DIPTERAN ASSEMBLAGES IN RED-FOOTED FALCON
(FALCO VESPERTINUS) NEST BOXES

ZOLTÁN SOLTÉSZ1,2, NÁNDOR SERES3 and ANIKÓ KOVÁCS-HOSTYÁNSZKI1

1Lendület Ecosystem Services Research Group, Centre for Ecological Research
Hungarian Academy of Sciences, H-2163 Vácrátót, Alkotmány u. 2–4, Hungary
E-mails: soltesz@entomologia.hu, kovacs.aniko@okologia.mta.hu
2Department of Zoology, Hungarian Natural History Museum
H-1088 Budapest, Baross u. 13, Hungary
3Bükk National Park Directorate H-3304 Eger, Sánc u. 6, Hungary
E-mail: seresnandi@gmail.com

The Red-footed Falcon (Falco vespertinus) is a strictly protected raptor species in Hungary (ca 600 pairs). It naturally breeds in rook, crow or magpie nests that are rebuilt every year, however, most of these nests disappeared by the end of the 20th century. In the early 2000’s more than a 3,000 artificial nest boxes were installed in the country, increasing the number of breeding pairs considerably. This prompts the question whether breeding birds might face an increased number of nest-dwelling ectoparasites due to the annual re-use of nest sites. The nest material was collected from 59 nest boxes (not cleaned for 3 years) in Northern Hungary after the breeding season in 2009 and from 17 nest boxes (cleaned in previous year) in 2010. Emerging dipteran imagoes were identified to species level. Altogether 45,487 individuals of 42 fly species (2010: 37, 2011: 14) were reared; 88.1% of that was Carnus hemapterus, a well-known blood-sucking parasite. The number of C. hemapterus was significantly higher in nests where the last breeding bird species was Common Kestrel than Red-footed Falcon. In freshly cleaned nest boxes one order of magnitude lower number of C. hemapterus specimens were found. Our results indicate the necessity of cleaning the nest boxes annually.

Key words: bird nest, Carnus hemapterus, nest box cleaning, parasites, saprophytic flies.

INTRODUCTION

In the 1940s about 2000–2500 pairs of Red-footed Falcons (Falco vespertinus Linnaeus, 1766) bred in Hungary predominantly using Rook (Corvus frugilegus Linnaeus, 1758) nests. However, due to poisoning of corvids and changes in land use including a decline of animal husbandry, approximately 90% of previously available rookeries either became demolished or moved to urban habitats (Seres & Likér 2015) that are unsuitable for Red-footed Falcons (Fehérvári et al. 2009). Consequently, by 2006 the estimated number of Red-footed Falcon pairs was reduced to less than 600. An international conservation
program (LIFE05 NAT/H/000122) initiated in 2006 with the primary objective to halt this tendency succeeded in increasing the number of breeding pairs, primarily through provisioning over 3,500 nest boxes. Today, approximately two-thirds of Red-footed Falcon pairs breed in these man-made structures in Hungary (Palatitz et al. 2015). However, the breeding birds might face new challenges here as compared to their natural nesting sites.

Colonial species, such as the Red-footed Falcon may experience higher prevalence of ectoparasites than solitary breeders (Brown & Brown 2004, Rózsa et al. 1996) that constitutes one of the main costs of coloniality (Brown & Brown 1986). Furthermore, while the Rook nests are rebuilt every year (Horváth et al. 2015), food remains and faeces accumulate in the litter of artificial nest boxes through subsequent years. Consequently, the number of blood-sucking arthropods, such as certain dipteran flies developing, overwintering or breeding in the nest material may increase in the boxes from year to year, resulting in increased parasitism for the nesting birds (Møller et al. 1990). Furthermore, bird species other than Red-footed Falcon also use these artificial nest boxes and they can possibly increase the abundance and diversity of ectoparasitic insects living there.

The nest-dwelling dipteran larvae are either (i) parasites sucking the birds’ blood or tissue fluids, (ii) or enter the nestlings’ epidermis to cause myiasis, (iii) or saprophages feeding on the litter and other organic substrates, (iv) or predators of other nidicolous invertebrates. Imagoes of some dipterans are sucking avian blood, while adults of some other fly species use avian nests as overwintering shelters.

