

## Cliff Swallows are good Masons for their Own Plan and Architecture of Nest

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### ABSTRACT

Cliff swallows (*Petrochelidon fluvicola*) construct a gourd shaped mud nests below the cliff or extensions of the buildings. For constructions this bird draws a blue print of the nest designed to be completed. The bird uses the beak for construction. The material of the construction includes mud of consistency with other organic materials in small quantity. The mud is converted into pellets before placing into organised shape. The arrangement of pellets follows a definite pattern of arrangement. Stepwise organization of pellets in left or right direction of planned axis is followed and coordinated by both the birds. The entire process of construction of nest and order of arrangement of mud pellets is documented as well analyzed and discussed using JPEG image process. These birds act as good mason for their own design of nest, a marvelous imprinted engineering in these birds.

**KEY WORDS:** Cliff, Mud Nest, Blue Print, order of arrangement, Mason, JPEG Image

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### I. INTRODUCTION

Cliff swallows have a highly developed phenomenon of nesting. These birds are migratory usually build mud nest on cliffs, rock over hangs, beneath the bridges, sloping edges of manmade construction. Four basic criteria are found to play a key role to establish colonial nests by swallows such as a open habitat for foraging, suitable surface for nest attachment, mud of proper consistency to build nests and water body to supplement drinking water to these birds [1]. Cliff swallow nests are gourd shaped enclosed structure with an entrance tunnel that opens downward. The tunnel is generally present but in a few cases it may be missing. The mud pellets used to build the nest consists of sand, smaller amount of silt and clay. The nest chamber is lined with grass, hair and feather [2] [3]. Among cliff swallows nest building is a social activity. Construction and mud gathering is even initiated and assisted by unmated swallows. Mated swallows may build more than one nest and all the nest may not be used for breeding there by count of nest under construction will not describe the number of pairs in a colony. Both male and female cliff swallows construct the nest [4]. The building activity proceeds slowly to allow the mud dry. Depending upon the availability of mud and weather conditions the construction may take 1 to 2

weeks [5] [6] [7]. The process of mud nest construction and pattern of nest design is an imprinted phenomenon that has been widely observed in many species of birds [8][9][10]. The process of construction of nest by the cliff swallows is discussed in detail in this article.

Indian Cliff swallows are also known as Streak Throated Swallows – *Petrochelidon fluvicola* are highly colonial; weigh about 10.6-15.0gm, migrant passerine birds. Cliff swallows exhibit no obvious sexual dimorphism and are sexually monochromatic with males and females essentially identical in all plumages. Within pairs the male may have larger patch on the head. They are diurnal, aerial insectivores, feeding exclusively on flying insects and can forage only when the weather conditions allow flying insects to be active. They build enclosed mud nests, gourd shaped that are approximately 15-20cm in diameter and have entrances that are 5-7cm wide. Individual nests in cliff swallow colonies are often densely packed and nesting is highly synchronous within colonies. Nest entrances are, an average approximately 25-30cm apart and nests often share walls. Most nests contain clutches ranging in size from 1-4 eggs clutches with more than 4 eggs are cases of intra specific brood parasitism or egg transfer or extra pair fertilization occurs frequently noticed only in

one case. Brood sizes generally range from 1-4 eggs nestlings per nest.

## II. MATERIALS AND METHODS

Material of the study comprises the colony of Cliff Swallows *Petrochelidon fluvicola*. The cliff swallows nest building activity is recorded by digital photography using "Sony Cyber-Shot DSC-HX7V" camera. Each step of the nest building is recorded on each day of nesting activity, starting from its blueprint marking of the nest till the complete guard shape with a tunnel is produced. Movement of swallows of both sex while building the nest is photo recorded. The use of beak and its artistry is well documented both by still and videography. Girth measurement of pellets, girth of the nest, its length is recorded by either using scale or by measuring tape. The size of the cliff, the cliff forming area the vegetation around, the distance of the water body from the above cliff are recorded by using measuring tape.

## GRAPHICAL ANALYSIS OF NEST CONSTRUCTION – PROCEDURE

Tool Used for the design: Adobe Photoshop 7.0[11]  
ABOUT THE TOOL

Adobe Photoshop [12] is a graphics editing application popular for its extensive amount of features. Photoshop is also, currently, the leading graphics editing application. Photoshop is also image creation software as well as an editor. Photoshop can create any effect or style needed in a drawing or painting or layout. There are graphic software that can do specialized work faster and more efficient than Photoshop (such as painter for realistic paint effects), but Photo shop can do it all in one program. Photoshop works by altering individual pixels in an image as opposed to a vector drawing program that draws with points, lines and objects mathematically. Photoshop is best with images that have complex textures, blends and photo realism, but Photoshop is also very good at vector drawing as long as the image doesn't need to be scaled and you do not need specialized CAD drawing tools.

