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 selected common bird species(18) in Sri Lanka in urban, suburban, wild, and captive populations were sampled opportunistically using a portable mini vacuum trap.ANOVA: single factor test was used to evaluate statistical significance at p<0.05. A total of 1493 mites were collected from 180 nests. The mites belonging to order Mesostigmata had the highest relative abundance (58.6%) and prevalence (74.4%) of all mite orders collected, followed by the Sarcoptiformes (41.1%, 72.8%), and Trombidiformes (0.3%, 2.2%). Mite diversity of host bird species was measured using the Shannon-Weiner diversity index (H'). *Pycnonotus cafer* 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 microhabitat 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 (1).

Mites are the most common and abundant of nest-dwelling arthropods (2). They 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 (3). The symbiotic relationship between nest-dwelling mites and their avian hosts is variable, ranging from beneficial to quite detrimental.

Mostly studied generas of nest dwelling mites are *Dermanyssus* (Dermanyssidae) and *Ornithonyssus* (Macronyssidae) where both groups are obligatory hematophagous parasites (3). Fowl mites belong to the genus*Dermanyssidae* and the adult fowl mites reach nests with host birds on their body or hatch in the nest (4). Adults have the ability to overwinter in nest material, yet most of the individuals spend the entire lives on an adult host or nestlings (4). Nymphal stages of the blood-feeding mites are mostly nest bound and they tend to visit the host when they need feeding (5). These mite groups have short generation times, and it favors them to rapidly build up huge populations (5).

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

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with aged nest materials than in boxes from which old nests have been removed (5). The quantity of nest material in a cavity, reinfestation, and nest microclimate can affect the numbers of hematophagous parasites in boxes (5). In a previous study states that old nest materials may contain and/or attract more ectoparasites than fresh material (1). 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 (6). The colonial nesting habits of the cliff swallow, which builds a protective domed nest of mud, encourage parasite maintenance and transmission of ectoparasites (7).

Nest-dwelling mites can have a significant negative impact on their avian hosts as well as human hosts. The increased cost of anti-parasite defences, 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. (8).

Since there are no previous information about the abundance and diversity of these nest-dwelling mites of common birds in Sri Lanka, the study 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), Maduru oya 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(9), 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 (10), 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. Relative abundance of mite orders were calculated by dividing the number of mites from one group by the total number of mites from all groups. For a representative mite group, prevelance is the percentage value of number of mite infested bird nests divided by the total number of sampled host bird nests.Shannon-Weiner diversity indices were calculated with respect to nest dwelling mites in each nest of a given bird species (11). 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.

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3.1 Diversity, Abundance and Prevelance of nest-dwelling mites

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

The collection of mites was represented by two super orders (Parasitiformes and Acariformes). Under Parasitiformes order Mesotigmata 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. sylviarum*, *Pellonyssus* spp. and *Androlaelaps* sp. Trombidiformes mites were belonged to genus *Bdellid* and Sarcoptifomes mites represented by family Aeroglyphidae and Oribatida. Genus *Glycycometus* was identified under family Aeroglyphidae. (Table 1, Figure 1).

Table 1: Nest-dwelling mite diversity

Order	Family	Genus	Species
Mesostigmata	Macronyssidae	*Ornithonyssus*	*Ornithonyssus bursa*
			Ornithonyssus sylviarum
		Pellonyssus	*Pellonyssus* spp.
	Laelapidae	*Androlaelaps*	*Androlaelaps* sp.
Trombidiformes	Bdellidae	*Bdellid*	*Bdellid* sp.
Sarcoptiformes	Aeroglyphidae	*Glycycometus*	*Glycycometus* sp.
	Oribatida		