Blood-sucking and nest-dwelling dipteran flies can exert various effects on avian broods. They might decrease the chicks’ condition (Hoi et al. 2010), increase nestling mortality (Richner et al. 1993), increase physiological stress (Martínez-Padilla et al. 2004, Tomás et al. 2008, Cantarero et al. 2013), or decrease their fitness indirectly by transmission of blood parasites (Richner et al. 1993, Martínez-De La Puente et al. 2013).

In this study we investigated the dipteran assemblages of 3 years old accumulated, and one year old fresh nest materials from nest boxes after the breeding season of Red-footed Falcons. We aimed to answer the following questions:

1) was the species richness and abundance of the dipteran larval assemblages in the 3-year-old nesting material affected by the (i) number of breeding bird species during the former 3 years; (ii) or the species of the last bird breeding in the box?

2) What is the composition of the Diptera community in the 3 years versus the 1 year old accumulated nest material?

3) Is the hatching of Carnus hemapterus synchronised with the breeding periods of the different bird species using the same box?
MATERIAL AND METHODS

study site and sampling

Field work was carried out in Borsodi-Mezőség, Mezőcsát (N47,769° E20,892°), Mezőnagymihály (N47,788°E 20,818°), at the protected area of the Bükk National Park Directorate in Northern Hungary in 2009 and 2010. Over 60–80 pairs of Red-footed Falcons bred in this area in nearly 200 artificial nest boxes each year, along with numerous Common Kestrels (*Falco tinnunculus* Linnaeus, 1758), Jackdaws (*Corvus monedula* Linnaeus, 1758) and Long-eared Owls (*Asio otus* (Linnaeus, 1758)). The investigated nest boxes were installed in the crown of Black locust (*Robinia pseudoacacia*) and poplar (*Populus* sp.) trees in 2006. The usual breeding bird sequence in a year is the following: Jackdaw, Long-eared Owl, Kestrel, Red-footed Falcon. Generally, Red-footed Falcons and the Kestrels start the breeding when the fledgling of Jackdaws left the nest boxes and, therefore, two consecutive species may occupy a given nest box in the same breeding season.

In 2009 we collected nest material from 59 nest boxes that were not cleaned for 3 years, while in 2010 we sampled the one-year old nest material from 17 nest boxes, cleaned in the year before. In the 2009 breeding season, the bird species breeding in the nest boxes were Long-eared Owl (n = 5), Jackdaw followed by Red-footed Falcon or Common Kestrel (n = 6), Red-footed Falcon (n = 16), Common Kestrel (n = 32); in 2010 all the nest boxes were occupied by Red-footed Falcon (n = 17). The nest materials were collected both years in October, when the nestlings already flew out, and stored in 10 × 30 cm linen sacks. As the identification of dipteran larvae is generally very difficult even at family level (*Smith* et al. 2000), we decided to rear the larvae to adults. We overwintered the nest substance in a cellar (to ensure stable temperature and similar overwintering probability). Translucent PET bottles were used in order to trap the hatching flies (Fig. 1). The hatching insects were collected in the next year from the end of April till August in every two weeks. All reared specimens were identified to species level.

statistical analyses

We used generalized linear mixed effects models (GLMMs) to assess effects of number of breeding species over the 3 years, and the last breeding species on the species.

**Fig.1.** Linen sack with translucent PET bottles were used to trap the hatching flies.
richness and abundance of all dipteran species and the abundance of \textit{Carnus hemapterus}. Abundance of all dipterans and that of \textit{C. hemapterus} were log10 transformed to reach normal residual distribution. We tested all predictor variables for multicollinearity by calculating the variance inflation factor (VIF) using vif function or Chi-squared test of independence for categorial variables. A maximum VIF value of 5 was taken as an indicator of multicollinearity (Rogerson 2001). The abundance of all dipterans was analysed at nest box level as collected, which were nested according to the colonies and those in settlements as random factors: settlement/colony. In addition, all pair-wise interactions were tested between the explanatory variables. Terms were removed sequentially in backward stepwise selection until only significant interactions and main effects ($P > 0.05$ from F test) remained in the minimal adequate model. All analyses were carried out in R, version 3.2.3 (R Core Team 2016) using the following packages: nlme (Pinheiro et al. 2017), stats (R Core Team 2016) and fmsb (Nakazawa 2015).

