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Alternative nest-building behavior of the Long-legged Buzzard (*Buteo rufinus*) and the Short-toed Eagle (*Circaetus gallicus*) in the Judean Foothills, and the parasitic and non-parasitic arthropod fauna in their nests

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ABSTRACT

One of the most common explanations of the alternative nest-building behavior in raptors' population is the "Ectoparasite-avoidance" hypothesis, which claims that switching to alternative nests each year reduces nests' parasites that could decrease their breeding success. Our aim was to investigate this hypothesis concerning the Judean Long-legged Buzzard (*Buteo rufinus*) and Short-toed Eagle (*Circaetus gallicus*) population, in Israel. Furthermore, we also investigated whether any specific parasites for each of these raptors' species actually exist.

Thirty-one nests of Long-legged Buzzards (LLB) and 61 nests of Short-toed Eagles (STE) were located and systematically examined during the period of February-September 2011, in an area of 450 km^2 in the Judean Foothills, Israel. Nest material samples were collected from the center of the nest of 26 LLB and 45 STE nests. Four specimens of the Mallophaga *Laemobothrion maximum* were isolated from three nests of LLB and one male of *Degeeriella leucopleura* from a nest of STE. In addition, a hard tick larva (*Rhipicephalus sp*.), an argasid nymph (*Argas sp*.) and six specimens of dermanyssid mites were isolated from nests of STE. In 82.1% of the LLB nests, Coleoptera larvae and/or adults were found, most of them

belonging to the families Scarabaeidae, Buprestidae, Elateridae and Dermestidae. In 89.8% of the STE nests, Coleoptera larvae and/or adults were found, most of them belonging to the families Buprestidae, Tenebrionidae, Curculionidae, Dermestidae, Elateridae, Coccinellidae and Chrysomelidae. The vast majority of the isolated beetles were damaged and in more or less small pieces. In addition, few specimens of silverfish (Lepismatidae), book lice (Psocidae), ants (Formicidae) and true flies (Muscidae), as well as spiders (Araneae), scorpions (Scorpionida) and pseudoscorpions (Pseudoscorpionida) were isolated from the nests of both species.
Although nest parasites were actually found, in significant small numbers, we cannot support the "ectoparasite-avoidance" hypothesis in our study system. Furthermore, no species specific ectoparasites for either LLB or STE were found.

KEY WORDS**:** Long-legged Buzzard, *Buteo rufinus*, Short-toed Eagle, *Circaetus gallicus*, alternative nest, parasites, arthropods, Israel.

INTRODUCTION

The Long-legged Buzzard (*Buteo rufinus* (Cretzschmar) (hereafter LLB) is a medium size raptor that nests in the southern Palearctic region and is not well studied (Vatev, 1987; Alivizatos and Goutner, 1997, 1998; Khaeghizadeh *et al*., 2005; Wu *et al*. 2008; Boyan, 2009; Wu, 2011). LLB is known to nest on cliffs (Frumkin, 1986; Vatev, 1987; Alivizatos *et al*., 1998; Mullarney *et al*., 1999; Wu *et al*. 2008) and only occasionally in trees (Cramp and Simmons, 1980; Paz, 1986; Shirihai, 1996). Nowadays, its nesting preference in its historical rocky areas of the Judean Mountains has substantially decreased, with many pairs of LLBs nesting now in a whole new area, i.e., the Judean Foothills, but in trees rather than on cliffs (Friedemann *et al*. 2011), as opposed to common literature (Cramp & Simmons, 1980; Frumkin, 1986; Paz, 1986; Vatev, 1987; Shirihai, 1996; Alivizatos, 1998; Mullarney *et al*., 1999).

A local large size raptor, which nests in the Judean Foothills is the Short-toed Eagle (*Circaetus gallicus* (Gmelin, 1788) (hereafter STE), which adopted this habitat as its main historical nesting area in Israel. This eagle builds its nests in a variety of trees, e.g., Aleppo and Stone pines (*Pinus halepensis* (Miler) and *Pinus pinea* L., respectively), Funeral cypresses (*Cupressus sempervirens* (L.)), Carobs (*Ceratonia siliqua* (L.)), Tamarisk (*Tamarix aphylla* (L.)), Christ's-thorn jujube (*Ziziphus spina-christi* (L.)), Palestinian terebinth (*Pistacia palaestina* (Boiss)) and Common oak (*Quercus calliprinos* (Webb)) all commonly used as nesting sites. These eagles invest a great amount of time and energy in building their relatively large nests. Throughout the territories of the Judean Foothills, the majority of the LLB and STE populations tend to occupy a different nest each year; hence they maintain several alternative nests in their territories. These alternative nests can be built on a different tree in the pairs' territory, which can range in distance of 30m-4,150m from the former nest.

