Are Bird Nests the Habitat for Ants? Implication from Ant Inventory (Hymenoptera: Formicidae) Across Various Bird Nests

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Abstract. This study aimed to do the inventory on ant species (Hymenoptera: Formicidae) that specifically inhabit the bird nests within the Universitas Andalas campus complex, Limau Manis, Padang. It had been conducted from January to August 2018, where the bird nests were purposively collected then followed with ant collection from each nest. Forty nests were sampled and identified as nests of Estrildidae, Pycnonotidae, Sylviidae and from the unknown taxa; 5 nests showed active breeding indications when collected. A total of 2,741 ant individuals belong to 13 species, 12 genera, 8 tribes, and 4 subfamilies extracted from 31 (of which 4 were active nests), out of 40, observed nests. The ant species inventory included the members of subfamilies Formicinae (5), Myrmicinae (5), Dolichoderinae (2) and Pseudomyrmicinae (1). We statistically detected correlation between nest biomass and number of ant individual and species infested in the bird nests, which explained the more species recorded from Estrildid nests that were averagely bulkier than other nests. This result offers strong indication that bird nests may serve as form of habitat, or at least a niche, for ants.

Keywords: ants, bird nests, campus complex, purposive sampling, species inventory, West Sumatra

1. Introduction

Ant’s diversity in the tropics is generally influenced by the factors such as predation, humidity, nesting sites, availability of food sources, topographical structures and vegetation composition [1]. The diversity and richness of ant species are also affected by the change of microclimates imposed by altitudinal increment [2]. Their abundance and vast distribution in most terrestrial habitats make them as ideal bio-indicators for ecological condition [3, 4].

Bird nests are generally constructed using variety of materials, mostly from common things found in the surrounding, including synthetick or residual materials resulted from human activities. Many birds use mud or silk fiber from insects or apply their own saliva to increase the resilience of nests they build [5]. Ants were reported to be detrimental to bird populations in Southern California, such as the argentin ants (*Linepithema humile*) which inhibit the construction of bird nests, despite this ant is not...
predator nor parasitic ant species [6, 7]. In Indonesia, research on ant or other insects that interact with birds is considerably minuscule, hence the nature of interaction between these different organisms remains unclear.

While some recent studies about ant in Sumatra yielded in a considerably robust species inventory, including the finding of a new Sumatran forest species [8], yet lack attention paid to study ants at uncommon habitats. Therefore, this research intends to provide a baseline inventory on ant species that inhabit bird nests as well as giving assessment on bird nests as an ant’s habitat.

2. Materials and Methods

2.1. Study Site

This study had been conducted at Universitas Andalas campus complex in Limau Manis area, 15 km eastward of the downtown of Padang City, the capital of West Sumatra Province (Figure 1). This area is very representative for various researches related to taxonomy, ecology, behavior and other fields in biology. In addition to the naturally vegetated area that mixed with campus environment, Universitas Andalas also possesses specially designated vegetated area namely Educational and Research Forest of Biology (148 hectares, hereafter HPPB), Arboretum (15 hectares) and Pharmaceutical Plant Garden (7 hectares) [9]. The last two sites are in close proximity and bound together as the perimeter for HPPB, hence better be referred as KTO-Arb. According to a recent study, Universitas Andalas’ campus complex harbors around 160 bird species [10], some are known to breed in this area. The nest collection had been performed in abovementioned area between January-August 2018, by walking along the wooded patches among the building complex and at the forested area. Bird nest samples were then analyzed in the Invertebrate Taxonomy Laboratory, Biology Department, Universitas Andalas.

Figure 1. Map of study site in Universitas Andalas’ Campus Complex, Limau Manis, Padang. a. Building complex, b. Arboretum, c. Pharmaceutical plant garden (KTO), d. Educational and Research Forest of Biology (HPPB)
2.2. Bird nest collection and identification

Bird nests were purposively collected in each aforementioned campus site. Upon spotted, bird nest photographed on its natural attachment, observed for its natural characters, and measured its height. Active (sign of breeding activity) and abandoned nests were assessed from the freshness of nest materials, overall condition of nest and existing eggs or chicks inside. Upon collected, the nest then sealed into plastic bag to avoid the escaping ants; plastic bags properly labelled before transported to the laboratory where the nests were weighed and assessed for its composing materials.

