EUROPEAN JOURNAL OF ENTOMOLOGY
ISSN (online): 1802-8829
http://www.eje.cz
Eur. J. Entomol. **122**: 164–172, 2025
doi: 10.14411/eje.2025.021
ORIGINAL ARTICLE

Host plant specialization and bioturbation by the Amazonian cicada *Orialella aerizulae* (Hemiptera: Cicadidae)

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Key words. Tree-insect interactions, rainforest, Fabaceae, *Tachigali*, Peru

Abstract. Adult cicadas in temperate zones are known for their synchronized, loud emergences after spending years underground as nymphs feeding on xylem sap. In contrast, the nymphal stage – where cicadas spend most of their lives – remains poorly understood, especially in the Neotropics. Spatial and host plant relationships between Amazonian cicada nymphs and host trees are virtually unknown, limiting our understanding of the ecological roles of cicadas in Amazonian forests. Here, we present the first detailed spatial ecology study of nymphs of *Orialella aerizulae*, a species that builds conspicuous turrets. Using systematic mapping and quantification of turrets around *Tachigali* spp. trees and random control trees, we provide the first quantitative evidence of a specific cicada-tree association by observing xylem-feeding on fine roots within these turrets. We examine the relationship between turret density, tree developmental stage and size, and document emergence and activity patterns over a 19-month field study in the Peruvian Amazon. Finally, we investigate the species' bioturbation impact and its potential relevance to tree growth.

INTRODUCTION

Cicadas (Hemiptera: Cicadidae) spend most of their life cycle underground as obligate xylem-feeders on the fine roots of woody vegetation, especially trees and shrubs (White & Strehl, 1978; Lloyd & White, 1987) and occasionally grasses (Callaham et al., 2000). Adaptations of cicadas for subterranean xylem feeding date from the mid-Cretaceous (Moulds, 2018) and include enlarged fossorial forelimbs, a long piercing labium reinforced with metal ions, and a robust cibarial pump, allowing cicadas to extract xylem (Jon et al., 2008; Reiter et al., 2023). Xylem, although being an abundant and reliable resource, is nutrient-poor in carbohydrates, amino acids, and vitamins (Redak et al., 2004). Consequently, cicadas must process and filter large volumes of xylem sap and form symbiotic relationships with *Sulcia muelleri* and *Hodkinia cicadicola* bacteria that supply essential amino acids that cicadas cannot synthesize themselves (Christensen & Fogel, 2011; Zheng et al., 2017; Huang et al., 2024).

Subterranean foraging for xylem has the benefit of reducing predation on nymphs by visual insectivores such as birds and primates. However, the exceedingly low nutrient content in xylem constrains nymphal growth rates, leading to prolonged developmental periods (White & Strehl, 1978; Karban, 2022). *Magicicada* species in temperate deciduous forests undergo subterranean developmental periods of up to 17 years (Marlatt, 1907). This combination of low predation rates, xylem feeding and extended developmental time may be associated with evolution of relatively large body size. Cicada body size may also be driven by fecundity selection in adult females and by sexual selection in adult males, who use their voluminous abdominal cavity as part of high-decibel acoustic signaling for mate attraction (Hart et al., 2015). Large body size is also favored by the physical demands of xylem extraction. Compared to phloem-feeding, the energetic cost of xylem extraction becomes prohibitively high at smaller body sizes (Novotny & Wilson, 1997).

Cicadas continue to feed on xylem during the adult stage. In temperate zones, adult cicadas are generally regarded as trophic generalists, utilizing a variety of trees with minimal resource accumulation through adult feeding (Christensen & Fogel, 2011; Hepler et al., 2023). Nevertheless, distinct taxa of adult cicadas in North America have been associated with specific plant communities (Sanborn & Phillips, 2013), and nymphs of cicada species in prairie grasslands are known to specialize in feeding on either C3 or C4 grasses (Callaham et al., 2000).

Comparatively little is known about the host plant preferences or behavioral ecology of cicada nymphs in any region. This is especially true for the highly diverse cicada assemblages in the Neotropics (Sanborn et al., 2011; Sanborn, 2014, 2023). A better understanding of the ecological interactions between cicadas and their host trees in tropical forests may help shed light on the extraordinary tree diversity of the Amazon, estimated to comprise approximately

16,000 species, with up to 250 species co-occurring within a single hectare (Ter Steege et al., 2016). While this hyper-diversity is often attributed to Janzen–Connell effects, whereby natural enemies reduce seedling survival through density-dependent pressures (Janzen, 1970; Terborgh, 2020), no consideration has been given to the role in which the accumulation and concentration of cicadas around host trees might factor in Janzen-Connell processes. It is possible that cicadas, which may reach high densities and exert negative impacts on tree hosts (Thoennes, 1941; Smith & Linderman, 1974; Flory, 2008; Gonzales et al., 2024), play a role in the Janzen-Connell processes, thus influencing tree diversity.

