

Original Research Article

Nest-dwelling Mites of Selected Common Bird Species in Sri Lanka

ABSTRACT

Bird nests primarily function to protect and incubate eggs and nestlings. However, nests are also host to a broad diversity and abundance of arthropod associates, primarily mites (Acari). Our knowledge of nest dwelling mites of common bird species in Sri Lanka is quite limited and necessitates further study. Five different types of nests of common bird species in Sri Lanka in urban, suburban, wild, and captive populations were sampled opportunistically using a portable mini vacuum trap. A total of 1493 mites were collected from 180 nests. The mites belonging to order Mesostigmata had the highest abundance (58.6%) and prevalence (74.4%) of all mite orders collected, followed by the Sarcoptiformes (26.3%, 57.8%), Oribatida (14.8%, 40.6%) and Trombidiformes (0.3%, 2.2%). Mite diversity of host bird species was measured using the Shannon-Weiner diversity index (H'). Pycnonotuscafer nests had the highest diversity of mites. Cup-shaped nests were host to the highest average abundance value (13.4) of mites, while cavity nests had the lowest value (5.7). Nests from captive populations had the highest average abundance (24.6) of mites and the nests of suburban populations had the lowest value (7.2). These findings can be used as a baseline data set for further detailed research studies on nest-dwelling mites of birds, focusing on avifaunal conservation and the impact on human health by nest-dwelling ectoparasites, built-in human habitations in Sri Lanka.

Keywords: Nest-dwelling mites, Bird nests, Mesostigmata, Sarcoptiformes, Oribatida, Trombidiformes

1. INTRODUCTION

Bird nests are a microcosm for a diverse array of arthropods, ranging from free-living predators to obligate blood-feeding parasites including mites, fleas, lice and other insects. They are the key microhabitats where these nest-dwelling arthropods feed, live, hibernate and reproduce within the nest materials through their entire life span or a part of it (Cantarero *et al.*, 2013).

Mites are the most common and abundant of nest-dwelling arthropods (Peters., 1930). Mites are minute arthropods that belong to order Acarina of the class Arachnida, and they can be present in the nest materials before the chicks hatch and can feed on females in incubation. At least 2500 species of mites from 40 families are closely associated with birds, occupying all conceivable habitats on the bodies and nests of their hosts (Proctor & Owens, 2000). The symbiotic relationship between nest-dwelling mites and their avian hosts is variable, ranging from beneficial to quite detrimental.

Mostly studied genera of nest dwelling mites are *Dermanyssus* (Dermanyssidae) and *Ornithonyssus* (Macronyssidae) where both groups are obligatory hematophagous parasites (Proctor & Owens, 2000). Fowl mites belong to the genera Dermanyssidae and the adult fowl mites reach nests with host birds on their body or hatch in the nest (Sikes and Chamberlain 1954). Adults have the ability to overwinter in nest material, yet most of the individuals spend the entire lives on an adult host or nestlings (Sikes and Chamberlain 1954). Nymphal stages of the blood-feeding mites are mostly nest bound and they tend to visit the host when they need feeding (Rendell & Verbeek, 1996). These mite groups have short generation times, and it favors them to rapidly build up huge populations (Rendell & Verbeek, 1996).

There are several factors that affect the abundance of nest-dwelling mites, such as the type of nesting materials, micro-environment parameters of the nest, shape or structure, and nest reuse. Nest-dwelling mites are more numerous in boxes with aged nest materials than in boxes from which old nests have been removed (Rendell and Verbeek, 1996). The quantity of nest material in a cavity, reinfestation, and nest microclimate can affect the numbers of hematophagous parasites in boxes (Rendell and Verbeek, 1996). In a previous study states that old nest materials may contain and/or attract more ectoparasites than fresh material (Cantero *et al.*, 2013). Birds tend to assemble different types of nests using a diversity of nesting materials which are in a variety of habitats. These nests come in a wide variety of forms and structures ranging from simple scrapes on the ground, which lack any structural component, through to deep cups formed by a variety of materials woven to form the nest (Hansell, 2000). The colonial nesting habits of the cliff swallow, which builds a protective domed nest of mud, encourage parasite maintenance and transmission of ectoparasites (Loye, 1985).

Nest-dwelling mites can have a significant negative impact on their avian hosts as well as human hosts. The increased cost of anti-parasite defenses, loss of blood or other tissues, loss of food, secondary infection of bite wounds and transmission of micro-parasitic diseases are some of the ways that nest-dwelling ectoparasites negatively impact their hosts. These detrimental effects can have negative impacts on host fitness, including reduced growth or survival, delayed or reduced reproductive output. Nest-dwelling parasites can have a negative impact on unintended hosts. Nests are frequently built alongside human inhabited buildings, and when the birds abandon the nest the mites may move into these buildings through windows, doors, vents or attic spaces and bite the occupants. The bite can be irritating and for some individuals the bite may result in chronic itching and painful dermatitis. (Denmark & Cromory, 2012).

