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# Wild bird nests as microhabitats for beetle assemblages in a Neotropical dry forest of northwestern Peru

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**Abstract**

Monthly sampling was conducted from August to November 2018 along a fixed-length linear transect (~5 km) using direct visual search and *ad libitum* methods, collecting 40 unoccupied nests per evaluation (total N = 160 nests) in Marcavelica, northwestern Peru. A total of 394 adult beetle specimens were recorded, belonging to 2 suborders (Adephaga and Polyphaga), 9 families, 13 subfamilies, and 17 species. Diversity patterns were evaluated using Shannon–Wiener (H’), Margalef (DMg), and Pielou (J’) indices. Non-parametric Kruskal–Wallis and PERMANOVA tests evaluated differences in abundance and community composition among nest types, while hierarchical cluster analysis (Bray–Curtis dissimilarity) characterized compositional similarity. Tenebrionidae showed the highest abundance (n = 304), with *Parepitragus pulverulentus* being the dominant species (n = 286). Nests of *Campylorhynchus fasciatus* harbored the highest abundance (n = 246) and richness (9 species).

**Key words:** Bird nests, dry forest, Coleoptera, nest material, northern Peru

## 1. INTRODUCTION

The richness of Peruvian beetle fauna was not systematically surveyed between Blackwelder (1944–1957) and Chaboo & Flowers (2015), who reported 99 families and approximately 1,045 species and subspecies (Smith et al. 2015). Given their extraordinary abundance, ecological diversity, and intimate association with plant formations—where they function as predators, herbivores, pollinators, and decomposers of organic matter—beetles have acquired particular relevance in ecological research, especially as indicators of biodiversity, ecosystem services, and habitat conservation (Ribera & Foster 1997; Alonso 2015; Juárez & González 2018).

Nest construction materials used by birds constitute a reliable indicator of habitat use and ecological requirements during the reproductive period, as each type of material serves a defined function—thermoregulation, insulation, structural support, among others—according to the physical properties of the vegetal components (Giraldo & Flores 2003; Vera et al. 2009). The diverse materials found in bird nests—including leaf litter, twigs, feathers, feces, and anthropogenic debris (plastic fragments, diapers, among others)—represent opportunistic microhabitats where beetles can engage in decomposition of organic matter, reside among the litter, or complete developmental stages of their life cycle, including metamorphosis, thereby contributing to the ecological equilibrium of the forest (Vera et al. 2009).

Despite the ecological importance of bird nests as microhabitats for invertebrates, studies specifically addressing beetle assemblages associated with wild bird nests in the dry forests of northwestern Peru remain scarce. The present study aimed to determine the species composition, abundance, and diversity of beetles present in wild bird nests in the Marcavelica district, Sullana province, Piura department, and to characterize the trophic structure of the beetle community at this locality.

## 2. MATERIALS AND METHODS

### 2.1 Study area:

The study was conducted in the district of Marcavelica and Salitral, province of Sullana, department of Piura, in northwestern Peru (04° 52′ 39.0″ S, 80° 41′ 51.0″ W) (Fig. 1). The area encompasses vegetation typical of the coastal desert, ranging from sparse cacti to forest dominated by *Neltuma piurensis* (algarrobo) (Espinosa et al. 2012). The climate is extremely arid, with annual rainfall ranging from under 50 mm to 300 mm and mean temperatures between 18°C and 24°C (More et al. 2014).

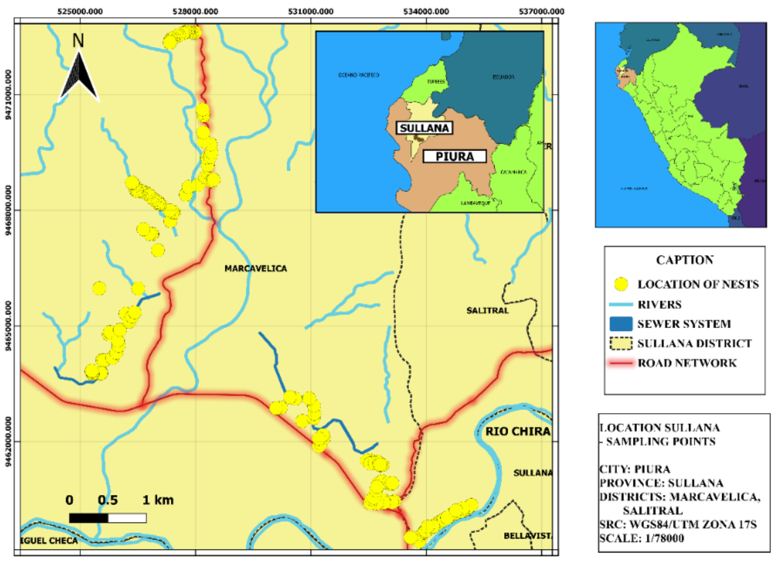


Fig. 1. Study locality and sampling points, district of Marcavelica and Salitral, province of Sullana, department of Piura, northwestern Peru.

### 2.2 Nest collection:

Monthly evaluations were conducted over four consecutive months (August–November 2018) along a fixed-length linear transect of approximately 5 km covering the survey route. Unoccupied, intact nests were located using direct visual searches and *ad libitum* observations within a 20-meter belt on both sides of the transect. In each monthly survey, an opportunistic sampling design was applied, collecting all available unoccupied nests until reaching a monthly quota of 40 nests, yielding a total sample of 160 nests (N = 160) across the study period. Each collected nest represented an independent sampling unit. Because sampling depended on natural field availability, the number of nests sampled per bird species (Ni) reflected their relative nesting incidence in the habitat rather than a pre-determined host quota. Geographic coordinates were recorded for each nest (MINAM 2015). Each nest was removed intact using gloves, pruning shears, and ladders, then placed in plastic bags or cotton-dacron fabric bags (40 × 50 cm, for spiny-branch nests) labeled with date, coordinates, and bird species identity (modified from Turienzo & Di Iorio 2008). Bird species were identified using Schulenberg et al. (2010) and Ugaz & Saldaña (2014).

