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NESTING ECOLOGY, TERRITORIALITY AND BROOD CARE IN RED-VENTED BULBUL, *Pycnonotus cafer stanfordi* DEIGNAN AT LUMAMI, ZUNHEBOTO DISTRICT, NAGALAND

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AUTHORS' CONTRIBUTIONS

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

In the present study we have examined nesting ecology, territorial integrity and brood care strategy in red-vented bulbul, *Pycnonotus cafer stanfordi* Deignan at Lumami (26^{o}N). Observations recorded on 300 nests from 2017-2021 showed that birds prepared loose textured cup-shaped nests between spring equinox and autumnal equinox with a seasonal peak appearing during May/June. Nests were made using locally available grasses within 4.50±0.25 (Table 1) days lurking into deep foliage of host plants/trees. Prior to fixing their nest, mates were seen ascertaining suitability of the site by eliciting motions of building a nest without nesting material. Entry and egress routes to the nesting sites were not common. Clutch size consisted of 2-3 pinkish-brown eggs which appeared to be regulated during nest construction. At rim level, an average diameter of nest with 3 eggs measured at 67.62±0.42 mm (n=240) which was significantly more ($p<.001$) as compared with nest with only 2 eggs (62.83±0.24 mm; n=60). Conversely, mean depth of nest with 3 eggs measured at 37.39±0.11 mm (n=240) and was significantly less ($p<.001$) as compared with nest holding only 2 eggs (42.40±0.23 mm; n=60). Basement area of nest with 2 eggs measured at 117.80±1.05 cm^2 which was significantly less ($p<.001$) as compared to basement area of nest with 3 eggs (150.34±3.15 cm^2). The bird was noticed to exhibit a strong tendency to safeguard its nest and brood against predators. Brood care began with deposition of first egg which grew progressively with completion of clutch size, incubation and hatching. Persistent predation pressure amidst incubation has led to the heightening of security concerns of mates and a consequent decline in foraging timings had triggered rejection of eggs and hatchlings appearing late. Fledglings were nourished and cared by parent

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birds until they had learnt to fetch nourishment for themselves and evade predation. It is suggested that red-vented bulbul is highly territorial and has a strong tendency to defend its brood vis-à-vis extending its territorial boundary.

Keywords: Nesting; territoriality; incubation; parental care; red-vented bulbul.

1. INTRODUCTION

Nidicolous birds construct nests which hold eggs and/or nestlings and also provide them safety against predation and inclement weather conditions sojourning on their breeding grounds [1-4]. In habitats where predation pressure is relatively high, these birds prefer placing their nest camouflaged and/or well screened by vegetation to make them become less noticeable. Such features form inherent characteristics of most of altricial species in strengthening their core survival fitness towards diligent proliferation of their progeny. Further, many avian species are accustomed to instituting well defined territory during breeding season and aggressively defend their nest and young ones against conspecific and/or heterospecific intruders [5-11]. According to various studies, birds forage in open forests where there are shrubs and low grasses and drink from several water sources such as standing water, residual rainwater in headland basins, lakes, rivers and so on [12-13]. Vegetation for birds is not only used as a place to find food, but also as a place to roost, rest, mate and nest. Each type of bird uses a tree with certain crowns, strata and parts to carry out its activities. The overarching behavioral plasticity observed amongst species in upholding their territorial integrity under varying ecosystems forms the key determinant of survival fitness during habitat occupancy. Several studies corroborate that presence of birds in a habitat is viewed from the suitability and availability of habitat in supporting birds' life processes. The high number of species that live in a particular habitat can indicate that the habitat has a good role for finding food, shelter, breeding and nesting [12,14-16]. This aspect of behavioral ecology is relatively less pronounced in Indian birds. In the present study we have examined nesting ecology, territorial behavior and brood care strategy of red-vented bulbul, *Pycnonotus cafer stanfordi* Deignan at Lumami (26^{o}N), Zunheboto district, Nagaland.