Since there are no previous information about the abundance and diversity of these nest-dwelling mites of common birds in Sri Lanka, we explored the diversity and abundance of nest-dwelling mites as a function of bird species, habitat demographic, nest type, and nesting material in common birds in Sri Lanka. Our findings in this study will create a baseline for future studies into nest-dwelling mites in Sri Lanka and also in the use of avian ecology, conservation and diseases of human caused by birds and zoonoses.

2. MATERIAL AND METHODS

Nest dwelling mites were sampled from March–November 2019 from five nest types (cup shaped, pendulum, platform, dome and cavity) of selected common bird species in Sri Lanka (Table 2).

Random nest sampling was done in urban, suburban, wild and captive populations. The sampling for urban nests was done in Colombo, Kalutara and Panadura. The suburban nests were sampled in Alubomulla, Arukgoda, and Bekkegama, village areas in Panadura and Bandaragama. Wild populations were sampled in Udawalawa National Park (NP), Maduruoya NP and Wilpattu NP. Captive nest sampling was done in the National Zoological gardens in Dehiwala, Sri Lanka.

Nests were sampled using an electric portable USB mini vacuum cleaner, which was modified with a cotton filter that was changed after each sample with a minimum disturbance and in a non-destructive manner. Nests were vacuumed for 3 minutes, and the cotton filter was removed after each nest and stored in 70% ethanol for later processing. The process of vacuuming of the nest was done for 3 minutes of time for each nest. Abandoned nests were collected into polyethylene zip-lock bags for subsequent extraction, and identifications. In the laboratory, arthropods were extracted from the cotton wool filter using a saltwater flotation method (Matis & Kiffe, 2005), and examined using a dissecting microscope. Mites were preserved in 70% ethanol. Mites were slide mounted using Hoyer's medium ringed with clear nail polish. Slides were examined using an OLYMPUS SZ51 dissecting microscope and OLYMPUS compound light microscope. The pencil diagrams and photographs of observed species were considered for the identification.

Mite identifications were done using species descriptions and keys when available. The identification of specimens was authenticated at Canadian National Collection of Insects, Arachnids and Nematodes. Shannon-Weiner diversity indices were calculated with respect to nest dwelling mites in each nest of a given bird species (Gannon and Willig, 1995). To determine the significant difference, ANOVA: Single factor test was done using MS Excel.

3. RESULTS AND DISCUSSION

During March – November 2019, 180 nests were sampled: cup-shaped 44, pendulum 28, platform 43, dome 30 and cavity 35. In total, 1493 nest dwelling mites were collected.

3.1 Diversity, Abundance and Prevalence of nest-dwelling mites

The collection of mites were represented by two super orders (Parasitiformes and Acariformes). Under Parasitiformes order Mesostigmata mites had the highest abundance. Super order Acariformes were represented by order Sarcoptiformes, Trombidiformes and Oribatida. Mesostigmatic mites depicted a diversity of *Ornithonyssus bursa*, *O. sylvarium*, *Pellonyssus spp.* and *Androlaelaps spp.* Trombidiformes mites were belonged to genus *Bdellid* and Sarcoptiformes mites represented by family Aeroglyphidae. Rest of the Acariformes mites were belonged to order Oribatida (Table 1, Figure 1).

Table 1: Nest-dwelling mite diversity

Class	Subclass	Super order	Order	Family	Genus	Species
Arachnida	Acari	Parasitiformes	Mesostigmata	Macronyssidae	<i>Ornithonyssus</i>	<i>Ornithonyssus bursa</i>
						<i>Ornithonyssus sylvarium</i>
					<i>Pellonyssus</i>	<i>Pellonyssus spp.</i>
				Laelapidae	<i>Andropaelaps</i>	<i>Andropaelaps sp.</i>
		Acariformes	Trombidiformes	Bdellidae	<i>Bdellid</i>	<i>Bdellid sp.</i>
			Sarcoptiformes	Aeroglyphidae		
			Oribatida			

