Does the abundance of ectoparasite in the nest affect nestling condition and fledging success?

By

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ABSTRACT

Nestlings of most passerine species face many stressors including early exposure to ectoparasites. Ectoparasites negatively impact the health of nestlings by feeding on their blood and feathers, leaving the nestlings in poor condition, and reducing their chance to fledge. European Starlings (*Sturnus vulgaris*) are cavity-nesting passerines; they nest in the holes of trees and artificial nest boxes which accumulate ectoparasites. Parents are known to line their nest with feathers to serve as a barrier to ectoparasites. Only one study on the ectoparasite community of European Starlings exists and it was done in Halifax, Nova Scotia (Fairn et al. 2014). My objectives were to 1) identify the abundance and types of ectoparasite in starling nests, 2) determine whether ectoparasite abundance reduces nestling condition and fledging success, and 3) determine whether the mass of feathers in the nest reduces ectoparasite abundance and to quantify the number of cigarette butts present in nests. This study was conducted in June 2020 on nine nests from the late broods of European Starlings. The number of ectoparasites per nest ranged from 8-31. The only ectoparasites found were adult hen fleas (*Ceratophyllus gallinae*). I found no relationship between ectoparasite abundance and a) mean nestling condition in the brood, b) proportion of nestlings that fledged and c) mass of feathers. These results suggest that nestlings were not affected by this particular prevalence of ectoparasites. It also suggests that feathers do not serve as a barrier which may instead be present in the nest to attract the opposite sex. Future studies should examine the effects of different ectoparasite prevalences on nestlings.

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INTRODUCTION

Development is a crucial stage in a young organism's life as ample energy is required to enable the successful growth of the various systems (such as the circulatory, digestive, and immune system) (Brzek and Konarzweksi 2007). The offspring of most birds and mammals usually depend heavily on their parents over their developmental period (Pryor and Castor 2017). Often, there is bi-parental care, where both parents are involved in taking care of the young (Moks and Tilgar 2014). However, even with a high degree of parental investment, external factors such as limited resources (food and water), predation and parasitism interfere with offspring development (Pryor and Castor 2017). The energetically costly demand of development combined with these external factors usually elevate the stress levels of young organisms and can reduce their growth rate and chance of survival (McCarty 2001).

Developmental stressors of nestlings

Like the offspring of other animals, nestlings face numerous stressors in the environment during their developmental period which can negatively impact their health and survival (Pryor and Castor 2017). The possibility of predation intensifies anti-predator behaviour such as hiding or playing dead, at the cost of foraging, self-care, maintenance, and reproduction (Thomson et al. 2010). Usually, prey respond to predator attacks by fleeing (Nelson et al. 2004) or fighting in defense (Rupia et al. 2016). Nestlings, however, are vulnerable and cannot yet fly during an attack, resulting in increased predator pressure (Pryor and Castor 2017). When the risk of predation is high at a nest site, parents limit

their number of visits to the nest as a way of ensuring their own survival (Moks and Tilgar 2014).

Nestlings also face difficulties in regulating their body temperature during adverse weather conditions. They lack body feathers at early stages of development, and so have little insulation during cold temperatures (Merino and Potti 1996). Due to the ectothermic nature of nestlings and their inability to thermoregulate, parents tend to brood them for longer periods (Lyon and Montgomerie 1985). Thomas et al. (2001) found that nestlings lose a lot of body fluid in high temperatures which impact their condition and survival. Adverse weather conditions reduce food availability, limiting parental provisioning which increases sibling competition for food resources; larger nestlings typically outcompeting their smaller siblings (Pryor and Castor 2017). Smiseth et al. (2003) found that in Bluethroats *(Luscinia svecica*), parents tended to favour larger nestlings over smaller ones when feeding their offspring during food scarcity because they were more likely to survive. Finally, nestlings also deal with ectoparasites.

Ectoparasites

Ectoparasites are a diverse group of organisms that live on the outside of their host (Kupler and Fessler 2018), at their expense, deriving benefits such as food (Price 1980). Their abundance in the environment fluctuates across the seasons. Most ectoparasites (e.g., fleas, flies) prefer to live in warmer climates (Mehlhorn et al. 2010). Some depend on both their host and the resources in the environment to survive as they do not spend their entire life cycle on their host (such as the Ixodid tick; Ixodidae). Others depend heavily on their host for survival (such as lice; suborder Mallophaga; Esberard et al.

2005) which may be due to their monoxenous nature where they are associated with a specific host species and have reduced survival on an atypical host (Esberard et al. 2005). Tomkins and Clayton (1999) reported that transferring mallophagan lice to a new host resulted in a reduced fitness of the lice. They concluded that the novel host may have lacked the necessary resources required by the mallophagan lice (Tomkins and Clayton 1999).