Tropical trees in the family Fabaceae have been suggested as favored hosts of cicadas in Costa Rica (Young, 1984) and in Panama (Johnson & Foster, 1986). However, there appears to be only one Amazonian study of nymphal behavioral ecology and their trophic associations (Béguin, 2020), which reports that *Guyalna chlorogena* (Walker, 1850), constructs conspicuous clay turrets during its final nymphal stage near *Tachigali* spp. Saint-Hilaire, 1824, a fabaceous tree in the Caesalpinioideae, that is widespread in Amazonia (Béguin, 2017).

Pre-emergence turrets have been documented in other cicada species as early as 1840 (Hildreth, 1847). However, the use of these structures to quantitatively assess the spatial distribution of nymphal populations and association with tree species has not yet been explored. Béguin (2020) suggested that turret aggregations produced by *G. chlorogena* are associated with trees from the genus *Tachigali* spp. (Fabaceae: Caesalpiniaceae), and also noted the occurrence of *Orialella aerizulae* Boulard, 1986, in proximity to *Tachigali* spp. trees. However, a quantitative spatial survey and comparison with other tree taxa was not attempted.

Here, we report the first study in the Amazon rainforest of the spatial ecology of a cicada by mapping and quantifying the distribution of *O. aerizulae* turrets (Fig. 1) around *Tachigali* spp. trees in comparison with randomly selected control trees, and observing xylem-feeding on fine roots within these turrets, we provide the first quantitative evidence of a specific cicada-tree association in this region. We examine the relationship between turret density and tree developmental stage and size and document emergence and activity patterns over a 19-month field study in the Peruvian Amazon. Finally, we investigate the species' bioturbation impact and its potential relevance to tree growth.

MATERIAL AND METHODS

Study site

The study was conducted from November 2023 to May 2025 at Los Amigos Biological Station (LABS), located at 12°33′40.0″S, 70°05′46.4″W within the Amazon basin, at an elevational range from 225 to 296 m a.s.l. The station is situated in the Madre de Dios region of southeastern Peru at the convergence of the Los Amigos and Madre de Dios rivers. The study area encompasses a range of habitats including mature old growth forest on terra firme terraces of ancient, weathered soils of low pH and both mature and successional forests found on the more fertile alluvial floodplains that are annually renewed by episodic flooding (Pitman, 2015). There are dense stands of *Guadua* Kunth bamboo and *Mauritia flexuosa* Linnaeus f.-dominated palm swamps (Martel & Cairampoma, 2012). Soils are primarily Ultisols and Inceptisols (Osher & Buol, 1998; Nikitina et al., 2011). The region is characterized by a tropical humid climate with a distinct rainy season from November to February and a dry season from June to September. Annual rainfall ranges between 2700 and 3000 mm and the mean annual temperature ranges from 21°C to 26°C.

Surveys of cicada turret tree associations

To assess habitat preference and possible associations between cicada nymphs of *O. aerizulae* and host trees, turret locations were surveyed along trails covering 24.5 km in terra firme and 17.3 km in floodplain habitats. These surveys followed the available trail network because it provided consistent access across the landscape and ensured adequate visibility for detecting turrets under dense forest conditions. Pairs of observers walked at a steady pace of approximately 2 km/h. Each observer assessed one side of the trail, covering a 20-meter-wide strip, assuming a visual range of 10 m per observer. When a turret aggregation site was located, the putative host tree around which the clay turrets were concentrated was identified, and its diameter at breast height (DBH) was measured. The tree's exact location was georeferenced, and a unique alphabetical code was assigned to it. Control trees in randomized locations were selected in the same DBH size range as the putative host trees for each habitat. The control trees were selected for surveys by generating random GPS coordinates within the boundaries of Los Amigos Biological Station using the random point generation tool in QGIS 3.28.2. To define the boundaries, a polygon representing the station property encompassing the trail system was created including topographical and habitat data, which allowed for the exclusion of areas unsuitable for sampling, such as non-forested regions and water bodies (QGIS Development Team, 2023). To account for habitat variability, the area was further divided into two polygons representing terra firme and floodplain habitats.