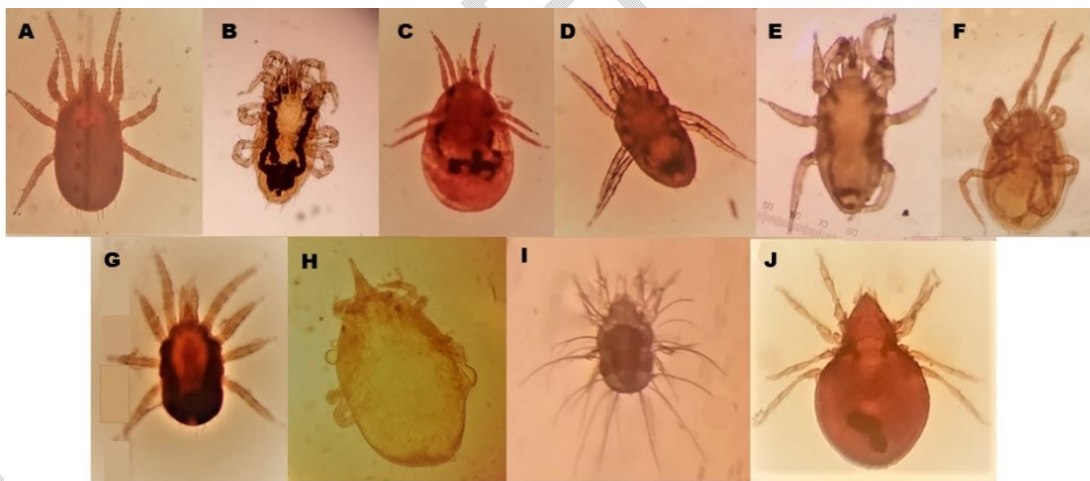


Figure 1: Nest-dwelling mites collected in Sri Lanka: (A) *Ornithonyssus bursa* (B) *Ornithonyssus sylvarium* (C) *Pellonyssus spp.* (D), (E) & (G) Mesostigmata (Unidentified) (F) Laelapidae (H) Bdellidae (I) Aeroglyphidae spp. (J) Oribatida

The mites belong to order Mesostigmata had the highest abundance (58.6%) of all mite orders collected, followed by the Sarcoptiformes (26.3%), Oribatida (14.8%) and Trombidiformes (0.3%). Highest mite prevalence was also depicted by Mesostigmatic mites and the value was followed by sarcoptiformes, Oribatida and Trombidiformes.

According to the resulted abundance and prevalence of the mite collection, highest abundance (58.6%) and prevalence (74.4%) were represented by order Mesostigmata. They are generally commensals, phoretic, and symbionts, as well as obligate blood-feeding ectoparasites of mammals and birds (Mansanet *et al.*, 2014). The most frequently encountered

mesostigatics in bird nests are obligate hematophagous species in the Dermanyssidae and Macronyssidae (Proctor & Owens, 2000). Our collection was included with family Macronyssidae and Laelapidae as mesostigmatic mites.

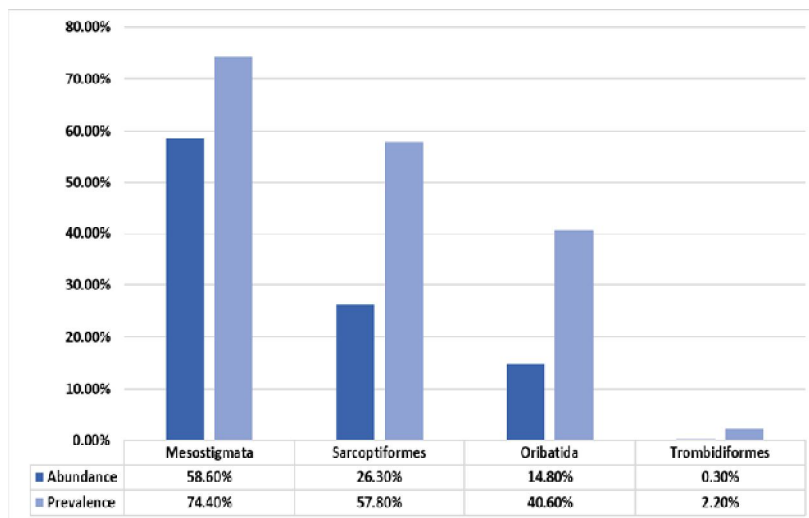


Figure 2: Abundance and prevalence of nest-dwelling mite orders

Mostly, Macronyssidae mites are also obligate parasites of vertebrates (Mullen and OConnor, 2019) and associated with wild and domestic birds (Phillis, *et al.*, 1976). Occasionally in the absence of an avian host hungry mites may attack human as well (Phillis, *et al.*, 1976). In this study, two parasitic Macronyssidae mite species *Ornithonyssus bursa* (Tropical fowl mite) and *O. sylvarum* (Northern fowl mite) were identified. *O. sylvarum* is a common ectoparasite of wild and domestic birds (Garvin *et al.*, 2004). This blood-feeding mite has been broadly collected from most of the birds in temperate region (Knee and Proctor., 2007). It is a cold tolerant species which is distributed mainly in the north temperate zone (Mansanet *al.*, 2014) reported from at least 72 species of birds in North America alone (Knee and Proctor 2007, Fenda&Schniererová, 2004). For the first time our study reveals the presence of this mite species in Sri Lanka, a country belongs to tropical zone of the world. Both *Ornithonyssus* species recognized as a pest to people where the roosts of birds present near homes and office buildings, due to the nesting birds where the mites in the nests crawl into the buildings (Phillis, *et al.*, 1976). Reduced weight and reduced growth rate of fledglings (Powlesland., 1977) can be caused by these mites when they are heavily infested the nests. They also cause prolonged itching and painful dermatitis for some people due to their irritable bites and there are several reports that these tropical mites tend to invade homes (Phillis, *et al.*, 1976).

