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Cases of unintentional phoresy of beetles (Insecta: Coleoptera) on birds

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Cases of unintentional phoresy of adult beetles on birds are discussed in this article. Five species of beetles from families Anobiidae, Curculionidae, Chrysomelidae and Dermestidae were recorded on five species of birds (families Columbidae, Muscicapidae, Phasianidae and Turdidae). Three species of beetles are openly living phytophages, and two species are invasive and/or cryptogenic nidicoles. The associations of beetles with nests increase the possibility of transferring phoronts during bird migrations possibly serving as one of the manifestations (avi-vector) of invasive species dispersal processes.

Ключевые слова: ecology, phoresy, beetles, birds, distribution, invasion.

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Introduction

Phoresy is a particular case of temporary commensalism in which one organism (phoront) uses another (host) for transport and dispersal (Houck, 2003). In some cases, the phoretic host may provide shelter and/or indirect protection to the phoront during transportation, but, despite this, there is no direct physiological benefits for the participants of the phoretic relationship. Phoresy may be both the final stage of development of interspecific relations, and the transition to parasitism. It often manifests itself in parasitic associations (Houck, 2003), where it is temporary or takes the form of ectoparasitism and/or commensalism, for example, in leyodid beetles of subfamily Platypsyllinae with insectivorous mammals and/or rodents (Peck, 1982; Wood, 1965). Purely phoretic relationships are most common among invertebrates. The oldest case of phoresy is known from the Carboniferous period for oribatid mite *Carbolohmannia maimaiphilus* Sidorchuk et Robin, 2016, and dates back to 320 Ma (Robin et al., 2016). A rather interesting case of phoresy has been described for crustaceans (Branchiopoda), which were found in mammoth wool together with plant remains (Kotov et al., 2018).

Phoretic behavior and adaptations to the role of phoronts in Coleoptera arose independently in different systematic groups. Hymenoptera parasitoids are known as phoronts; these are the Meloidae and Rhipiphoridae triungula (Clausen, 1976). Among the predators, phoresy is observed in *Trichodes ornatus* larvae (Linsley et MacSwain, 1943) from family Cleridae, also associated with hymenopterans (Linsley and MacSwain, 1943). At the definitive stage, phoresy is recorded in the adults of genus *Antherophagus* (Cryptophagidae) (Crowson, 1981), the larvae of which develop in bumblebees' nests.

A peculiar type of phoretic relations is known for the myrmecophilous clown beetles of the subfamily Haeteriinae (Histeridae), associated with nomadic ants of the genus *Eciton* (Beeren and Tishechkin, 2017). These ants are characterized by the "Army Ant Syndrome" behavioral feature (Brady, 2003), which implies the absence of permanent anthills and frequent movements. During the migration of the

colony, Haeteriinae species either travel with ants in or out of the common stream, or attach to the ant's body (usually to the head of working individuals). Adults of a recently described species from Costa Rica, *Nymphister kronaueri* von Beeren et Tishechkin, 2017 latch to the space between the petiole and the postpetiole of the ant using their mandibles.

It should be noted that all the cases of phoresy described above are associated with social insects and are aimed at phoront's penetration into the host's nest. However, other cases of phoresy particularly unintentional are no less important in the distribution of phoronts. Such transfers can act as hypothetical vectors of invasion and settlement of certain species not only because of human activity (during transportation), but also in the course of natural processes, for example, the migration of birds and their local migrations. In addition, there are more complex forms of a phoresy, such as entomochoric phoresy (Sosina and Sklyar, 1985), when it is possible that the parasite is not transferred to the host directly, but as a phoront of the carrier organism into the nest or onto the host's body.

Material and methods

Studies were carried out in the period 2001–2016. The basis of coleopterological material was the accompanying collections of beetles obtained during the study of ectoparasites and symbionts of birds.

We examined 150 individuals of *Columba livia* (Gmelin, 1789) (during 5 years, Moscow region); 120 individuals of *Luscinia luscinia* (Linnaeus, 1758); 35 individuals of *Saxicola rubetra* (Linnaeus, 1758) (during 10 years, Moscow region); 170 individuals of *Phasianus colchicus* (Linnaeus, 1758) (during 11 years, Rostov region) and 7 individuals of *Turdus iliacus* (Linnaeus, 1766) (during 1 year, Murmansk region).

For small birds, the collar technique ("ethyl acetate bath") was used. The birds were placed in a plastic container, a collar made of waterproof fabric was put on the head (Fig. 1), 10–20 drops of ethyl acetate were added to the container and the bird was kept for 10–20 minutes (depending on the size of the individual). This technique of intravital study of living birds makes it possible to minimize losses among animals.

Results and discussion

Phoresy is perhaps the most fragmentary studied among the biotic interspecific relationships. While there is a detailed and diversified interest in bird parasitocenoses, not excluding phoretic relations (Balashov, 2001; Keirans, 1975; Matyukhin, 2016; Proctor and Owens, 2000), the non-parasitic inhabitants of the feather cover remain virtually unstudied.

The first studies on the role of birds in the dispersal of non-parasitic invertebrates appeared at the beginning of the 21st century (Krivolutsky and Lebedeva, 1999, 2003; Krivolutsky et al, 2001, 2003; Lebedeva, 2005, 2013; Lebedeva and Krivolutsky, 2001, 2003). They have mainly considered the soil-dwelling microarthropods of the Arctic islands, in particular, oribatid mites and springtails, which radically changed the existing ideas on the geographical distribution of this group (Lebedeva, 2013). Along with the transfer of microarthropods, which, due to

Fig. 1. An example of the use of the collar technique ("ethyl acetate bath").

their small size, have a high dispersal capacity by air currents and by rafting, the avi-vector has probably had a significant impact on the modern appearance of the island invertebrate fauna (Lebedeva, 2013; Lebedeva and Krivolutskiy, 2003).