\section*{RESULTS}

During the two-year study period 45,487 specimens of 42 dipteran species (2010: 37 species; 2011: 14 species) were reared from the 76 nests. According to the feeding habit of the larvae, 10 species (Muscidae, Sarcophagidae and Scenopinidae) were predatory, 32 species saprophagous, and only imagoes of 2 species proved to be blood-suckers. The overwhelming majority (88.1\%) of individuals represented a single species, \textit{Carnus hemapterus} (Table 1).

\begin{table}[h]
\centering
\begin{tabular}{llllll}
\hline
Family & Species & LFH & 2009 & & 2010 & \\
     &        &     & N & OR (\%) & N & OR (\%) \\
\hline
Anthomyiidae & \textit{Anthomyia procellaris} Rondani, 1866 & SA & 10 & 10.2 & 21 & 29.4 \\
Carnidae & \textit{Carnus hemapterus} Nitzsch, 1818 & SA & 39795 & 96.6 & 283 & 76.5 \\
 & \textit{Hemeromyia anthracina} Collin, 1949 & SA & 586 & 64.4 & 14 & 17.6 \\
 & \textit{Hemeromyia longirostris} Carles-Tolra, 1992 & SA & 8 & 8.5 & 0 & 0 \\
 & \textit{Meoneura neottiophila} Collin, 1930 & SA & 0 & 0 & 8 & 23.5 \\
 & \textit{Meoneura prima} (Becker, 1903) & SA & 43 & 18.6 & 0 & 0 \\
Cecidomyiidae & & SA & 134 & 18.6 & 0 & 0 \\
Drosophilidae & \textit{Drosophila bifasciata} Pomini, 1940 & SA & 1 & 1.7 & 0 & 0 \\
 & \textit{Drosophila busckii} Coquillett, 1901 & SA & 2 & 1.7 & 0 & 0 \\
Fanniidae & \textit{Fannia canicularis} (Linnaeus, 1761) & SA & 24 & 20.3 & 0 & 0 \\
 & \textit{Fannia lineata} (Stein, 1895) & SA & 3 & 1.7 & 0 & 0 \\
 & \textit{Fannia manicata} (Meigen, 1826) & SA & 2 & 1.7 & 0 & 0 \\
\hline
\end{tabular}
\caption{Dipteran species reared, their larval feeding habit (LFH), total number of individuals (N) and occurrence ratio (OR) in the three-years old (2009) and one-year old (2010) nest box material. Abbreviation: SA = saprophagous, PR = predator.}
\end{table}
### Dipteran Assemblages in Red-Footed Falcon Nest Boxes