2. MATERIALS AND METHODS

2.1 Distribution Pattern

Red-vented bulbul, *Pycnonotus cafer* is a sedentary finch which belongs to the family *Pycnonotidae*. This species is divided into 8 subspecies, of which, *Pycnonotus cafer stanfordi* is confined to north-eastern Indian states (southern part of Assam, Arunachal Pradesh, Nagaland, Manipur, Meghalaya, Tripura), Bangladesh, northern Myanmar and south-western parts of Chinese provinces [17].

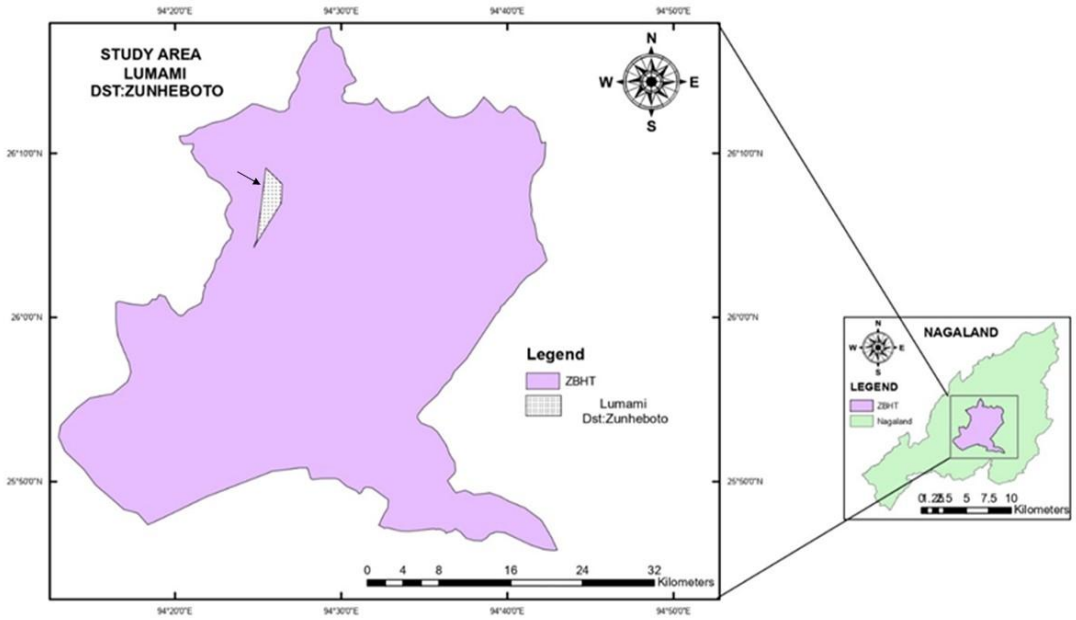

Fig. 1. Map of Nagaland State showing the location of study site at Lumami (26^{o} N) in Zunheboto district (shaded area pointed with arrow)

2.2 Study Site

Present study was conducted from 2017-2021 in a stretch of about 5km^2 in the vicinity of Nagaland University at Lumami (Fig. 1). During the study period, 300 nests were physically visited, their height from the ground were noted and measurements were recorded at rim-level and the bottom of the nest in millimeter (mm). Materials used during nest-construction were analyzed soon after fledglings had deserted nest. Regular observations on different aspects of reproductive behavior such as pair-bonding, courtship display, territory establishment, nest-building, copulation/mating, egg laying, clutch size, incubation, development of chicks and parental care were recorded manually and/or with the help of binocular (Canon-60x60). Canon EOS 700D-DSLR Camera was used to accomplish photographic details.

2.3 Statistical Analyses

Data were analyzed using Student's '*t*' test. Significance was determined at 95% confidence limit ($p<.05$) [18].