Ideally, a nest is identified in related to the bird attends it. Whenever this was not possible, the identification would use general bird nest characters provided in the bird field guide for western Indonesia archipelago [11]. If nest identification resulted indecisive, the nest was then labelled as ‘unknown.’

2.3. Ant Extraction and Identification

The nest samples were thoroughly examined for searching ants that dwelled among nest materials. This process was managed through hand collection method by carefully disentangling every piece of nest material to spot ant individual. Extracted ant individuals then preserved within vials containing 96% ethanol, bagged together in relation to their origin nest and labelled accordingly.

Ant samples were identified based on their morphometric aspects, before mounted, labelled, photographed and measured. Identification process was guided by appropriate identification manuals and previously curated specimens in the laboratory [12, 13].

2.4. Data Analysis

Nest parameters (height, weight) were listed according to respective measured nest, along with total ant species collected in each nest. The relationships between measured nest parameters and ant inventory were statistically tested with R program version 3.2.3 [14]. The data were also descriptively outlined using tables, figures and graphs to denote the characteristics of bird nest per family and its relationship to the infesting ants.

The identified ants were grouped according to their taxonomical orders; species, genus and subfamily. Total individual and species extracted from each bird nest, individual count from each species, as well as the total species, genera, tribes and subfamilies were also presented. Data then displayed using tables and graphs which then descriptively outlined.

3. Result

3.1. Collected Bird Nests

There have been 40 bird nests collected in this study, identified mainly from the family Estrildidae (Munias) with 26 nests, Pycnonotidae (Bulbuls) with 8 nests, Sylviidae (Tailorbirds and Prinias) with two nest and four unidentified nests (Table 1). Among them, 5 nests were active, detected from the eggs or chicks contained in the nest chamber. The Estrildid nests were made from mainly plant materials, spherical or doom-shaped, thick-wall, entrance positioned on top or slightly near the top and nest chamber lined with finer plant materials (Figure 2). The Sylvid nests were spherical-shape or pouch-like structure, much smaller than the Estrildid’s, constructed from finer plant fibres and entrance hole located on the side. Pycnonotid nests are neat, cup-shaped structure constructed on the forking branches, the exposed nest chamber was lined with fibres, leaf skeletons and sometimes with fine grass blades. Their nests were much smaller than the other two families. Two unidentified nests resembled the shape
of Estrildid’s, but somewhat unstructured and built from rough plant materials. The other two unidentified nest were huge in size, consisted of twigs and branches that carelessly piled with central part of it seemed to serve as nest chamber as it was lined with palm and coconut fibres. No birds seen attending these unidentified nests during the survey nor their characters matched to any known species in Universitas Andalas campus complex, hence they were labelled as ‘unknown.’ Thirty-one nests, comprised of twenty-seven inactive and four active nests, contained ants in which four ant queens were collected from Estrildidae, Pycnonotidae and unidentified nests (Table 1).

The Estrildidae nests were collected more in number than the other two families, presumably due to their well-assimilation with human environment and in other impacted area. Meanwhile, Pycnonotidae and Sylviidae tend to construct their nests in more secluded site and with secretive manner, concealing it from any potential predator, including human [11]. The most collected nests observed from Campus Area (Table 1), as it had better access across the location and accommodated a thorough survey; this situation was found lack at two other sites.

| Table 1. Detail of bird nest collected in each study site |
|---------------------------------|
| Bird Family | Site | Total | Remark |
|-------------|------|-------|--------|
| | Campus Area | KTO-Arb | HPPB | |
| Estrildidae | 4 | 16 | 5 | - | 1 | 26 | One nest from campus area contained a queen |
| Pycnonotidae | - | 3 | 1 | 4 | - | - | 8 | One nest from campus area contained a queen |
| Sylviidae | - | 2 | - | - | - | - | 2 | |
| Unknown | - | 1 | - | 3 | - | - | 4 | One nest from KTO-Arb contained two queens |
| Total | 4 | 22 | 1 | 12 | 0 | 1 | 40 | |