### 2.3 Laboratory processing:

On the same day of each field evaluation, nests were transported to the Zoology Research Laboratory of the Universidad Nacional de Piura, where each nest was carefully dismantled over a plastic tray using gloves and forceps. Adult beetles were collected and transferred to glass vials with screw-top lids containing 70% ethanol (Galante & Marcos-García 1988; Villareal et al. 2004), each properly labeled.

### 2.4Taxonomic identification:

Specimens were identified to species level whenever possible, consulting Ciro et al. (2008), Juárez & González (2018), Chaboo & Flowers (2015), Monné & Chaboo (2015), Ratcliffe et al. (2015), Smith et al. (2015), and Giraldo & Flores (2016). Voucher specimens were deposited in the entomological collection of the Zoology of Invertebrates Laboratory, Universidad Nacional de Piura (Peru).

### 2.5 Data analysis:

To address the uneven sampling effort across bird species (Ni), species richness was evaluated using both observed values and sample-based rarefaction. Alpha diversity was characterized for each bird nest type using the Shannon–Wiener diversity index (H') and Pielou's evenness (J'). Each individual nest was treated as an independent replicate. Differences in univariate response variables (beetle abundance and species richness per nest) among host bird species were tested using the non-parametric Kruskal–Wallis test. Furthermore, differences in beetle community composition among nest types were evaluated using a One-Way Permutational Multivariate Analysis of Variance (PERMANOVA) based on the Bray–Curtis dissimilarity matrix with 9,999 permutations, accompanied by a PERMDISP test to verify homogeneity of multivariate dispersions. Multivariate hierarchical cluster analysis (Hellinger transformation, Bray–Curtis distance, Ward's D2 clustering method) was used to visualize compositional similarity among host species. All analyses were performed using R (vegan package) and PAST version 3.

## 4. RESULTS, OR RESULTS AND DISCUSSION

A total of 394 beetle specimens were recorded, distributed across 2 suborders—Adephaga (1 family) and Polyphaga (8 families)—13 subfamilies and 17 species. Chrysomelidae and Tenebrionidae exhibited the highest species richness (3 species each). Tenebrionidae was the most abundant family with 304 individuals. *Parepitragus pulverulentus* was the dominant species with 286 individuals, followed by *Aeolus sp.* with 28 individuals and *Ammophorus rubripes* with 16 individuals.

**Table 1.** *Checklist and abundance of beetles collected in wild bird nests at a locality in northwestern Peru*

| Family | Beetle Species | Wild Bird Nests | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | CC | CF | ZA | SS | FL | ZM | SF | LV | ML | PM |
| Carabidae | *Notiobia peruviana* (Dejean 1829) | 1 | | | | 1 | | | 2 | | |
| | *Clivina* sp. | | | | | 2 | | | | 2 | |

| Family | Beetle Species | Wild Bird Nests | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | CC | CF | ZA | SS | FL | ZM | SF | LV | ML | PM |
| | (Latreille 1802) | | | | | | | | | | |
| Scarabaeidae | *Anomala sp.* (Samouelle, 1819) | | 1 | | | | | | | 1 | |
| Elateridae | *Aeolus* sp. (Eschscholtz 1829) | 4 | 7 | 3 | 3 | 8 | 1 | | | | 2 |
| Dermestidae | *Trogoderma sp.* (Dejean 1821) | | 1 | | | | 1 | | | | |
| Bostrichidae | *Amphicerus cornutus* (Pallas 1772) | | 4 | | | | | | | | 2 |
| | *Dinoderus minutus* (Fabricius 1775) | 1 | | | 4 | | | | 2 | 3 | |
| Coccinellidae | *Paraneda pallidula guticollis* (Mulsant 1850) | | | | | | | 2 | | | |
| | *Scymnus rubicundus* (Erichson 1847) | | | | | 1 | | | | | 1 |
| Tenebrionidae | *Parepitragus pulverulentus* (Erichson 1847) | 19 | 214 | 7 | 2 | | | | 23 | 9 | 12 |
| | *Psammetichus costatus* (Guérin 1830) | | | 2 | | | | | | | |
| | *Ammophorus rubripes* (Solier 1837) | | | | 10 | | | | | 6 | |
| Cerambycidae | *Eburia pilosa* (Erichson 1834) | 1 | | | | | | | 1 | | |
| | *Eburia rufobrunnea* (Perroud 1855) | | 2 | | | | | | 2 | | |

| Family | Beetle Species | Wild Bird Nests | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | CC | CF | ZA | SS | FL | ZM | SF | LV | ML | PM |
| Chrysomelidae | *Glyptoscelis* sp. (Chevrolat 1836) | | 11 | | 1 | | | | | 2 | |
| | *Sennius peruanus* (Pierce 1915) | | 4 | | | | | | | 1 | 3 |
| | *Amblycerus piurae* (Pierce 1915) | | 2 | | | | | | | | |
| **Abundance** | | 26 | 246 | 12 | 20 | 12 | 2 | 2 | 30 | 24 | 20 |
| **Species Richness** | | 5 | 9 | 3 | 5 | 4 | 2 | 1 | 5 | 7 | 5 |
| **Legend: CC:** *Columbina cruziana*, **CF:** *Campylorhynchus fasciatus*, **ZA:** *Zenaida auriculata*, **SS:** *Synallaxis stictothorax*, **FL:** *Furnarius leucopus*, **ZM:** *Zenaida meloda*, **SF:** *Sicalis flaveola*, **LV:** *Leptotila verreauxi*, **ML:** *Mimus longicaudatus*, **PM:** *Pleocryptes melanops* | | | | | | | | | | | |

Regarding biodiversity indices (Table 2), all nest types showed low Shannon-Wiener diversity (H'). The nests of *Mimus longicaudatus* yielded the highest H' value (1.653), followed by *Synallaxis stictothorax* (1.333), whereas nests of *Sicalis flaveola* returned the lowest value (H' = 0). For Pielou's evenness (J'), *Zenaida meloda* presented the maximum value (J' = 1), followed by *M. longicaudatus*, while *S. flaveola* again returned the minimum. The Kruskal-Wallis test yielded p = 0.074 (>0.05), indicating no statistically significant differences in beetle assemblages among wild bird nest types.