### DESIGN PROCESS

The JPEG (24 bits/pixel - 16 million colors) image "CurveShapedSphere.jpeg" which is showed in the fig.01 is used to represent the pellet as the basic component of the design in the canvas area, the area where the complete design takes place. The image was resized by selecting "Image Size" from the "Image" menu to almost 35%-40% of the original size and the resultant image was subjected to Stroke Layer Style effect by selecting "Add a layer style" button under "Image" menu on the highlighting that Layers of the image "CurveShapedSphere.jpeg" in Layers window with

the color "red". A single layer was made to hold a single pellet in it which was designed with above procedure i.e. a pellet in each layer. The words pellet and layer signifies same in our discussion, sometimes the name can be used interchangeably. By using the "MOVE" tool from the "Tool" window we can position the pellet at any position in the canvas. Using the oblique - "Marquee" tool from the "Tool" window we draw a dotted circle as to signify the base mark, which is used to guide the shape of nest construction. Now multiple the pellet by the duplication method by clicking the "Duplicate" button by right-clicking on the layer in the "Layer" Window. Once the multiple pellets have been created using the duplication process, place the pellet according to the design pattern using the "MOVE" tool for "Tool" window to design the complete nest. Once the complete nest is designed or partially nest design is done if you need to record/save the JPEG images go to "Settings," select "JPEG" from the drop-down menu. Go to the dropdown menu with "JPEG High" displayed. There you can determine the quality of the image. Naturally, higher quality images will have a larger file size. It is not necessary that images be extremely high quality. Usually, "Medium" is a good setting to choose. To refine the quality of the image, use the "Quality" setting. Here, you can save the JPEG as a percentage of the original image's quality. For example, 50% would be half the quality of the original image. When you are ready, click "Save" and save the image by giving it a file name.

## III. OBSERVATIONS AND DISCUSSION The Nest.

The nest is (Fig-15b) constructed using mud of suitable quality, the mud often mixed with grass for preparing the mud pellet for construction each of the steps observations are as below. The metric profile of the nest revealed that the girth of the nest  $43.5 \pm 1.3$ cms with a length of  $17.8 \pm 0.5$ cms. The width of the entrance 3.8cms. The depth of the nest ranged 9.5 to 12.3cms, with a diameter of 10.2cms, the girth of the mud wall of the nest was 1.2cms at the base 1.4cms in the middle and 1.5cms at the entrance [6] Each pair of birds construct the nest according to the blue print mark drawn earlier on the nesting surface. For construction the bird uses its beak (Fig-15a). Both the sexes are involved in construction. Interestingly a single pellet of soil is first placed at the exact half of the lower hemisphere of the nest marking (blue print) subsequently the birds alternatively carry mud pellets mix it well before aligning and the pellets are arranged on both the sides of this centrally placed pellet to form a platform. After partial

completion of the lower basal lining the pellets are allowed to dry for 2-3 days. Consequence of this a hard basal lining of pellets is produced above this additional 2-3 layer arranged the sides the basal line were also extended by the arrangement of pellets. After this the days of rest ranged between 2-8 days to construct additional layers. Whenever the nest layers were constructed the proceedings were recorded both by still & video graphics. After completion of the lower half of the nest is the form of a semi lunar cup, the upper half was initiated. The initiation as usual started with the laying of a single pellet and subsequent arrangement on arch upper line marked earlier layer by layer and pellet by pellet arrangement done as the mason workers do, by each of the birds. This construction continued till a gourd shape in alignment with the lower half is produced. After the entrance construction was initiated here also same of alignment is followed. Around 1000 pellets are arranged to construct the nest.

#### **Process of Nest construction**

The construction material majorly consists of mud from a selected site. During this process the mud is chewed well by the bird to mix with its saliva; and filled into the mouth carried to the nest site. The other partner which was on the nest waits each time for the arrival of the other with the contingent mud to be placed for construction. Even though the pellet alignment is completed by the bird compulsorily waited arrival of the partner as an act of safeguard to protect the nesting material that could be stolen by the neighbour in the colony. Often the bird washes off its beak by dipping into the water below the cliff may be to clear off the mud struck or it may be an act of drinking water.