Ectoparasites affect many vertebrates such as dogs, birds, and humans, and negatively impact their health. Most research conducted (Lehmann 1993; Pryor and castor 2017; Wolfs et al. 2012), detected an increase in anemia and a decrease in fitness of vertebrate hosts who were infested with hematophagous (blood-feeding) ectoparasites such as red mites (*Dermanyssus gallinae*). Other hematophagous ectoparasites such as the carnid fly (*Carnus hemapterus*) and hen fleas (*Ceratophyllus gallinae*) have also been found to decrease nestling survival (Lehmann 1993) by feeding on their blood (Fairn et al. 2014). Non-hematophagous species of ectoparasites such as chewing lice (*Menacanthus eurysternus*) leave wounds on their host which can become infected with bacteria. The open wound also invites other ectoparasites such as blowflies (*Cochliomyia hominivorax*), causing skin irritation (Mehlhorn et al. 2010).

Ectoparasites are vectors of many diseases. For example, the blacklegged tick (*Ixodes scapularis),* is a vector of Lyme disease, babesiosis and anaplasmosis by harbouring and transmitting *Borrelia burgdorferi*, *Babesia microti* and *Anaplasma phagocytophilum* respectively (Khatchikian et al. 2012). Vertebrates (e.g., humans) exposed to the bite of the blacklegged tick exhibited symptoms such as fever, muscular pains, and neurological and cardiac diseases (Khatchikian et al. 2012). The cat flea

(*Ctenocephalides felis*) is another example of an ectoparasitic disease vector. They harbour the bacteria *Rickettsia* and transmit it to their target hosts (humans, cats, and dogs; Turebekov et al. 2019), causing rickettsial disease. Research by Nguyen et. al (2020) reported that infected hosts (dogs) who were exposed to the bite of cat fleas showed disease symptoms such as fever, aching muscles, and a rash.

Effects of ectoparasites on birds

Common avian ectoparasites are carnid flies, hen fleas, chewing lice, red mites, and northern fowl mites (*Ornithonyssus sylvarium*) (Clayton et al. 2010). Some studies have reported that there are ectoparasites present in the nest material and on the feathers of most bird species (e.g., European starlings (*Sturnus vulgaris*); Fairn et al. 2014, Tree Swallows (*Tachycineta bicolor*); Rendell and Verbeek 1996, Harriman et al. 2013, and Blue tits (*Cyanistes caeruleus*); Tripet and Richner 1997, Bouslama et al. 2002). When present in the nest, ectoparasites adversely impact the health of their avian host. Clayton (1990) showed that pigeon lice (*Columbicola columbae*) feed on the barbules of the abdominal feathers of its avian host. Moller (1991) suggested that chewing lice puncture holes in the vanes of pennaceous flight feathers, thereby reducing aerodynamic performance. High ectoparasite loads decrease the probability of finding a mate. Females prefer males with bright plumage which usually signals good genes or high fitness. Damage caused by feather lice reduces the luminosity of the plumage making that male unattractive to females (Tris et al. 2002).

Ectoparasites increase the resting metabolic rate (RMR) of nestlings. RMR refers to the lowest metabolic rate of an individual at rest (Sun et al. 2020). Nestlings

infested with ectoparasites are usually malnourished (Thomas and Shutler 2001) and have high immune activity as a result of energetically costly behaviours such as begging, which increases their RMR (Sun et al. 2020). Ectoparasites affect nestling condition by feeding on their blood and feathers which leads to high immune activity and a poorer body condition (Moss and Camin 1970). Prolonged feeding on nestlings by parasites significantly reduces the body mass of the nestlings and this can potentially decrease the chance that a nestling will fledge (Aviles et al. 2009). Weddle (2000) found a negative correlation between the mass of fledglings and load of hematophagous nest mites (*Pellonyssus reedi*). However, even if successful in leaving the nest, fledglings had a reduced survival rate due to their prior exposure to ectoparasites in the nest (Lehmann 1993).

How birds deal with ectoparasites

As ectoparasites pose a serious challenge to birds, birds have evolved several ways to reduce their ectoparasite abundance (Clayton et al. 2010). One of these techniques is water bathing (Rothschild and Clay 1952; Clayton et al. 2010). This behaviour not only results in a reduction in parasite accumulation on the host but also serves as a means of cooling down. Another technique known to be employed by birds is preening which involves pulling their feathers between their beak which removes ectoparasites that may be hiding in the feathers (Ash 1960; Boyd 1951). Most bird species spend a substantial amount of their day preening (Losito et al. 1990). Birds can also allopreen each other especially in the areas of the neck and head where it is impossible to self-preen (Harrison 1965).