Nesting in several alternative nests each year is a well known phenomenon in raptor ecology (Newton, 1979; Margalida *et al*., 2003; Ontiveros *et al*., 2008), and the LLB and STE fit into this pattern.

One of the possible explanations for this behavior is based on the “Ectoparasite-avoidance” hypothesis, which assumes that the use of different nests each year is a mechanism that helps these raptors avoid ectoparasites that remain in the nest during the breeding off season and can cause damage and even mortality to the nestlings in the next breeding season (Wimberger, 1984) and thus significantly influence their breeding success.

Ectoparasites could significantly influence the health of their avian host and accordingly decrease their breeding success (Newton, 1979; Oppliger, 1994; Harriman and Alisauskas, 2010). This could happen from the bites of blood sucking arthropods such as insects, mites and ticks, which can cause a strong pruritus. In addition, infested animals could spend significant amounts of time and energy in scratching and grooming themselves. Both pruritus and scratching can damage the skin of the animal, which could lead to secondary infections. A large number of blood sucking parasites could also cause anemia, while some insects and ticks are vectors of viral, bacterial, fungal, helminthic and protozoan parasites, which again could have a negative effect to the health of the infested animals (Soulsby, 1982). In addition, some permanent ectoparasites such as Mallophaga (chewing lice) could be present in large numbers, especially in young birds, feeding on epidermal cells and feathers and may consume blood by puncturing soft quills near the bases and gnawing through the covering layers of the skin itself. These lice could cause nestlings mortality by damaging their feathers (Franc, 1994).

Adding “green material” as plant leaves to their nesting material (Wimberger, 1984), or building nests in the upper parts of trees, where they are strongly exposed to sun (Kristofik *et al*. 2009), could have a repellent activity and diminish nest ectoparasites. Other options are (a) to inhabit a nest of other species, which are effective groomers and accordingly keep low numbers of ectoparasites, (b) to inhabit a nest of a species which left behind their specific parasites which could not infest the new inhabitants, and (c) to inhabit an existing nest which was not used for several seasons, as the majority of parasites would not survive long periods of starvation (Wimberger, 1984; Gallizzi *et al*. 2008).

Nevertheless, LLB tends to “steal” STE nests from former breeding seasons. Using nests of other birds could also have the advantage of not getting exposed to parasites, which are specific only to the other bird species.

To the best of our knowledge, a thorough analyzes of the internal nest material of the LLB and STE has never been done before. Yet, the reason for the alternative nest switching behavior of these raptors is critical to better understand those steps that should be taken for their conservation, since raptor population size is limited by the available territories and nesting sites (Newton, 1979).

The permanent ectoparasites such as chewing lice (Mallophaga) and feather mites could not be examined on the wild bird itself without causing any damage to its health or to its breeding behavior, therefore, it was decided to analyze the internal parts of the nests as an alternative to examining the bird. A comprehensive nest analysis could show whether the alternative nest switching behavior derives from the "Ectoparasite-avoidance" hypothesis, and whether specific parasites exist in the nests of each of these two raptor species.

The aim of this study was to examine the ectoparasite fauna and the fauna of free-living arthropods in the nests of LLB and STE, and by doing so to address two main questions: 1) whether ectoparasites play a role in the nest switching behavior of LLB; 2) due to the fact that the majority of the LLB population changes their nesting sites each year and at the same time also steals STE nests from former breeding seasons, it is questioned, whether there are specific parasites for each of the examined raptors.

MATERIALS AND METHODS

Examined nests

Samples were collected from the center of 26 LLB nests and 45 STE nests, due to the absence of proper nest material in the rest of the 21 nests found in this area. The nests were located mainly on the trees or large bushes, usually in sunny and exposed areas of the plant and localized in the vicinity of 56 agricultural settlements in the Judean Foothills, Israel.

Details regarding the age of the nest, degree of sun exposure and the species of the raptor, which inhabited this nest during the year (s), were noted. During the study period, each nest was visited and monitored at least twice throughout the breeding season.