**Table 2.** Diversity indices calculated from beetle abundance collected in wild bird nests at a locality in northwestern Peru

| Index | Wild Bird Nests | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | CC | CF | ZA | SS | FL | ZM | SF | LV | ML | PM |
| Shannon-Wiener (H´) | 0.893 | 0.618 | 0.959 | 1.333 | 0.983 | 0.693 | 0 | 0.858 | 1.653 | 1.201 |
| Margalef | 1.23 | 1.45 | 0.8 | 1.34 | 1.21 | 1.44 | 0.0 | 1.18 | 1.89 | 1.34 |
| Pielou (J') | 0.554 | 0.281 | 0.873 | 0.828 | 0.709 | 1 | 0 | 0.533 | 0.849 | 0.746 |
| Kruskal-Wallis | 0.074 | | | | | | | | | |
| **Legend**: **CC**: *Columbina cruziana*, **CF**: *Campylorhynchus fasciatus*, **ZA**: *Zenaida auriculata*, **SS**: *Synallaxis stictothorax*, **FL**: *Furnarius leucopus*, **ZM**: *Zenaida meloda*, **SF**: *Sicalis flaveola*, **LV**: *Leptotila* | | | | | | | | | | |

| Index | Wild Bird Nests | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | CC | CF | ZA | SS | FL | ZM | SF | LV | ML | PM |
| *verreauxi*, **ML**: *Mimus longicaudatus*, **PM**: *Pleocryptes melanops* | | | | | | | | | | |

The Margalef diversity index revealed moderate variation in beetle richness among bird nest types (Table 2). *Campylorhynchus fasciatus* (CF) and *Mimus longicaudatus* (ML) exhibited the highest richness values, indicating greater ecological heterogeneity and resource availability within their nests. In contrast, *Sicalis flaveola* (SF) showed the lowest diversity value, reflecting simplified assemblage structure. Margalef values ranged from 0 to 1.89, indicating generally low to moderate richness among beetle assemblages associated with bird nests (Fig 2).

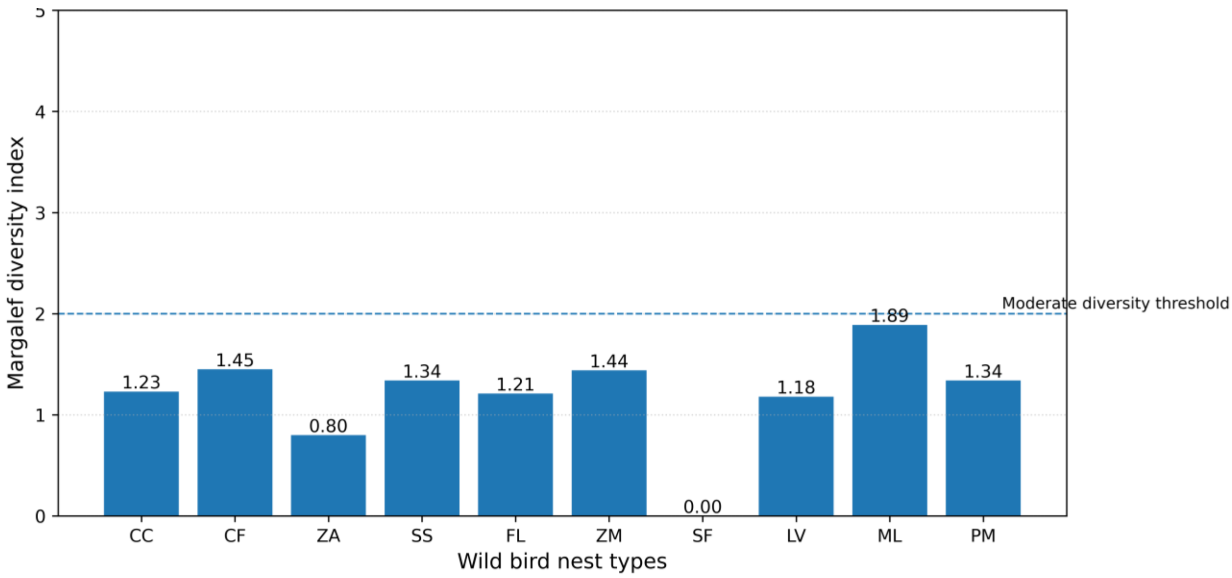


Fig. 2. Margalef diversity index among beetle assemblages associated with wild bird nests.

The Bray-Curtis quantitative similarity index revealed that the beetle community showed the greatest compositional similarity between nests of *Leptotila verreauxi* and *Columbina cruziana*, followed by the pair *Pleocryptes melanops* – Campylorhyknchus fasciatus, and *M. longicaudatus* – *S. stictothorax*. The least similar group relative to the remaining species comprised *Z. meloda* – *Furnarius leucopus* (Fig. 3).