The lowest nest was observed in Pycnonotid, around 0.5 m from ground surface, although the lowest height average was found in Sylviid, 1.82 m (Table 2). In contrary, the highest nest was the 12.5 m Estrildid nest, yet in average, the unknown taxa nests were higher with 6.59 m. Two unidentified nests became the heaviest nests collected, as they were constructed from twigs and branches. The nests of Estrildid were averagely heavier (44.4 g) than the nests of Pycnonotid (17.9 g) and Sylviid (36.4 g). In addition, one Estrildid nest that collected from campus area, weighed until 127 g. This bulky structure was resulted from repetitive use of a same nest construction, in which new materials kept added during subsequent breeding times. It is unbeknown, however, if this nesting behaviour also applied among the other two families.

| Table 2. Nests’ parameters and its capacity for ant species |
|-----------------|
| Bird Family | Parameter | Weight (g) | No. ant species recorded |
| Estrildidae | min. | max. | av. | min. | max. | av. | |
| | 1.7 | 12.5 | 4.43 | 6.5 | 127 | 44.4 | 1-4 |
| Pycnonotidae | 0.5 | 5 | 2.22 | 5.8 | 50.6 | 17.9 | 1-2 |
| Sylviidae | 1.64 | 2 | 1.82 | 27.5 | 36.4 | 32 | 2 |
| Unknown | 4.75 | 8.3 | 6.59 | 14.3 | 186 | 121 | 1-2 |
3.2. Ant Species Extracted from Bird Nests

A total of 2,741 ant individuals which belong to 13 species, 12 genera, 8 tribes, four subfamilies were identified from collected bird nests (Table 3). Myrmicinae and Formicinae were subfamilies with the highest number of species (5 each) followed by Dolichoderinae (2) and Pseudomyrmiciniae (1). The detail on ant species, the origin nests where they extracted and their collection sites were listed in Table 3.

Campus complex site observed with the highest number of ant species (12 species, 2,043 individuals), followed by KTO-Arboretum (7 species, 578 individuals) and HPPB (4 species, 20 individuals). Twelve ant species were observed from Estrildid nests with 1-4 ant species were possibly found infesting a single nest, while four and two species recorded respectively from Pycnonotid and Sylviid nests, with possibility of their nests infested with 1-2 ant species (Figure 3). Prominent presence of ants in Estrildid nests compared to what observed on the nests of Pycnonotid or Sylviid was presumably accommodated by the profound nest structure and availability of abundant biomass usable for developing and sustaining ant colonies. The doom-shaped of Estrildid nests somehow perceived as a niche for ants to settle in, while bird droppings benefit ants either through direct consumption or indirectly through the organisms that attracted to the bird fecal which thought to be potential foods for ants. Ant species and community are significantly affected by temperature and humidity, which usually kept stable within the nest structures by the owner birds. Ants can live optimally by hitchhiking within the nest environment that usually set between 18-28 °C temperature [15].

Table 3. Ant species collected from bird nests from Universitas Andalas’ Campus Complex

| Subfamily       | Tribe         | Location  | Total ind. | Total ant ind. per identified nest |
|-----------------|---------------|-----------|------------|-------------------------------------|
| Dolichoderinae  | Dolichoderini | Dolichoderus sp. 45 of SKY 210 | 108        | 108 (Estrildidae,1)                |

Figure 2. Nest of Estrildidae (left), Pycnonotidae (middle) and Sylviidae (right)
| Subfamily | Location | Total | Total ant ind. per identified nest |
|-----------|----------|-------|-----------------------------------|
|           | Campus area | Arboretum | HPPB |
| Tapinonomini |           |       |       |
| *Tapinoma melanocephalum* (Fabricius, 1793) | 262 | - | - | 262 (Estrildidae, 3 active) |
| Formicinae |           |       |       |
| Campotini |           |       |       |
| *Camponotus (Tanaemyrmex) arrogans* (Smith, 1858) | 356 | 50 | - | 406 (Estrildidae, 9); 110 (Pycnonotidae, 3); 77 (Sylviidae, 1) |
| *Polyrachis (Myrmhopla) bicolor* (Smith, 1858) | 3 | - | - | 3 (Estrildidae, 1) |
| Oechophyllini |           |       |       |
| *Oechophylla smaragdina* (Fabricus, 1755) | - | 102 | - | 102 (Unidentified nest, 1) |
| Plagiolepidini |           |       |       |
| *Eupronolepis procera* (Emery, 1900) | 704 | 140 | 1 | 845 (Estrildidae, 7); 273 (Pycnonotidae, 2); 100 (Sylviidae, 1) |
| *Paratrechina longicornis* (Latreille, 1802) | 13 | - | - | 13 (Estrildidae) |
| Myrmicinae |           |       |       |
| Attini |           |       |       |
| *Pheidole quadraensis* | - | 15 | 2 | 17 (Estrildidae, 2); |
| *Crematogaster (Orthocrema) longipilosa* (Forel, 1970) | 81 | 30 | - | 111 (Estrildidae, 3) |
| *Crematogaster (Paracrema) modiglianii* (Emery, 1990) | - | 237 | 237 | 217 (Estrildidae, 3); 20 (Pycnonotidae, 1) |
| *Monomorium floricola* (Jerdon, 1851) | 516 | - | 16 | 532 (Estrildidae, 5); 150 (Pycnonotidae, 2) |
Among the active nests sampled in this study, *Tapinoma melanocephalum* inhabited three of them with 7, 6 and 250 individuals collected respectively from each nest. This species is known as invasive ant in household, consuming any leftovers it can find. This finding may indicate the extent of their ability to colonize various habitat, including bird nests. This ant was also observed inside the nest mound of sea turtles [16], as they predate on the hatchlings. The role of *T. melanocephalum* in regard to the breeding of birds, however, requires further investigation.

