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MORPHOLOGY AND NEST MAKING BEHAVIOUR OF LITTLE SWIFT: *APUS AFFINIS*

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Abstract: **Nest-building is a widespread behaviour among vertebrates, but it is especially significant in birds. Bird nests are often easy to observe, showing considerable variation in structure between species. As a result, ornithologists frequently focus on nesting behaviour when studying birds. Common swifts, for example, are highly aerial and gather food and nesting materials mid-flight. They spend most of their non-breeding period airborne, with younger swifts landing only during adverse weather. This study highlights the Little Swift (*Apus affinis*), identified by distinctive features such as gray-black eye rings, white neck and rump patches, crossed wing patterns, Pamprodactyl feet, and specific feather counts—16 remiges and 12 rectrices. Unlike species that build enclosed nests, Little Swifts create open, cup-shaped nests with both inner and outer layers. The inner layer comprises jute, grass, or straw, arranged in spiral and cross-stitch designs. The outer layer includes feathers such as filoplumes, remiges, and rectrices, structured with various cross-stitching patterns. The research also investigates how Little Swifts use natural materials to engineer sustainable, resilient structures. It provides insights into the relationship between nest design and material use, shedding light on the principles behind animal architecture and the potential applications in human engineering and biomimicry.**

Index Terms: **Birds Behaviour, Biomimicry, Endoskeleton, and Exoskeleton, Nest making, Saliva, Swift**

Introduction

The Little Swift (*Apus affinis*) is a medium-sized aerial bird that resembles the barn swallow and house martin (Jobling, 2010). It is predominantly blackish-brown with a distinctive white or pale grey patch on the chin and rump, usually not visible from a far. Adult swifts measure around 16–17 cm in length, with a wingspan of 38–40 cm, and weigh between 35 and 56 grams (Esmaili, 2016; Green, 2022).

Renowned for their near-continuous aerial lifestyle, Little Swifts spend up to ten months in uninterrupted flight during the non-breeding season, feeding, mating, and even sleeping in the air (Hedenström, 2016; Esmaili, 2016; Green, 2022). Their top horizontal flying speed has been recorded at 111.6 km/h (Bourton, 2010). They exhibit distinct social behaviors such as "screaming parties" during summer evenings, where groups call loudly while flying in coordinated formations (Nilsson, 2019).

Swifts feed exclusively on airborne insects like mosquitoes, aphids, and beetles, and even collect nesting materials such as feathers, jute, and grass while flying (Swift, 2020). They typically build open cup-shaped nests high on vertical surfaces like cliff crevices, rooftops, and church towers. These nests were made of lightweight plant material and feathers, held together by the bird's saliva. Both parents incubate eggs and raise the young, generally producing one brood per season consisting of 2–3 eggs (Corrales, 2013; Swift, 2020).

Swifts prefer nesting in colonies and select locations that were shaded, spacious, and elevated. Without nearby conspecifics, even ideal nesting sites may remain unused. They show strong site fidelity, returning to the same nests each year and forming lifelong monogamous pairs. Juvenile birds may begin forming pair bonds by age one but typically begin successful nesting by four years of age. Lifespan can extend beyond a decade, with the oldest ringed individual recorded at 21 years (Breeding, 2020).

As migratory birds, Little Swifts breed across a wide geographic range from Portugal to China, including northern Africa and parts of the Middle East. After breeding, they migrate via different routes to sub-equatorial Africa, where they overwinter. Breeding and migration timing is closely tied to light cycles and varies by latitude (White, 2020; Akesson et al., 2012).

The overall anatomy, nest construction pattern, and behaviour of the common Little swift, *Apus Affinis*, were all covered in this article. The Little swift often have a grayish-black ring around their eyes, a crisscross wing pattern, a white neck and rumps, papprodactyle legs, 16 remiges and 12 rectrices. Instead of building domed-over cavity nests, they often build open cup nests. Both an exterior and an interior endoskeleton cover the nests. Simple, crisscross, and spiral patterns make up the endoskeleton, which is composed of jute, grass, and/or straw. Straw, Jute, and grass comprise the endoskeleton, while contour, down, and filoplume types of feathers make up the exoskeleton of steaching patterns, Feather versus feather and/or insertion type. They successfully sew the elements together in every situation by using their productive saliva.