3. RESULTS

3.1 Courtship Display, Pair-bonding and Nest-site Selection

Courtship display and pair-bonding were seen in birds from mid-February to mid-September with peak nesting timing clustering around May-June. Courtship display and pair-bonding behavior (Plate A, 1) were characterized by 2-3 males competing to win the favor of a female by perching closer and uttering a sequel of long, soft chirping calls of varying magnitudes. Cooing was followed by wooing of female to win her favor as a mate. Female was noticed to submit to the male of her choice by gentle flapping of her wings (Plate A, 7, 8 and 9). Pair-bonding was strengthened further by mates grooming feathers of each other (Plate A, 3, 5 and 6). During mutual interaction, sexes were found to bring their bills and feathers in contact (Plate A, 2 and 4) and eventually, their wings got interlocked making them grounded for a few seconds before their wings became unlocked. Courtship display lasted for about a week after which birds left the group in search of a suitable nesting site. Pairs visited trees one after the other and exhibited intent hopping from one branch to other to find a suitable site for placing nest. Trees holding remains of nest built in preceding season were at preference for fixing fresh nest. Further, before the site was mutually determined, birds kept hopping at a forked-bough tilting and turning their body towards each other and exhibit motions characterizing building nest without nesting material. This feature was consistent amongst nesters. Nest entry and exit routes were found to be determined prior to fixing nest at the host bough. Small trees or bushes glued on sides of open areas made preferred sites for placing nest.

3.2 The Nest

Data on host plant preference for 300 nests during the study period are shown in Table 2. Birds were found making cup-shaped nest generally at the center of a multi-forked branch of the host-plant/tree at approximately 2-6 meters from the ground. Nest construction was found to begin with making a 'rim' which later formed the opening of nest (Plate B, 1 and 2). The rim was carefully adhered to fork using compact masses of spider webs (Plate B, 3 and 4). In a few instances soft inner surfaces of supporting branches of fork were injured before fixing them with the rim. Occasionally, thin jute or plastic ropes were used for tying nest with the host-branch. Dry pliable leaf-rachis of Gulmohar (*Delonix regia*) and culms of thatch grass were curved in inverted dome-shape to connect opposite sides of rim and then seal them with spider webs to create a lattice which was subsequently filled with loose interlacing of dry leaf-blades and thin stems of thatch grass (Plate B, 5 and 6). In following steps, enmeshed stuffs were slowly compacted from the top toward bottom. The bottom of nest was found to be parked at the base of the fork and knitted with long leaf-blades, flower rachis and thin stems of thatch grass (Plate B, 1). Side walls of nest were knitted with small holes here and there (Plate B, 7and 8). Both sexes of bulbuls were seen collecting nesting materials and arranging them to architect a cup-shape structure. The female was seen arranging nesting materials and periodically quivering to create a smooth cavity large enough to accommodate brood and mother. On clear sunny days, a nest could be made within 4.50±0.25 days, but when intercepted by inclement weather conditions, the finish was delayed owing to availability of dry nesting materials. Recurrent appearance of predators and/or hetero-specifics at nesting site has prompted birds to abandon their nest unfinished. At no point of time, two active nests could be seen parked in the same tree. Average inside diameter at rim level of nest with 3 eggs and 2 eggs were at 67.62±0.83 mm (n=240) and 62.83±0.47 mm (n=60) and depth at 37.39±0.22 mm (n=240) and 42.40±0.46 mm (n=60) respectively. The basement area of nest with 2 and 3 eggs measured at 117.80±2.10 cm^2 and 150.34±3.15 cm^2 respectively (Table 2). Mean basement area of nest with 3 eggs was significantly more ($p<.001$) and depth significantly ($p<.001$) less as compared to nest with 2 eggs only (Table 2).