Studies have suggested that nests of some bird species such as Song thrushes (*Turdus philimelos*), House finches (*Haemorhous mexicanus*) and European starlings contain cigarette butts (e.g., Hamel and Wagner 1984; Igic et al. 2009; Rodriguez et al. 2012). These bird species likely add them for the nicotine alkaloid compound that is retained in smoked cigarettes which is believed to repel ectoparasites (Wu et al. 1997; Rodriguez et al. 2012). The nicotine alkaloid, produced by the tobacco plant (*Nicotiana* sp.) (Rodriguez et a. 2012) is used for self-defence against herbivores (Rodgman and Perfetti 2008). It has been introduced in agriculture to act as an arthropod repellent in crops (Rodgman and Perfetti 2008) and is also used to control ectoparasites in poultry (Lans and Turner 2011).

Lastly, birds are known to line their nest with feathers as a preventive method for ectoparasite accumulation. Feathers present in the nest are thought to repel ectoparasites by acting as a barrier to their movement (Stephenson et al. 2009; Mainwaring et al. 2016). However, some studies (Winkler 1993; Chaplain et al. 2002; Stephenson et al. 2009; Mainwaring et al. 2016) have suggested that feathers may instead serve as insulation to keep nestlings warm.

Sturnus vulgaris as a model

Sturnus vulgaris, also known as European starlings, belong to the order Passeriformes and are a member of the family Sturnidae. They are native to Europe and were introduced to North America in the 1800s (Linz et al. 2007). Starlings are cavity-nesting passerines; they nest in the holes of trees, crevices in buildings and in artificial nest boxes (Linz et al. 2007). They are double-brooded with an early brood occurring from late April to early

June and a late brood occurring from early June to late July. Their eggs are ovoid in shape and pale blue in colour (Pryor and Castor 2017). Some clutches have eggs with reddish-brown spots thought to be blood spots or fecal matter from the Dipteran fly, *Carnus hemapterus* (Feare 1984), that feeds on the incubating parents (Hornsby et al. 2013). Female starlings lay one egg per day and this usually occurs around 1000h. Clutch size ranges from 3-7 eggs (Feare 1984). Both parents incubate for twelve days and nestlings fledge at about 21-23 days of age (Linz et al. 2007).

Knowledge gap

Starlings were chosen for this study because as cavity-nesting passerines, their nests accumulate more ectoparasites which makes them a good model for ectoparasite research (Pryor and Castor 2017). Most of the research conducted on starlings focuses on parental investment (e.g., Hornsby et al. 2013; Aviles et al. 2009; Pryor and Castor 2017), breeding success (e.g., Feare 1984; Wolfs et al. 2012), and the effects of brood size on nestling mortality (e.g., Kessel 1957; Crossner 1977). Few studies have focused on the detrimental effects that ectoparasites may have on starling nestlings (Mazgajski 2007; Pirrello et al. 2015). Furthermore, only one study has reported on the community of ectoparasites for this avian species in Halifax, Nova Scotia (Fairn et al. 2014). In their study, the prevalent ectoparasites identified were northern fowl mites, two different species of lice (*Menacanthus eysternus* and *Brueelia nebulosa*), the Carnid fly and hen fleas. My research aims to expand on this knowledge and identify the common species of ectoparasites in the nest material of European starlings to determine if they are similar to

those identified by Fairn et al. (2014), and whether they adversely affect nestling condition and fledging success.

Objectives and Predictions

My first objective is to compare the abundance and types of ectoparasites found in European starling nests to those found at the same study site in past years (2009 and 2010; Fairn et al. 2014). The second objective is to determine whether the abundance of ectoparasites present in nest material affects nestling condition. The final objective is to determine whether the mass of feathers reduce ectoparasite abundance in the nest, and to quantify the number of cigarette butts found.

Starlings clean out their nest boxes between broods, however, ectoparasites still accumulate in the nest. Clayton et al. (2010) suggested that ectoparasites find their way into the nest by hiding in the feathers of the parents and are transferred to the nestlings through contact. Parasite load is usually much higher for later-season broods compared to early-season broods (Feare 1984). Kessel (1957) found an increased mortality rate, poorer physical condition, and lower fledging success for nestlings of later-season than early-season broods.

I predict that the nests with a greater mass of feathers would have a reduced parasite abundance. I also predict that nestlings in nests with more ectoparasites will have poorer body condition and reduced fledging success compared to nestlings in nests with fewer ectoparasites due to the adverse impacts documented in other studies that ectoparasites have on nestlings.