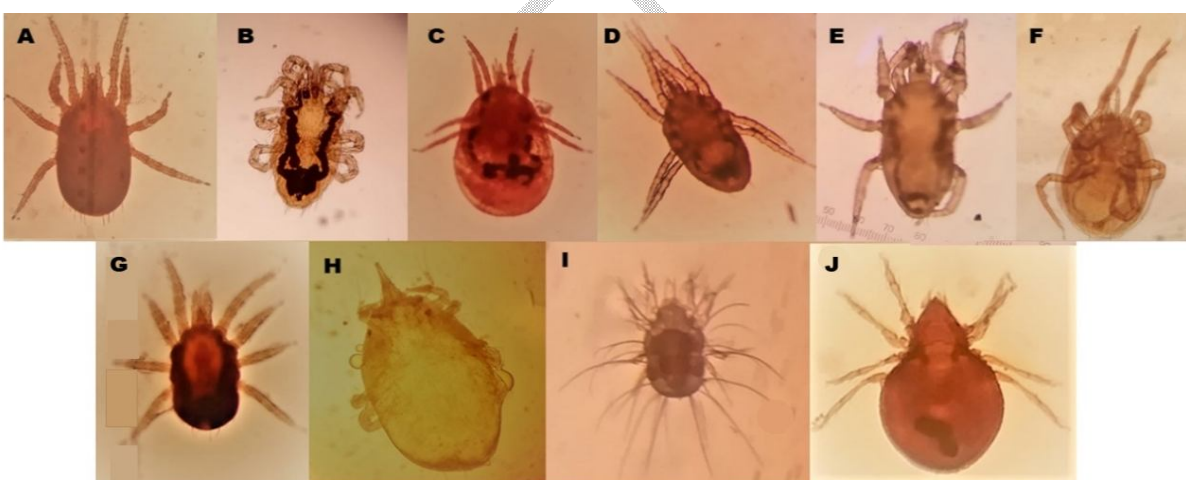

Figure 1: Nest-dwelling mites collected in Sri Lanka: (A) *Ornithonyssus bursa* (B) *Ornithonyssus sylviarum* (C) *Pellonyssus* spp.(D), (E) & (G) Mesostigmata (Unidentified) (F) *Androlaelaps* sp. (H) *Bdellid* sp. (I) *Glycycometus* sp.(J) Oribatida

The mites belong to order Mesostigmata had the highest relative abundance (58.6%) of all mite orders collected, followed by the Sarcoptiformes (41.1%), and Trombidiformes (0.3%). Highest mite prevalence was also depicted by Mesostigmatic mites and the value was followed by Sarcoptiformesand Trombidiformes.

According to the resulted relative 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 (12). The most frequently encountered mesostigatics in bird nests are obligate hematophagous species in the Dermanyssidae and Macronyssidae (3). Our collection was included with family Macronyssidae and Laelapidae as mesostigmatic mites.

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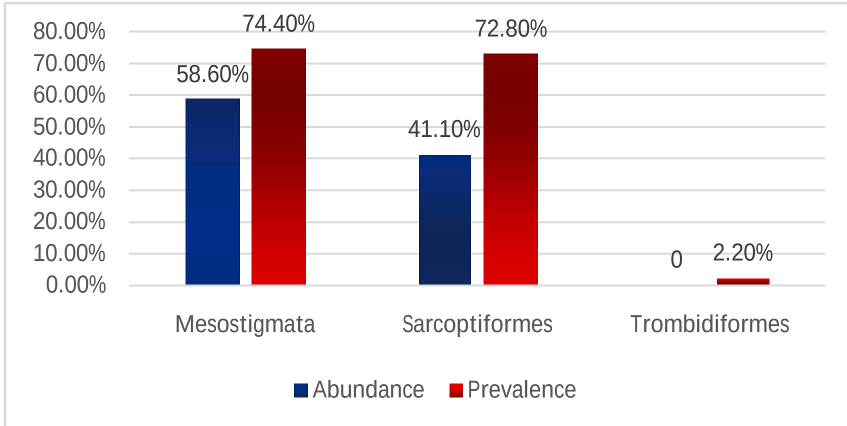

Figure 2: Abundance and prevalence of nest-dwelling mite orders

Mostly, Macronyssidae mites are also obligate parasites of vertebrates (13) and associated with wild and domestic birds (14). Occasionally in the absence of an avian host hungry mites may attack human as well (14). In this study, two parasitic Macronyssidae mite species *Ornithonyssus bursa* (Tropical fowl mite) and O. *sylviarum* (Northern fowl mite) were identified. O. *sylviarum* is a common ectoparasite of wild and domestic birds (15). This blood-feeding mite has been broadly collected from most of the birds in temperate region (16). It is a cold tolerant species which is distributed mainly in the north temperate zone (12) reported from at least 72 species of birds in North America alone ((16, 17). This study reveals the presence of *O. sylviarum* 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 (14). Reduced weight and reduced growth rate of fledglings (18) 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 (14).