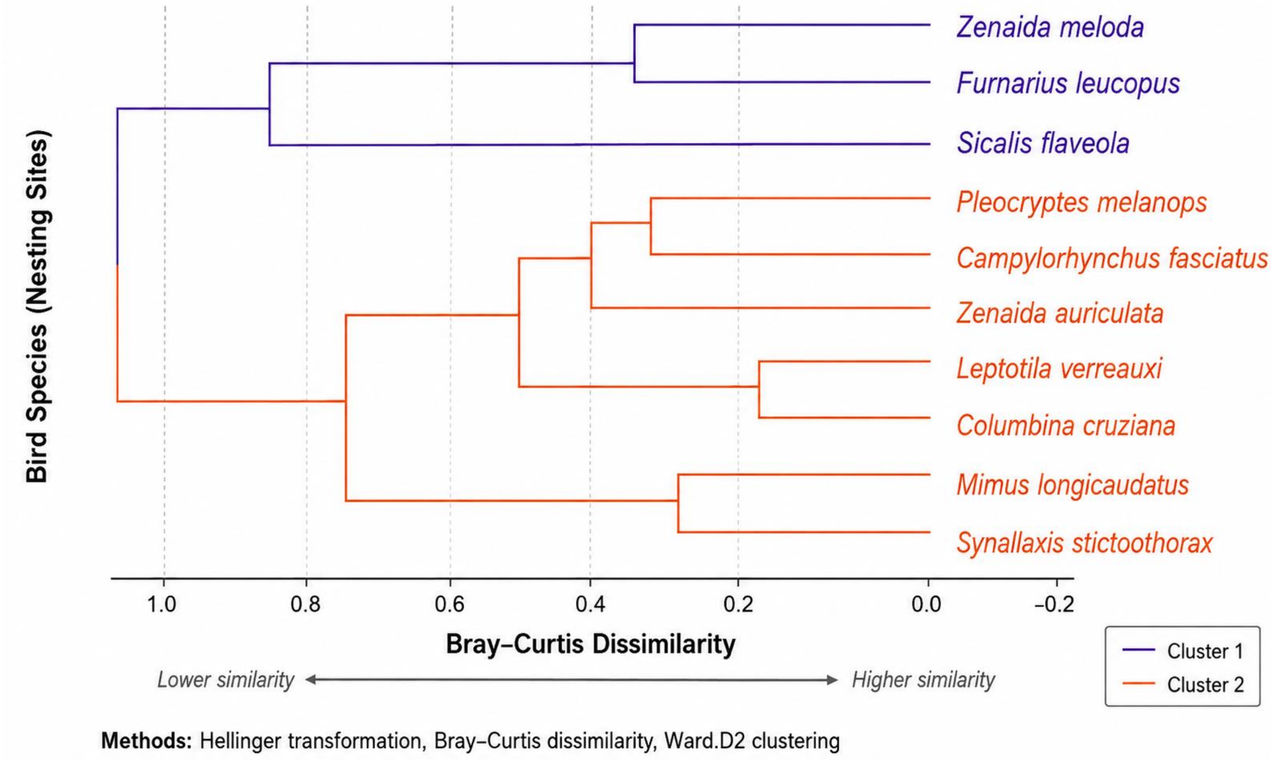


Fig. 3. Similarity dendrogram of the beetle community collected in wild bird nests at a locality in northwestern Peru.

Collectively, the similarity analysis revealed that beetle assemblages associated with bird nests were not randomly distributed among host bird species, but instead formed two major ecological clusters reflecting differences in nest structure, substrate composition, and resource availability. The first cluster, composed of *Zenaida meloda, Furnarius leucopus*, and *Sicalis flaveola*, grouped nests characterized by relatively simplified assemblages, low species richness, and reduced structural heterogeneity. Within this group, *Z. meloda* and F. leucopus shared the highest compositional similarity, suggesting comparable nesting materials and microenvironmental conditions that favor a limited subset of beetle taxa. In contrast, the second and larger cluster included *Pleocryptes melanops, Campylorhynchus fasciatus, Zenaida auriculata, Leptotila verreauxi, Columbina cruziana, Mimus longicaudatus*, and *Synallaxis* stictothorax, all of which supported more diverse and compositionally structured assemblages. Within this cluster, the strongest associations occurred between *Pleocryptes melanops* and *Campylorhynchus fasciatus, Leptotila verreauxi* and *Columbina* cruziana, and *Mimus longicaudatus* and Synallaxis stictothorax.

These species pairs likely share similar nesting architecture, organic matter accumulation, and microclimatic conditions that promote colonization by comparable beetle guilds. The dominance of saprotrophic Tenebrionidae, particularly *Parepitragus pulverulentus*, across several nest types further indicates that organic debris accumulation constitutes a major ecological driver shaping assemblage composition in this arid ecosystem. Overall, the clustering patterns support the hypothesis that bird nests function as ecologically differentiated microhabitats in which structural complexity, resource concentration, and substrate heterogeneity act as environmental filters influencing beetle community assembly within seasonally dry tropical forests.

Figure 4 revealed substantial variation in beetle family richness among bird nest types, indicating that nest architecture and substrate heterogeneity strongly influence the taxonomic and functional structure of beetle assemblages in the dry forests of northwestern Peru. Nests of *Campylorhynchus fasciatus* supported the highest overall richness, harboring representatives of nearly all recorded beetle families, followed by *Mimus longicaudatus* and *Leptotila verreauxi*. These nests exhibited a broader representation of trophic guilds, including saprotrophic Tenebrionidae, xylophagous Cerambycidae and Bostrichidae, predatory Coccinellidae and Carabidae, and phytophagous Elateridae, suggesting that structurally complex nests provide highly heterogeneous microhabitats capable of sustaining multiple ecological functions simultaneously.

The predominance of Tenebrionidae across most nest types highlights the ecological importance of accumulated organic debris and dry vegetal matter as key resources for saprophagous beetles in arid ecosystems. In contrast, nests of *Sicalis flaveola* and Zenaida meloda exhibited markedly simplified assemblages, characterized by low family richness and limited trophic representation, indicating stronger ecological filtering associated with reduced structural complexity. These simplified communities likely reflect lower microclimatic stability, reduced organic matter accumulation, and diminished niche availability. Intermediate richness patterns observed in *Synallaxis stictothorax, Pleocryptes melanops, and Columbina cruziana* suggest that even moderate increases in nest complexity may facilitate the coexistence of multiple beetle families.

Particularly noteworthy was the recurrent occurrence of Tenebrionidae across nearly all nest types, reinforcing the role of saprotrophic beetles as the dominant functional component of nest-associated arthropod communities in seasonally dry forests. Likewise, the co-occurrence of predatory families such as Carabidae and Coccinellidae with decomposer and wood-boring taxa suggests the presence of trophically structured assemblages rather than random species accumulations. Overall, the observed richness patterns support the ecological hypothesis that bird nests function as biodiversity-supporting microhabitats in which structural complexity, resource concentration, and substrate heterogeneity regulate beetle community assembly and trophic organization at the local scale.

In terms of beetle species richness per nest type, *C. fasciatus* nests harbored the highest richness (9 species), followed by *M. longicaudatus* (7 species), whereas *S. flaveola* nests presented the lowest (1 species) (Fig. 4).