The first indication of the fact of Staphylinidae beetles (without specifying the species) transfer by birds was described by N.V. Lebedeva (2005). In the present work, we describe cases of unintentional phoresy of beetles on birds that were detected during our studies (Table 1).

As a result, five species of beetles from families Anobiidae, Curculionidae, Dermestidae (1 species each) and Chrysomelidae (2 species) were found in the plumage of five birds species from the families Muscicapidae (2 species), Turdidae, Columbidae and Phasianidae (1 species each). The following is a brief ecological description of each of the found beetles and possible variants of unintentional phoresy.

Anobiidae

Stegobium paniceum Linnaeus, 1758 – an exceptionally polyphagous, synanthrope, is common in residential and warehouse premises where it can harm food supplies. For Russia, it is considered a cryptogenic species, the natural range is unknown. Outside the premises, beetles and larvae are noted in the nests of pigeons (Woodroffe, 1953) and in hives (Delobel and Tran, 1993). Adults do not feed (Lefkovitch, 1967), are resistant to low temperatures (Solomon and Adamson, 1955).

In our research, the species *Stegobium paniceum* was found on the body of redwing *Turdus iliacus* (Linnaeus, 1766) from the Murmansk region, caught in the ornithological mistnet. The beetle probably got into the plumage directly from the nest, where the larvae could have developed. *S. paniceum* was not previously recorded for the Murmansk region, although it is known from the neighboring Komi Republic and the Leningrad Region (Kovalev, 2018), and our find is one of the most northern for this species.

Chrysomelidae

Chaetocnema concinna (Marsham, 1802) is a phytophagous plant, widely distributed in the Palearctic, known in European Russia from the taiga to the steppe zone. Occurs along the banks of reservoirs, in meadows, in the meadow steppe, in garden plots. Development is associated with Polygonaceae (Bienkowski, 2004).

In our studies, the species *C. concinna* was in the plumage of the nightingale *Luscinia luscinia* (Linnaeus, 1758) in the vicinity of vil. Klementyevo (Mozhaisk district, Moscow region). A possible variant of contact with a bird is from the environment from the floodplain biotopes adjacent to the Iskona River.

Longitarsus picicollis Weise, 1900 – monophage, develops on species of the genus *Verbascum*. Steppe species, distributed in southeastern Europe, in Asia Minor and Central Asia, the Caucasus, in southern Kazakhstan, known from Iran, Iraq and Afghanistan (Benkovsky, 2018).

Our find in the plumage of the pheasant *Phasianus colchicus* Linnaeus, 1758, taken from hunters, is the first indication of the species *L. picicollis* for the south of the European part of Russia, the previous nearest finds are known in the south of Ukraine and in the Crimea (Benkovsky, 2018). The beetle probably got into the plumage from the fodder plant.

Curculionidae

Coeliodinus rubicundus (Herbst, 1795) is a monophage, developing in *Betula pendula* Roth flowers (Dieckmann, 1972). In Russia, the species is distributed in the European part, parts of the Caucasus, is known from Siberia (Alonso-Zarazaga et al., 2017).

In our studies, one specimen was found in the plumage of whinchat *Saxicola rubetra* (Linnaeus, 1758). Whinchat nests in high grass, so the beetle probably got on to the bird from a birch where it fed or rested.

Dermestidae

Attagenus smirnovi Zhantiev, 1973 feeds on organic remains, is an invasive obligate synanthropic species for the Palaearctic. The native range is located in East Africa, now has a cosmopolitan distribution (Šefrová and Laštůvka, 2005). In nature, it pursues nidicolous lifestyle, development takes place in the nests of birds and bats (Zhantiev, 2009).

A. smirnovi was found on the body of a weakened sick common pigeon *Columba livia* (Gmelin, 1789) in Moscow. The beetle has got to plumage, most likely, directly from a nest. The common pigeon, being a synanthropic species, breeds in residential landscapes, which can also contribute to the invasive process of associated alien invertebrate species.

Table 1. Coleoptera species found on birds during the study.

Phoront (beetle species)	Host (bird species)	Date	Locality
Attagenus smirnovi	*Columba livia*	16.03.2016	Moscow
Chaetocnema concinna	*Luscinia luscinia*	27.08.2013	Moscow region
Coeliodinus rubicundus	*Saxicola rubetra*	10.05.2010	Moscow region
Longitarsus picicollis	*Phasianus colchicus*	02.11.2001	Rostov-on-Don
Stegobium paniceum	*Turdus iliacus*	03.08.2007	Dal'niye Zelentsy

Conclusions

The presence of beetles in the plumage of birds is random and appears to be extremely rare. Thus, during the whole time of research, coleopterological collections were carried out only on five bird species. The geography of cases of unintentional phoresy of beetles on birds is heterogeneous and presented from tundra to steppe in latitudinal aspect.

The study identified two possible paths of unintentional phoresy of adult beetles on bird plumage: accidental transfer from fodder plants (in the case of phytophages) and phoront's transfer onto the host's body directly from the nest (in the case of nidicoles). The structure of the feather cover facilitates latching of the phoront, and in some cases, it may even lead to the death of the beetle. However, invasive and/or cryptogenic species of beetles were observed in two out of five cases of unintentional phoresy on birds. They are also associated with nests during their development, which increases the possibility of transferring such phoronts during bird migrations and can serve as one of the manifestations (avi-vector) of invasive species dispersal processes.

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