3.3 Establishment of Territory

Soon after nesting site was determined, birds became desperate to setup a territory by earmarking more than 30 square meters' area surrounding nesting spot. Pairs were seen vigorously defending their nesting-territory against con-specific and/or hetero-specific intruders. This tendency was noticed growing stronger amidst egg-deposition and incubation. Once hatchling appeared, birds become excessively aggressive in defending their territory against con-specific/heterospecific intruders and were often seen uttering continuous alarms (*phonetically sounding as "twee twee twee"*) with tough gesture to combat predators tiptoeing their territory. A dry vertical branch on the neighboring tree-top was usually engaged as the view point by the male bird to guard surroundings (Plate C).

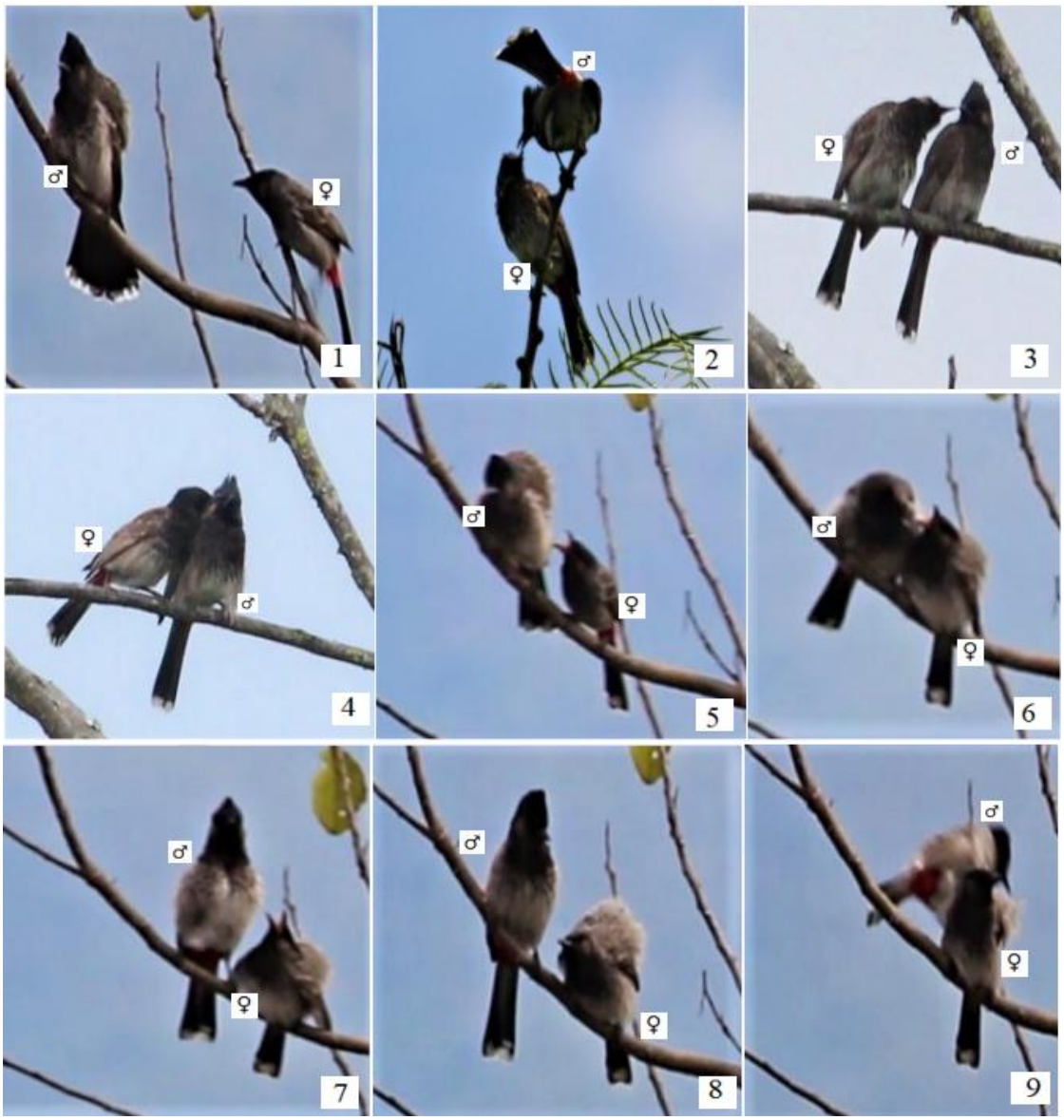

Plate A. Photograph showing courtship display and pair formation leading towards mating.
1.Female bird approaching male responding to his cooing.
2. Bill contact in male and female birds.
3. Pair of bird perching together and interacting with each other.
4. Female grooming male bird.
5-7. Female responses to male as a mate.
8.Female bird puffs her feather begging for mating.
9.Male attempts mounting the female bird

Plate B. Photograph showing development of nest of red-vented bulbul

1-2. Framing of nest-rim and subsequent adherence to host tree bough on day1
3-4. Enmeshing nest with thatch grass materials in the nest on day 2.
5-6. Further enmeshing of nest cage on day 3.
7. Enmeshed materials compacting from top towards bottom on day 4.
8. Nest bedded with soft leaf and flowers to complete nest on day 5.

Plate C. A male red-vented bulbul guarding its territory sitting on a dry branch at the apex of host tree

Significant Findings

• In red-vented bulbul, *Pycnonotus cafer stanfordi*, 2-3 males competed to win a female. Mate selection was followed by site-location for placing nest. After site was mutually consented, birds prepared cup-shape nest within 4.50±0.25 days lurking into dense foliage of trees/plants. Nests were raised between spring and autumn equinox with peak nesting timings clustering around May/June. Approach and exit routes to the nesting sites were not common.

• A clutch size of 2-3 pinkish-brown eggs were raised. Number of eggs in the clutch seemed to be regulated during nest construction. Basement area of nest with clutch size of 3 eggs measured significantly more compared with basement area of nest holding 2 eggs.