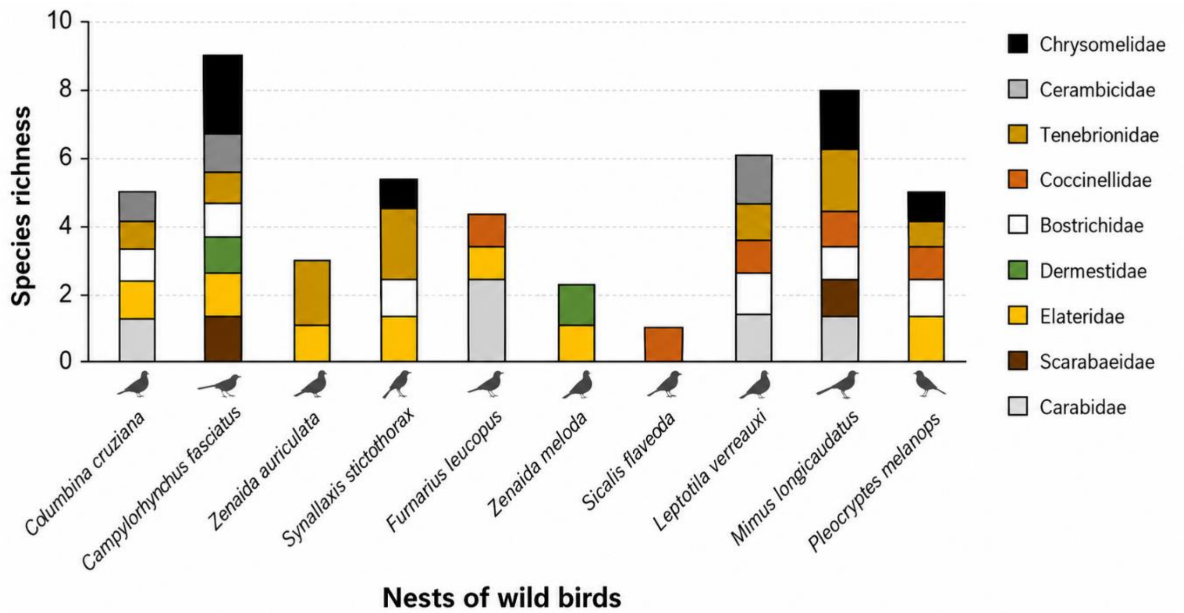


Fig. 4. Species richness of beetle families collected in wild bird nests at a locality in northwestern Peru.

## 4. DISCUSSION

The 17 beetle species recorded in wild bird nests at Marcavelica represent approximately 1.63% of the approximately 1,045 species and subspecies documented for Peru (Chaboo & Flowers 2015). This figure gains ecological significance when considered in the context of the dry forest ecosystem of northwestern Peru, which supports a depauperate yet functionally specialized invertebrate fauna adapted to the extreme aridity of the Tumbes-Piura corridor (More et al. 2014; Espinosa et al. 2012). The subfamily Pimeliinae (Tenebrionidae) alone accounted for 288 of the 394 specimens, underscoring that bird nests constitute a distinctive and productive microhabitat within this landscape. Recent global analyses of beetle distributions have highlighted that arid Neotropical regions remain among the least-sampled beetle habitats, and that many species persist in cryptic microhabitats such as soil, organic litter, and precisely the kind of enclosed nesting structures surveyed here (He et al. 2024). The present results reinforce the premise that bird nests, as discrete packages of organic matter in otherwise resource-scarce environments, can act as important refuges and biodiversity hotspots for Coleoptera at the local scale.

Bird nests have been increasingly recognized as ecologically rich microhabitats that harbor taxonomically and functionally diverse arthropod assemblages. Jaworski et al. (2022), studying nest boxes of six bird and two mammal species across forest, farmland, and urban environments in Poland, recorded 119 insect species from eight orders, confirming that organic debris accumulated in nest boxes—including plant detritus and animal remains—is actively exploited by a broad spectrum of insects, with Coleoptera consistently among the most represented. Similarly, Hanzelka et al. (2023) demonstrated that cavity-breeding birds in boreal forests generate species-specific microhabitats that sustain distinct arthropod communities, and that the composition of nesting material is a key driver of arthropod community structure. At a broader scale, Maziarz et al. (2026), studying ground-nesting Wood Warblers in the primeval Białowieża Forest, found that ephemeral bird nests on the forest floor host more abundant and slightly more diverse macroarthropod communities than adjacent leaf litter, constituting important hubs of local invertebrate biodiversity. The results from Marcavelica align with this global pattern: despite being located in a markedly different biome—a hyper-arid Neotropical dry forest—the surveyed nests harbored assemblages that were compositionally distinct across host species and substantially richer than would be expected from the surrounding environment, consistent with the nest-as-microhabitat framework now well supported in the literature (Maziarz et al. 2026; Jaworski et al. 2022; Hanzelka et al. 2023).

Among the insects previously associated with *Neltuma piurensis* (algarrobo), the dominant tree of the dry forests of Piura (La Torre & Linares 2008), Coleoptera had been represented by 40 species, with Coccinellidae comprising 8 species (Juárez & González 2016). The present study confirmed that six of these species—*Scymnus rubicundus, Paraneda pallidula guticollis, Anomala sp., Amphicerus cornutus, Eburia pilosa and Amblycerus piurae*—co-occur in bird nests, representing approximately 15% of all insect species associated with N. pallida. Wood-boring families such as Cerambycidae and Bostrichidae, and darkling beetles (Tenebrionidae), are characteristic pests of N. pallida (Juárez & González 2016; Morón 1999). Exactly these same families, alongside predatory Coccinellidae, Carabidae, and Elateridae, were recorded in the bird nests of Marcavelica—a finding that reveals a direct ecological bridge between the arboreal fauna of *N. piurensis* and the nest microhabitat. Families such as Bostrichidae and Dermestidae, classically associated with dry organic matter and stored products (including feathers and woody plant material), are well documented as scavengers in bird and mammal nests globally (Jaworski et al. 2022), and their presence in the nests of Marcavelica is therefore ecologically coherent. Collectively, these interspecific associations point to a complex trophic network within the nest: xylophagous and saprotrophic beetles (Bostrichidae, Dermestidae, Tenebrionidae) provide prey resources for predatory guilds (Carabidae, Coccinellidae, Elateridae), mirroring the multilayered food-web structure described for arthropod communities in bird nests elsewhere (Jaworski et al. 2022; Hanzelka et al. 2023).