Turret abundance and distribution were recorded within a 5-m radius around putative host trees and control trees. Clay turrets were counted and mapped within concentric radii of 1, 2, 3, 4, and 5 m from the trunk of each tree. A quadrant system was established using four ropes extended toward the cardinal directions – north, south, east, and west – with markings at 1-m intervals. This system further subdivided each quadrant into five radial segments corresponding to the 1-, 2-, 3-, 4-, and 5-m distances from the tree. Each quadrant was examined, and the number of turrets was recorded within each radial segment at each of the five distances from the tree trunk.

When it was determined that *O. aerizulae* nymphs were indeed associated with mature *Tachigali* spp. trees, a more comprehensive survey of *Tachigali* spp. trees was conducted to document the relationship between turrets and host tree developmental stage. Transects of 50 by 10 m were walked in each cardinal direction from each of the 32 original *Tachigali* spp. trees identified in terra firme, covering a total area of 6,400 m² surveyed. *Tachigali* spp. trees found during this extensive survey were classified into four size categories based on their height and diameter at breast height (DBH): size 1, seedlings – height less than 30 cm, DBH less than 5 cm; size 2, saplings – height greater than 30 cm, DBH between 5 and 10 cm; size 3, juveniles – height greater than 30 cm, DBH between 10 and 25 cm; and size 4, adults – height greater than 30 cm, DBH greater than 25 cm.

Fig. 1. Aggregation of mud turrets constructed by *Orialella aerizulae* fifth instar nymphs in terra firme forest.

Nymphal feeding activity

To investigate nymphal behavior, turrets were removed at soil surface level, and a F405S-A Ralcam borescope equipped with LED lighting and video capability was inserted to visually observe the nymphs within the burrows. The borescope's insertion tube, marked from 1 to 100 cm, was gradually inserted into each burrow until reaching the nymph, and the depth at which it was found was recorded. The nymph's behavior was classified into feeding – identified by having their mouthparts inserted into the burrow wall or a root, with visible pumping of the cibarial pump; perching – characterized by remaining stationary with their mouthparts retracted; or building – identified by transporting a mass of clay on top of the head.

Bioturbation was quantified in two ways. First, the 1-m length borescope tube was gently pushed until the bottom of the burrow was reached, allowing for accurate recording of burrow depth. In instances where the full length of the insertion tube did not reach the bottom, the burrow depth was recorded as greater than 100 cm. Second, the amount of clay displaced by turret building was estimated by drying turrets and weighing the amount of soil utilized in building. Turret soil texture and organic content were observed by pulverizing dried turrets, and then mixing the pulverized soil in water, allowing it to settle for separation, to finally mixing and sieving the solution through a cotton cloth.

Cicada phenology and identity

To confirm the cicada species identity and determine emergence patterns from turrets, 32 mesh cages were placed over closed clay turrets, which were installed in early June 2024 and monitored until the end of February 2025. The cages were inspected every two days, and when an emerged cicada was detected inside, the specimen was collected. The sex of each individual and the date of capture were recorded. Adults were identified using morphological characteristics aligned with the descriptions provided by the Catalogue of Life (Catalogue of Life, 2024) and verified against the detailed species account of *O. aerizulae* in Maccagnan & Sanborn (2015). One adult specimen captured emerging from a turret was DNA barcoded at the Centre for Biodiversity Genomics (University of Guelph), confirming its identity as *Orialella aerizulae* (BOLD Systems, 2025). To determine whether *O. aerizulae* showed attraction to light sources and its phenology, cicadas were manually collected each night from a 2.20 × 4-m white sheet illuminated by a 150W LED Light Bulb. Light trap sampling was conducted nightly from November 2023 through May 2025. The light was activated every day at 6:00 PM, and cicadas present at the sheet were manually collected at 7:30 PM. The number and sex of individuals for each captured species were recorded.

RESULTS

Host tree association and turret distribution

In the initial survey of terra firme versus floodplain, a total of 35 turret aggregations of *O. aerizulae* nymphs were located in mature terra firme and floodplain. The majority of these aggregations (N = 32) were found in terra firme, and only 3 were found in floodplain (Fig. 2). These ag-