METHODS

Field work

This research was conducted in June 2020 on nine nests in which all nestlings had fledged from the late broods of European starlings. The nests of early broods (late April to early June) were not examined due to a province-wide lockdown resulting from the global COVID- 19 pandemic. Nest boxes were located across the campus of Saint Mary's University (44.6313° N, 63.5815° W) in Halifax, Nova Scotia, Canada. The nests were checked daily until clutches were complete. They were again monitored during the hatch period; the first day of hatch was recorded as Day 0. On Days 5 and 11, nestling mass was determined to the nearest 0.5 grams using a Pesola spring scale. Mean tarsus length was also recorded with digital calipers to the nearest 0.1 mm. Mass and tarsus length on Day 5 (Figure 1) and Day 11 (Figure 2) were tightly correlated and they were good to use in determining nestling condition. Nestlings were banded on Day 5 with a plastic leg band of a different colour on their right tarsus so as to tell them apart from their siblings. When they were 11 days old, they received an aluminum Canadian Wildlife Service (CWS) band on their right tarsus. Nestlings fledged when they were between 21 and 23 days old (Feare 1984).

Lab methods

After nestlings fledged, all nine nests were each placed in a plastic bag and frozen at a temperature of -18 degrees Celsius for about three months. To separate the ectoparasites in the nests from the nesting material, the nests were first dried by transferring each one

into a baking pan and placing it in a Fisher Isotemp incubator/drying oven (Model 503) with two nests in the oven at a time for 48 hours (Dawson 2004), at a temperature of 50 degrees Celsius. Each nest was then weighed using a 600gram digital weighing scale (Ohaus Scout Pro Balance) after they had cooled down for 15 minutes. Next, the nests were sieved for about 5 minutes with a 2mm, 0.0787inches U.S.A Standard Test Sieve to obtain ectoparasites. Then all nest material left in the sieve was manually examined to further remove any ectoparasites that were missed during sieving. All ectoparasites collected from the sieve and the manual process were transferred into vials containing 70% ethanol to preserve them. They were then counted and identified (Bland and Jacques 2010) with a dissecting microscope to the Genus level (Fairn et al. 2014) and were transferred back into the vials after identification. The mass of feathers that were in each nest were also quantified (Mainwaring et al. 2016; Stephenson et al. 2009) as were the number of cigarette butts found.

Statistical analysis

Normality of data for the number of ectoparasites, mass of feathers in each nest, as well as nestling condition were each tested using the Anderson-Darling normality test with GraphPad Prism 6.0 statistical software. The results were considered to be normally distributed when $P \geq \alpha$ (0.05). Next, I ran a linear regression of mass against mean tarsus length. Nestlings with residuals that were above the regression line on Day 5 (Figure 3) and Day 11 (Figure 4) were considered to be in good condition while those that fell below the regression line were considered to be in poor condition. Finally, I performed Pearson's correlation tests to determine whether a relationship existed between the

number of ectoparasites in a nest and a) the mean nestling condition in the brood, and b) mass of feathers in each nest. Results were considered significant when $P \leq 0.05$.

RESULTS

Ectoparasite abundance, nestling condition and fledging success

Ectoparasite abundance in the nest ranged from 8-31 per nest (Table 1), with adult hen fleas being the only ectoparasite found across broods in my study. Pupae of the carnid fly (Diptera: Carnidae; *Carnus hemapterus*) and blowfly (Diptera; Family: Calliphoridae) were also found (Table 2). Other arthropods (i.e., ants and beetles) were found across broods (Table 3). Four cigarette butts were also found in three different nests (Table 1). Ectoparasites did not influence nestling condition as no significant relationship was found between the abundance of ectoparasites and mean nestling condition on either Day 5 (r_s = 0.1345, n = 9, P = 0.73; Figure 5) or Day 11 (r_s = 0.5799, n = 9, P = 0.11; Figure 6) of the nestling period. Brood condition was not significantly different on Days 5 and 11 (Mean $\pm$ SE: -1.801 $\pm$ 0.74 vs. -4.573 $\pm$ 1.86 respectively; Paired t = 1.692, df = 8, P = 0.13). Similarly, no significant relationship was detected between ectoparasite abundance and the proportion of nestlings that fledged (r_s = 0.3404, n = 9, P = 0.37; Figure 7). Finally, the presence of feathers did not seem to reduce ectoparasite abundance; no significant relationship was found between ectoparasite abundance and the mass of feathers in each nest (r_s = 0.1681, n = 9, P = 0.67; Figure 8).