The nest of *Campylorhynchus fasciatus* "choqueco" was particularly noteworthy, harboring 246 beetle individuals—62.4% of the entire sample—with Parepitragus pulverulentus (214 individuals) as the overwhelmingly dominant species. This tenebrionid is classified as a saprotrophic epigeal decomposer, typical of arid Neotropical ecosystems and characteristic of the subfamily Pimeliinae—"desert tenebrionids" sensu Smith et al. (2015) and Giraldo & Flores (2016). The bulky, dome-shaped, enclosed nests constructed by C. fasciatus in dry-forest shrubs are notably large relative to body size, with walls averaging 3.2 cm in thickness, and incorporating highly heterogeneous material—feathers of *Athene cunicularia*, *Gallus gallus, Meleagris gallopavo* and *Zenaida* sp.; plant materials including *Cocos nucifera husks, Sporobolus sp., Cynodon dactylon, Neltuma pallida, Parkinsonia aculeata leaves, Phragmites australis*, soil and fecal matter; and abundant anthropogenic debris—diaper fragments, guitar strings, popsicle sticks, threads, fabric scraps, silicone batting, toilet paper, tinsel, raffia, cotton, frosted formica sheets, and plastic bags. The incorporation of anthropogenic materials into bird nests has been documented globally and is increasingly viewed as an adaptive behavioral response to the proliferation of such materials in the environment (Jagiello et al. 2023; Hiemstra et al. 2025). While these materials may offer structural and insulative advantages to the bird, their presence substantially alters the nest microhabitat for invertebrate inhabitants—modifying moisture regimes, thermal properties, and the composition of available organic substrates (Jagiello et al. 2023). In the case of the *C. fasciatus* nests at Marcavelica, the thickness and heterogeneity of nest walls is hypothesized to provide a thermally buffered, resource-rich environment that may favor the mass establishment of *P. pulverulentus*, a species that actively exploits accumulated organic matter as both substrate and food resource (Smith et al. 2015; Castañeda 2018). This pattern of disproportionate abundance in structurally complex nests parallels findings by Jaworski et al. (2022), who reported that nests with greater quantities of organic debris supported significantly higher insect abundances.

Viewed as a structured microhabitat, the bird nests of Marcavelica supported four distinct functional guilds of beetles: phytophagous (Elateridae: 1 species), predatory (Coccinellidae: 2 species), saprotrophic (Tenebrionidae: 3 species), and omnivorous (Carabidae: 2 species) (Castañeda, 2018). The co-occurrence of these guilds within a single microhabitat reflects the trophic complexity typical of vertebrate nests, which have been described as "complex networks of interspecific relationships" including herbivores, fungivores, saprophages, and predators (Jaworski et al. 2022; Maziarz et al. 2026). The role of Carabidae as generalist omnivorous predators—well documented in both Neotropical dry forest systems (Ariza et al. 2021) and temperate beetles communities—implies that they actively regulate the abundances of saprophagous and phytophagous beetles within the nest. The presence of Coccinellidae, similarly documented as effective intraguild predators in beetle communities (Rondoni et al. 2021), further reinforces the notion that bird nests function as self-contained trophic systems. The observed species richness differences among nest types—from 9 species in Campylorhynchus fasciatus nests to 1 species in *Sicalis flaveola* nests—are consistent with the well-established relationship between nest structural complexity, organic matter content, and arthropod community diversity (Hanzelka et al. 2023; Jaworski et al. 2022): larger and more architecturally elaborate nests provide greater niche heterogeneity for beetle colonization.

The low Shannon-Wiener diversity values ($H' \leq 1.653$) recorded across all nest types are consistent with assemblages dominated by one or few highly abundant species—a pattern commonly observed in microhabitat-specialist insect communities subjected to ecological filtering (Ariza et al. 2021). The dominance of *Parepitragus pulverulentus* (72.6% of all specimens) represents an extreme case of numerical dominance typical of arid-adapted tenebrionids, whose populations can irrupt rapidly in response to resource pulses of organic matter in desert environments (Henschel, 2021). Margalef richness values ranged from 0.00 to 1.89 across nest types (Table 2), reflecting low to moderate local species richness. The non-significant difference in assemblage structure among nest types (Kruskal–Wallis $p = 0.074$) indicates that, at the local spatial scale, beetle occurrence is relatively widespread across available nesting structures. Consequently, the groupings observed in the Bray–Curtis dendrogram represent descriptive compositional similarity trends rather than statistically segregated communities. While complex nests such as those of Campylorhynchus fasciatus harbored higher abundances ($n = 246$), driven by Parepitragus pulverulentus, we hypothesize that nest volume and material heterogeneity may buffer microclimatic conditions; however, microclimatic parameters and organic matter composition were not quantitatively measured in this study and warrant direct experimental validation. Furthermore, because surrounding leaf litter, soil, and bark substrates were not sampled concurrently, bird nests should be interpreted as localized microhabitats rather than confirmed regional biodiversity hotspots.

From a conservation perspective, the present findings highlight that the decline of nest-building birds in the dry forests of northwestern Peru may carry previously overlooked consequences for invertebrate biodiversity. Maziarz et al. (2026) explicitly warned that widespread population declines of nest-building vertebrates could reduce the availability of nest resources and pose an underappreciated threat to invertebrate conservation. This concern is directly applicable to the dry forests of Piura, where species such as *Campylorhynchus fasciatus*—whose large, permanent nests supported the richest beetle assemblages in this study—are experiencing increasing habitat pressure from land conversion and overgrazing. Long-term monitoring programs that integrate bird nest surveys with invertebrate community assessments would be valuable tools for tracking the ecological integrity of these threatened ecosystems and for identifying functionally keystone bird-beetle interactions deserving targeted conservation attention.

The marked differences in beetle family richness among bird nest types reinforce the hypothesis that nest architecture acts as a major ecological filter shaping arthropod community assembly in seasonally dry forests. Structurally complex nests, particularly those of *Campylorhynchus fasciatus* and *Mimus longicaudatus*, supported the highest taxonomic richness and trophic diversity, suggesting that increased structural heterogeneity promotes niche diversification and resource partitioning among beetle guilds. Similar patterns have been documented in temperate and boreal ecosystems, where nests containing diverse vegetal substrates and accumulated organic matter sustain richer arthropod assemblages through enhanced microhabitat availability and microclimatic buffering (Jaworski et al. 2022; Hanzelka et al. 2023).