Methods:

1. Recording the location of the nest

We have noted where the nests were located in the Varanasi train station, Varanasi District, Uttar Pradesh; 25.3269ºN, 82.9863º E. The nests of the Little Swift birds were found in several (100) colonies. When traversing areas, we took extra care to avoid disturbing, stepping on, or uprooting other birds' nests. Relocating a nest can be unexpectedly and vexingly difficult since nests, particularly open cups, were extremely skilled at concealing in plain sight. We took several pictures of where the nest was. We provide a figure that shows the different stitching patterns used for Little Swift nests, as well as the nest's height and approximate placement on the Varanasi station's roof of the platform areas. We have monitored about 20 colonies and 10 nests in each colony. Details about the nest, all parameters like branch orientation and any distinctive markings were also noted on nest finding

2. Number of nest visits The number of nest visits needed was depend on the specific goals of the study, but visits were planned thoughtfully to minimize potential disturbance. For instance, we accurately identified fledging dates that may require multiple visits during a key stage of the nesting cycle. However, we observed and maintaing progress, with limiting visits to once per day that can help to reduce harm to the nest. We made sure that all of the equipment we need (such as a data sheet, clipboard, research tools, cameras, stopwatch, staircase etc.) was ready and readily available before visiting a nest. This way, we can spend as little time as practicable getting to the nest site or setting up our observation post. In order to reach the nests high up on the train station's roof, we also made good use of the ladder (staircase) from the electrical department.

3. Appropriate time and venue for visiting nests

We avoid visiting nest sites early in the early morning. Many passerines may be disturbed during their morning egg-laying. Because they haven't eaten since the previous evening, parents also have a tendency to feed nestlings more vigorously in the morning. Additionally, it was not a good idea to inspect nests in the late evening when parents could be going back to the nest to spend the night with the nestlings or the eggs. We avoided nest visits on rainy or cold days because food, particularly insects, may be more difficult to find on these days, making nestlings more stressed. For the majority of birds, including open cup nesters and cavity nesters, we observe the nest(s) in question from a distance to ensure that a little swifts were not sitting on the nest and only approach it when the bird leaves on its own.

4. Measurements of nests and nestlings

After the nestlings have left the nest, any physical measures of the nest, such as its size or the materials used for nesting, were taken. For the investigation purpose, which required the proper description, we only had taken one abundant nest. When examining nests that were not damaged in any way, we measured the Little Swift species' nest. The inside dimensions of a nest were measured using bamboo strips or flex-metal tape. Handling nestlings without the proper authorization was not advised.

5. Study of the abandoned nest

We discovered a nest with no nestlings or eggs and no parents. We took the nest to confirm its existence and investigated Little Swift's nest-building habits.

1. Just because we did not see the parent birds nearby for a few minutes or even hours did not mean that the nest was abandoned.

2. Neither the nestlings nor the eggs were touched by us. Without the appropriate authorization, this was probably against the law.

3. Nestlings were not raised by the adult birds. In addition, this was unlawful without the proper authorization.

6. Nest making behaviour of Little swift:

The study was conducted at the Varanasi Cantonment area Railway Station in Uttar Pradesh, India at the coordinate 25.3269° N, 82.9863° E. Since the year 1999, a colony of approximately 100 breeding pairs of swifts has nested annually in the roof of each of the six platforms (each measuring 180 by 30 by 30 cm) on the upper floors of the main building, which were between 20 and 30 meters high. To gather the Swift nest for the purpose of studying the building pattern of nest creation, a long ladder (Staircase 20–25 meters) high was taken. Two nests were gathered in order to examine the components and construction method of the nest. As soon as the nests taken, they were inspected. The nests were maintained in separate, sealed containers at 25 °C and 80% relative humidity throughout the study to ensure consistent environmental conditions.

After being carried for three to four days to the Department of Zoology at Banaras Hindu University to investigate the bird's general morphology, an adult was taken for revealing of general morphology and released back to its nesting place. A single operator and a partial examination of observational data were used to study the behaviours within and/or outside of the cup nest. For the course of the study's 21 days, every observation was made regarding the nest-making location and its features. The photo of the bird nesting place utilized for the study was obtained using a Leica camera. The nests were carefully opened around the stitching in a reverse direction as the bird stitched the nest at their homing ground in order to examine the components and nest-making pattern. All of the components were taken out of the cup-shaped nest, and each stitching pattern's orientation for the saliva was meticulously noted. After observing the swift nest's overall morphology, nesting pattern of Little Swift, and steaching pattern from the study, the colour diagram was sketched.