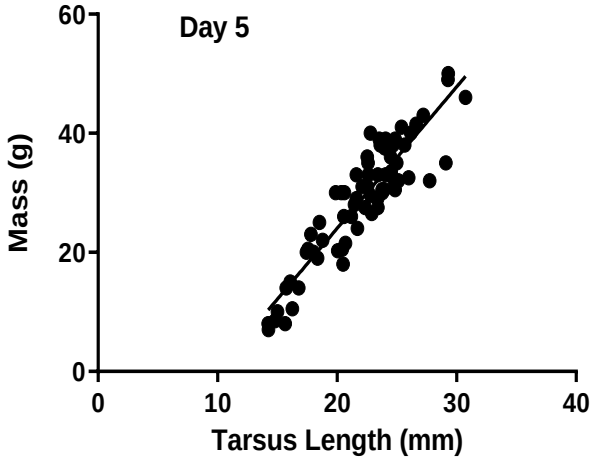

Figure 1. Linear regression of mass against tarsus length on Day 5 of the nestling period. The black line is the regression line while the black dots represent each individual nestling on the study site (n = 71).

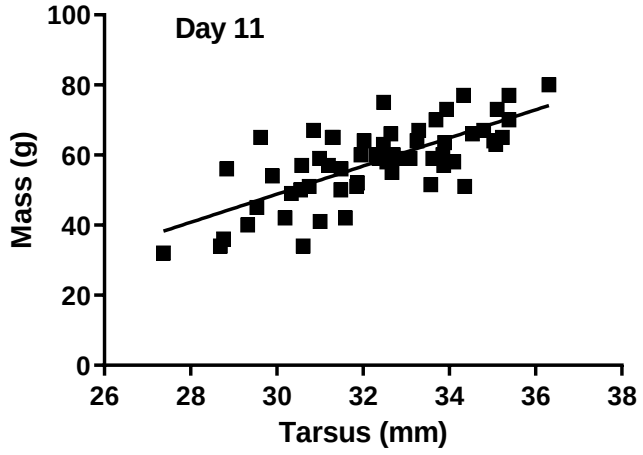

Figure 2. Linear regression of mass against tarsus length of Day 11 nestlings. Black dots represent each individual nestling on the study site (n = 58).

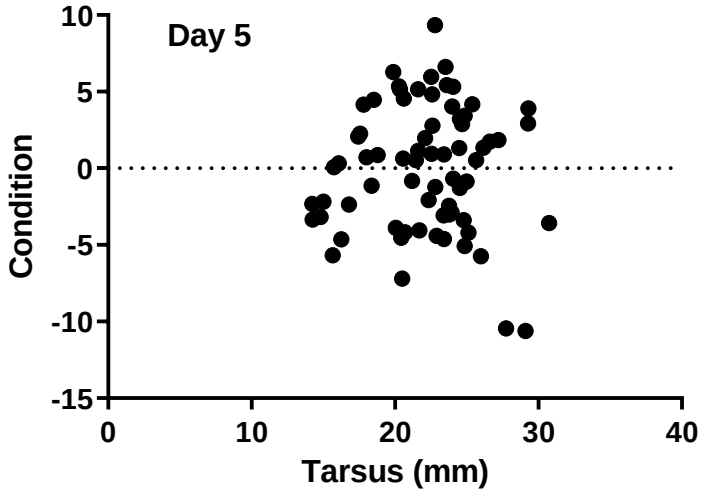

Figure 3. Residuals (index of condition) from a linear regression of nestling mass against tarsus length for Day 5 nestlings. The black dots are the residual points for each individual nestling. The residual points above the line at zero represent nestlings who are in a good condition while those below the line represent nestlings in poor condition.

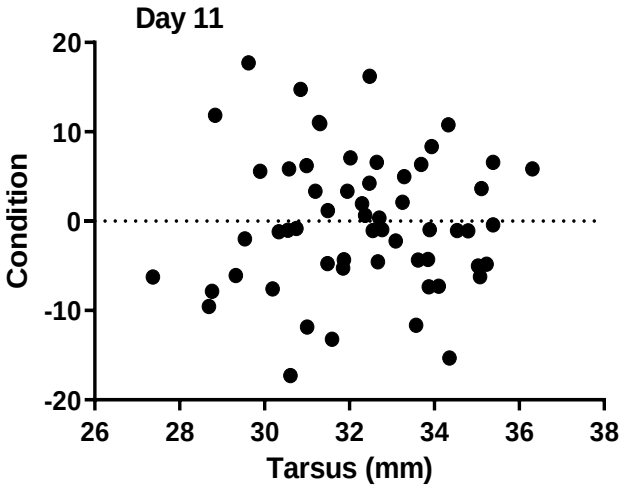

Figure 4. Linear regression of nestling condition against length of tarsus on Day 11 of the nestling period. Black dots represent the residual points (condition) for each individual nestling.