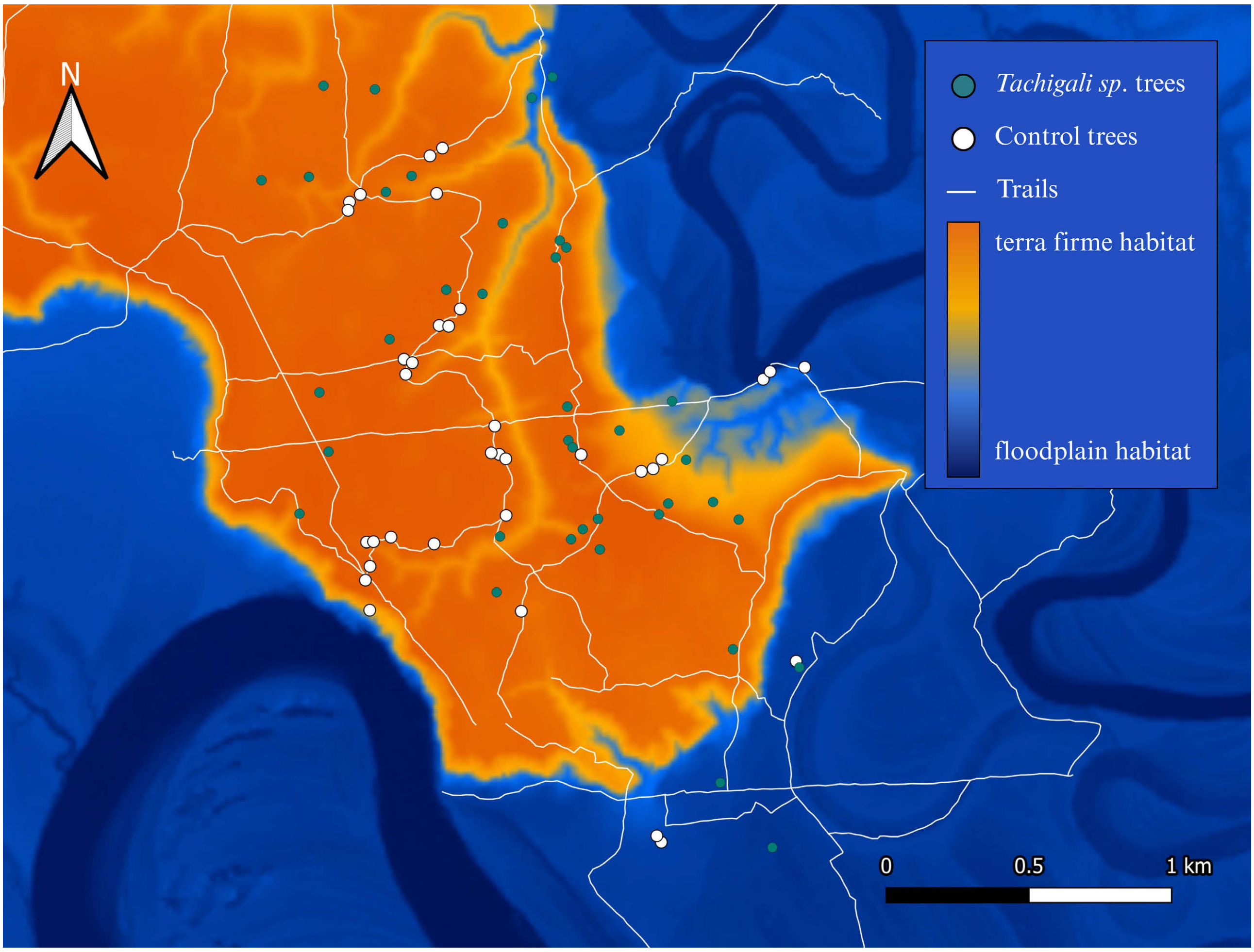

Fig. 2. Map of the study site showing habitat types derived from LiDAR data, with a color gradient from orange (terra firme habitat) to blue (floodplain habitat), locations of *Tachigali* spp. trees (white points) and control trees (green points), along with the trail network.

gregations were exclusively found in close proximity with trees of the genus *Tachigali* spp., and a total of 1,036 turrets were located and mapped. In contrast, none of the 35 control trees had aggregations of cicada turrets within a 5-m radius. These control trees included the following genera, with the corresponding number of individuals evaluated in parentheses: *Acacia* Miller (1), *Apuleia* Martius (1), *Bertholletia* Bonpland (1), *Bixa* Linnaeus (2), *Cecropia* Loefling (1), *Faramea* Aublet (1), *Hevea* Aublet (3), *Inga* Miller (3), *Iryanthera* Warburg (1), *Jacaranda* Jussieu (3), *Lauraceae* Jussieu (1), *Lecythidaceae* Bory (1), *Meliosma* Blume (1), *Nealchornea* Huber (1), *Pourouma* Aublet (7), *Pouteria* Aublet (2), *Pseudolmedia* Trécul (1), *Sapotaceae* Jussieu (1), and *Sloanea* Linnaeus (3).