In ecological terms, these nests likely function as localized microhabitats within the resource-limited matrix of Neotropical dry forests by concentrating organic substrates, refuges, and trophic resources that facilitate the establishment of multiple beetle families. The predominance of Tenebrionidae across nearly all nest types, together with the overwhelming abundance of *Parepitragus pulverulentus*, indicates that saprotrophic beetles represent the dominant functional component of nest-associated assemblages in this ecosystem. Darkling beetles are widely recognized as characteristic elements of arid and semi-arid environments because of their physiological tolerance to desiccation and their ability to exploit ephemeral pulses of organic matter (Henschel 2021; Smith et al. 2015). The strong representation of Tenebrionidae in nests containing abundant vegetal debris and anthropogenic materials suggests that these microhabitats provide concentrated nutrient reservoirs capable of sustaining decomposer populations under otherwise resource-limited conditions. Comparable ecological responses have been reported in disturbed tropical dry forests, where saprophagous beetles rapidly dominate communities subjected to environmental filtering and habitat simplification (Ariza et al. 2021).

Consequently, the dominance patterns observed in the present study likely reflect both the arid environmental conditions of the study area and the high availability of decomposing organic substrates within bird nests. The compositional clustering observed in the Bray-Curtis dendrogram further demonstrates that beetle assemblages were structured according to similarities in nest architecture and substrate composition rather than randomly distributed among bird species. The segregation of nests into two major clusters suggests that differences in structural complexity, organic matter accumulation, and microclimatic stability strongly influence beetle colonization dynamics. In particular, the close association between *Pleocryptes melanops* and *Campylorhynchus fasciatus*, as well as between *Mimus longicaudatus* and *Synallaxis stictothorax*, indicates that nests sharing similar structural characteristics tend to support compositionally similar beetle assemblages. This pattern is consistent with ecological frameworks proposed for arthropod communities inhabiting vertebrate nests, in which substrate heterogeneity and nest permanence play a central role in determining community organization and trophic complexity (Maziarz et al. 2026; Jaworski et al. 2022). Overall, the present findings support the view that bird nests operate as functionally structured microecosystems capable of regulating local arthropod diversity through habitat filtering, trophic resource concentration, and environmental heterogeneity within seasonally dry tropical forests.

## 5. CONCLUSIONS

Species Composition: A total of 394 adult beetle specimens representing 17 species across 9 families were identified in wild bird nests, with Tenebrionidae (3 species, 304 individuals) and Chrysomelidae (3 species) displaying the highest richness.

Abundance and Dominance: Parepitragus pulverulentus was the overwhelmingly dominant species (286 individuals, 72.6% of total abundance). Nests of Campylorhynchus fasciatus contained the greatest overall abundance (246 specimens), driven primarily by darkling beetle aggregations.

Diversity and Functional Structure: Alpha diversity was low across all nest types ($H' \leq 1.653$), reflecting high numerical dominance by a few dry-adapted taxa. Four functional guilds (phytophagous, predatory, saprotrophic, and omnivorous) were represented. Assemblage composition showed structural clustering associated with nest complexity, confirming that wild bird nests function as ecologically structured microhabitats for Coleoptera in the Neotropical dry forest of northwestern Peru.

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## 8. REFERENCES

Alonso, M. (2015). Clase Insecta: Orden Coleoptera. Departamento de Biodiversidad y Biología Evolutiva. Museo Nacional de Ciencias Naturales (CSIC), Madrid. *Revista IDE@ - SEA*, *55*, 1–18.

Ariza, G. M., Jacome, J., Esquivel, H. E., & Kotze, D. J. (2021). Early successional dynamics of ground beetles (Coleoptera, Carabidae) in the tropical dry forest ecosystem in Colombia. *ZooKeys*, *1044*, 1–28. https://doi.org/10.3897/zookeys.1044.59475

Castañeda, L. (2018). *Propuesta de monitoreo de variables comunitarias al evento El Niño (1998-2001, 2010) en las Lomas de Lachay, Perú* [Master's thesis, Universidad Nacional Agraria La Molina]. UNALM Institutional Repository.

Chaboo, C., & Flowers, W. (2015). Beetles (Coleoptera) of Peru: A survey of the families. Chrysomelidae: Eumolpinae Hope, 1840. *Journal of the Kansas Entomological Society*, *88*(3), 375–379. https://doi.org/10.2317/0022-8567-88.3.375

Ciro, W., Anteparra, M., & Hermann, A. (2008). Dermestidae (Coleoptera) en el Perú: revisión y nuevos registros. *Revista Peruana de Biología*, *15*(1), 15–20.

Espinosa, C. I., De La Cruz, M., Luzuriaga, A., & Escudero, A. (2012). Bosques tropicales secos de la región Pacífico Ecuatorial: diversidad, estructura, funcionamiento e implicaciones para la conservación. *Revista Ecosistemas*, *21*(1-2), 167–179.

Galante, E., & Marcos-García, M. A. (1988). Métodos generales de preparación y conservación. In Asociación Española de Entomología (Ed.), *Bases para un curso práctico de entomología* (pp. 25–34). Universidad de Alicante.

Giraldo, A., & Flores, G. (2016). Peruvian Tenebrionidae: A review of present knowledge and biodiversity. *Annales Zoologici*, *66*(4), 499–513. https://doi.org/10.3161/00034541ANZ2016.66.4.001

Hammer, O., Harper, D. A. T., & Ryan, P. D. (2001). PAST: Paleontological statistics software package for education and data analysis. *Palaeontologia Electronica*, *4*(1), 1–9.