• Birds are highly territorial. They established territory in area exceeding 30 square meters around nesting spot which they continued defending against con-specific and hetero-specific intruders.

• Red-vented bulbuls exhibited brood care which began with deposition of first egg in the nest and intensified further through incubation and hatching. Persistent predation pressure amidst hatching has elevated security concern of mates and resultant shrinkage in foraging timings prompted mates to discard young ones born late. Fledglings were nourished by parents till they grew to fend for themselves and evade predation.

4. BROOD CARE

Brood care began with deposition of first egg which intensified further with more eggs added to the nest. Further increase in brood care occurred at hatching of eggs when birds posed maximum security concerns amidst obligatory feeding requirements of chicks. Both sexes were seen fetching food comprising of larvae of moths and butterflies, insects (grass hoppers, aphids, thrips, ants and winged-termites, *etc.*), spiders, nectar, small flower buds and fruits (banana, papaya, guava, cherry, mulberry, black plums, black nightshade and velvetleaf fruits, *etc.*) to nourish young ones. Feeding was made by both parents in turns. Recurrent perturbations owing to anthropogenic activities and/or enhanced predation pressure amidst hatching, heuristically occasioned mates to heighten security concerns and a consequent drop in feeding timings prompted birds to reject chicks born late. On clear days' fledglings emerged from nest on 14±0.11 days of incubation. Fledglings kept wandering aimlessly risking themselves to predation. Parent birds continued nourishing them and through customized acoustic signals guided them to evade predators. At hopping stage, young birds were strategically skilled by parents for catching insects. At this stage, parents and young birds maintained acoustic linkages and one of parents remained around them with a morsel of food. Occasionally, sensing presence of predators around, parents alarmed young birds to hide from the sight of predators. Youngs were noticed instantly pushing them to a corner and sit ideal with their heads buried under wing-feathers until parents arrived to rescue them. Skilling schedule was seen to continue for about a fortnight during which young birds became fully equipped with tricks for acquiring food and dodging predators. During night, parents and young birds were seen roosting together in bushy trees until such times they became part of a foraging flock.