Pellonyssus is another genus we came across in our mite collection under family Macronyssidae and according to Radovsky (2010) this genus contains 13 valid species, all parasites of birds, and widely distributed mainly in warmer latitudes. One previous study (Szabó *et al.*, 2002) suggest that the genus *Pellonyssus* has an association with the increased stress level, acute inflammation, and fitness consequences of sparrow fledglings, yet no direct detrimental consequence on survival and growth of sparrow chicks.

Family Laelapidae was represented by the genera *Androlaelaps*. This family comprises nearly 146 genera and 1520 species that have a higher variety of mites and they are usually free-living or associated with arthropods, mammals, or birds (Lindquist *et al.*, 2009) According to the previous taxonomic studies, these mites are distributed in Palearctic, Nearctic, Australian, Neotropical and Oriental regions of the world (Moreira and Moraes., 2015). They are more like predators of other mites and arthropod associates while being found in nesting materials of birds like starlings (Moreira and Moraes., 2015). The only genus which were present in our collection *Androlaelaps* is known to be ectoparasites of birds but there are no direct evidence of them being hematophagous when they are exposed to bird hatchlings (Moreira and Moraes., 2015). Therefore, it can be assumed that these mites are present in nesting materials as it provides a good place for predation on other mites and arthropod associates since Laelapids are generally predators.

Order Sarcoptiformes was second most abundant (26.3%) and prevalent (57.8%) mites in the cohort and represented family Aeroglyphidae mites. They are commonly known as dust mites or storage mites which studies have identified as mostly occurred in stored hay, grain, straw, the dust of grain and hay at storage (Resh and Carde, 2009). It can be

assumed that bird nests are harboured by these dust mites due to incorporation of green and dry plant materials where they can inhabit. Dust mites which are relative to the human association, feed on the dermal detritus and crawl down into the nest material (Proctor & Owens, 2000).

Order Oribatida was the third most abundant (14.8%) and prevalent (40.6%) mite group. They are generally known as beetle mites and the diversity of Oribatid mite species is large in soils from many different localities that can be also found in grasslands and hardwood forests in high numbers (Wehner *et al.*, 2018). Oribatids tend to feed on higher plant materials which make them microphagous, sometimes they strictly feed on microflora (microphytophages) and also can be fed on all kinds of plant and fungal tissues (Siepel, & Dijkman, 1993). Bird nests are microecosystems, which provide a habitat to many different microflora and that may be a reason for the presence of Oribatid mites in the nests as they are microphagous mites according to the evidence. Oribatid mites also serve as intermediate hosts for about 27 species of tapeworms in the family Anoplocephalidae (Mullen and O'Connor, 2019). Though there are lots of information on soil dwelling Oribatids the nest dwelling Oribatid mites are scarcely described and our study reveals the presence of oribatid mites in bird nests.

Family Trombidiformes mites were represented by a single family, Bdellidae and genus *Bdellid* in Sri Lankan bird nests. The abundance and prevalence of trombidiformes was 0.3% and 2.2% in order representing the lowest abundance and prevalence to other orders of mites in the collection. Some of the Trombidiformes mites tend to feed on living plant tissues which possibly invade bird nests due to the incorporation of plant materials by host bird nests (O'Connor, 2009). Particularly mites of family Bdellidae are known as snout mites that show a predatory lifestyle in the inhabited soil, intertidal rocks, leaves and leaf litter (Hernandes, *et al.*, 2016).

3.1.1 Shannon-Wiener diversity index

Shannon-Wiener diversity index (H') and the evenness (E) were used to characterize the diversity of nest-dwelling species. *Pycnonotuscafer* nests had the highest diversity (1.936) of nest associates with an evenness of 0.8407 while *Nectariniazeylonica* had the lowest diversity (0.163) of nest associates with an evenness of 0.2352 (Table 2) from 18 bird species.

Pycnonotuscafer is a common resident bird and distributed all over the country. They have evolved mostly to build their nests on bushes and small tree human habitations (Manju and Sharma, 2013). According to the observation of this study, it is a bird that is highly evolved to build up their nests in home gardens and also on the structures such as lampshades and elevated structures inside the houses. The selection of new nesting sites probably indicates its behavioral adaptations with human habitations (Manju and Sharma, 2013). As this bird species shows the highest diversity of nest-dwelling mites, it represents the hematophagous mites such as *Ornythonyssus bursa* and *O. sylvarium* under order Mesostigmata and they can cause negative health impacts to people around the nesting sites such as irritable bites, prolong itching and skin dermatitis.