#### **Graphical Analysis of Nest construction**

The design of the nest construction at the initial stage starts from the making on the cliff as shown in the Fig.02, the marking is not exactly in the shape of circle or elliptical as shown but it is rough surfaced circle. The first pellet is placed on the marking approximately at the base, as the direct contact with the cliff with enough physical and chemical property in the sand to withstand the gravitational force as shown in the Fig.03. Then the preceding pellets can be placed as the neighbour pellets to the first pellet in any of the pattern shown in the Fig.05. The Fig.04 gives a graphical/pictorial representation of how the different flow of pattern can be observed in the sense of formation of first layer (B1 in Fig.06) of the base construction by different birds. Once the initial pellet (1: Initial) is placed at random position at the base of the marking the preceding pellets can be either to the

left (2:1L) of the initial pellet or to the right (3:1R) of the initial pellet. Once the preceding second pellet is placed as the neighbour of initial pellet the pattern may be as 2:1L or 3:1R in the Fig.05. The other preceding pellets from the current 2-pellet pattern (P2) to the 3-pellet pattern (P3) can take a formation of the pattern 4:2L or 5:2R/3L or 6:3R depending upon the left dominant pattern or the right dominant pattern or the hybrid (combination of left & right) dominant pattern. The same design procedure is followed for the 4-pellet (P4), 5-pellet (P5) and 6-pellet (P6) pattern. In any pattern the design flows at the final stage of the base layer-1 formation the common pattern will be formed as shown in 16:Base Layer-1 in Fig.05 as the 7-pellet (P7) pattern. Here in our analysis we have taken 7-pellet pattern, i.e 1 as the initial pellet & 3 each pellet to the left & right of the initial pellet. But this is an example pellet pattern we have taken for the discussion; but in reality it may be the same 7-pellet pattern what we are discussing or it may 9-pellet pattern to 15-pellet pattern depending upon the architectural technique of the bird building the nest. The complete layer-1 design pattern with Initial pellet and left or right or hybrid pellet pattern can be summarized as shown in Fig.04.

The same procedure will be followed for the formation of Base layer-2 and Base layer-3, but here we follow the left dominant pattern for the analysis and explanation of the nest design pattern. The front view of the nest once the three layers of the base are formed is shown in Fig.06 and this is main strategy of the architectural technique to withstand the complete nest against the gravitational force. Hence the base formation of the nest is stressed and considered as the main part of our discussion. As mentioned we follow the left dominant pattern for the explanation and analysis as to support it and for the understanding purpose we have numbered each pellet in the design from 1 to 26. Here the 1 indicates the first pellet to be used for the design strategy, the preceding numbers after 1 again which indicates the preceding pellets after the first/main pellet respectively by what we follow the left dominant pattern. And a observation should be made while referring the number assigned to the pellets that there are few numbers missed out at 13 to 22 the reason with this is, once the B1 is formed by using 7-pellet design formation with the numbers representing 1 to 7, the layer B2 will be the next step of design strategy to act as the supportive withstand force to and with B1 for the gravitational force issues. The B2 as per our design is the next step as soon as the formation of B1 is done; hence it takes the next number from 8 to 12. Now the concern is that why the representation of number 13 to 22 is missing, the reason is that once

the B2 is formed the next step of design is not B3 as we think but it is in the B1 as the second course i.e U2 in Fig.08 and in this graphical view we have named B1 even as U1, hence both indicate the same layer and can be used interchangeably. The pellets from 13 to 19 will be used to form the B1-U2 layer and pellets numbered with 20 to 22 will be used to form the B2-U2 layer and this pellets 13 to 22 is not shown as the limitation of the 2-dimension plane. The same design issue will be related with the formation of horizontal layers (U2 & U3) formation as we have graphically represented in the Fig.08 with the Base Thick-2 and Base Thick-3, which represents the thickness of the base horizontally. The design pattern of the front and the side view of the base formation of the nest construction which is shown in Fig.06 and Fig.07 can be summarized as shown in the Fig.08 and Fig.09 respectively, where the arrow indicates the flow strategy of the nest construction in the process of main pellet or the first pellet positioned and the phases to follow with the positioning of neighbour pellets. The dashed arrow is used in to represent the tracing back to the upper layer for the design pattern. Once the complete base formation is as per the architectural design of the bird. It has enough belief that the base will act and react to withhold the weight which will be formed as the construction of the nest moves towards the completion and the base is able to withstand the gravitational force. It is observed that layer B1 is has the enough strength to withstand the pressure of 25% of nest construction, but the further nesting build may be subjected to un handled pressure and may collapse completely, hence for this reason with the intelligent move from the bird it has a design plan to build a three layer horizontal & vertical thickness to hold and handle the 100% pressure of the nest with combinational physical property of the base layers to withstanding all the phases and stages of the construction.

