Observations on the reproduction and feeding habit of a rare colubrid, Indian bridal Snake *Lycodon nympha* Daudin 1803 (Serpentes:Colubridae) from Southern India.

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Abstract: The reproductive biology and dietary habits of *Lycodon nympha,* a small, rare colubrid that occurs in India and Sri Lanka, are mostly unknown, except for a few notes on its reproduction. Herein we provide the basic data on their reproduction (clutch size, dimensions of the eggs, incubation period, morphometry and physical description of the hatchlings) and detailed description of their unique feeding habit (oophagy) based on observations on ten specimens. We also report of the largest specimen of this species recorded so far.

Keywords: Colubridae; *Lycodon nympha*; India; Natural history; Oophagy; Reproduction; Serpentes.

Introduction: The Asian endemic genus *Dryocalamus* comprised six species of rare and poorly known colubrids distributed across South and Southeast Asia until it was synonymized with the genus *Lycodon* in 2016 (Figueroa et al. 2016, Wostl et al. 2017). In India this genus was represented by two species namely *Dryocalamus nympha* and *Dryocalamus gracilis* (Smith, 1943).

These small, semi-arboreal snakes are excellent climbers and strictly nocturnal in habit (Whitaker and Captain 2004), mostly encountered under the loose bark of large trees, eg. tamarind trees (*Tamarindus indica*), or in the entangled aerial roots of banyan trees (*Ficus benghalensis*) (pers.obs). They have an affinity to enter human settlements, probably in search of gecko eggs. *Lycodon nympha* shows similarity to juvenile common Kraits, *Bungarus caeruleus* and common wolf snake *Lycodon aulicus* [which is a well known Batesian mimic of common Kraits (O'Shea et al. 2018)]. As a result, *L. nympha* and *L. aulicus* are often killed due to misidentification, although *L. nympha* are rarely encountered.

Various aspects of the life history of this species including major ecological traits like reproduction, diet etc., still remain dubious or undetermined due to the paucity of observations. For example, information on reproductive biology of this species are scarce, limited only to short notes about copulation observed in the wild (Krishnakumar 2014), an observation of a female with eggs (Krishnakumar et al. 2016) and sightings of three juveniles (Kartik 2017). No publications on feeding habits exist, the only anecdotal information on possible food items are provided by various authors and consist of geckos and skinks (Wall 1921; Whitaker and Captain 2004; Das and De Silva 2005).

Here we contribute new data on basic reproductive information such as clutch size, dimensions of the eggs, incubation period, morphometry and physical description of the hatchlings and a repertoire of feeding behavior (oophagy) by *L. nympha*, along with a brief discussion on the probable correlation between this particular diet and the reproduction.

Methods and materials: Observations were made on ten specimens (males: n=3; SVL:TL=394mm:98mm; 330mm:91mm; 213mm:59mm); (females: n=5; SVL:TL= 460mm:114mm; 404mm:108mm; 393mm: 108mm; 390mm:93mm; 270mm:89mm), (neonates: n=2; SVL:TL=138mm:42mm; 146mm,44mm; sex undetermined). Individual snakes were housed in 36×30×18cm well-ventilated plastic containers, provided with bark, branches, and ad libitum access to water in bowls. Moistened vermiculite was used as the incubation medium.

The feeding trials included neonates and juvenile geckos (appropriate to the gape size of each specimen) of the species namely, *Hemidactylus brooki, H. frenatus, H. laschtenaulti, H. triedrus, and Cnemaspis sp*., young skinks: *Eutropis carinata*, and *Lygosoma punctata*, hatchling garden lizards (*Calotes versicolor*), hatchling fan throated lizards (*Sitana ponticeriana)*, eggs of *C. versicolor* (range=14.2-16.01mm in length), *H. brooki, H. frenatus,* (range=7.98-9.46mm, at the longest part of the egg) and common house crickets (*Acheta domesticus*).