Table 2: Diversity and evenness of nest-dwelling mites in the nests of selected bird species

Bird order	Bird species	H'	E
Columbiformes	<i>Columba livia</i>	1.08	0.99
	<i>C. liviademestica</i>	0.91	0.83
	<i>Geopeliacuneate</i>	1.52	0.95
	<i>Spilopeliachinensis</i>	1.90	0.85
	<i>Streptopeliadecaecto</i>	1.83	0.94
	Passeriformes	<i>Chrysommasinense</i>	1.56
<i>Dicaeumsp.</i>		0.51	0.74
<i>Hirundorustica</i>		0.66	0.95
<i>Lonchurastrata</i>		1.18	0.73
<i>L.malabarica</i>		1.20	0.74
<i>L. punctulata</i>		1.36	0.85
<i>Nectariniaasiatica</i>		0.42	0.30
<i>N. zeylonica</i>		0.16	0.24

Psittaciformes	<i>Ploceusphilippinus</i>	0.51	0.32
	<i>Pycnonotuscafer</i>	1.94	0.84
	<i>Agapornissp.</i>	0.47	0.68
	<i>Melopsittacus undulates</i>	1.55	0.96
	<i>Psittaculakrameri</i>	0.68	0.98

3.2 Comparison of mite abundance in five types of nests

In relation to the total number of nest-dwelling mites collected from each nest type, average abundance of nest parasites in a particular nest type were calculated using ANOVA: Single factor test. A significant difference of average abundance value of nest-dwelling mites was resulted between the five different nest types of birds (cup, dome, pendulum, platform, cavity). Cup nests had the highest average abundance value (13.4), while cavity nests show the lowest average abundance (5.7) compared to all five types of nests.

Generally, evidences from previous studies are very poor to explain the reasons for the difference of mite abundance in different types of nests. The study of Rendell and Verbeek in 1996 finds that the quantity of nest material in a cavity, can affect the numbers of hematophagous parasites in boxes. By that we can assume the presence of material in a nest can increase the nest-dwelling mite abundance as well. Since we studied cavity nests of birds with very less amount of nesting materials compared to other nest types, it can be assumed that the lowest abundance of mites is due to very less amount of nesting materials in the cavities. When it comes to cup nests, they are always carefully made with different nesting materials mainly by different plant materials, using plant structures like twigs, leaves and vines. We assume that this structure of the cup nest gives a proper space to nest-dwellers such as mites to inhabit and thrive inside the nests. Cup nests are also open an easy to enter and leave by arthropods unlike other nest types. Though there is a noticeable influence of nest type of the bird on the abundance of mites in the nest, the phenomenon should be carefully studied to find solid evidences.

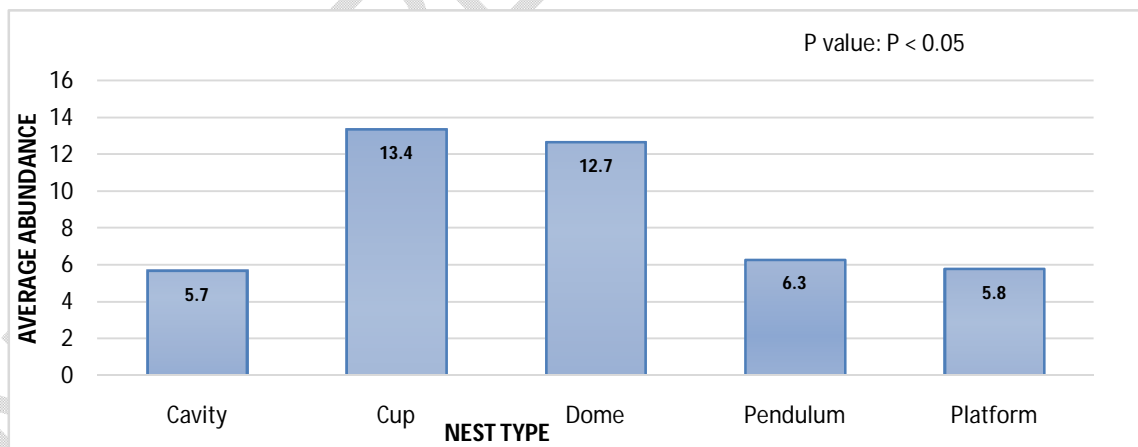


Figure 3: Distribution of nest associates in relation to nest type.

3.3 Comparison of mite abundance between urban, suburban, wild and captive nests

There was a significant difference between the average abundance values of urban, suburban, captive and wild nests. Captive nests had the highest average abundance, while suburban nests had the lowest value.