<table>
<thead>
<tr>
<th>Family</th>
<th>Species</th>
<th>LFH</th>
<th>2009</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>N</td>
<td>OR (%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>N</td>
<td>OR (%)</td>
</tr>
<tr>
<td>Fanniidae</td>
<td><em>Fannia scalaris</em> (Fabricius, 1794)</td>
<td>SA</td>
<td>2</td>
<td>1.7</td>
</tr>
<tr>
<td></td>
<td><em>Fannia</em> sp. 1</td>
<td>SA</td>
<td>1</td>
<td>1.7</td>
</tr>
<tr>
<td></td>
<td><em>Fannia</em> sp. 2</td>
<td>SA</td>
<td>1</td>
<td>1.7</td>
</tr>
<tr>
<td>Heleomyzidae</td>
<td><em>Chiropteromyza broersei</em> (de Meijere, 1946)</td>
<td>SA</td>
<td>12</td>
<td>3.4</td>
</tr>
<tr>
<td></td>
<td><em>Tephrochlamys laeta</em> (Meigen, 1830)</td>
<td>SA</td>
<td>1</td>
<td>1.7</td>
</tr>
<tr>
<td></td>
<td><em>Tephrochlamys rufiventris</em> (Meigen, 1830)</td>
<td>SA</td>
<td>21</td>
<td>20.3</td>
</tr>
<tr>
<td></td>
<td><em>Tephrochlamys tarsalis</em> (Zetterstedt, 1847)</td>
<td>SA</td>
<td>1338</td>
<td>50.8</td>
</tr>
<tr>
<td>Hippoboscidae</td>
<td><em>Ornithoica turdi</em> (Olivier in Latreille, 1811)</td>
<td>SA</td>
<td>1</td>
<td>1.7</td>
</tr>
<tr>
<td>Milichidae</td>
<td><em>Leptometopa latipes</em> (Meigen, 1830)</td>
<td>SA</td>
<td>1451</td>
<td>71.2</td>
</tr>
<tr>
<td></td>
<td><em>Madiza glabra</em> Fallén, 1820</td>
<td>SA</td>
<td>11</td>
<td>3.4</td>
</tr>
<tr>
<td>Muscidae</td>
<td><em>Hydrotaea armipes</em> (Fallén, 1825)</td>
<td>PR</td>
<td>13</td>
<td>6.8</td>
</tr>
<tr>
<td></td>
<td><em>Hydrotaea hennigi</em> Pont, 1985</td>
<td>PR</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td><em>Hydrotaea</em> sp.</td>
<td>PR</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td><em>Muscidae</em> sp. 1</td>
<td>PR</td>
<td>1</td>
<td>1.7</td>
</tr>
<tr>
<td></td>
<td><em>Muscidae</em> sp. 2</td>
<td>PR</td>
<td>8</td>
<td>1.7</td>
</tr>
<tr>
<td></td>
<td><em>Muscina stabulans</em> (Fallén, 1817)</td>
<td>PR</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td><em>Potamia littoralis</em> Robineau-Desvoidy, 1830</td>
<td>PR</td>
<td>5</td>
<td>5.1</td>
</tr>
<tr>
<td>Psychodidae</td>
<td><em>Psychoda minuta</em> Banks, 1894</td>
<td>SA</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Sarcoptagidae</td>
<td><em>Sarcophaga argyro斯塔</em> (Robineau-Desvoidy, 1830)</td>
<td>PR</td>
<td>11</td>
<td>5.1</td>
</tr>
<tr>
<td></td>
<td><em>Sarcophagidae</em> sp.</td>
<td>PR</td>
<td>1</td>
<td>1.7</td>
</tr>
<tr>
<td>Scenopinidae</td>
<td><em>Scenopinus fenestralis</em> (Linnaeus, 1758)</td>
<td>PR</td>
<td>30</td>
<td>27.1</td>
</tr>
<tr>
<td>Sciaridae</td>
<td><em>Bradyisia</em> sp.</td>
<td>SA</td>
<td>1</td>
<td>1.7</td>
</tr>
<tr>
<td></td>
<td><em>Sciaridae</em> sp.</td>
<td>SA</td>
<td>1</td>
<td>1.7</td>
</tr>
<tr>
<td>Sphaeroceridae</td>
<td><em>Apteromyia claviventris</em> (Strobl, 1909)</td>
<td>SA</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td><em>Coproica hirtula</em> (Rondani, 1880)</td>
<td>SA</td>
<td>11</td>
<td>10.2</td>
</tr>
<tr>
<td></td>
<td><em>Ischiolepta pusilla</em> (Fallén, 1820)</td>
<td>SA</td>
<td>4</td>
<td>6.8</td>
</tr>
<tr>
<td></td>
<td><em>Spelobia</em> sp.</td>
<td>SA</td>
<td>1</td>
<td>1.7</td>
</tr>
<tr>
<td></td>
<td><em>Spelobia luteilabris</em> (Rondani, 1880)</td>
<td>SA</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td><em>Spelobia pseudosetaria</em> (Duda, 1918)</td>
<td>SA</td>
<td>15</td>
<td>15.3</td>
</tr>
<tr>
<td></td>
<td><em>Telomera flavipes</em> (Meigen, 1830)</td>
<td>SA</td>
<td>1</td>
<td>1.7</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td>43550</td>
<td></td>
</tr>
</tbody>
</table>
In boxes with nest material accumulated through three years, only the species identity of the last breeding bird had a significant effect on the number of *C. hemapterus* (df = 52, F = 4.187, p = 0.046). It was significantly higher when Common Kestrels bred in the same box in the former year, as compared to Red-footed Falcons (t = 2.1, df = 48.572, p = 0.041).