All photos were taken with Canon EOS 7D DSLR camera. The temperature and humidity were measured with a digital temperature and humidity meter (Extech Instruments; www.extech.com/display/?id=14444). The following data were collected: 1. Length (SVL and TL in mm) of the adults and the hatchlings (using measuring tape to the nearest 0.1 mm and millimeter graph sheet respectively), 2. Dimensions of eggs (with Mitutoyo digital vernier caliper; of accuracy ±0.1mm). 3. Weight of the hatchlings (in g with Eagle digital weighing machine, of accuracy ±0.1g). 4. Sex (with professional sexing probe).

All snakes were released in their respective spots of capture after the study.

Observation:

Reproduction: Data herein reported were obtained from the gravid female (SVL 404 mm, TL 108 mm, caught on June 13th 2015) and the neonates.

1. Oviposition: The snake laid two eggs (fig. 2A) on June 23rd 2015, at around 00:30 h IST. Completion of the process took nearly two hours. The eggs measured 31.3×9.8 mm and 38.2×9.9 mm.

2. Incubation and hatching: For incubation, the eggs were kept on moistened vermiculite with humidity maintained above 95% at all times. The temperature was between 28°c to 30°c during the incubation period.

The first egg (31.3×9.8 mm) was observed hatching (fig. 2B) on August 20th (58th day of laying) at around 02:30 h IST. Later on the same day at around 23:15 h IST the second egg (38.2×9.9 mm) hatched (fig. 2C).

3. Description of the hatchlings: The first hatchling measured 180 mm in total length (SVL-138 mm, TL-42 mm), weighed 1.6g and had 49 bands from head to tail tip.

The second hatchling measured 190mm in total length (SVL-146mm, TL- 44mm), weighed 1.7g and had 53 bands from head to tail tip.

Both the hatchlings were black above and on the sides, while the ventral sides were uniform white. Prominent bluish-white bands (n= 49 and 53) were present from the back of the head to the tail tip. Each band width occupied roughly two scales, scales on the bands lacked spots; most of the bands were forked on the sides. Bands on the posterior part of the head

Figure 1. *Lycodon nympha* **A.** hatching; **B.** feeding on a gecko egg. Photo by G. Melvinselvan