Turret density across sites was highest within 1 m of the *Tachigali* spp. trunk and declined significantly with increasing distance (Fig. 3). Using a negative binomial regression model to account for overdispersion in the data, we identified a significant negative relationship between the distance from the tree and the number of turrets ($z = -2.42$, $p = 0.0155$). The distance coefficient was –0.301 (± 0.124 SE), indicating that for every 1-m increase in radius, the expected number of towers decreased by approximately 26%.

The presence of mud turrets associated with *Tachigali* spp. trees was size dependent. In our more extensive terra firme survey, 355 *Tachigali* spp. trees of varying developmental stages were located, of which 314 were seedlings, 19 saplings, 6 juveniles and 16 adults. To assess the relationship between tree developmental stage and turret presence, the data were converted into a contingency table based on the proportion of individuals in each tree size class that showed an association with mud turrets (Table 1). A Fisher's Exact Test applied to the contingency table indicated a highly significant difference in turret presence across size classes ($p < 2.2e-16$). Notably, *O. aerizulae* nymphs began their association with *Tachigali* spp. trees at

Table 1. Association between *Tachigali* spp. developmental stage and the presence of cicada mud turrets. The table shows the number of individuals in each tree stage (seedling, sapling, juvenile, adult) that were observed either with or without turrets at their base.

Developmental stage	with turrets (n)	without turrets (n)	Total
Seedling	5	309	314
Sapling	7	12	19
Juvenile	5	1	6
Adult	16	0	16

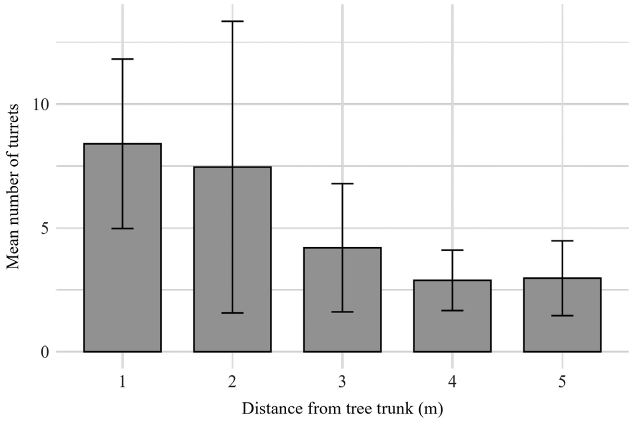

Fig. 3. Mean number of cicada turrets at increasing distances from tree trunks (1–5 m) across all sampled *Tachigali* spp. trees. Bars represent mean turret counts per distance, and error bars indicate the standard error of the mean (SE).

the seedling stage, and the presence of turret aggregations increased progressively with tree developmental stage, with all of the adult trees associated with turret aggregations (Fig. 4). Although some turrets were found near seedlings and saplings, we cannot rule out the possibility that these nymphs were exploiting the roots of nearby larger trees whose roots extended beneath the smaller individuals. Nonetheless, the increasing frequency of turret presence with tree size strongly supports a primary association with larger, more developed *Tachigali* spp. individuals.

To analyze the relationship between tree size (measured as DBH) and turret abundance, we applied a Generalized Additive Model (GAM) to the initial dataset of 35 adult trees, using the number of associated mud turrets as the response variable, which revealed a marginally significant non-linear relationship (smooth term: p = 0.0534, effective degrees of freedom = 5.583). The GAM analysis suggested that turret abundance increases for medium-sized trees (40–100 cm DBH) but decreases for both smaller and larger trees (Fig. 5).

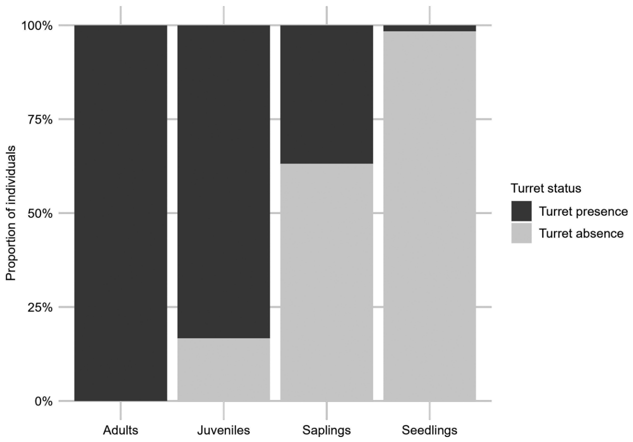

Fig. 4. Proportional distribution of mud turrets associated with *Tachigali* spp. tree developmental stage. The graph shows the proportion of individuals in each tree's developmental stage (seedlings, saplings, juveniles, and adults) that exhibited turret presence or absence. The proportion of turret presence increased progressively with tree's developmental stage, with seedlings showing the lowest association and adults showing the highest.