The nests were examined twice: during the chick-rearing period (~30 days after hatching) and again two weeks after fledging. Out of the 71 examined nests, 13.2% of them were built the same year, 25% a year earlier, 7.4% two years earlier, and 54.4% three years earlier or more.

Out of 71 nests, 19.1% were inhabited only by LLB, 66.1% only by STE and 14.8% by both species.

Examination of the nests

The central part of these nests was mainly composed from thin branches, green leaves, pine needles, feathers, fecal material, and in the case of LLB nests some contained even plastic material. Samples were collected in plastic bags and brought to the laboratory. Later, the very large pieces were removed by hand, and the remaining material was sieved with a 5 mm mesh sieve. One to 2 g of this material was conserved at 5-6ºC until examination.

Examination of the nest material

The nesting material was placed in 100 ml of 70% ethyl alcohol and after thorough shaking by hand, 25 ml of it was transferred to a Petri dish with a diameter of 9 cm, the bottom of which was marked with lines, subdividing the dish in 12 strips. The strips were screened under a stereo microscope (Nikon, SMZ 645); isolated mites and ticks were embedded in Hoyer's solution and identified under light microscope (Motic BA310), while the remaining arthropods were identified under the stereo microscope.

RESULTS

Regarding ectoparasites, three females and one nymph of the Mallophaga *Laemobothrion maximum* (Scopoli) were isolated from three different nests of LLB and one male of *Degeeriella leucopleura* (Nitzsch) from one nest of STE.

In addition, a hard tick larva (*Rhipicephalus sp*.) and a soft tick nymph (*Argas sp*.) were isolated from two different nests of STE, while 6 specimens of dermanyssid mites were isolated from two additional nests of STE.

Coleoptera larvae and/or adults were found in 82.1% of the LLB nests and 89.8% of the STE nests (Table 1). Specimens of the Buprestidae, Dermestidae and Elateridae families were found both in LLB and STE nests, specimens of the Scarabaeidae only

Table 1
List of arthropods found in 26 Long-legged Buzzard nests and 45 Short-toed Eagles nests, found in the Judean Foothills.

Order	Family	Species	LLB	STE
Coleoptera	Scarabaeidae	*Onthophagus* sp.	+	
		Oxythyrea sp.	+	
	Buprestidae	*Sphenoptera* sp.	+	+
		Perotis chlorana (Laporte de Castelnau and Gory)	-	+
		Acmaeodera sp.	-	+
		Coniocleonus nigrosuturatus (Goeze)	-	+
	Dermestidae	*Anthrenus (Anthrenus) pimpinellae* (Fabricius)	+	+
		Dermestes sp.	+	+
	Tenebrionidae	*Tenebrio* sp.	-	+
	Elateridae	*Lacon candezei* (Desbrochers des Loges)	+	+
	Coccinellidae	*Scymnus* sp.	-	+
	Chrysomelidae	*Psylliodes* sp.	-	+
Thysanura	Lepismatidae		+	+
Psocoptera			+	+
Hymenoptera	Formicidae		+	+
Diptera	Muscidae		+	+
Araneae			+	+
Scorpiones			+	+
Pseudoscorpionida			+	+

in LLB nests and specimens of the Tenebrionidae, Coccinellidae and Chrysomelidae families only in STE nests. The vast majority of the isolated beetles were damaged and found in small pieces. The only exception was the larvae and adults of *Anthrenus (Anthrenus) pimpinellae* (Fabricius), which were found intact.

In addition, few specimens of silverfish (Lepismatidae), book lice (Psocidae), ants (Formicidae) and true flies (Muscidae), as well as spiders (Araneae), scorpions (Scorpionida) and pseudoscorpions (Pseudoscorpionida) were isolated from the nests of both species.

Out of 31 LLB pairs examined in 2011, 22.5% nested in a previous STE nest. Furthermore, only 29% of the LLB pairs nested in the same nest they inhabited in 2010.

The majority of the LLB and STE nests were built on the treetops south-facing, so that the nestlings were left exposed to the sun's heat, high temperatures and heat load. The daily mean sun exposure was 57.4% ± 4.7 (n=31) at the LLBs' nests sites and 72.75% ± 2.82 (n=61) at the STEs' nests sites.

During the entire breeding season these raptor pairs upholster their nest with fresh "green material" such as Aleppo and Stone Pines, Carobs, and Eucalyptus leafs.