Results:

After being caught, one bird was brought to the lab to be studied for general morphology. The birds have a wingspan of 38–40 cm (15–16 inches) and measure 16–17 cm (6.3–6.7 inches) in size. The birds were uniformly blackish-brown, with the exception of a little patch of white or light grey on the underside of the tail and on the chins. Additionally, they have a ring or whorl of gray around their eyes. Their wings were quite long and swept back, giving them the appearance of a boomerang or crescent. They also have a short forked tail. The term "wall-glider" (Pamprodactyl) refers to the bird's habit of clinging to vertical surfaces with its extremely small legs. They have 12 Rectrices in their tail and 16 Remiges in each pair of wings (Figure 1).

Different bird species use different materials and construction techniques to build their nests, and currently, no information was known about how these structures' architecture and function relate to one another. This study examines the construction of nests made by the swift *Apus affinis* nest on railway station roofs utilizing threaded saliva by combining experimental methods and diagrammatic representations. The Swift has complete control over the structural characteristics at a very high precision by using their own saliva as building material—a technique that was comparable to additive manufacturing. The mechanical characteristics of the nest's structural regions—the wall, the centre of the cup, and the rim—were predicted by the birds to differ mostly due to architectural design in order to provide structural support and sustain the weight of the eggs and birds naturally.

The nests were suspended from the train station's roof, as seen in Figure 2. Some (2-5) colonized nests had a square or circular form, while others had a rectangular one. The fibers with a brown tint were composed of straw, jute, or grass. The materials in white, grey, or black hues consisted of down feathers, filoplumes, and contour feathers (remiges/rectrices). We discovered 80–100 colonized nests near the train station. The nests' areas measured 122 cm2, and their heights measured 4 and 8 cm from two sides. The nest has a 245 cm3 capacity. This study was made from 5 cup nests of the little swift. We did not destroyed their nests for studying the length and width of the nests. With their effective saliva, the flat surfaces on the rims of the cup nests were adhered to the train station roofs. While the majority of the nests had been inhabited, several nests had been discovered to be single nests that were abundant by the birds. Multi-storey cup nests hanging from one another were present in some of the nests. The chicks were housed in dome-shaped nests. Numerous labyrinths (more than one aperture in each nest) and linkages to other nests within the colony were features seen in the majority of colonized nests. The finished dome-shaped nests in the colony housed the eggs and young birds, while the paired parental birds often occupied the cup-shaped nests. There were two different kinds of components needed to make a nest. Dried grass or leaves, jute fibers, straw, other plant fibbers, and sticky saliva were the components that built up the endoskeletons. Feathers or weeds make up the exoskeleton. The feathers were either down feathers, Filoplumes, or contour feathers

(Remiges/ Rectrices). Weeds were composed of dried flowers, polythin, or pieces of paper. There were three varieties of endoskeletons: spiral, helical/crisscross, and simple. The basic type was constructed using two; three, or more simple stitching types, and each connection point of the steach was where their effective saliva was utilized. Several strands were employed in a helical pattern at each junction point in helical stitching. The nest of Apus affinis relies mostly on grass and feathers for structure and comfort, with saliva used to bind these components together securely. These specialized ingredients enable the Little Swift to create sturdy, weather-resistant nests in diverse locations, from man-made structures to natural cliff faces.

Saliva was used to assist create twists between strands in spiral stitching techniques. Straw with feather, feather with feather, and insertion type comprise the endoskeleton. With the use of saliva, the straw/grass or jute fibbers were sewn together with the contour feather's barbs in the feather-adorned straw varieties. The saliva-stained barbs of the feather with feather type two sewed together the alternating contour feathers. The filoplumes or down feathers were sewn together in the insertion type using saliva, dried grass, or jute fibers.