5. DISCUSSION

5.1 Courtship Display, Pair-bonding and Nest-site Selection

Beginning of courtship display around 2nd week of February seemed to trigger onset of pair-bonding and search for a suitable nesting site.Since mutual interactions between mates augmented amplitude and frequency of chirping calls [19] and these changes were associated with gonadal recrudescence, it may not be unreasonable to assume that these behavioral features began under the influence of increasing circulatory levels of gonadal steroids. Sex steroids are well known to influence seasonal changes in multiple facets of behavioral attributes of many bird species [20-23]. The fact that birds with small and inactive gonads under constant short day-lengths fail to exhibit courtship behavior supports this view [24-25]. Interestingly, courtship displays and pair-bonding during February/March occurred only in few pairs leading to egg deposition in March/April. It may therefore be argued that experienced breeders of red-vented bulbuls start reproduction at the beginning of breeding season. Reportedly, in some avian species, experienced members enter into breeding earlier than others in the population [26-28]. Such an adaptation might benefit birds in capitalizing on food resources available in the habitat with less intense vying. This supposition merits attention in view of the fact that nomadic populations of red-vented bulbuls had arrived in the study area only during March/April to occupy discrete pockets of the habitat keeping pace with resident birds and a sizable chunk of them had entered into nesting during May/June to represent peak breeding season. This feature has also been noticed in red-vented bulbul populations nesting in Bhamo district of Myanmar [29]. Yet again, several pairs had attempted nesting during August/September. This might include naive birds which had entered into breeding for the first time or pairs which had

accidently lost their clutch earlier in the breeding season. There are reports to support that in many species, nestlings born late in the season are mandatorily required to pass through longer days for full expression of their neuroendocrine-gonadal axis [30] and that birds missing their clutches due to predation or inclement weather conditions, attempt re-nesting in the later part of the breeding season [31,32].

The observation that bulbul pairs are habituated to visit trees one after the other and kept hopping from one branch to the other before deciding suitable site for fixing nest, might denote the care birds take prior to stepping into egg deposition to ensure successful rearing and thus better survival prospects [33]. Though, at present, there is no convincing data to support that red-vented bulbuls might exhibit habitat and site tenacity but our long-term observations provide sufficient clue to take a positive note on it. The fact that bulbuls preferred fixing fresh nests in trees having remains of nests fixed in preceding season corroborates the practice of natal philopatry. Site fidelity has also been reported in red-winged blackbirds [34], piping plovers [35] and common tail birds [36].

5.2 Nest-construction Strategy

Birds always fixed nest lurking amongst deep foliage preferably at the center of the tree probably to reduce vulnerability of eggs and young ones against predation. Additionally, placing nest at the center of the tree might mitigate the impact of probable injury inflicted by splashing rains, sleets and hails which are not uncommon during the breeding season. The height of nest off the ground was more at locations where vegetation under the host tree was relatively thick (Neelakshi, unpublished). This might reflect at the elementary strategy to protect fledglings against probable injury on their prematurely hoping out of nest. In the present study, no nest could be seen fixed on any human raised structure or at sites other than trees, shrubs and bushes as reported earlier for red-vented bulbul [37-42]. Further, out of 300 active nests examined over a period of 5 years, 150 (50%) were fixed in the mango tree (*Mangifera indica*, March-September), 90 (30%) in wild cherry (*Prunus avium*, May - June), 25 (8.33%) in Gulmohar (*Delonix regia*, June-August), 20 (6.67%) in pride of India plant species, (*Lagerstroemia speciosa*, May-June), 12 (4%) in bitter bean, stink bean or twisted cluster bean (*Parkia speciosa*, June-July), and 3 (1%) in marigold or Mexican sunflower plants (*Tithonia diversifolia*, June-July,Table 2). It is interesting to note that preference for host-plant for placing nest chiefly relied on foliage and probable interference by con-specific and/or hetero-specific individuals. Mango trees most suitably fitted into such a requirement, for reasons that it is abundant in the study area and remain densely packed with green leaves throughout the length of breeding season. Despite abundance and dense foliage, cherry made second option because of its ripening fruits during March-April which attracts many feeder birds and thus nesting in cherry tree before May is likely to risk territorial integrity of breeders.