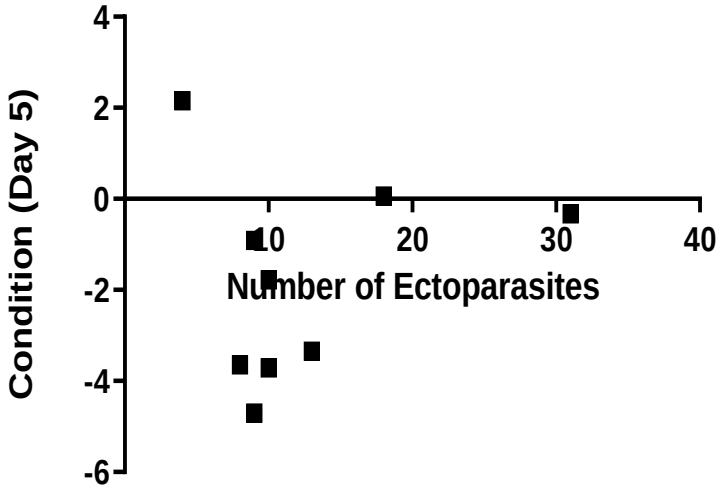

Figure 5. Relationship between brood condition (average condition of all nestlings in a nest) and ectoparasite abundance for Day 5 nestlings (n = 9 broods).

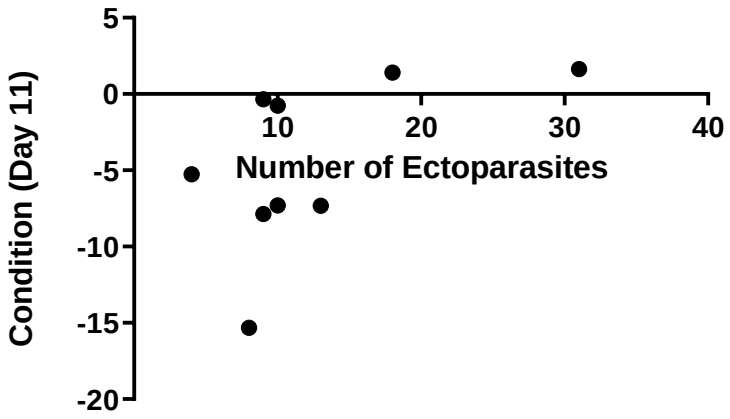

Figure 6. Relationship between brood condition and ectoparasite abundance for Day 11 nestlings (n = 9 broods).

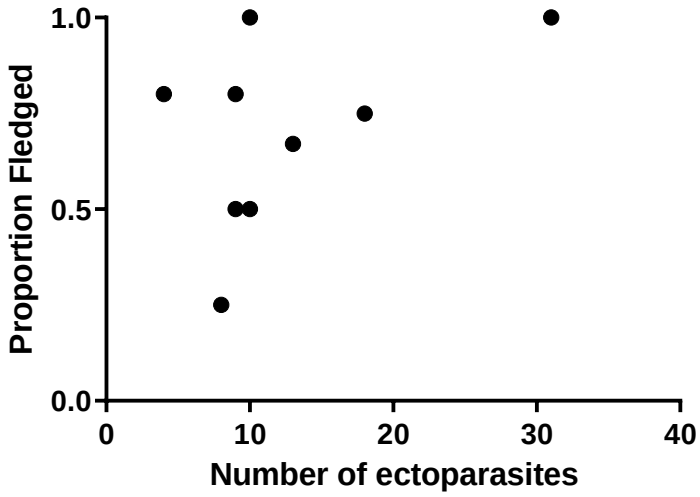

Figure 7. Relationship between the proportion of nestlings that fledged in each nest and ectoparasite abundance (n = 9 broods).

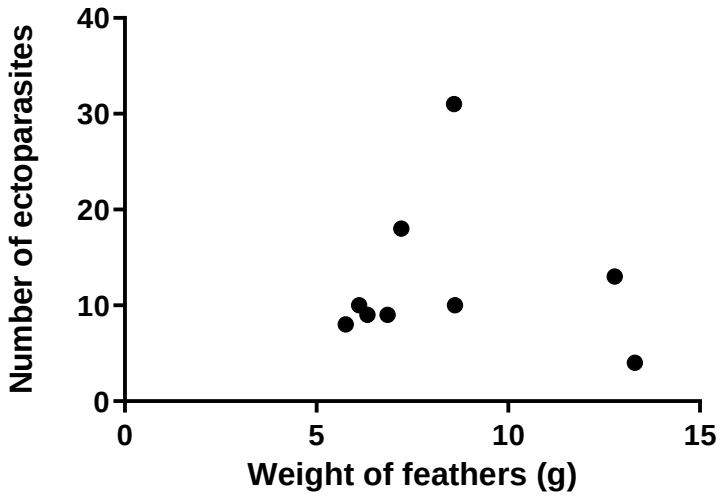

Figure 8. Relationship between ectoparasite abundance and the mass of feathers incorporated into the nest (n = 9 nests).