Hanzelka, J., Baroni, D., Martikainen, P., Teva, T., & Laaksonen, T. (2023). Cavity-breeding birds create specific microhabitats for diverse arthropod communities in boreal forests. *Biodiversity and Conservation*, *32*(12), 3845–3874. https://doi.org/10.1007/s10531-023-02684-7

He, P., Bai, M., Li, L., Lu, Y., Li, J., & Yan, Z. (2024). Spatial dynamic simulation of beetles in biodiversity hotspots. *Frontiers in Ecology and Evolution*, *12*, Article 1358914. https://doi.org/10.3389/fevo.2024.1358914

Henschel, J. R. (2021). Long-term population dynamics of Namib Desert tenebrionid beetles reveal complex relationships to pulse-reserve conditions. *Insects*, *12*(9), Article 804. https://doi.org/10.3390/insects12090804

Hiemstra, A. F., Jedlikowski, J., & Polak, M. (2025). Birds documenting the Anthropocene: Stratigraphy of plastic in urban bird nests. *Ecology*, *106*(2), Article e70010. https://doi.org/10.1002/ecy.70010

Huanachin, A., & Huamantinco, A. (2018). Composición y estructura de la comunidad de coleópteros acuáticos (Insecta: Coleoptera) a lo largo de un gradiente altitudinal, Cusco, Perú. *Revista Peruana de Biología*, *25*(2), 131–140. https://doi.org/10.15381/rpb.v25i2.13818

Jagiello, Z., Reynolds, S. J., Nagy, J., Mainwaring, M. C., & Ibanez-Alamo, J. D. (2023). Why do some bird species incorporate more anthropogenic materials into their nests than others? *Philosophical Transactions of the Royal Society B: Biological Sciences*, *378*(1880), Article 20220156. https://doi.org/10.1098/rstb.20220156

Jaworski, T., Gryz, J., Krauze-Gryz, D., Plewa, R., Bystrowski, C., Dobosz, R., & Horak, J. (2022). My home is your home: Nest boxes for birds and mammals provide habitats for diverse insect communities. *Insect Conservation and Diversity*, *15*(4), 461–469. https://doi.org/10.1111/icad.12558

Juárez, G., & González, U. (2016). Coleópteros (Insecta: Coleoptera) del campus de la Universidad de Piura. *The Biologist (Lima)*, *14*(2), 183–198.

Juárez, G., & González, U. (2018). Lista de coleópteros (Insecta: Coleoptera) de la región Piura, Perú. *Folia Entomológica Mexicana (Nueva Serie)*, *4*(1), 1–27.

La Torre, M., & Linares, R. (2008). Mapas y clasificación de vegetación en ecosistemas estacionales: Un análisis cuantitativo de los bosques secos de Piura. *Revista Peruana de Biología*, *15*(1), 31–42.

Margalef, D. (1977). *Ecología*. Ediciones Omega.

Maziarz, M., Broughton, R. K., Foster, C. W., Lesniewska, M., Mazur, M. A., Rutkowski, T., Trigos-Peral, G., Witek, M., & Hebda, G. (2026). Bird nests support a diverse, dynamic and distinctive macroarthropod community on the forest floor. *Insect Conservation and Diversity*. Advance online publication. https://doi.org/10.1111/icad.70067

Ministerio del Ambiente. (2015). *Guía de inventario de la fauna silvestre*. Dirección General de Evaluación, Valoración y Financiamiento del Patrimonio Natural.

Monné, M., & Chaboo, C. (2015). Beetles (Coleoptera) of Peru: A survey of the families. Cerambycidae, Disteniidae, Vesperidae. *Journal of the Kansas Entomological Society*, *88*(1), 34–120. https://doi.org/10.2317/0022-8567-88.1.34

Montero, J. (2011, May 30). *Estudios de la estructura de las comunidades*. Diversidad, Comunidad y Diversidad. **Error! Hyperlink reference not valid.**

More, A., Villegas, P., & Alzamora, M. (2014). *Piura, áreas prioritarias para la conservación de la biodiversidad*. Naturaleza y Cultura Internacional; PROFONANPE.

Morón, M. (1999). Belleza, diversidad y rareza de escarabajos mexicanos. *Biodiversitas*, *26*, 1–6.

Ratcliffe, B., Jameson, M., Figueroa, L., Cave, R., Paulsen, M., Cano, E., Beza, C., Jiménez, L., & Reyes, P. (2015). Beetles (Coleoptera) of Peru: A survey of the families. Scarabaeoidea. *Journal of the Kansas Entomological Society*, *88*(2), 186–207. **Error! Hyperlink reference not valid.**

Ribera, I., & Foster, G. (1997). Uso de artrópodos como indicadores biológicos. *Boletín de la Sociedad Entomológica Aragonesa (SEA)*, *20*, 265–276.

Rondoni, G., Athenas, C., Pizzol, J., Malausa, E., Szucs, L., Ninkovic, D. W., & Conti, E. (2021). Interactions among native and non-native predatory Coccinellidae influence biological control and biodiversity. *Annals of the Entomological Society of America*, *114*(2), 119–135. **Error! Hyperlink reference not valid.**

Schulenberg, T., Stotz, D., Lane, J., O'Neill, J., & Parker, T. (2010). *Birds of Peru* (Rev. ed.). Princeton University Press.

Smith, A., Mendoza, A., Flores, G., & Aalbu, R. (2015). Beetles (Coleoptera) of Peru: A survey of the families. Tenebrionidae. *Journal of the Kansas Entomological Society*, *88*(2), 221–228. **Error! Hyperlink reference not valid.**

Tabarelli, M., Martinez-Garza, C., Lima, V. V. F., & Vanderlei, R. S. (2025). Chronic anthropogenic disturbances reorganize tropical dry forest biota. *Trends in Ecology & Evolution*. Advance online publication. **Error! Hyperlink reference not valid.**
Turienzo, P., & Di Iorio, O. (2008). Insects found in birds' nests from Argentina: Anumbius annumbi (Vieillot, 1817) (Aves: Furnariidae). *Zootaxa*, *1871*(1), 1–55. **Error! Hyperlink reference not valid.**
Ugaz, A., & Saldaña, I. (2014). *Aves de Piura*. Emdecosege S.A.
Vera, P., Marín, M., Belda, E., & Morós, J. (2009). Estructura y composición del nido del Escribano Palustre Iberoriental Emberiza schoeniclus witherbyi. *Revista Catalana d'Ornitologia*, *25*, 43–48.
Villareal, H., Álvarez, M., Córdova, F., Fagua, G., Gast, F., Mendoza, H., Ospina, M., & Umaña, A. (2004). *Manual de métodos para el desarrollo de inventarios de biodiversidad*. Instituto de Investigación de Recursos Biológicos Alexander Von Humboldt.

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