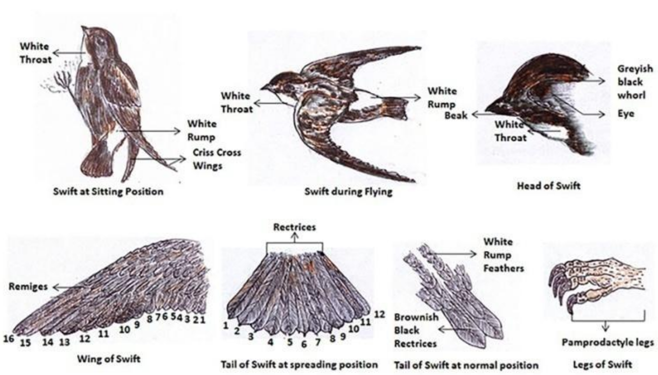


Figure 1. General Morphology of the Little Swift: The size of a common swift was 16–17 cm (6.3–6.7 inches), and its wingspan is 38–40 cm (15–16 inches). The birds were uniformly blackish-brown, with the exception of a little patch of white or light grey on the underside of the tail and on the chins. Additionally, they have a ring or whorl of gray around their eyes. Their wings were quite long and swept back, giving them the appearance of a boomerang or crescent. They also have a short forked tail. Swifts, whose name means "wall-glider" in the literal sense, were mostly known for using their extremely small legs to cling to vertical walls. They have 12 Rectrices in their tail and 16 Remiges in each pair of wings.

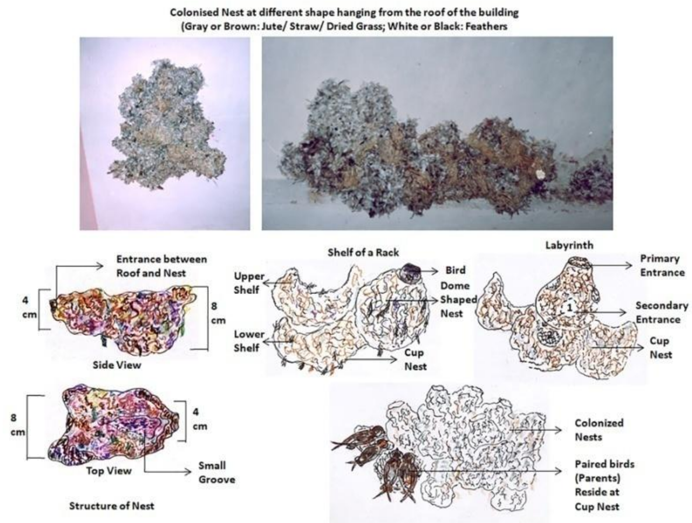
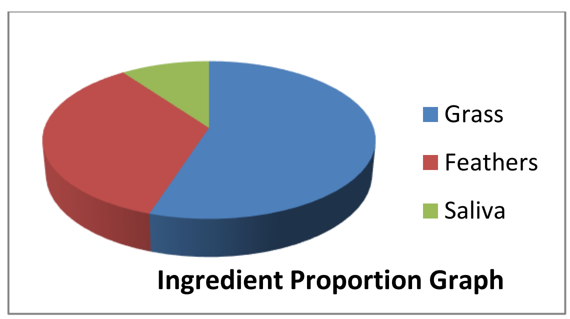


Figure 2. General construction of Cup and Dome shaped Nest of Little Swift: The camera captured a photo of the nests that were suspended from the train station's roof. Straw, jute, or grass makes up the fibers with a brown tint. Filoplumes, down feathers, and contour feathers (Remiges/ Rectrices) make up the white, grey, or black hues. The nests' areas were 122 cm2, and their heights were 4 and 8 cm from two sides. The nest has a 245 cm3 capacity. The interior of the cup nests included a groove and flat surfaces that were effectively sealed with the railway station roofs by their saliva. A number of the nests had been found to be single nests, despite the fact that most of the nests had been occupied. Multi-story cup nests hanging from one another were present in some of the nests. The youngsters were housed in dome-shaped nests where the eggs were placed. Numerous labyrinths (more than one aperture in each nest) and linkages to other nests within the colony were features seen in the majority of colonized nests. The finished dome-shaped nests in the colony house the eggs and young birds, while the paired parental birds often reside in the cup-shaped nests.