Table 1: The number of hematophagous ectoparasites (Hen fleas), feather mass and number of cigarette butts found in each nest box.

Nest boxes	Number of ectoparasites	Mass of feathers (g)	Number of cigarette butts
2	9	6.85	0
5	8	5.76	0
8	10	8.61	2
9	9	6.33	0
15	31	8.59	1
17	10	6.11	0
21	18	7.21	0
43	4	13.3	0
49	13	12.78	1

Table 2: The number of pupae of carnid flies and blowflies found in each of the nine nest boxes.

Nest boxes	*Carnus* pupae	*Calliphorid* pupae
2	2	0
5	0	0
8	20	0
9	1	0
15	53	2
17	4	0
21	14	0
43	46	0
49	28	0

Table 3: The number of non-parasitic arthropods found in each of the nine nest boxes.

Nest boxes	Carpenter ants	Beetles
2	16	20
5	8	11
8	8	10
9	6	15
15	44	20
17	16	8
21	22	16
43	33	4
49	54	16

DISCUSSION

Ectoparasite load and nestling condition

Contrary to my prediction, nest-dwelling ectoparasites did not influence nestling condition. This result is consistent with findings from other studies on European starling nestlings (e.g., Clark and Mason 1988; Fauth et al. 1991; Wolfs et al. 2012). One possible explanation is that ectoparasite numbers in this study were very low. In Fairn et al. (2014) study, ectoparasite abundance were found to be 141 and 155 in 2009 and 2010, respectively. It is unknown why this would be the case for this study, as late broods as those that I studied, typically have higher ectoparasite loads compared to early broods (Feare 1984), even after being cleaned out between broods either by the parents (Mazgajski et al. 2004) or by researchers. Fairn et al. (2014) also quantified the number of ectoparasites collected on the nestlings from dust ruffling which this study did not include and this could account for the low ectoparasite numbers in this study. Again, in my study, I only detected hen fleas; no living or dead *Carnus hemapterus* were found, although their pupae were evident in the nest. Fairn et al. (2014) found that the hematophagous ectoparasites in the nests they examined on my study site consisted mainly of mites (*Ornithonyssus sylvarium*), hen fleas (*Ceratophyllus gallinae*) and a small number of carnid fly (*Carnus hemapterus*).

Another possibility is that parents provisioned offspring at a higher rate in nests having higher ectoparasite loads. Nestlings beg to communicate their hunger level to parents (Granadeiro et al. 2000; Leonard and Horn 2001), and parents respond to increased begging by more provisioning visits (Corney and Barber 2018). Therefore, parents may have fed the nestlings more frequently to compensate for ectoparasites which

would have enhanced nestling condition (Stephenson et al. 2009; Johnson and Albrecht 1993).

Finally, my study had a small sample size, and with a larger sample size, a relationship might have been detected. However, interestingly it looks like an increased number of hen fleas might result in nestlings being in better condition rather than the poorer condition that I had predicted.

Ectoparasite load and fledging success

Nestling fledging success was not influenced by ectoparasite abundance which is also consistent with other studies on European starlings (Powlesland 1977; Lack 1948; Mazgajski 2007). Mazgajski (2007) found a greater number of fledglings in their study due to adult starlings cleaning out their nest box before use. Powlesland (1977) also found that a higher percentage of eggs laid survived to fledging despite the nestlings being parasitized by the fowl mite *Ornithonyssus bursa.* However, Powlesland (1977) noticed that most of the nestlings were underweight and this was ascribed to malnourishment as the study was conducted during a period of drought in 1974-1975. In subsequent years (1975-1976) when precipitation was high, there was no difference in weight observed between heavily and lightly infested nestlings. In Lack's (1948) study, even though majority of nestlings fledged, most of them died a few days after leaving the nest and this was attributed to the nestlings being underweight from malnourishment and parasite infestation. This further suggests that nestling fledging success could be dependent on different factors (e.g., malnourishment, ambient temperature, ectoparasite abundance) interacting together (Powlesland 1977).

Although adult hen fleas were the only hematophagous ectoparasite present in the nests, Carnid fly pupae were also abundant, which suggests that adult *Carnus* had been present in the nests despite no adults being collected. Female carnid flies lay eggs in the nest; these eggs eclose into larvae which then feed on dead organic matter in the nest (Liker et al. 2001). The larvae then emerge into pupae which overwinter in the nest material (Roulin 1998) and are usually inactive. They are not considered as ectoparasites as this stage of life. The timing of these pupae emerging as adults is synchronized with the hatching of the nestlings (Liker et al. 2001). The *Carnus* flies are initially winged as adults (Grimaldi 1997; Roulin 1998) but lose their wings when they find a suitable host (a nestling) (Papp 1998; Grimaldi 1997). Once nestlings develop feathers, the adult flies disappear off the host or in some cases, die (Liker et al. 2001) which could account for why adult flies were not found in the nest material.