The average number of *C. hemapterus* in 2009 (3-year old nest material) was 674.5 ind./nest, while in 2010 (one year old nest material) it was 16.6 ind./nest. The hatching time curve of *C. hemapterus* was bimodal from the 2009 nest material from those nests, where both Jackdaws (early peak in May) and Kestrels or Red-Footed Falcons (a second peak in July) bred. Contrarily, this curve was unimodal from nest boxes with only one late breeding bird species in the last year, with its maximum in the second part of the summer (Fig. 2).

**DISCUSSION**

The breeding population of the Red-footed Falcon has been successfully increased in Hungary by using artificial nest boxes during the last ten years.

![Fig. 2. Phenology of emergence of Carnus hemapterus imagoes from three years old accumulated nest material (collected in 2009), grouped by the last breeding bird species (n = number of nest boxes) within the nest (mean ± SEM)](image-url)
DIPTERAN ASSEMBLAGES IN RED-FOOTED FALCON NEST BOXES

(Palattitz et al. 2015). The adjoining arthropod communities in the accumulating nest material and the potential harms they may cause to the nestlings, however, are still poorly known. There are only a few studies dealing with the dipteran communities of the nests of raptor birds (Philips & Dindal 1990, Kálovský et al. 2009). In our study we sampled the Diptera assemblages of these artificial nest boxes and our aim was to survey the entire dipteran fauna connected to the nest boxes with a special focus on parasitic flies.

Our investigations have been carried out in two separate nest box colonies installed for Red-footed Falcons. During the two years of sampling from 76 nest box materials, in which four bird species bred, altogether 45,487 dipteran specimens belonging to 42 species were reared. These numbers, regarding both the number of species and individuals, are remarkably higher than found in raptor bird nests by the former investigations (Philips & Dindal 1990, Papp & Paulovics 2002, Kálovský et al. 2009, Lesko & Smallwood 2012, Lange 2015). A possible reason for this difference is the different breeding habit of the birds, as most raptors are solitary breeders, while the Red-footed Falcon tends to breed colonially. Colonial species may experience higher prevalence of ectoparasites as compared to solitary breeders (Rózsa et al. 1996, Brown & Brown 2004).

Analysing the frequency of the dipteran species in our samples, we found that 90% of the species (38 species) were rare (i.e., less than 0.01% of the whole sample). This ratio is very similar to that of found in case of free-living dipteran species utilizing point-like food sources, such as dung, fermenting fruit etc. (Papp 1998). The majority of the reared individuals were C. hemapterus, a well-known blood-sucking parasite of bird chicks. Due to ethical reasons, we collected nest materials only after all birds left the colony, and probably this is the reason why we found no parasitic Calliphoridae and Muscidae specimens.

In former investigations, only 8 dipteran species, C. hemapterus, Cynomya mortuorum, Meoneura neottiaphila, Ornithomya avicularia, Potamia littoralis, Protocalliphora avium, Scenopinus fenestralis and Scoliocentra brachypterna were known to occur in the nests of the four bird species involved in our study (Red-footed Falcon, Common Kestrel, Jackdaw and Long-eared Owl) (Hicks 1959, Hicks 1962, Bohm 1978, Rotheray 2012, Amat-Valero et al. 2013, Sumasgutner et al. 2014, Lange 2015). We found only three of these species (C. hemapterus, M. neottiaphila, S. fenestralis), therefore, all the other 39 species are new for the nest fauna of these birds. It is worth mentioning that while the samples collected in 2009 originated from the nests used by four bird species, the samples from 2010 were exclusively from the nest boxes of the Red-footed Falcon. Formerly only C. hemapterus was found in the nests of Red-footed Falcon (Hicks 1962, FeHérvári et al. 2015) and, therefore, the additional 13 dipteran species recorded from the 2010 samples are reported here for the first time to occur in the nests of F. vespertinus. The samples included 8 dipteran species.
(Drosophila bifasciata, Drosophila busckii, Hydrotæa hennigi, Psychoda minuta, Coproica hirtula, Spelobia pseudosetaria) which were recorded by us for the first time to occur in avian nests. In addition, one of the species, Fannia lineata, is new for the fauna of Hungary. Since formerly only a very few studies targeted the dipteran assemblages of the bird nests in Hungary (Likér et al. 2001, Papp & Paulovics 2002), the occurrence of this Fannia species in the Hungarian fauna was probably overlooked.