Pellonyssus is another genus we came across in our mite collection under family Macronyssidae and according to Radovsky in 2010, this genus contains 13 valid species, all parasites of birds, and widely distributed mainly in warmer latitudes (19). One previous study (20) 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 (21) According to a previous taxonomic study, these mites are distributed in Paleartic, Neartic, Australian, Neotropical and Oriental regions of the world (22). They are more like predators of other mites and arthropod associates while being found in nesting materials of birds like starlings (22). The only genus which was 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 (22). 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 relatively abundant (41.1%) and prevelant (72.8%) mites in the cohort and represented families of Aeroglyphidae and Oribatida. Aeroglyphidae mites are commonly known as dust mites or storage mites which studies have identified mostly occurred in stored hay, grain, straw, the dust of grain and hay at storage (23). The genus found in the nests under this family was *Glycycometus.* They are reportedly be associated with insects, nests of small mammals like bats and rats, bird nests and dust collected from human dwellings (24). Dust mites which are relative to the human association, feed on the dermal detritus and crawl down into the nest material (3). According to the given information, It can be assumed that bird nests are harboured by these mites due to incorporation of green and dry plant materials and the presence of other associate arthropods lin the nests where they can inhabit.

Family Oribatida 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 (25). Oribatids tend to feed on higher plant materials which make them microphagous, sometimes they strictly feed on microflorae (microphytophages) and also can be fed on all kinds of plant and fungal tissues (26). Bird nests are microecosystems,

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which provide a habitat to many different microflora and that may be a reason for the presence of Orbatid 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 (13). 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 relative abundance and prevelance of trombidiformes was 0.3% and 2.2% in order, representing the lowest abundance and prevelance 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 (27). 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 (28).

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. *Pycnonotus cafer* nests had the highest diversity (1.936) of nest associates with an evenness of 0.8407 while *Nectarinia zeylonica* had the lowest diversity (0.163) of nest associates with an evenness of 0.2352 (Table 2) from 18 bird species.

*Pycnonotus cafer*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 (29). According to the observation of this study,itis 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 (29). As this bird species shows the highest diversity of nest-dwelling mites, it represents the heamatophagous 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 iritable 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	*Columba livia*	1.08	0.99
	C. livia domestica	0.91	0.83
	Geopelia cuneate	1.52	0.95
	Spilopelia chinensis	1.90	0.85
	Streptopelia decaocto	1.83	0.94
Passeriformes	*Chrysomma sinense*	1.56	0.80
	Dicaeum sp.	0.51	0.74
	Hirundo rustica	0.66	0.95
	Lonchura striata	1.18	0.73
	L.malabarica	1.20	0.74
	L. punctulata	1.36	0.85
	Nectarinia asiatica	0.42	0.30
	N. zeylonica	0.16	0.24
	Ploceus philippinus	0.51	0.32
	Pycnonotus cafer	1.94	0.84
Psittaciformes	*Agapornis* sp.	0.47	0.68
	Melopsittacus undulates	1.55	0.96
	Psittacula krameri	0.68	0.98

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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 (5). 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.

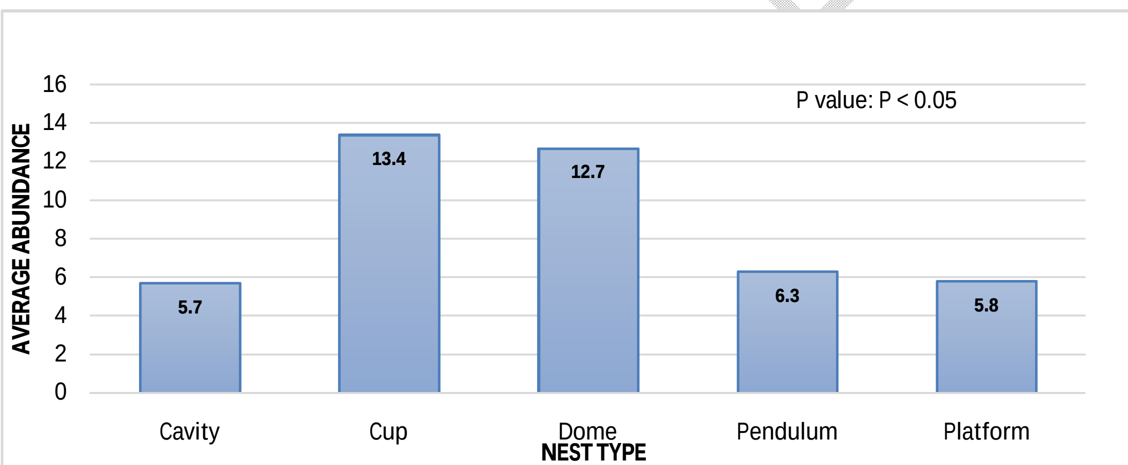
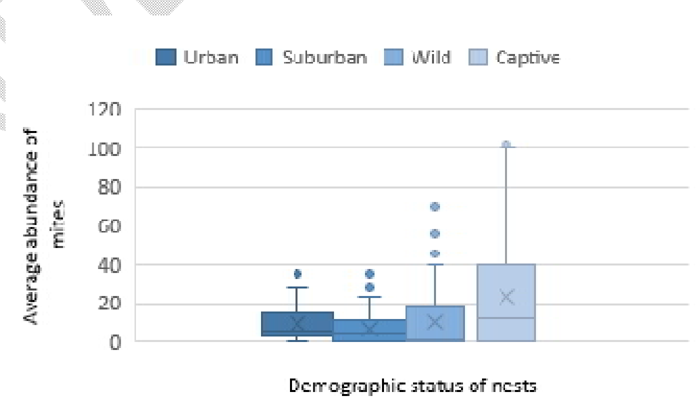