DISCUSSION

In the present study, out of 31 LLB pairs examined in 2011, 22.5% nested in a previous STE nest. Furthermore, only 29% of the LLB pairs nested in the same nest, which they inhabited in 2010, suggesting that nest substitution is significantly important for this species.

In a previous study it was found that out of 32 nests of LLB examined 34% did return to the nest of the previous year, while 66% nested in a different nest. Out of 43 LLB pairs examined in 2007/2008, 32.6% nested in former STE nest, showing that the majority of LLB pairs change their nests every year. It was also observed that 25 out of 52 LLB pairs (48.1%) built their nest on tree tops where the nest were strongly exposed to sun (Friedemann, *et al*., 2009).

During the same study, 21 nestlings were found dead, three of which were heavily infested with parasites; one with the protozoan *Trichomonas gallinae* (Rivolta*)*, a second one was heavily infested with lice and ticks, while the third one with fly maggots. However, none of these ectoparasites were further identified.

In a study conducted at the coastal region of Israel, 210 cattle egret (*Bubulcus ibis* (L.)) nests from six colonies (each with 25-40 nests) were examined for ectoparasites and the cattle egret argas (*Argas arboreus* Kaiser, Hoogstraal and Kohls) was collected from all six colonies. Approximately 10,500 specimens of this species were collected, while up to 4,040 specimens were collected from a single colony (Mumcuoglu, *et al*. 2005). These results show that a heavy burden of ectoparasites can exist in the nest of wild birds, which could significantly influence their physiology and behavior.

In the present study, one male of *D. leucopleura* was isolated from a nest of LLB and four specimens of *L. maximum* were found in other LLB nests.

Earlier, *D. leucopleura* was described from STE examined in Spain (Perez *et al*., 1996), while additional louse species such as *Craspedorrhynchus triangularis* (Rudow) and *Falcolipeurus quadripustulatus* (Burmeister) were also found on STE (Clay, 1958).

In Israel, Theodor and Costa (1967) identified four louse species isolated from *B. rufinus*: *Craspedorrhynchus platystomus* (Burmeister), *Degeeriella fulva* (Giebel), *L. maximum* and *Kurodaia fulvofasciata* (Piage), while in Turkey, *L. maximum*, *D. fulva, C. platystomus,* and *Colpocephalum nanum* (Piaget) were identified on LLB specimens in captivity (Dik, 2006; Dik and Ozkayhan, 2007; Inci *et al*. 2010). In addition, *Colpocephalus turbinatum* (Denny) was isolated from LLB specimens (Price *et al*., 2003).

Although the examined two raptor species were found to be infested with parasites that can negatively influence their breeding success, in this present study, no significant numbers of temporary ectoparasites (nest parasites) such as fleas, bugs, dermanyssid mites or argasid ticks were actually found.

In addition, we can also claim that specific parasites for LLB and specific parasites for STE do not exist. Therefore, we can suggest that the "Ectoparasite-avoidance" hypothesis that can be explained for the alternative nest-building behavior in other raptor species, may not entirely fit to the Judean LLB and STE populations.

A possible explanation for this behavior could be the "Signal-function hypothesis" (Newton, 1979) in which raptors use several nests in their territories, placed in the tree crowns and use fresh greenery during the entire breeding season in order to "signal" their nesting territory from intra-specific and inter-specific competitors. Furthermore, one can also explain that the STE nest stealing by the LLBs derives from the will of these buzzards to decrease the possible resource competition (Margalida, 2003) between both species. But, these possible explanations won't be discussed in this current study.

In the present study, neither the adults nor the nestlings were examined directly due to nature conservation issues. Accordingly, the few permanent ectoparasitic lice found in the nests, might not represent the real picture of parasites, which could be found on the birds, but it can be a suitable platform for evaluating the nest situation.

The large number of Coleoptera, which were found heavily damaged within the nests, could be explained that they originated from the intestinal tract of rodents and reptiles, which are used as food and later expelled as a pellet by the two raptors examined.

A. (A.) pimpinellae, which was found mainly as intact larvae and adults in the nests of both bird species, is most probably the only beetle, which lives inside the bird nests and are nourished from the proteinaceus material existing with the nests.

The small number of other arthropods found with the nests could be accidentally introduced specimens.

To the best of our knowledge, the Mallophaga species *Laemobothrion maximum* was earlier reported from Israel on *Buteo buteo (L.), Gyps fulvus* (Hablizl) and *Milvus migrans* (Boddaert), while *Degeeriella leucopleura* was never reported from this country.

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