Latreille, 1802
Coleoptera	Trogidae	*Trox scaber*		Linnaeus, 1767
Diptera	Calliphoridae	*Protocalliphora* sp.	Haematophagous blowflies	Hough, 1899
Hymenoptera	Ichneumonidae		Ichneumonid wasps	
Phthiraptera	Ischnocera		Biting lice	Kellogg, 1896
Siphonaptera	Ceratophyllidae	*Ceratophyllus gallinae*	Hen flea	(Schrank, 1803)

Table 1. Taxonomic table of nest dwelling arthropods recovered from great tit nests. Information collated from the Integrated Taxonomic Information System (ITIS) in November 2011. Taxonomic authority is for species where a species-level identification was possible and for family/sub-order in all other cases.

Taking wing length and weight of a 15-day old great tit nestling

There were notable differences in ectoparasite communities between nests. In particular, the relative importance of lice (Ischnocera) in the nest ectoparasite community was highly variable, and there was a tendency for nests with abundant sheep's wool to support large lice populations. The time in the breeding season (early *versus* late nests) was an important influence on nest ectoparasite community: *Protocalliphora* larvae were present in 90% of late nests (those started after the mid-point of the breeding season) but absent from early nests (those started before the mid-point of the breeding season). The number of individual ectoparasites in the nests was high: 1,275 individuals were found in one nest (including non-parasitic life stages). There was, however, considerable variability in nest parasitic load, both overall and for individual species; for example, the number of adult hen fleas per nest ranged from 5 to 119 (mean = 36). Interestingly, there was no relationship between the number of chicks and either total ectoparasite abundance or the abundance of any individual species. Furthermore, no significant relationships were found between the abundance of different arthropod species in the nests (i.e. the presence or abundance of one species did not appear to influence the presence or abundance of any other species). The only significant relationship was between different life stages of the same species: the number of adult hen fleas correlated positively with the number of larval hen fleas (as would be expected).

By definition, parasites should reduce the fitness of their host and we also examined condition measures (relative mass, determined by dividing weight of chicks at day 15 post-hatching by wing length taken at the same age) to see if such a relationship existed. In fact, there was no relationship between the overall parasite burden and the condition of great tit chicks; a result that might seem surprising but is actually not unprecedented. Indeed, the absence of a (measurable) effect of parasitism agrees with studies in the USA on nestbox-breeding eastern bluebirds in relation to hen flea abundance and work on chestnut-backed and mountain chickadees parasitised by *Protocalliphora*. It is possible that young chicks have physiological or behavioural compensatory responses, such as increasing preening, to reduce the intensity of parasitism or to buffer its impact. Alternatively, parasitism might only cause measurable detriment to condition when nestlings are under stress, for example during food shortages, or costs could be passed on to parents if they have to forage more to buffer the impacts of parasitism.

It is clear that bird nests constitute an important habitat for a range of arthropods with differing ecological functions and life history traits. Although bird-parasite interactions are extremely interesting, and of importance to avian research and conservation initiatives, the findings here demonstrate that these "hidden" habitats support many more free-living species than is usually realised. Further surveys of these habitats for arthropods in general would be useful, and we suggest that a sensible first step would be to investigate patterns in prevalence, abundance and community structure of nest-dwelling arthropods in terms of location, host species, and time of year.