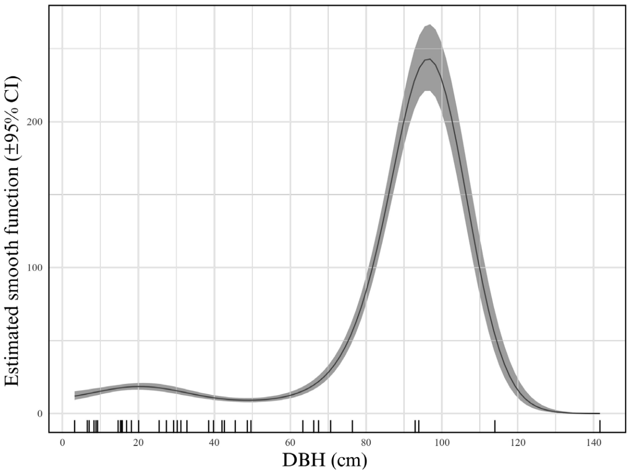

Fig. 5. Smooth function of diameter at breast height (DBH, measured in cm) as a predictor of the total number of cicada turrets, estimated using a GAM with a Poisson distribution. The solid black line represents the fitted smooth function, while the shaded gray area denotes the 95% confidence interval. Rug marks along the x-axis indicate the observed DBH values in the dataset. The results suggest a non-linear relationship between DBH and turret abundance, with a peak at intermediate DBH values before declining at larger sizes.

Feeding behavior

Cicadas were visually observed feeding on fine roots protruding into the burrow cavity or embedded in the smooth burrow wall surface. This feeding occurred only in the upper soil layer where fine roots were abundant. A Kruskal-Wallis rank sum test was conducted to compare the depth of nymphs observed during feeding, perching, and building activities (Fig. 6). The test revealed a significant difference in depth between the feeding and non-feeding activities (Kruskal-Wallis chi-squared = 22.888, df = 2,

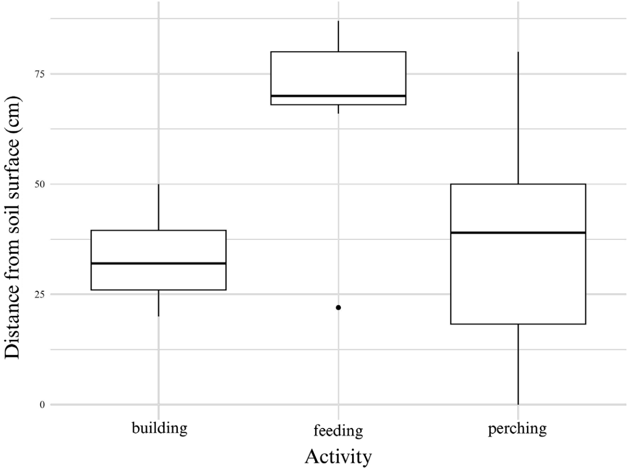

Fig. 6. Distribution of nymph depths associated with different activity types: building, feeding and perching. The distances from the soil surface are represented for each activity, with significant differences in depth observed. Feeding nymphs were located significantly shallower than those engaged in perching and building activities. No significant difference in depth was found between nymphs observed perching and building.

$p = 1.072 \times 10^{-5}$). Feeding nymphs were located at significantly shallower depths compared to when perching ($p = 3.7 \times 10^{-5}$) and building ($p = 0.01$). Post-hoc pairwise comparisons using the Wilcoxon rank sum test with Bonferroni correction indicated that there was no significant difference in depth between nymphs observed perching and collecting mud for turret building ($p = 0.98$).

Bioturbation

Aggregations of cicada nymphs moved a substantial amount of soil around their host trees. The average individual turret weight (N = 40) was 267.98 g (± 95.04 g). Using this average weight, the total soil bioturbation attributed to cicada activity around the 35 surveyed mature trees was estimated at 277.62 kg**.** The turret soil was found to be fine, uniformly textured clay, virtually free from organic debris or coarse particulate matter.

Burrow depths (N = 33) ranged from 28 cm to more than 100 cm, with an IQR of 29 cm, a mean depth of 69.1 cm (± 9.9 cm) and a median depth of 67 cm. Burrow width (N = 33) was an average 1.87 cm (± 0.22 cm).