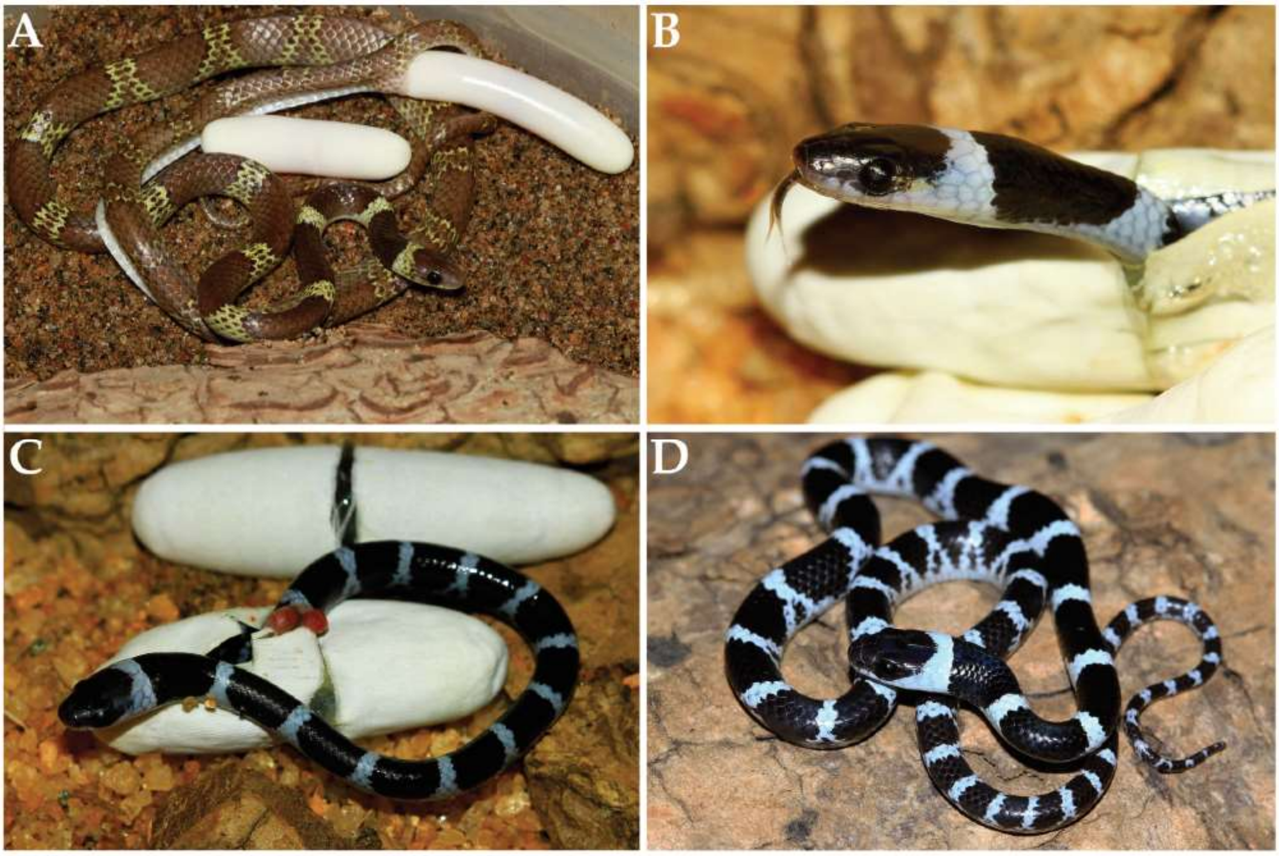

Figure 2. Oviposition and hatching in *Lycodon nympha*. **A**. the female depositing eggs, **B.** hatching of the biggest egg (38.2×9.9 mm.) and **C.** hatching of smallest egg (31.3×9.8 mm) **D.** a hatchling (SVL-138mm, TL-42mm),after its first slough. Photo by G. Melvinselvan

and nape were the widest, forming the characteristic 'veil' of the species (latin *nympha* = bride). No significant change in the appearance was observed after the first slough, except the bands turned whiter (fig. 2D).

Feeding habit:

The snakes only accepted gecko eggs in the feeding trials, except one specimen that showed interest in a *Calotes* egg but failed in the attempt to puncture the leathery eggshell.

Following the introduction of a gecko egg in the individual containers, the snakes exhibited slight increase in tongue flicks, and eventually started investigating the egg by making frequent contact with the eggshell by its tongue (fig. 3A). After confirmation of the introduced object as food the snakes started encircling the egg (fig. 3B; probably to prevent the egg from rolling over as gecko eggs are round and calcified, thus prone to get displaced with minimal force). This typical manner of seizing the egg was followed by grasping the egg by extending the jaws forward over the other end of the egg, until the enlarged posterior maxillary teeth and anterior enlarged mandibular teeth are properly placed on the eggshell (fig. 3C and 3D). Occasionally they pushed the egg against their body to gain advantage in pushing the jaws forward (in case the eggs are bigger than the relative gape size of the snakes).

Following the engagement of the jaws on the eggshell great force was applied that resulted in cracking of the shell.

In a few cases (especially if the snakes are juvenile) they used a body coil to apply additional pressure at the tip of their snout (fig. 3E) which altogether acts as leverage, the pressure point being the enlarged maxillary teeth.

The snakes were then observed to insert their upper jaw into the punctured point of the shell (fig. 4A), swallowing the egg content simultaneously (fig. 4B and 4C), while the anterior enlarged mandibular teeth holds and prevents the egg from getting displaced.