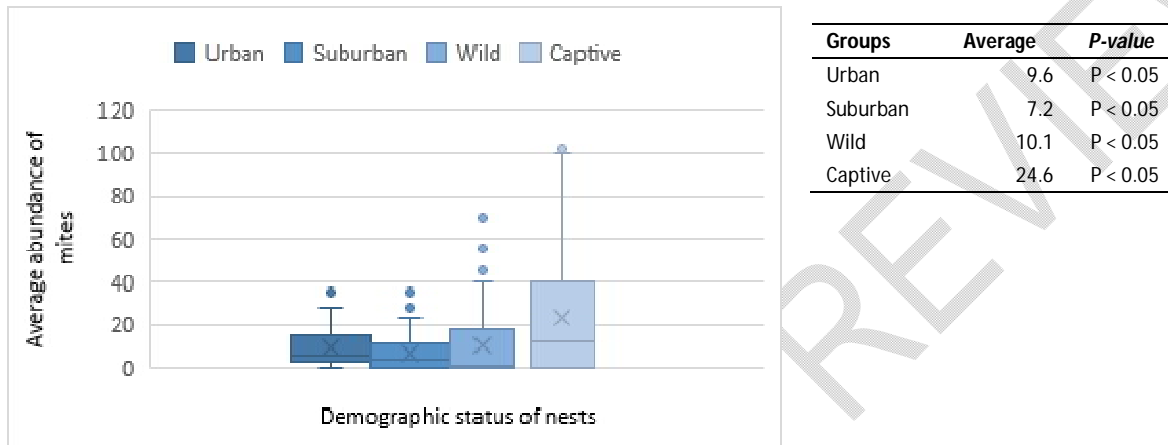


Figure 4: Average abundance of nest-dwelling mites Vs demographic status of the nests

Captive birds are more prone to parasites as compared to birds in other demographic conditions who leave unfavorable environment and naturally handle health challenges as compared to captive birds which might suffer consequences of poor and inadequate management protocols (Ombugaduet *al.*, 2018). Some of the mites in our findings are parasitic. Parasitic infections are among the most common sanitary problems affecting captive birds, especially in high density populations due to an increased risk of exposure (Ombugaduet *al.*, 2018). Parasitic diseases often represent a major concern in zoo animals due to the poor maintenance of confined cages leading to high level of environmental contamination as well as a possible zoonotic potential (Citino., 2003). Sanitation and cleanliness are the keys to ectoparasite control in captive birds. Sanitation includes cleaning and disinfecting bird cages, facilities and equipment. Eliminating the contact between flocks and wild birds can reduce the potential transfer of external parasitic mites (Ombugadu et al., 2018). Since the life cycle of lice and mites is approximately 2 weeks, treatments should be repeated every two weeks as needed (Clayton *et al.*, 2010).

3.4 Overview of nesting material selection by different bird species

It is important to give the attention for the nesting material incorporation by birds in their nests as nesting materials have an interesting relation between the presence of mites and other ectoparasitic arthropods.

The materials that were present in the nests were categorized in a qualitative method in order to have an overview on material incorporation by host bird species. Most of the nests had dry plant materials except in cavity nesting birds *Psittaculakrameria* and *Melopsittacus undulates*, as well as in the *Columba liviadomestica* nests. Mud was only incorporated in *Hirundorustica* nests, and anthropogenic material (i.e. metals, nylon) were only present in *Columba livia* nests.

Table 3: Nesting material of common Sri Lankan birds (+ presence, - absence)

Bird species	Material	Dry plant material	Green plant material	Fecal matter	Feathers	Mud	Anthropogenic materials
Agapornis sp.		+	-	-	-	-	-

	Chrysommasinense	+	+	+	-	-	-
	Columba livia	+	-	+	+	-	+
	Columba liviademestica	-	-	+	+	-	-
	Dicaeum sp.	+	-	-	-	-	-
	Geopeliacuneata	+	-	-	-	-	-
	Hirundorustica	+	-	+	+	+	-
	Lonchuramalabarica	+	+	-	-	-	-
	Lonchurapunctulata	+	+	-	-	-	-
	Lonchurastrata	+	+	-	-	-	-
	Melopsittacusundulatus	-	-	+	-	-	-
	Nectariniaasiatica	+	+	-	-	-	-
	Nectariniazeylonica	+	+	-	-	-	-
	Ploceusphilippinus	+	-	-	-	-	-
The matter	Psittaculakrameri	-	-	-	-	-	-
	Pycnonotus cafer	+	+	-	-	-	-
	Spilopeliachinensis	+	-	-	-	-	-
	Streptopeliadecaecto	+	-	-	-	-	-

dry was

represented by dry plant twigs which were both fine and thick, sticks, dry leaves, and dry vines. The incorporation of green plant matter was only seen in few species of birds. In the urban nests of *Pycnonotuscafer* and *Chrysommasinense* had green plant matter such as the vines with leaves of *Desmodium sp.* and leaves of *Murraya sp.* There are evidence for green plant material incorporation by *Pycnonotuscafer* that the parent pair used fine twigs of herbs and grasses for building nest. The plants preferred for nest building included Zizipus, Hibiscus, Citrus, Acacia (Manju and Sharma, 2013). The observation of incorporation of green plant materials is supported by the evidences of previous studies that some birds include green plant materials or feathers in their nests which reduce the fitness of ectoparasites (Winkler 1993). It is suggested that birds use secondary chemicals contained in green plants to control ectoparasites (Fauth et al, 1991). In the study of Wimberger (1984) has been found green vegetation was significantly correlated with nest reuse in 49 species of Falconiformes. Fauth et al (1991) says that the majority of green nesting material is added before copulation and the behavior decreases dramatically upon egg-laying in European starlings. An alternative, but not mutually exclusive, explanation for the use of green nesting material is that it plays a role in mate selection or pair bonding (Fauth et al, 1991).