Carnus hemapterus is an obligatory nest-dwelling avian ectoparasite, having been found in the nests of >50 bird species (Grimaldi 1997, Brake 2011) including raptors. Certain studies indicated that C. hemapterus infestations had a negative effect on the condition of the chicks of Colaptes auratus (Wiebe 2009), Sturnus unicolor (Avilés et al. 2009) and Merops apiaster (Hoi et al. 2010), but no significant negative effects were found in case of raptors (Dawson & Bortolotti 1997, Kaľavský et al. 2010). However, apart from blood loss and discomfort caused by their bites, these flies are also important as vectors of Plasmodium and Haemoproteus infections (Vaclav et al. 2016).

In the nest litter accumulated through three consecutive years, the number of Carnus hemapterus individuals was on average an order of magnitude higher than in the one year old nest materials. The formerly published data on the abundance of C. hemapterus (Likér et al. 2001, Valera et al. 2003, Sumasgutner et al. 2014) were roughly similar to our samples from the one-year old nest boxes. This fact indicates a marked increase of C. hemapterus abundance during the re-use of nest through consecutive years. Certain investigations pointed out that in the nests of Kestrels (Sumasgutner et al. 2014) and Barn Owls (Roulin 1998) the abundance of C. hemapterus was higher in nests with accumulated litter than in cleaned ones. Although in these cases there was no significant correlation between the increased parasite numbers and the breeding success, the accumulation periods were shorter and the increase of parasite abundance was much smaller than in our study. In nests not cleaned for years, the increase of C. hemapterus abundance is supposedly greater because the pupae may exhibit diapause through several years (Valera et al. 2006). Furthermore, the saprophagous larvae may also benefit from greater food resources and higher relative humidity in the accumulating debris of uncleaned nest boxes. The lower competition of larvae for the larger amount of multi-years nest material could also positively influence the development and survival of immatures and, consequently, the number of hatched adults. The nest boxes in the Hungarian breeding colonies are often not cleaned every year, therefore, subsequent studies should clarify the effect of accumulated nest litter on the breeding conditions of birds.

Our study indicated that the abundance of C. hemapterus was significantly higher when the Kestrel was the last breeder in the nest box, as compared
to cases when the Red-footed Falcon was the ultimate breeder. The reason of this difference could be the different size of their broods: the Kestrel is larger-bodied and it has usually 5–6 nestlings, while the Red-footed Falcon is smaller and it has only 3–4 chicks. Supposedly, a larger mass of chicks in Kestrel broods may maintain more parasitic flies, that can lay more eggs and, therefore, the abundance of the next generation of flies may be larger as well.

The synchronisation of the *C. hemapterus* generations to bird breeding was recorded in different nestling developmental stages of the same bird species (Liker et al. 2001, Calero-Torralbo et al. 2013), as well as to different bird species breeding in the same area, but not in the same nests (Valera et al. 2003). This synchronisation is inevitable for the flies because the freshly hatched adults die without feeding within 2–3 days (Calero-Torralbo et al. 2013). We also observed synchronisation to 2 bird species subsequently occupying the same nest within a single breeding season. In the samples hatching in 2010 there were two peaks of *C. hemapterus* abundance (in May and in July) in the nest boxes used by Jackdaws and *Falco spp.*, while there was only one summer peak in the other nests used only by *Falco spp.* (Fig. 2). This likely indicates that some of the flies synchronised their life cycle to Jackdaws, while others to the Common Kestrels and Red-footed Falcons that breed remarkably later.

Our study demonstrates that the nest boxes installed for the Red-footed Falcons and used by more bird species are inhabited by surprisingly diverse dipteran assemblages. We plan future studies to investigate the behaviour of parasitic dipterans and to compare the composition of fly assemblages in colonial versus solitary nest boxes. Moreover, the comparison of the assemblages of these nest boxes and the natural breeding sites in Rook colonies would provide further important information about the accommodation of these dipteran groups to the different nest types. Finally, further studies would be necessary to clarify the possible effect of the accumulation of nest litter to the composition and abundance of the dipteran assemblages inhabiting avian nests.

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REFERENCES


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