By reciprocating jaw movement the egg content was swallowed by the snakes entirely (they likely do not puncture the extra-embryonic membrane that separates the egg content and the shell). Parts of the broken shell were swallowed along with the content and any liquid oozing out of the snakes mouth or from the egg was never observed.

Peristaltic movements of the esophageal muscles were observed as the snake swallowed the egg content. After the entire feeding episode was over, the leftover eggshell without any sign of moisture inside was discarded (fig. 4D).

Discussion:

Reproduction: Neonates have been observed during August-September (pers. obs.). However a copulating pair was observed in late August in northeastern Tamil Nadu (Krishnakumar 2014), further in 2017 a snake with 3 eggs were sighted in early August in the Coromandel coastal plains (Krishnakumar et al. 2016), and two juveniles were sighted in March and August in northeastern Tamil Nadu and another in October in south Tamil Nadu (Kartik 2017). These observations may suggest the hatching time to coincide with the onset of the monsoon. This arrives around June in the Western Ghats (South-West monsoon), whereas in the northeastern region it starts around October (North-East monsoon). Detailed study is required on the seasonal reproductive pattern to understand if this species reproduces throughout the year or if a more seasonal reproductive cycle exists. These data will also predict the sexual maturity, fecundity and reproductive frequency for individual snakes.

We hypothesize that the relatively large size of the hatchlings is directly related to the habit of feeding on gecko eggs. In the present study the mean ratio of the hatchling's SVL to the mother's SVL is 0.4; and the clutch size (n=2, total length of both eggs-69.5 mm).In the previous report clutch size n=3, dimensions of the eggs 21×8mm, 27×9mm and 28×7mm (Krishnakumar et al. 2016).We suspect the size of the hatchlings facilitates feeding on the smallest available gecko eggs (suitable to the gape size of the hatchlings) and producing young of this size results in lesser number of eggs, probably restricted to only two to three eggs per clutch. The data on clutch size of this species are limited only to these studies (present and Krishnakumar et al. 2016), but considering the large size of the females (total length 512mm in present study and 515mm in