The estimated space cleared beneath the soil by cicada burrows was calculated assuming a simple cylindrical shape for each burrow. The average burrow depth was 69.1 cm (± 19.9 cm), and the average burrow diameter was 1.87 cm (± 0.22 cm). Using these dimensions, the average volume of a single burrow was estimated to be 189.78 cm^3 (± 70.58 cm^3). With a total of 1036 burrows observed, the combined soil volume displaced by cicada burrowing activity was approximately 197,000 cm^3, based on the average measurements.

Cicada capture and identification

Over the monitoring period, a total of 2,879 cicada individuals were collected at the light trap, corresponding to approximately 39 putative species based on preliminary DNA barcoding results. This diversity represents about one-third of all cicada species currently known from Peru (Sanborn, 2020). Only two individuals of *O. aerizulae* were captured at the light trap, on September 13th and October 24th, 2024, accounting for just 0.07% of the total captures. In contrast, fourteen individuals emerged from turrets enclosed in cages between October and December 2024, with no emergence recorded outside this period. All emerged individuals were *O. aerizulae*, comprising 10 females (71.4%) and 4 males (28.6%). No clear temporal overlap was observed between light trap captures and turret emergence events.

DISCUSSION

The strong association between *O. aerizulae* aggregations of fifth instar nymphs and *Tachigali* spp. trees suggests a specialized relationship between the two. Nymphs were observed feeding on the xylem from the fine root hairs of these trees, indicating a likely dependency on these trees for nourishment. *Tachigali* spp. trees were concentrated in terra firme habitat, suggesting a habitat restriction of *O. aerizulae* to this habitat because of host specificity.

The consistent association of *O. aerizulae* aggregations with *Tachigali* spp., starting early in the tree's development, raises the question of what makes *Tachigali* spp. preferred hosts. Circumstantial evidence suggests that *Tachigali* spp. provide *O. aerizulae* with access to a relatively rich nitrogen resource. While many Caesalpinioideae trees lack nitrogen-fixing bacteria in their roots, *Tachigali* spp. are one of the exceptions (Parker, 2008; Tian et al., 2015). If xylem nutrient concentration limits rate of nymphal development (Karban, 2022) it follows that cicadas may prefer trees that have nitrogen-fixing capacity. *Tachigali* spp. grown with *Eucalyptus* L'Héritier in Brazil show that the nitrogen content of *Tachigali* spp. is 4–5 times higher (Silva et al., 2019). Studies of temperate zone *Magicicada* Davis, 1925 species showed that nymphs associated with trees fertilized with nitrogen grew larger than those in control plots (White & Lloyd, 1985). In a region of Bolivia, south of Los Amigos Biological Station, a survey of tree growth rates revealed that a cohort of *Tachigali* spp. exhibited by far the highest growth rate, characterized by the development of a large leafy crown and low-density wood (Poorter et al., 2005). This rapid growth of *Tachigali* spp. may be facilitated by their capacity for nitrogen fixation which in turn would confer a growth rate advantage on xylem feeders and may explain the attraction of *O. aerizulae* to *Tachigali* spp.

However, nitrogen fixation alone is unlikely to fully explain why *O. aerizulae* associates specifically with *Tachigali* spp. trees over other Fabaceae species. A key difference is that, unlike most rainforest trees, which are iteroparous and reproduce multiple times throughout their lives, most *Tachigali* spp. trees follow a semelparous life cycle, reproducing only once before dying (Foster, 1977; Young & Augspurger, 1991). This strategy involves a prolonged vegetative phase, during which the trees accumulate substantial resources for a single large reproductive event (Lopes, 2018). Given that cicadas feed on root xylem, which is typically nutrient-poor, a semelparous strategy may provide a temporary but richer nutrient source in the xylem compared to iteroparous trees. This higher nutrient availability could make *Tachigali* spp. trees optimal feeding sites for developing cicadas. Host specialization in cicadas is likely shaped by a complex interplay of ecological opportunity and evolutionary history. The absence of other cicada species associated with *Tachigali* spp. suggests that this relationship may represent a rare, lineage-specific specialization. Further comparative studies are needed to determine whether access to nitrogen-rich hosts is a general driver of cicada-host associations or a unique feature of this particular case.

Tachigali is a widespread Neotropical genus comprising 98 described species, with over 23,000 occurrence records available on the Global Biodiversity Information Facility (GBIF), suggesting a broad geographic range and ecological abundance of its members (GBIF 2025a). In contrast, the cicada *Orialella aerizulae* is known from only 23 occurrence records (GBIF, 2025b), which is presumably due to its low attraction to light traps.