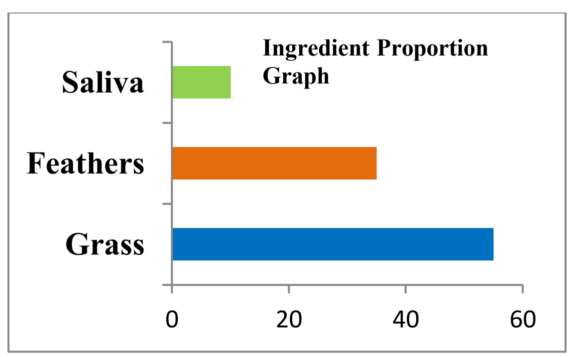


Figure 3. Ingredients proportion Graph: Percentage of nest making ingredients i. e., Grass, Feathers and Saliva

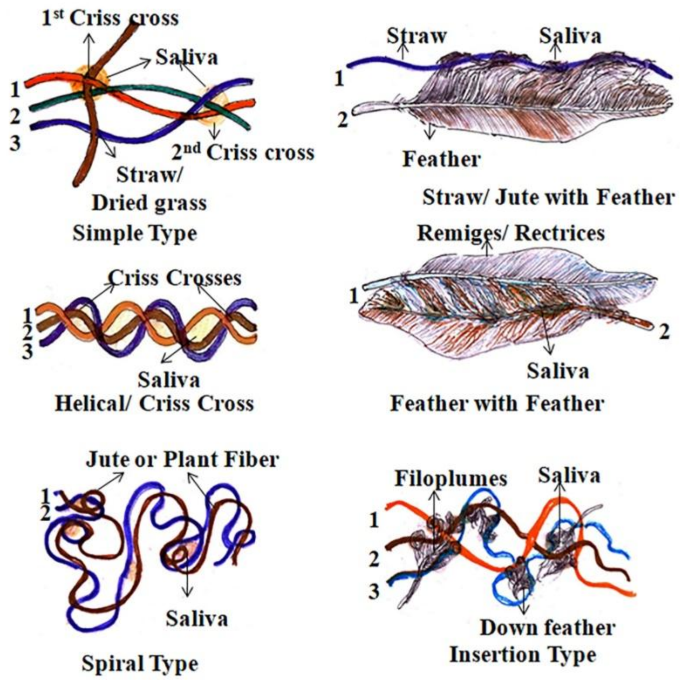


Figure 4. Nest making pattern of Little Swift: There were two different kinds of components needed to make a nest. Dried grass or leaves, jute fibers, straw, other plant fibers, and sticky saliva were the components that built up the endoskeletons. Feathers or weeds make up the exoskeleton. The feathers were either down feathers, Filoplumes, or contour feathers (Remiges/ Rectrices). Weeds were composed of dried flowers, polythin, or pieces of paper. There were three varieties of endoskeletons: spiral, helical/crisscross, and simple. The basic type was constructed using two, three, or more simple stitching types, and each connection point of the steach was where their effective saliva was utilized. Several strands were employed in a helical pattern at each junction point in helical stitching. Saliva was used to assist create twists between strands in spiral stitching techniques. Straw with feather, feather with feather, and insertion type comprise the endoskeleton. With the use of saliva, the straw/grass or jute fibers were sewn together with the contour feather's barbs in the feather-adorned straw varieties. The saliva-stained barbs of the feather with feather type two sewed together the alternating contour feathers. The filoplumes or down feathers were sewn together in the insertion type using saliva, dried grass, or jute fibers.

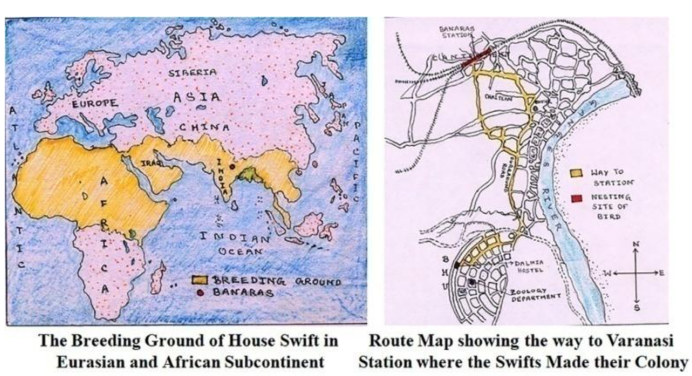


Figure 5. Location of the study: The breeding grounds of Little Swift across the African and Eurasian subcontinents were depicted in yellow on the map on the right. The journey to Varanasi Station, the location of the Swifts' colony, was seen on the map on the left.