With regards to blowfly pupae found in the nest, adult blowflies lay eggs in the nest material and the eggs hatch within 24-48 hours (Sabrosky et al. 1989). The larvae feed on the blood of the nestlings and hence are considered parasitic (Wittmann and Beason 1991). They grow to about 15mm in length and pupate (Wittmann and Beason 1991; Sabrosky et al. 1989). However, blowfly pupae are not parasitic and as only two pupae were found in the nest material, it could be that the larvae were not abundant in the nest to affect the nestlings.

Arthropods not classified as ectoparasites were also found in the nest, with carpenter ants (Formicidae: *Camponotus herculeanus*) being the dominant species present across nest boxes (Table 3). Beetles (Order: Coleoptera), belonging to the Family *Carabidae* (ground beetle), *Dermestidae* (skin beetle), *Elateridae* (click beetle) and

Staphilinidae (rove beetles) were also present in the nest boxes. These arthropods have rarely been reported in European starling nests (Feare 1984) and are not considered to be ectoparasites. Furthermore, they may have been serving different roles in the nest. For example, beetle larvae serve as food for the nestlings and were probably brought in by the parents. Adult beetles also feed on other invertebrates such as ants as well as small flowers and leaves in the nest. Although carpenter ants are not known to be ectoparasites, they can cause discomfort and disturbance to the nestlings through their biting and stinging behaviour.

Ectoparasite abundance and feathers in the nest

Feathers present in the nest did not prevent ectoparasites from living in the nest, although ectoparasite abundance was low. This result supports those found by Lombardo et al. (1995) and Stephenson et al. (2009) where no relationship was found between the number of feathers and ectoparasite abundance in the nests of Tree Swallows. In my study, the nests at the two extremes of feather mass (5.7 vs. 13.3 g) had ectoparasites. This finding suggests that feathers may not act as an ectoparasite barrier and may instead be present in the nests to serve as insulation (Pryor and Casto 2017; Mainwaring et al. 2016; Stephenson et al. 2009). In addition, feathers in the nest may play a role in courtship. The courtship hypothesis (Mainwaring et al. 2016; Gwinner et al. 2000; Gwinner 1997; Fauth et al. 1991) suggests that males carry feathers into the nest as decoration, when a female is watching, and they usually do this to attract the female to pair with them.

Cigarette butts, green vegetation and ectoparasite abundance

European starlings on my study site did incorporate cigarette butts into their nests. However, they were few; only four cigarette butts (2:1:1) were found in three different nests, and these nests still had ectoparasites within them. This suggests that cigarette butts may have not been enough to influence ectoparasite abundance.

Numerous studies have also tested for the effects that green vegetation might have on ectoparasite abundance (Gwinner et al. 200; Dawson 2004; Wimberger 1984; Clark and Mason 1988; Milton and Dean 1998; Rodgers et al. 1988; Sengupta 1981). Starling males are known to incorporate fresh vegetation (e.g., tree leaves and pine needles, cedar, herbs, and grasses) in the nest. Gwinner (1997) suggested that male European starlings exhibit this behaviour for courtship purposes as vegetation can potentially attract a female. Moreover, the green vegetation contains volatile compounds which may have insecticidal properties that repel ectoparasites (Dawson 2004; Gwinner et al. 2000). Therefore, vegetation may have played a role in improving the body condition of the nestlings in my study by repelling ectoparasites and reducing their numbers in the nest. But since I did not quantify the amount of greenery nor test the effects that the greenery has on nest-dwelling ectoparasites, I cannot comment on this. In addition, the effects of green vegetation on ectoparasite abundance in the nest is quite difficult to determine as there might be other materials (e.g., feathers, cigarette butts) and environmental factors (e.g., ambient temperature) (Merino and Potti 1996) present that could be influencing ectoparasite numbers.

CONCLUSION

To summarize, nest-dwelling hematophagous ectoparasites did not affect nestling condition or fledging success in this population of European starlings, although ectoparasite abundance was low. Feathers and cigarette butts incorporated into nests also did not appear to deter ectoparasites from being present in the nest.

FUTURE RESEARCH

Future studies should examine the effects that ectoparasites at different intensities have on nestlings and determine why adults incorporate so many feathers into their nest. Future research should also take into consideration the amount of greenery in the nest material to determine whether greenery does play a role in reducing ectoparasite abundance.

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