### 3.3. Correlation between Bird Nests and Infested Ants

Combination between weight and height of nests showed no effect to the existence of ant species in bird nests, after tested with the General Linear Model (GLM). The calculation of all factors combination, Akainu information criterion (AIC) model gave the best model ~ 1, with \( p = 0.241 \) (calculation not showed here). Proceed to Anova test between nests’ parameters and bird families (including the unknown nests), it was indicated that the height and weight had singular effect toward infested ant species (Table 4). The t-test performed to see how these nests’ characters applied among families. Both weight and height of Estrildid and unknown nests differed significantly than what observed with Pycnonotid nests (Table 5). Both characters may work together influencing the rate of ant infestation (individual and species) in a nest, but it seems that the bulkier and heavier a nest, the more ant species it can accommodate (Figure 3). The sizeable Estrildid, and unknown, nests provide more spacious habitat for ants than the smaller nests from the other two families found in this study.

| Subfamily | Location | Total ind. | Total ant ind. per identified nest |
|-----------|----------|------------|-----------------------------------|
| Tribe     | Campus area | Arboretum | HPPB |
| Species   |          |            |      |
| Solenopsidini |          |            |      |
| Solenopsis germinata (Fabricus, 1804) | - | 104 | - | 104 |
| Pseudomyrmecinae |          |            |      |
| Pseudomyrmecini |          |            |      |
| Tetraponera allaborans (Walker, 1859) | - | - | 1 | 1 |

**Table 4.** Anova test on nest weight and height with bird families (including unknown nests) with 95% confident level. Asterisk (*) indicates significant value
Table 5. T-test on nest weight and height per bird family (including unknown nests). Asterisk (*) indicates significant difference between family

| Species/parameter | Weight |       |       | Height |       |       |       |
|-------------------|--------|-------|-------|--------|-------|-------|-------|
|                   | Estr   | Pyc   | Syl   | Unk    | Estr  | Pyc   | Syl   | Unk   |
| Estrildidae       | -      | 0.035*| 0.997 | 0.161  | -     | 0.007*| 0.306 | 0.372 |
| Pycnonotidae      | -      | -     | 0.578 | -      | -     | 0.998 | -     | -     |
| Sylviidae         | -      | -     | -     | 0.451  | -     | -     | -     | 0.075 |
| Unknown           | -      | -     | -     | -      | -     | -     | -     | -     |

Figure 3. Average ant species that possibly infest a bird nest in each bird family collected in this study

4. Discussion

The existence of ants in bird nests tend to follow several possible causes, such as availability of food source within the nests, the nature of relationship between nesting bird with other organism (including ants) in its surrounding and within the nest, as well as the habit of ants. For predator ants, which diets consist of meat from other organisms, bird nests and the contents within can be thought as their potential food sources [17, 18]. Nevertheless, the grazing and herbivore ants will be also likely to roam in bird nests recall that the nest materials, and to some extent the mushrooms possibly grow on humid and moist nests, would provide them with food items. Some birds have been known to let ants infested their nests purposively to take benefits from; 1) ants’ ability to clean any parasitic organisms, 2) ants’ defensive mechanism that can be directed against any other nest predator, and 3) ants can serve as critical ‘snack’ item, even for granivorous birds [17, 19, 20]. The granivorous and herbivorous birds like Munia and Passer, during their breeding season, will physiologically require more protein intake [11] which possibly supplied from practically and conveniently available resource within their grasp in their nests and proximity.