Some birds living in cities incorporate cigarette butts into their nests due to the substantial amounts of nicotine and other compounds that may also act as arthropod repellents, but the effect of this behavior remains unclear (Sua´rez-Rodri´guez et al, 2012). The amount of cellulose acetate from butts in nests of two widely distributed urban birds have been negatively associated with the number of nest-dwelling parasites (Sua´rez-Rodri´guez et al, 2012).

4. CONCLUSION

This a pioneer study which was explored to present the general information such as diversity, abundance and prevalence of nest dwelling mites in Sri Lankan bird nests. A total of 1493 mites were collected from 180 nests. The majority of resulted mite species were represented by order Mesostigmata (58.6%) with prevalence of 74.4% which was represented by *Ornythyonyssus bursa*, *O. sylvarium* and *Pellonyssus sp.* Mites. This values were followed by the Sarcoptiformes (26.3%, 57.8%), Oribatida (14.8%, 40.6%) and Trombidiformes (0.3%, 2.2%). Mite diversity of host bird species was measured using Shannon-Weiner diversity index (H'). *Pycnonotuscafer* nests had the highest diversity of mites. Cup-shaped nests were host to the highest mean infestation value (13.4) of mites, while cavity nests had the lowest value (5.7). Nests from captive populations had the highest abundance (24.6) of mites and the nests of suburban populations had the lowest abundance (7.2). The study gives an overview for the nesting material selection of selected bird species in Sri Lanka as well. These results can be used as a baseline data set for nest-dwelling mites in Sri Lanka. These data will be helpful to use for further detailed studies on the biodiversity conservational aspects in Avifaunal community and also the impact on human health by nest dwelling mites, built-in human habitations in Sri Lanka.

ETHICAL APPROVAL (WHERE EVER APPLICABLE)

Ethical clearance was obtained from the Institute of Biology, Sri Lanka (ERC IOBSL 188 02 19). Permission for bird nest sample collection was obtained from the Department of Wildlife Conservation (No. WL/3/2/62/19), subject to provisions of the Flora and Fauna Protection Ordinance (FFPO).

REFERENCES

- Cantarero, A., López-Arrabé, J., Rodríguez-García, V., González-Braojos, S., Redondo, A. J., & Moreno, J. (2013). Factors affecting the presence and abundance of generalist ectoparasites in nests of three sympatric hole-nesting bird species. *Acta Ornithologica*, 48(1), 39-54.
- Citino, S. B. (2003). Bovidae (except sheep and goat) and antilocapridae. In: Fowler, M. E. and Miller, R. E., editors. *Zoo & Wild Animal Medicine*. 5th ed. Saunders, W. B., Philadelphia, PA, 672 pp.
- Clayton, D. H., Koop, J. A. H., Harbison, C. W., Moyer, B. R. and Bush, S. E. (2010). How Birds Combat Ectoparasites. *The Open Ornithology Journal*, 3:41- 71.
- Denmark, H. A., & Cromroy, H. L. (2012). Tropical Fowl Mite, *Ornithonyssus bursa* (Berlese) (Arachnida: Acari: Macronyssidae). *Fact Sheet EENY*, 297.
- Fauth, P. T., Kremetz, D. G., & Hines, J. E. (1991). Ectoparasitism and the role of green nesting material in the European starling. *Oecologia*, 88(1), 22-29.
- Fendá, P., & Schmiererová, E. (2004). Mites (Acarina: Mesostigmata) in the nests of *Acrocephalus* spp. and in neighbouring reeds. *Biologia (Bratislava)*, 59(Suppl 15), 41-47.
- Garvin, M. C., Scheidler, L. C., Cantor, D. G., & Bell, K. E. (2004). Abundance and temporal distribution of *Ornithonyssus sylviarum* Canestrini and *Fanzago* (Acarina: Mesostigmata) in gray catbird (*Dumatellacarolinensis*) nests. *Journal of Vector Ecology*, 29, 62-65.
- Hansell, M. (2000). *Bird nests and construction behaviour*. Cambridge University Press.
- Hernandes, F. A., Skvarla, M. J., Fisher, J. R., Dowling, A. P., Ochoa, R., Ueckermann, E. A., & Bauchan, G. R. (2016). Catalogue of snout mites (Acariformes: Bdellidae) of the world. *Zootaxa*, 4152(1), 1-83.
- Knee, W., & Proctor, H. (2007). Host records for *Ornithonyssus sylviarum* (Mesostigmata: Macronyssidae) from birds of North America (Canada, United States, and Mexico). *Journal of Medical Entomology*, 44(4), 709-713.
- Knee, W. (2018). New species of parasitic nasal mites infesting birds in Manitoba, Canada (Mesostigmata, Rhinonyssidae). *ZooKeys*, (786), 1.
- Lindquist, E.E., Krantz, G.W. & Walter, D.E. (2009) Order Mesostigmata. In: Krantz, G.W. & Walter, D.E. (Eds.), *A Manual of Acarology* 3rd Edition. Texas Tech University Press, Lubbock, USA. pp. 124–232.
- Loye, J. E. (1985). The life history and ecology of the cliff swallow bug *Oeciacus vicarius* (Hemiptera: Cimicidae). *Cahiers ORSTOM. Série Entomologie Médicale et Parasitologie*, 23(2), 133-139.
- Manju, S. H. A. R. M. A., & Sharma, R. K. (2013). Breeding biology of red-vented bulbul (*Pycnonotus cafer*). *International Journal of Zoology and Research*, 3(5), 1-4.
- Mašán, P., Fendá, P., Krištofik, J., & Halliday, B. (2014). A review of the ectoparasitic mites (Acari: Dermansoidea) associated with birds and their nests in Slovakia, with notes on identification of some species. *Zootaxa*, 3893(1), 77-100.
- Matis, J. H., & Kiffe, T. R. (2005). Predicting the Africanized bee invasion. *Statistics. "A Guide to the Unknown, FITTING CUMULATIVE SIZE MECHANISTIC MODELS TO INSECT POPULATION DATA*, 1(5), 5.