Discussion:

Little swifts exhibit a wide range of design variations across families and exceptional nest building abilities (Bailey et al., 2014; Biddle et al., 2015; Biddle et al., 2017; Deeming. 2017). They use nests for various purposes, including safe growth, egg incubation, comfort, sexual signalling, protection against parasites or diseases, and thermoregulation (Casteren et al. 2012; Dubiec et al. 2013; Tomas Et al. 2013; Clark, 1985; Dubiec et al. 2013; Asokan et al. 2008; Mayer et al. 2009). These nests were evolutionarily chosen for specific purposes, indicating that materials were specifically chosen for specific purposes, while building was directed by specific manufacturing programs. However, a comprehensive functional investigation of the choice of materials for specific tasks in fast nest structures was still lacking (Biddle et al. 2018).Birds construct nests using various materials, including stitching, weaving, interlocking, stacking up, moulding, and adhering together (Hansell, 2000). The main goal of stitching was to maintain the nest's physical integrity and attachment to the nesting place. Some materials, like mucus, adhere well due to their efficient saliva, while others require specific spatial arrangements (Hansell, 2000).

Animals employ diverse structural and architectural strategies when constructing nests, a topic that has increasingly attracted the attention of zoologists (Ripley & Bhushan, 2016). For example, orangutans interweave branches to form robust platforms, while swifts build nests with distinct internal and external layers for both strength and comfort (Casteren et al., 2012). The inner structure was composed of materials like straw, jute, and dried grass, which were arranged using saliva to form various stitching styles. The outer shell was reinforced with jute, straw, feathers, and intricate stitching patterns (see Figure 3). Similarly, orb-weaving spiders from the Araneidae family use seven different silk glands to spin webs with remarkable tensile strength and elasticity, contributing to their highly specialized nest architecture (Figure 3; Vollrath & Knight, 2001).

Table 1. Nest-making behavior of the House Swift, Barn Swallow, and House Martin

Feature/Species	House Swift (*Apus affinis*)	Barn Swallow (*Hirundo rustica*)	House Martin (*Delichon urbicum*)

Nest Location	Cliffs, under roofs, in buildings and caves	Inside buildings, barns, under eaves	Under eaves, ledges of buildings, cliffs
Nest Material	Saliva (glue-like)	Mud and grass, bound with saliva	Mud pellets mixed with vegetation
Nest Shape	Cup or bracket-like structure	Open cup-shaped	Enclosed dome with small entrance hole
Attachment Surface	Vertical or overhanging surfaces	Flat vertical walls or beams	Under horizontal ledges or eaves
Reusability	Often reused and added to	May be reused if intact	Frequently reused and repaired
Colony Nesting	Yes – colonial species	Sometimes solitary, sometimes in colonies	Yes – usually colonial
Nest-Building Duration	~1–2 weeks	~1 week	1–2 weeks
Unique Features	Uses only saliva; nest often hard to see	Fast flyers, collect mud from puddles	Dome structure with entrance hole reduces predation

Here we explained the explanation of Components & Relationships of Nest of House swift:

- Saliva (cementing / adhesive): Many swifts (and especially edible-nest swiftlets) use their saliva as a binding agent or "glue" to hold the nest together and attach it to surfaces.
- Structural support: The main skeleton or framework of the nest is built from stiffer plant fibers, small twigs, or rootlets.
- Filler / insulation / soft lining: Inside the nest, for comfort and insulation, swifts may use feathers, animal hair, down, or fine plant materials (moss, grasses) to line the nest.
- Fine materials (grasses, moss, rootlets) act as intermediate materials, filling gaps and helping integrate the structural materials with the adhesive saliva.

Little swift makes their nests under cliffs, under roofs, in buildings and caves. Barn swallow makes their nests inside buildings, barns and under eaves. House martin makes their nests under eaves, ledges of buildings and under cliffs. Little swift makes their nests with saliva (glue-like). Barn swallow makes their nests with mud and grass, bound with saliva. House martin makes their nests with mud pellets mixed with vegetation. The Little swift makes their nest with cup or bracket like structure. Barn swallow makes their nests with Open cup-shaped structure. House martin makes their nests with Enclosed dome with small entrance hole (Table 1). The attachment surfaces of little swift are vertical or overhanging surfaces. The attachment surfaces of Barn swallow are flat vertical walls or beams. The attachment surfaces of house martin are under horizontal ledges or eaves. Little swift reuse their previously built nests and they built their nests within ~1-2 weeks. Barn swallow reuses their previously built nests if it's found intact and they use their nests within ~1 week. House martin reuses their previously built nests if its frequently if it`s repaired and they built their nests within ~1-2 weeks. Little swifts are colonial species. Barn swallows are sometimes solitary sometimes colonial. House Martin are usually colonial. Little swifts use only saliva and their nests are often hard to see. Barn swallows are fast flyers and they collect mud from puddles. House martin uses dome shaped structure with entrance hole reduces predation (Table 1).

