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Nest Structure and Prey Selection in the Mud Dauber Wasp *Sceliphron madraspatanum*

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ABSTRACT

Carbronid and Sphecid wasps are known for constructing distinctive nests with specific architectural designs, which serve as sites for egg-laying and larval development. This study examined the nest characteristics and prey selection for the mud dauber wasp, *Sceliphron madraspatanum*, at the A.V.C. College campus from January to March 2019. The research focuses on both active and abandoned nests, revealing that *S. madraspatanum* nests are typically built on bright surfaces, offering protection from water and direct sunlight. The average height of the nests was less than two feet, with a nest length of less than 5 cm, and a cell width or depth of less than 3 cm. On average, there were 6 orifices or cells, with cell lengths ranging from 2.25 cm to 1.92 cm. Most nests had a rectangular shape, although some were irregular. In comparison, active nests were positioned lower to the ground and had fewer orifices or cells than inactive nests. However, the nest length, cell width, depth, and weight of active nests were higher than those of inactive ones. A total of 24 larvae were extracted from 20 cells, weighing approximately 3.15 g. The prey, consisting of 153 paralyzed spiders from the order Araneae, weighed a total of 17.27 g. The findings indicate that the mud dauber wasp exhibits a species-specific nest architecture and preys on spiders within agroecosystems. This research suggests that mud dauber wasps may be beneficial insects in agricultural environments.

Keywords: Nest architecture, Mud dauber wasp, Nest orientation, Prey, Paralyzed, Spider

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Introduction

Wasps, whether solitary or social, build nests using artificial or natural materials as their substrate. The genus Sceliphron is home to 35 species globally [1]. Some crabronid and sphecid wasps are known for constructing distinct nests with specific architectural designs to house their eggs and care for their larvae. Those nests are made from mud collected from nearby puddles, earning these wasps their common name, “mud daubers” or “dirt daubers.” The family Sphecidae, which includes solitary or social bees, contains several digger wasps such as *Sceliphron madraspatanum* (Fabricius), a well-known species within the thread-waisted wasp category. The construction of nests is crucial for protecting the larvae from predators and providing long-term food storage. The materials and techniques used for nest construction are specific to each species of wasp. Previous studies have explored nest characteristics and prey selection in various wasp species [2-5].

The behavior of individual foraging, where different members of a population specialize in hunting distinct types of prey, has been studied in animals, but its impact on food webs and population dynamics in invertebrates remains underexplored [6]. In Sceliphron, females construct mud nests in isolated, dry locations, though some are often found in human-inhabited areas. A female starts by creating a single cell, filling it with one spider, and sealing it before moving on to construct another. Several cells are usually created together to form a nest, with incomplete cells sometimes sealed temporarily overnight [7, 8]. Many of the cells in a nest are covered by a layer of mud [9-12]. Halder *et al*. [2] observed that each cell in *S. madraspatanum* required 10–13 round trips to build, with each trip involving the collection of soft mud from irrigated fields or nearby channels, carried by the wasp using its mandibles and forelegs.
This study focuses on the architectural features of mud dauber nests and the site selection for their construction, as well as the availability of prey within the nest cells of active mud dauber wasps.

Materials and Methods

Nests were collected from the A.V.C. College Campus, located in Mayiladuthurai, Mannampandal, Tamil Nadu. The area is part of a vegetable agroecosystem, where crops like bhendi, brinjal, and banana are cultivated. A total of 25 *S. madraspatanum* nests were randomly collected between January and March 2019, with 2 to 3 nests collected and analyzed each week. These nests were transported to the laboratory and placed in plastic boxes (10 x 8 x 5 cm). Upon opening the nests, the cells and the structures were examined. The bait (spiders) was separated from the cells by species and manually counted. Spider identification was done using Indian spider field guides and related literature [13]. Additional observations of the nests were made directly at the collection site. Statistical analyses, including diversity indices and a correlation matrix, were performed to assess the significance of the data using IBM SPSS version 25.

Results and Discussion

The mud nests of *S. madraspatanum* were typically constructed on well-lit surfaces, shielded from direct sunlight and water. Some nests were particularly large, with strong bases that made them difficult to separate. The average height of the nests from the ground was 52.44 ± 28.86 cm, with an average length of 4.78 ± 1.67 cm and width of 2.35 ± 0.44 cm. The mean weight of the nests was 13.94 ± 11.70 g. The average number of orifices was 6.0 ± 1.58, with the highest count recorded at 10 orifices and the lowest at 4. The nests contained an average of 6.0 ± 1.58 chambers (n = 25), with the length of the chambers ranging from 2.25 cm to 1.91 cm. Most nests (96%) were rectangular, while a small proportion (4%) had irregular shapes. In terms of substrate orientation, 40% of the nests faced east, 32% faced north, and 28% faced west. Approximately 80% of the nests were built on walls, with the remaining 20% on other materials, such as bamboo poles, cloth, switch boxes, and tables. The study also found that 84% of the nests were inactive, while the rest were active and selected for further analysis of their contents.
Among the 25 nests, 4 were identified as active, with an average height of 32 ± 14.99 cm. The average nest width and length for active nests were 5.13 ± 1.45 cm and 2.48 ± 0.21 cm, respectively. The weight of these nests varied between 10.26 g and 42.49 g, with an average of 21.94 ± 7.50 g. The number of orifices in these nests ranged from four to six, with an average of 5 ± 0.41. Active nests contained an average of 5.0 ± 0.7 chambers, with chamber lengths between 2.25 cm and 1.91 cm. The chamber diameters ranged from 0.52 cm to 0.46 cm.
The active nests were opened for further investigation into the larvae and prey within. A total of 24 larvae were retrieved from the 4 active nests, with an average weight of 3.15 g. The prey found in the nests consisted of 153 individual spiders, with a total weight of 17.27 g. The highest frequency and diversity of prey were observed in the family Salticidae (five genera), followed by Lycosidae (one genus) and Araneidae (1 genus) **(Table 1)**.