- Moreira, G. F., & Moraes, G. J. D. (2015). The potential of free-living laelapid mites (Mesostigmata: Laelapidae) as biological control agents. In *Prospects for biological control of plant feeding mites and other harmful organisms* (pp. 77-102). Springer, Cham.
- Mullen, G. R., & O'Connor, B. M. (2019). Mites (Acari). In *Medical and veterinary entomology* (pp. 533-602). Academic Press.
- O'Connor, B. M. (2009). Astigmatid mites (Acari: Sarcoptiformes) of forensic interest. *Experimental and Applied Acarology*, 49(1), 125-133.
- Ombugadu, A., Echor, B., Jibril, A., Angbalaga, G., Lapang, M., & Micah, E. (2018). Impact of parasites in captive birds: a review. *Curr Res Environ Biodivers*, 2019(04), 1-12.
- Peters, H. S. (1930). Ectoparasites and bird-banding. *Bird-Banding*, 1(2), 51-60.
- Phillis, W. A., Cromroy, H. L., & Denmark, H. A. (1976). New host and distribution records for the mite genera *Dermanyssus*, *Ornithonyssus* and *Pellonyssus* (Acari: Mesostigmata: Laelapoidea) in Florida. *Florida Entomologist*, 89-92.
- Powlesland, R. G. (1977). Effects of the haematophagous mite *Ornithonyssus bursa* on nestling starlings in New Zealand. *New Zealand Journal of Zoology*, 4(1), 85-94.
- Proctor, H., & Owens, I. (2000). Mites and birds: diversity, parasitism and coevolution. *Trends in ecology & evolution*, 15(9), 358-364.
- Radovsky, F. J. (2010). Revision of genera of the parasitic mite family Macronyssidae: (Mesostigmata: Dermanyssoidea) of the world. Indira Publishing House.
- Rendell, W. B., & Verbeek, N. A. (1996). Are avian ectoparasites more numerous in nest boxes with old nest material. *Canadian Journal of Zoology*, 74(10), 1819-1825.
- Resh, V. H., & Cardé, R. T. (Eds.). (2009). *Encyclopedia of insects*. Academic press.
- Siepel, H., & de Ruiter-Dijkman, E. M. (1993). Feeding guilds of oribatid mites based on their carbohydrase activities. *Soil Biology and Biochemistry*, 25(11), 1491-1497
- Sikes, R. K., & Chamberlain, R. W. (1954). Laboratory observations on three species of bird mites. *Journal of Parasitology*, 40(6)
- Suárez-Rodríguez, M., López-Rull, I., & Macías García, C. (2013). Incorporation of cigarette butts into nests reduces nest ectoparasite load in urban birds: new ingredients for an old recipe. *Biology letters*, 9(1), 20120931.
- Szabó, K., Szalmás, A., Liker, A., & Barta, Z. (2002). Effects of haematophagous mites on nestling house sparrows (*Passer domesticus*). *Acta Parasitologica*, 47(4), 318-322.
- Wehner, K., Heethoff, M., & Brückner, A. (2018). Seasonal fluctuation of oribatid mite communities in forest microhabitats. *PeerJ*, 6, e4863.
- Wimberger, P. H. (1984). The use of green plant material in bird nests to avoid ectoparasites. *The Auk*, 101(3), 615-61
- Winkler, D. W. (1993). Use and importance of feathers as nest lining in Tree Swallows (*Tachycineta bicolor*). *The Auk*, 110(1), 29-36.