To our knowledge, this is the first report to detail nest-construction strategy of red-vented bulbul. Earlier reports have described breeding performance of red-vented bulbuls without description of nest-building strategy [37-52]. Nest construction to begin with preparation of nest-rim and its subsequent sealing with the host-bough using compact masses of spider webs and use of jute and plastic threads by red-vented bulbuls during nest construction have also been reported in earlier studies [49-52]. Present finding that no metal wires were used during nest-building fails to corroborate observation of Lamba [53]. Wounding and/ or injuring soft inner surfaces of the fork in some instances before sealing them with nest-rim represents unique feature of red-vented bulbul, not described before for any other bird species. This is undoubtedly an intelligent step to prevent nest-dislodging by gusty winds which is not uncommon at the study site during nesting season. The observation that leaf-rachis of Gulmohar (*Delonix regia)*, Morning Glory (*Ipomoea hederifolia lutea*, *Ipomoea alba* and *Ipomoea indica*) vines and thatch grasses growing at the study site were used for nest construction may denote that red-vented bulbul is accustomed to build nest using locally available materials within 4-5 days upholds suggestion of other workers [38-42,49-52]. However, strategic compacting of nesting materials from top to bottom and final finish of the nest-base using soft materials in the present case makes fresh revelation not described earlier. It is thus obvious that nest-architecture in red-vented bulbuls represents an evolutionary trait of the species and within its normal bound, habitat ecology and nest building materials do not influence the tenure of its completion. The well perforated side walls of nest probably denote that similar to some other species [54] nest in red-vented bulbul primarily provides structural support than insulation. The observation that threat perception on account of anthropogenic activities or recurrent threats posed by predators amidst nest building prompted birds to abandon nest unfinished has also been reported in Siberian jay [55]. Further, the finding that no two active nests ever existed in the same tree may be ascribed to acute territorial integrity of red-vented bulbuls during the breeding season as evidenced in the chestnut-sided warblers [56].

The observation that entry and exit routes to nest were determined at the time of fixing them at the host bough represents a unique feature of red-vented bulbuls and to our knowledge so far, this is not reported for any other avian species. Further, less base area with significantly more depth of the nest with a clutch size of 02 eggs as compared to the nest with 03 eggs might denote that clutch size in red-vented bulbul is determined as per basement area and depth of the nest. This finding finds support from the study of Moller et al [57] who based on sampling from 17,472 nests for 21 species from different latitudes have drawn similar conclusion. Reportedly, in some birds, clutch size vary in relation to nest size and mismatch in nest and the clutch volume has been found to reduce egg survival and fledgling success in black tailed gull [57-59].

5.3 Establishment of Territory

The observation that in red-vented bulbuls, mates are accustomed to defending their territory against con-specific and/or hetero-specific individuals and that this tendency became progressively stronger through egg deposition, incubation and hatching resemble findings in stonechats [5-11]. Though, it is yet to establish for red-vented bulbul, seasonal changes in plasma levels of gonadal steroids like Dihydroepiandrosterone (DHEA), progesterone, testosterone and their functional receptors have been shown to sustain territorial integrity of birds [5-6, 22-23, 60-65].