Table 1. Spider species found in inactive nests of *S. madraspatanum* during the study period (n = 2)

Spider species	Common name	Family	Nest I	Nest II
Hyllus semicupreus	Semi-coppered heavy jumper	Salticidae	20	17
Hasarius adansoni	Adanson's house jumper		1	1
Menemerus bivittatus	Grey wall jumper		1	1
Bavia kairali	Jumping spider		41	13

Telamonia dimidiata	Two-striped jumper		9	1
Lycosa Mackenziei	Wolf spider	Lycosidae	7	3
Neoscona nautica	Brown sailor spider	Araneidae	6	4
Unidentified Species			19	9
Total			**104**	**49**

The diversity indices indicated minimal variation between the two mud dauber nests. Measures such as dominance index species richness, Simpson diversity index, Shannon's index, and evenness were similar across the nests, with the main differences being in the number of individuals found in each nest **(Table 2)**.

The shape of the active mud dauber nests was predominantly rectangular, and the orientation of the nests showed a preference for the west (75%), followed by the east (25%). Walls were the preferred substrate for nest construction. Statistical analysis revealed that water sources had a positive impact on several factors, including nest height from the nest length, ground, waste material accumulation, and the number of orifices. Nest height was positively correlated with nest length, and nest length, in turn, influenced nest weight. Additionally, nest length had a significant effect on the number of orifices and nest weight **(Table 3)**. The correlation matrix for active nests highlighted that nest height from the ground had a significant effect on spider weight, the number of larvae, and larval weight **(Table 4)**.

Table 2. Diversity indices of spiders in inactive nests of mud dauber (n = 2)

Indices	**Nest I**	**Nest II**
Species richness	8	8
Total individuals	104	49
Dominance index	0.2413	0.2362
Simpson diversity index	0.7587	0.7638
Shannon H' index	1.642	1.644
Evenness	0.6456	0.6472

Table 3. Correlation matrix of variables for *S. madraspatanum* nests collected during the study period (irrespective of nest type)

Variables	**Water source**	**Nest height**	**Nest width**	**Nest length**	**No. of orifices**	**Nest weight**	**Waste materials**
Water source	1	-	-	-	-	-	-
Nest height	0.226	1	-	-	-	-	-
Nest width	-0.113	-0.192	1	-	-	-	-
Nest length	0.129	0.035	-0.247	1	-	-	-
No. of orifices	0.324*	-0.174	-0.089	0.491*	1	-	-
Nest weight	-0.293	-0.356	0.205	0.455*	0.082	1	-
Waste materials	0.192	-0.132	-0.048	0.031	0.221	-0.028	1

Note: Correlation is significant at the 0.05 level (2-tailed).

Table 4. Correlation matrix of variables for active *S. madraspatanum* nests collected during the study period

Variables	**NHG**	**WS**	**NW**	**NL**	**NO**	**NWt**	**WM**	**SW**	**No L**	**LW**	**No S**
NHG	1	-0.469	0.298	0.792*	0.073	0.690*	-0.601	0.932*	0.914*	0.934*	0.258
WS	-0.469	1	-0.719	-0.026	0.846*	-0.310	0.987**	-0.566	-0.170	-0.595	-0.914
NW	0.298	-0.719	1	-0.346	-0.596	-0.306	-0.734	0.143	-0.114	0.180	0.913*
NL	0.792*	-0.026	-0.346	1	0.423*	0.892*	-0.143	0.836*	0.970*	0.815*	-0.314
NO	0.073	0.846*	-0.596	0.423*	1	0.028	0.748*	0.881*	0.838*	0.866*	-0.857

NWt	0.690*	-0.310	-0.306	0.892*	0.028	1	-0.370	0.881*	0.838*	0.999**	-0.093
WM	-0.601	0.987**	-0.734	-0.143	0.748*	-0.370	1	-0.662	-0.303	-0.690	-0.888
SW	0.932*	-0.566	0.143	0.836*	0.881*	0.028	-0.662	1	0.902*	0.999**	0.254
No L	0.914*	-0.170	-0.114	0.970*	0.838*	0.838*	-0.303	0.902*	1	0.888**	-0.127
LW	0.934*	-0.595	0.180	0.815*	0.866*	0.999**	-0.690	0.999**	0.888**	1	0.291
No S	0.258	-0.914	0.913*	-0.314	-0.857	-0.093	-0.888	0.254	-0.127	0.291	1