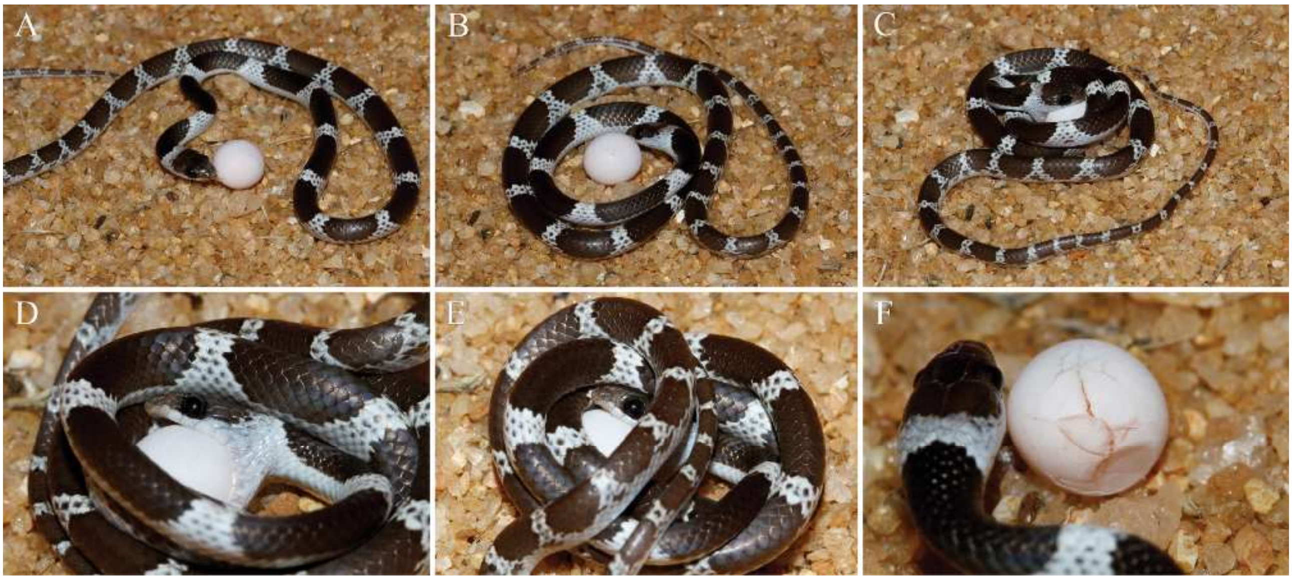

Figure 3. Feeding repertoire of *Lycodon nympha*. **A.** investigating the egg by making frequent contact with the eggshell by its tongue, **B.** encircling the egg **C.** grasping the egg by extending the jaws forward over the other end of the egg, **D.** positioning the enlarged posterior maxillary teeth and anterior enlarged mandibular teeth on the eggshell, **E.** using the body coil to apply additional pressure at the tip of the snout, **F.** prominent puncture marks on the egg shell and comparison of the head size with the egg size. Photo by G. Melvinselvan.