Construction of a layer that supports the base construction is crucial. In this phase the pellet will be placed above the base layer-1 (B1) on the marking as the leftmost pellet in the layer or the rightmost pellet in the same layer as shown in Fig.10. The preceding pellets will be placed in the layer from leftmost pellet or the rightmost pellet which may converge approximately at the centre pellet or it may convergence approximately at the leftmost pellet if the design flow is flown from the rightmost pellet towards the right most pellet and vice versa for the completion of the layer as shown in the Fig.11. In our discussion we take the convergence of centre approximation. The process explained and the pattern shown is followed with the same procedure for the formation

of next stages of the construction, and we end up with the view of the nest as shown in the Fig.12. The further construction process will be carried out in the same fashion. The design pattern what we have discussed till the 80% can be summarized with the graphical view as shown in the Fig.13. Till the construction of around 80% the pattern follows as explained with the approximated centre convergence pattern and once this state is reached the bird goes with the circular pattern in an anti clockwise or clockwise direction or even the random circular point pattern. As shown in the Fig.14 (a) and extending its entrance as a narrow pipe pattern as shown in Fig.14 (b). The completed nest structure a gourd shape with outer rough surface with coarse pellets where as the inner surface will be neatly finished with fine granular plaster surface. This kind of surface variations may play a role in temperature maintenance with in the nest that has to be understood by further investigation.

#### IV. CONCLUSION

The nest construction process initiated at the stage of placing a single pellet as the main pellet. Through this base construction follows to make the base strong enough to with stand against the gravitational force and to hold the complete weight of the nest, the weight is evenly distributed over the leftmost and rightmost pellets in each of the upper layer placed on the base layer till the structure is complete. The three basic patterns followed by the bird during the construction process were Base, Mid and final construction stages. At the base stage Left-, Right- or Hybrid-dominant stretch pattern followed, at the mid stage Left most, Right most or Random convergence pattern followed and the final stage the Clockwise or Anti-clockwise convergence pattern followed to form the entrance and the entrance extended. All these predictive analysis reveals the marvelous avian engineering skill imprinted through evolution in these birds.

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**FIGURES**



Fig. 01: CurveShapedSphere.jpeg



Fig.02: Approximated marking on the cliff



Fig.03: First pellet placed at the base of the marking



Fig.04: Initial pellet and left or right or hybrid pellet pattern summarized flow.

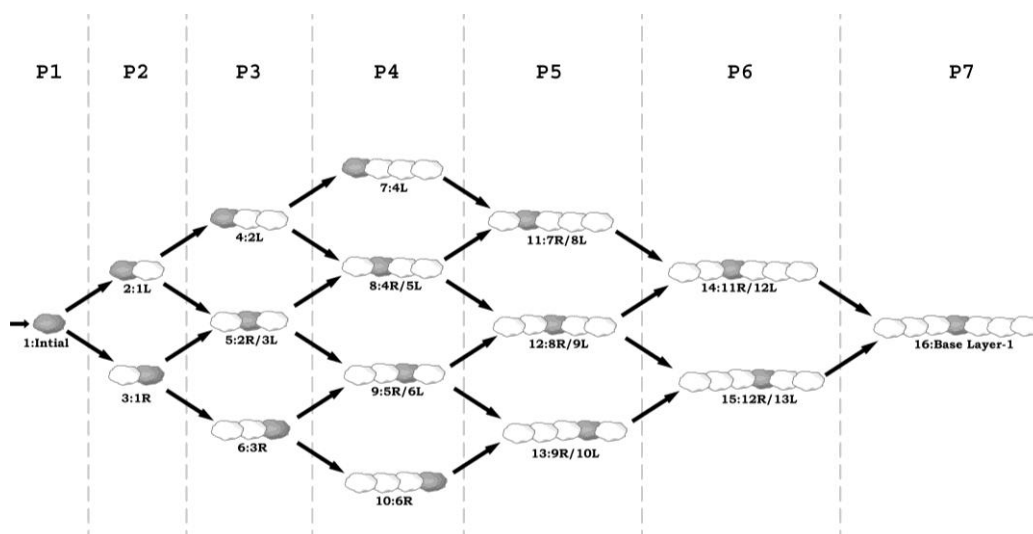


Fig.05: Flow diagram based on possible design pattern for the formation of Base Layer-1.