O. aerizulae did not exhibit a peak or synchronous emergence in the emergence cages. Unlike some other cicada species that arrived in swarms at the light trap, *O. aerizulae* emerged only during specific months of the year, from October to December. This suggests that their turret building and emergence are concentrated in a particular seasonal period, rather than being a year-round activity.

The reason why these turrets are being constructed by *O. aerizulae* remains unclear. The fact that remarkably similar turrets are also constructed by *G. chlorogena* suggests a functional convergence rather than mere coincidence. In contrast to other cicada species, such as *Magicicada* spp., which construct short-lived mud turrets only a few weeks prior to adult emergence to cap their emergence tunnels (Marshall, 2008), both *G. chlorogena* and *O. aerizulae* construct turrets that may persist for up to two years before emergence (Béguin, 2020). This prolonged presence suggests that the turrets serve an ecological function beyond merely facilitating adult emergence. Béguin (2020) proposes that the turrets may help nymphs regulate critical environmental parameters such as humidity, pressure, and gas concentrations (O_2 and CO_2), enhancing their chances of survival.

An alternative explanation is that the turrets formed by accumulated excavated soil may be by-products of a specific foraging strategy employed by fifth instar nymphs. These nymphs feed on fine root hairs in the upper layers of the soil and retreat to deeper, predator-free zones when not feeding. The considerable volume of soil displaced during burrow construction requires an effective means of disposal. Simply pushing the soil onto the forest floor would expose the nymphs to predators, such as armadillos (*Dasypus* spp. Linnaeus), anteaters (*Myrmecophaga tridactyla* Linnaeus), and other potential threats, and could create soil accumulations that would funnel water into the burrow. Therefore, constructing a turret provides an optimal strategy – it exposes only a small surface area, allowing the nymph to quickly retreat deep underground when a predator approaches, while simultaneously facilitating soil disposal and providing easy access to roots for feeding at different depths.

In contrast, generalist-feeding cicada nymphs in temperate zones do not construct these kinds of turrets. Instead, they may forage laterally by moving between trees and backfilling the soil behind them, a strategy that allows them to exploit a broader range of roots while minimizing predation risk. Their ability to forage across different root systems without being confined to a single tree contrasts with the strategy of *O. aerizulae* and *G. chlorogena*, which remain tied to specific *Tachigali* spp. trees, feeding repeatedly on the same fine roots over extended periods.

In any case it is clear that the two cicada species that appear to target individual *Tachigali* spp. as a long-term host do so over multiple years during their development. Understanding these interactions is also of practical relevance, as they may have implications for forest management and conservation strategies. Plantations of *Schizolobium amazonicum* Huber, a close relative of *Tachigali* spp., may experience 20% productivity losses due to the cicada *Quesada gigas* Olivier, 1790 (Monteiro et al., 2013). However, mitigation of this negative interaction might occur if the loss of xylem fluid is offset by the significant bioturbation observed and the opening of the soil for atmospheric and water percolation to depths of a meter around *Tachigali* spp. trees. Rhizobial inoculation improves when soil aeration and access to moisture are elevated (Torabian et al., 2019) and other aspects of microbiome-mediated release of soil nutrients are also enhanced by aeration (Sun et al., 2022). Testing of the potentially mutualistic aspect of this cicada-tree association was beyond the scope of this study, but it remains a topic amenable to experimental exploration.

Tachigali spp. are increasingly used as trees for climate mitigation, ecological restoration and in agroforestry applications in Amazonia (Silva et al., 2019) warranting further explorations of this particular association, Moreover, the great specificity of the cicadas-tree association documented here suggests a need for deeper exploration of the relationships existing between the highly diverse cicada assemblages and the extreme floristic diversity of Amazonia.

ACKNOWLEDGEMENTS. We thank the Andes Amazon Fund for funding and supporting this research. We also acknowledge the Asociación para la Conservación de la Cuenca Amazónica (ACCA) for hosting us at the Los Amigos Biological Station (LABS), E. Hernandez for assistance with field data collection, and the Biodiversity Institute for Conservation Synthesis (BICS) for providing DNA barcodes. Cicada specimens were collected under SERFOR permit N° AUT-IFS-2022-043.

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Received May 8, 2025; revised and accepted July 28, 2025

Online supplementary files:
S1 (http://www.eje.cz/2025/021/S01.mp4). Video S1. Nymph feeding from a root on the burrow wall.
S2 (http://www.eje.cz/2025/021/S02.mp4). Video S2. Nymph covering damage.
S3 (http://www.eje.cz/2025/021/S03.mp4). Video S3. Nymph feeding from a superficial root.
S4 (http://www.eje.cz/2025/021/S04.mp4). Video S4. Nymph defending burrow.