Subfamily Formicinae (5 species, 5 genera) and Myrmicinae (5 species, 4 genera) became the taxa with most species recorded in this study, followed by Dolichoderinae (2 species, 2 genera) and
Pseudomyrmicinae (1 species, 1 genera). The Formicinae currently consists of 49 genera and 3,700 species found only in Australian region, which indicates a prominent possibility for its members to be observed in the nearby region, such as in Indonesia [21]. This family is the second largest and most widespread subfamily in the world [22]. It can nest on moist soil, tree branches, dead wood and plant roots. Ants from this subfamily are arboreal, general foragers, general predators that usually prey on other arthropods in the forest [23]. These facts may help explaining the finding of this species inside bird nests as observed in this study.

Similarly, Myrmicinae is the largest subfamily, where its members widely distributed throughout the world, either in tropical, subtropical and temperate regions [21]. The members of Myrmicinae act as predator, seed-eater and decomposer in the environment. The genus Pheidole, Crematogaster, Monomorium and Solenopsis dominate this subfamily [24]. Myrmicinae has also been observed to dominate in some locations in West Sumatra [18]. It was also dominant ants recorded from various habitats such as settlements, plantations, up to the forested areas.

There were 8 tribes found infesting bird nests in this study. Campus area and KTO-Arboretum were observed with 5 tribes each. Tribe Campotini, Plagiolepidini and Crematogastrini were with 2 genera respectively, while only one species recorded for each tribe of Dolichoderini, Tapinomini, Attini, Solenopsidini and Pseudomyrmicini. Only genus Crematogaster found with two species in study, while other genera were all with single species.

**Figure 4.** Some ant specimens collected from bird nests in Universitas Andalas campus complex: *Euprenolepis procera* (left), *Tetraponera allaborans* (middle), and *Tapinoma melanocephalum* (right)

*Euprenolepis procera* was commonly observed along with its colonies infesting non-active nests in this study. It is nocturnal ant species, avoid direct sunlight and prefer being in the shaded habitats (Figure 4). In addition, this ant consumes *Agaricus* and *Pleurotus* mushrooms that grow on cellulose [26] that commonly found in bird nest substrates. The infestation of *E. procera* in non-active bird nests is mainly based on this fact, as they can secure an easy access to food source for feeding their colony. Genus *Tetraponera* was with only individual found inside a non-active Estrildid nest collected from HPPB. This finding may require further investigation as this ant genus usually colonizes bark, branches, and twigs. Most of somewhat 40 species of this genus have obligative mutualistic relationships with dormatia-bearing plants [12]. This species is found more often at undisturbed and densely vegetated area [22].

The result of this study, nevertheless, offers a convenient indication that bird nests may contain resource to sustain the live of ants and ant colonies, hence it is reasonable to be considered as a habitat type, or at least as a niche, for ants. The size of bird nests may serve as the determinant factor to help ants maintain their colonies, due to more resources contained. On the other hand, sheer number of ant individuals, species and subfamilies recorded from bird nests in this study was comparable with those that found inhabiting in regular habitats, as observed in some previous studies [27, 28, 29, 30]. The finding of queens among collected bird nests added further base for this proposed claim, as these queens indicated the existence of steady colonies within the bird nests. Further studies regarding factors that regulate the live of ants in bird nests, the roles of ants or ant colony to the nesting birds, as well as the possible nature of ant-bird relationships should be added into the future study agenda.
Conclusion
Of the forty nests collected between January to August 2018 from campus complex and the adjacent forested area, they consisted of 26 Estrildidae nests (four active nests), 8 Pycnonotidae nests (one active nest), two Sylviidae nests and four unidentified nests. As many as 2,043 ant individuals collected from 31 nests (included four active nests), identified into 13 species, 12 genera, 8 tribes and 4 subfamilies. The finding of queens among collected *Euprenolepis procera* individuals strongly indicated that this ant colonized bird nests as their habitat, the case which may happen with other species observed. There is also strong indication that ants use sizeable nest with bulk nest materials as the habitat for their colonies.

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