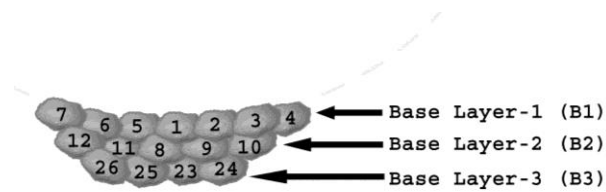


Fig.06: Front view Design of Layer1-3 with the left dominant pattern with pellet numbers

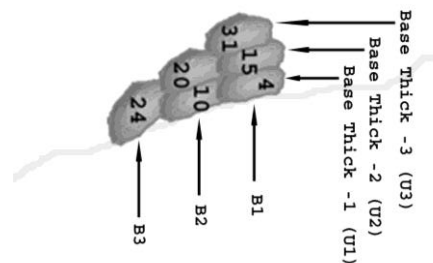


Fig.07: Side view Design of Layer1-3 with the left dominant pattern with pellet numbers

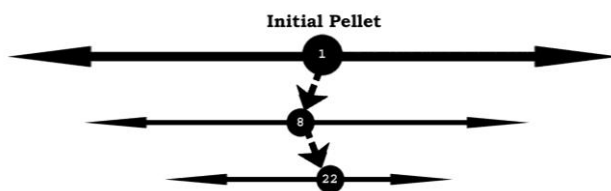


Fig.08: Front view Design pattern summarized for Layers1-3 with the hybrid dominant pattern.

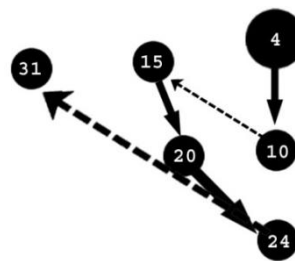


Fig.09: Side view Design pattern summarized for Layers1-3 with the hybrid dominant pattern.

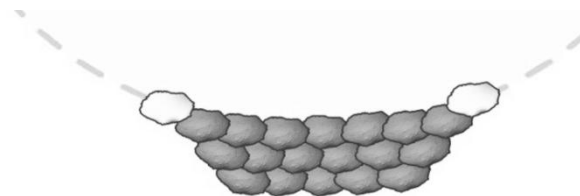


Fig.10: The pellet placed at layer above the base layer as the rightmost pellet and leftmost pellet

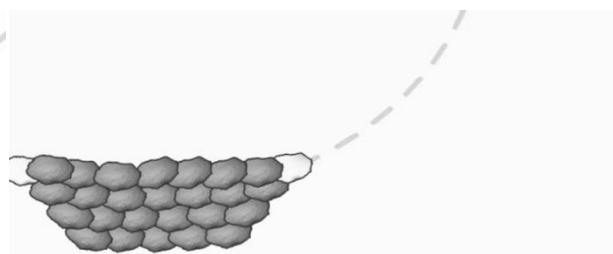


Fig.11: The base upper layer pellets placed to form the complete layer.

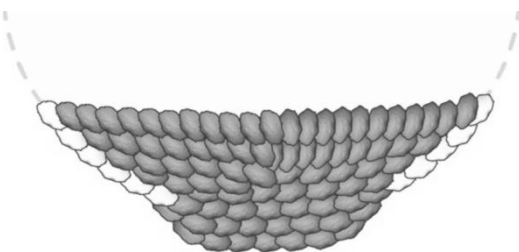


Fig.12: Approximate Centre convergence of upper layers for ~25% completion.

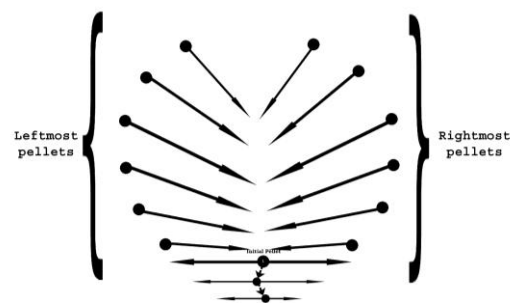


Fig.13: The Approximate centre of convergence for the complication for upper layers

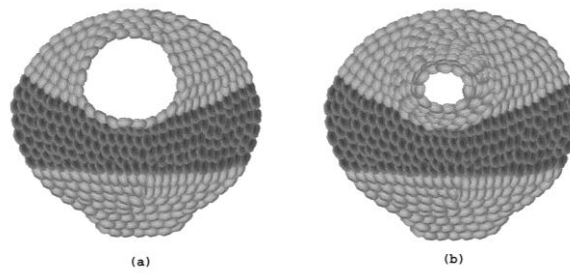


Fig.14: The Nest construction design with Circular Pattern (a) at 90% completion and (b) at extension of entrance



Fig15-a: The bird in nest construction



Fig15-b: Nest

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