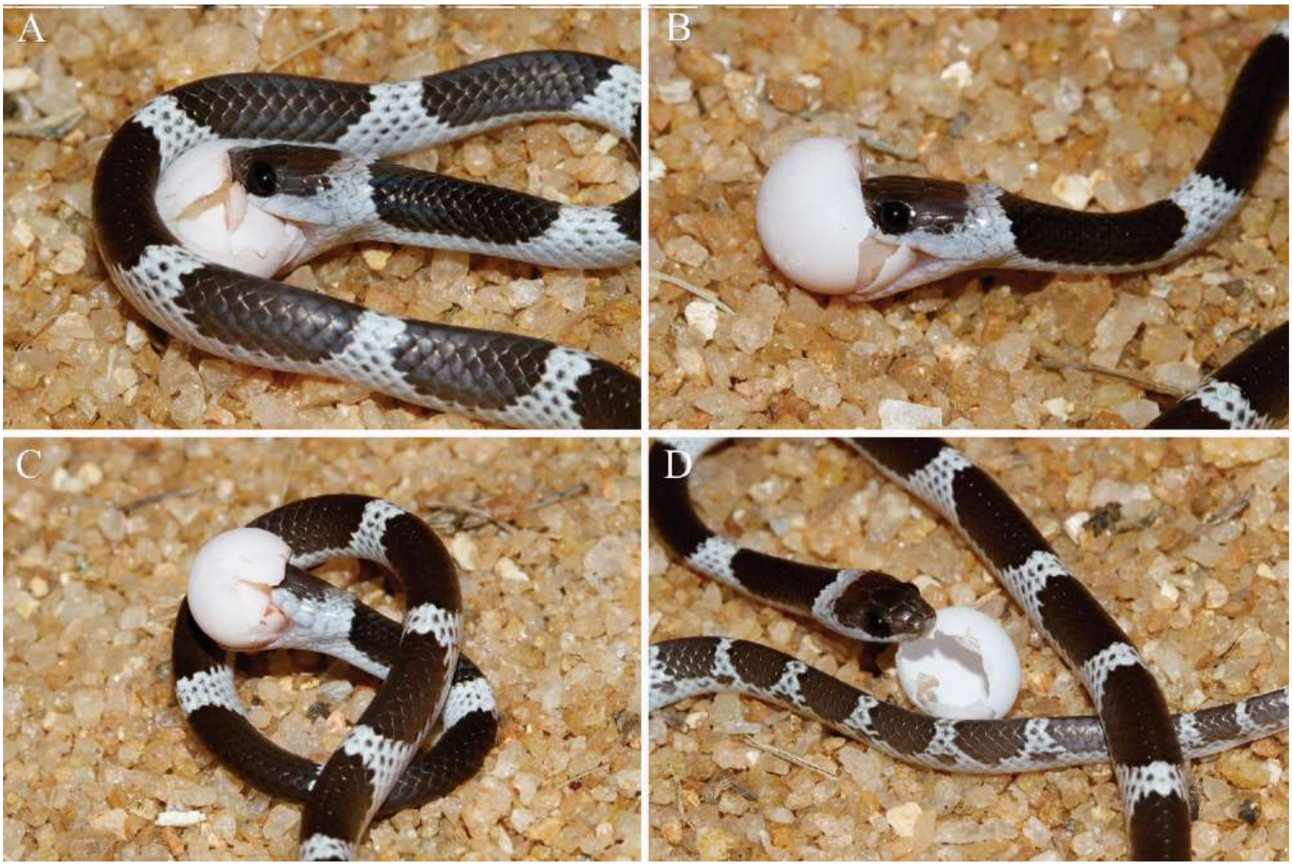

Figure 4. A. inserting the upper jaw from the punctured point of the shell, **B.,C.** swallowing the egg content simultaneously (along with the broken eggshell), while the anterior enlarged mandibular teeth holds the egg from getting displaced. **D.** discarded leftover eggshell, without any sign of moisture inside. Photo by G. Melvinselvan.

Krishnakumar et al. 2016; maximum size reported 520mm, Wall 1920, Smith

1943,Whitaker and Captain 2004), the number of eggs laid, is significant. Moreover lower clutch number probably indicates the high survivorship of the neonates.

There is a conspicuous difference in appearance of the neonates and that of the mother. The neonates were black with white bands, whereas the female was brown in color with yellowish bands. The bands were 3-4 scales wide with a dark spot on each band scale for the female, while the hatchlings had narrower bands that were two scales wide, and the band scales lacked spots.

The maximum length for the species is 520 mm (total length) as cited in Wall 1920, Smith 1943, and Whitaker and Captain 2004. However the present study reports of a female of length 574 mm (SVL 460mm, TL 114mm) that appears to be the largest specimen of the species recorded thus far.

Feeding habit:

Dentition: Ten maxillary teeth, without grooves, conical and stout, increasing in size posteriorly, diastemae absent; palatine and pterygoid teeth very small and all of about the same size; nineteen mandibular teeth, the first five of which are slightly enlarged (Müller 1924).

Selection of a particular food item among a range of other options provided probably indicates that the diet of *L. nympha* consists of a specific food type, precisely calcified reptile eggs of diameters suitable to relative gape size of the snakes. From this it can be hypothesized that the shape and position of different sized teeth on the jaw help in holding the calcified egg in place between the jaws and asserting enough muscular effort to break open the egg, the position of the enlarged maxillary teeth is advantageous for exerting greater mechanical effort on a restricted area, but are certainly not suitable for any sawing or piercing action required to slit open flexible leathery shelled eggs of snakes and lizards. As observed in this study, *L. nympha* consumes as much as half of the eggshell in the process of breaking the shell and eating the egg content, and digests the egg shell, it can be assumed that smaller eggs of other species of geckos, e.g dwarf geckos (*Cnemaspis spp*.) can be swallowed entirely by larger specimens and digested.

In peninsular India geckos (*Hemidactylus brookii, H. frenatus, H. laschtenaultii, H. triedrus, Cnemaspis spp.* etc) lay eggs almost throughout the year yielding an abundant and constant supply of food for *L. nympha*. Moreover competition over gecko eggs between *L. nympha* and its sympatric snake species is less, as the other specialized and facultative-egg-eating snakes found in the region consume leathery shelled reptilian eggs and hard shelled avian eggs predominantly.

The data presented here will help in understanding the basic reproductive biology of these snakes. But this study is certainly not exhaustive, still various topics like sexual size dimorphism, gestation period, growth rates, sexual maturity, fecundity, reproductive frequency etc., remain unknown or data deficient. Further studies are needed to fill the knowledge gaps, which will help us in understanding these rare snakes better.

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