*Note: Correlation is significant at the 0.05 level (1-tailed), *Significant at the 0.01 level (1-tailed); NHG = nest height from the ground, WS = water source, NW = nest width, NL = nest length, NO = no. of orifices, NWt = nest weight, WM = waste materials, SW = spider weight, No L = no. of larvae, LW = larval weight, and No S = no. of spiders

Exploring the nests of various fauna provides valuable insights into their natural history [14-16]. Research shows that *S. madraspatanum* typically constructs its nests on well-lit surfaces, such as walls and under tables, while also being protected from direct sunlight and water. Naumann [17] observed that *Sceliphron laetum* tends to build its nests in partially shaded areas, shielded from both rain and direct sunlight. Similarly, nests of *Syzygium formosum* have been found on walls that are protected from rain but well-ventilated. Callan [11] also noted that *Syzygium formosum* nests are often located in sheltered, illuminated environments.

In this study, nests were found to be located less than two feet off the ground, which could be attributed to the availability of suitable nesting spots, ease of maintenance, and the relatively short time taken to construct the nests [3]. The nests of *S. madraspatanum* measured less than 5 centimeters in length, with a cell width or depth of less than 3 centimeters. On average, the nests contained 6 orifices, with lengths ranging from 2.25 to 1.92 centimeters. These findings are consistent with previous research on *Anoplius infuscatus* and *Episyron* sp. [18]. Camillo [7] reported similar results for *Sceliphron fistularium* nests, where the number of cells varied from 1 to 54, with cell lengths between 20.8 and 29.7 mm and diameters ranging from 7.6 to 11.7 millimeters.

The nests of *S. madraspatanum* predominantly have a rectangular shape, with some being irregular. This is similar to the nest construction of *Sceliphron assimile*, as members of the genus *Sceliphron* typically build rectangular mud nests consisting of individual cells [9]. The orientation of the nest substrate plays a crucial role in protecting it from both abiotic factors, such as sunlight, wind, and water, and biotic factors, such as predators like geckos, dragonflies, and spiders. The current study found that the majority of nests faced east, followed by south and north orientations. This orientation is likely related to the wasp's flight patterns when it leaves the nest to capture prey [19].

Furthermore, the study revealed that 84% of the nests were inactive, with the remaining nests being active. Future research will focus on examining activities such as feeding within the nest chambers.

The analysis revealed that inactive nests had a lower mean height from the ground, and fewer orifices or cells compared to active nests. In contrast, the active nests showed greater nest length, cell depth or width, and weight. A total of 24 larvae were extracted from 20 cells, weighing approximately 3.15 g. Similarly, 153 paralyzed prey items, all belonging to the order Araneae, were recovered, weighing a total of 17.27 g. Of the 4 active Mud dauber nests, only two contained prey, with the highest frequency and diversity observed in the Salticidae family, followed by Araneidae and Lycosidae.

Sceliphron wasps have been widely studied for their prey selection behavior. Halder *et al*. [2] and Gonzaga and Vasconcellos Neto [20] investigated the same species and found that the spiders collected from Mud dauber nests were predominantly *Neoscona odites* (Simon) (Araneidae), commonly known as orb-weaver spiders; *Lycosa* spp. (Lycosidae), or wolf spiders; and *Marpissa* spp. (Salticidae), or jumping spiders, all of which were abundant in the vegetable ecosystem. While orb-web spiders (such as Araneidae) are often the dominant prey [21-23], some species, like *Sceliphron formosum* (Smith), mainly target Salticidae [11]. Additionally, size has been identified as a significant factor in prey selection [24].

The active Mud dauber nests had a rectangular shape, and the substrate orientation was predominantly westward (75%), with the remaining nests facing east (25%). The nesting substrate, mainly walls, was chosen to ensure the longevity of both the larvae and the wasps. This study also introduced the diversity indices of spiders found in wasp nests, noting that there was little variation between the 2 nests of Mud daubers. The species, dominance index, richness, Simpson diversity index, Shannon H's index, and evenness were nearly identical, though the number of individuals varied between the nests.

Previous literature has highlighted that some insects, such as predatory mites, Acroceridae flies, harvestmen (*Pholcus phalangioides*), and Pompilidae wasps, consume spiders for survival, particularly in ecosystems like rice fields [25]. However, this study concludes that the Mud dauber wasp, *S. madraspatanum*, is a spider hunter, and it uses spiders as a primary food source to ensure the survival of its offspring.

Conclusion

In conclusion, the study of nests and their associated trophic relationships has long been a cornerstone of natural history research. These studies contribute significantly to our understanding of various species and their environments. The growing trend in research now leans toward a comparative and hypothesis-driven approach, extending beyond simple life-history observations. This shift is evident in the broader fields of biology and ecology. Similarly, the present research on the Mud dauber wasp's nest offers valuable insights into its natural history, detailing the structure and various characteristics of the nest.

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