Bird nests display specialized mechanical features that can endure impact from large insects without damage (Craig, 1987; Köhler &Vollrath, 1995; Gosline et al., 1999). Among birds, only a select few species, such as swifts and certain insects like silkworms and bees, use secretions in nest building (Römer & Scheibel, 2008). These species exhibit precise control over the deposition of construction materials, producing more uniform and rigid structures than those built from gathered resources (Deeming & Mainwaring, 2015; Biddle et al., 2018). Swifts, for instance, use their saliva to build nests on vertical surfaces, forming dense foundations with closed pores (Kang et al., 1990; Goodfellow, 2001). Their horizontal layering technique produces elongated closed cavities within the hardened saliva matrix (Biddle et al., 2017). Other birds, including House Martins, construct similarly shaped nests, typically half-cup-like and built against vertical walls, sometimes using the roof as structural support. However, the economic advantages of secreted versus gathered materials remain unclear and likely vary across species (Hansel, 2014).

The Apodidae family, which includes about 90 swift species, demonstrates varied nest-building behaviors, with some incorporating both saliva and collected materials such as feathers (Howard & Moore, 1994). The edible-nest swiftlet stands out as the only species to construct its nest entirely from saliva. While secreted materials were structurally optimized for tensile loads (Hansell et al., 2014), gathered materials mostly serve compressive functions (Valli & Summers, 1990). A Phylogenetic analysis could shed light on the evolutionary pathways of nest-building strategies involving both saliva and external materials (Deeming et al., 2015). The studied nests were not randomly assembled; they featured a base that was securely attached to the wall and had a larger surface area than the nest's rim (Hansell, 2000; Hansell & Hansell, 2005; Biddle et al., 2015, 2017). Two main types of materials were identified in nest construction: an inner endoskeleton of plant materials and saliva, and an outer exoskeleton consisting of feathers or weeds. Endoskeletons were categorized into spiral, helical/crisscross, and simple forms, while exoskeleton layering could be feather-to-feather or involve material insertion.

The overall nest design supports structural integrity, particularly around the egg-laying area, by using a thin wall between the eggs and the rim. Two structural strategies help reduce internal stress: a cross-section that narrows toward the edge and a fiber orientation that redistributes force horizontally. These design principles minimize stress levels well below the material's fracture threshold (Silva et al., 2010). The innermost section, where eggs or chicks reside, experiences reduced mechanical strain due to its optimized structure, ensuring the nest can safely bear the loads imposed by its inhabitants. This efficient load management was a shared trait in various bird species and contributes to the durability of the nest (Silva et al., 2010).

This study explores the use of materials like grass, straw, jute fibers, and feathers in animal engineering to create sustainable and robust structures. It also explores the Nest's design principles, which control the relationship between structure and material usage, providing new insights into animal-made structures (Theraulaz et al. 1998; Greene et al. 2010; Krafft & Cookson , 2012; Feinerman & Korman 2017).

This study explores the use of materials like grass, straw, jute fibers, and feathers in animal engineering to create sustainable and robust structures. It also explores the Nest's design principles, which control the relationship between structure and material usage, providing new insights into animal-made structures (Theraulaz et al. 1998; Greene et al. 2010; Krafft and Cookson , 2012; Feinerman and Korman 2017).

CONCLUSION

In conclusion, the study of nest-building behaviors, particularly in birds, offers valuable insights into the diverse ways in which animals use natural materials to create functional, sustainable structures. The Little Swift (*Apus affinis*) serves as an exemplary case of intricate nest design, with its open, cup-shaped nests that feature multiple layers made from materials like jute, grass, and feathers. This research not only underscores the adaptability of birds like the Little Swift in using available resources but also highlights the role of material use and structure in fostering resilience. Understanding these natural engineering strategies enhances our appreciation of animal architecture and opens new possibilities for biomimicry, with potential applications in human design and construction.

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FOOTNOTES

KG contributed to perception, overall design, analysis, writing and editing of the manuscript. KA contributed to writing and Editing of the manuscript. KG and KA approved for final submission.

CONFLICT OF INTERST

The author declares no conflict of Interest.

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