Figure 3: Distribution of nest associates in relation to nest type.

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.



Groups	Average	*P-value*
Urban	9.6	P < 0.05
Suburban	7.2	P < 0.05
Wild	10.1	P < 0.05
Captive	24.6	P < 0.05

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 unfavourable environment and naturally handle health challenges as compared to captive birds which might suffer consequences of poor and inadequate management protocols (30). 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 (30). 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 (31). 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 (30). Since the life cycle of lice and mites is approximately 2 weeks, treatments should be repeated every two weeks as needed (32).

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 *Psittacula krameria* and *Melopsittacus undulates*, as well as in the *Columba livia domestica* nests. Mud was only incorporated in *Hirundo rustica* 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.	+	-	-	-	-	-
Chrysomma sinense	+	+	+	-	-	-
Columba livia	+	-	+	+	-	+
Columba livia domestica	-	-	+	+	-	-
Dicaeum sp.	+	-	-	-	-	-
Geopelia cuneata	+	-	-	-	-	-
Hirundo rustica	+	-	+	+	+	-
Lonchura malabarica	+	+	-	-	-	-
Lonchura punctulata	+	+	-	-	-	-
Lonchura striata	+	+	-	-	-	-
Melopsittacus undulatus	-	-	+	-	-	-
Nectarinia asiatica	+	+	-	-	-	-
Nectarinia zeylonica	+	+	-	-	-	-
Ploceus philippinus	+	-	-	-	-	-
Psittacula krameri	-	-	-	-	-	-
Pycnonotus cafer	+	+	-	-	-	-
Spilopelia chinensis	+	-	-	-	-	-
Streptopelia decaocto	+	-	-	-	-	-

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The dry matter 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 *Pycnonotus cafer* and *Chrysomma sinense* 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 *Pycnonotus cafer* that the parent pair used fine twigs of herbs and grasses for building nest. The plants preferred for nest building included Zizipus, Hibiscus, Citrus, and Acacia (29). 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 (33). It is suggested that birds use secondary chemicals contained in green plants to control ectoparasites (34). In the study of Wimberger (1984) has been found green vegetation was significantly correlated with nest reuse in 49 species of Falconiformes (35). The majority of green nesting material is added before copulation and the behavior decreases dramatically upon egg-laying in European starlings (34). 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 (34).

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 (36). 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 (36).

4. CONCLUSION

This a pioneer study which was explored to present the general information such as diversity, relative 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 *Ornythonyssus bursa*, *O. sylviarum,Pellonyssus* spp. and *Androraelaps* sp. Mites. These values were followed by the Sarcoptiformes (*Glycycometus* sp. and Oribatida mites) (41.1%, 72.2%), and Trombidiformes (*Bdellid* sp.) (0.3%, 2.2%). Mite diversity indeces of host bird species was measured using Shannon-Weiner diversity index (H'). *Pycnonotus cafer* 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 mean abundance (24.6) of mites and the nests of suburban populations had the lowest average 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.

CONSENT (WHERE EVER APPLICABLE)

Not Applicable

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).

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