5.4 Brood Care

The observation that both sexes of red-vented bulbuls guarded their eggs and young ones against predators corroborates findings of other workers in red-vented bulbuls and related species [41,42,49-52,66-72]. The fact that female continued keeping hatchlings warm for more than 10 days denotes that red-vented bulbul is an altricial bird in which nestlings demand prolonged care to complete their developmental stages. Enhanced brood care with successive increase in clutch size and heightened security of nestlings with obligatory feeding requirements using larvae of moths and butterflies, insects (grass hoppers, ants and winged termites etc.), spiders, small flower buds and fruits (banana, papaya, cherry, mulberry, black plums, black nightshade and velvetleaf fruits etc.) further support this view. It was interesting to note that parent birds made nestlings accustomed to swallowing larger pieces of food before rewarding them. This may add to the adaptive value as it helps preventing choking of throat during feeding. It is intriguing to observe that recurrent disturbance amidst hatching had enhanced brood care and consequent decrease in foraging timings prompted mates to reject hatchlings born late. This feature of red-vented bulbul is unique and to our knowledge so far, has not been described for any other species. Territorial integrity and parental care were sustained so long fledglings had grown to fetch food and became skilled to evade predation. This characteristic of Red-vented bulbuls has much similarity with other passerines which exhibit biparental care of the young [73].

Table 1. Time taken for completion of nest by red-vented bulbul at Lumami (26^{o}N) Zunheboto district Nagaland

Observation and Spots	Days for nest completion	Mean±SEM*
1	5	4.5±0.25
2	4	
3	5	
4	4	

**based on observation at 4 different sites within study area during May (2) and June (2) 2020*

Table 2. Host- plant preference by red-vented bulbul for placing Nest at Lumami (26^{o}N) Zunheboto district Nagaland

Common Name	Botanical Name	Months	No. of Nests/percentage	Height from the ground (Meter)
Mango	*Mangifera indica*	March-September	150(50%)	2-6
Wild Cherry	*Prunus avium*	May – June	90(30%)	2-6
Gulmohar	*Delonix regia,*	June-August	25(8.33%)	2-5
Pride of India	*Lagerstroemia speciosa*	May-June	20(6.67%)	2-4
Bitter bean	*Parkia speciosa*	June-July	12(4%)	5-6
Mexican Sunflower	*Tithonia diversifolia*	June-July	3(1%)	1.5-2

Table 3. Diameter, depth and basement area of the nest of red-vented bulbul, *Pycnonotus cafer stanfordi* Deignan at Lumami (26°N) Zunheboto district Nagaland

Nest Diameter at Rim Level (mm±SE)		Total Depth of Nest (mm±SE)		Basement Area of Nest (cm^2±SE)	
With 3 Eggs (N=240)	With 2 Eggs (N=60)	With 3 Eggs (N=240)	With 2 Eggs (N=60)	With 3 Eggs (N=240)	With 2 Eggs (N=60)
67.62±0.42	62.83±0.24[c]	37.39±0.11	42.40±0.23[c]	150.34±3.15	117.80±1.05[c]

[c]differs from the corresponding values of different parameters compared with nest holding 3 eggs at p<.001 level (Student's 't' test)

6. CONCLUSION

At Lumami (26°N), Red-vented bulbul, *Pycnonotus cafer stanfordi* starts nesting during vernal/spring equinox and continues up to autumnal/fall equinox with peak nesting timings during May/June. Nests were constructed using locally available plant-materials and spider's webs within 4.50±0.25 days amidst trees packed with green lush and were not easily noticeable. Approach and exit routes to nest were not common. Birds deposited a clutch size of 2-3 eggs depending upon basement area of nest. The bird is highly territorial and exhibited a strong tendency of safeguarding its nest and brood against predation. Further, owing to persistent predation pressure and less availability of foraging timings amidst brood care, mates rejected eggs and young ones hatching late. Fledglings care was ensured until they grew to fetch nourishment and evade predation. It is suggested that red-vented bulbul has site fidelity and a strong tendency to guard its territory and clutch size against predation.

DATA AVAILABILITY

Supplementary data will be made available on request.

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COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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