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Underwater Hunting in an Arboreal Snake: Predation Notes on Amazonian Frog Larvae

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ABSTRACT

Colubrid snakes are generalist predators and are well documented to predate on adult anurans and their eggs. However, there is limited information on predation of amphibian larvae (tadpoles). This is particularly true for rarely observed species such as arboreal rainforest snakes and frogs. *Chlorosoma viridissimum* is a common arboreal snake found in the Amazon rainforest. Here, we report multiple events of juvenile *C. viridissimum* hunting underwater for tadpoles of frogs (*Trachycephalus resinifictrix, T. hadroceps, and Osteocephalus oophagus*) breeding in water-filled tree cavities. The observations were made through video monitoring and direct observations in the tropical rainforest at Nouragues Nature Reserve, French Guiana. Our observations suggest that juveniles of *C. viridissimum* are underwater hunters and may be a key predator for canopy-breeding frog larvae.

1 | Introduction

Snakes represent one of the most ecologically diverse taxa of reptiles in terms of distribution, morphology and behaviour (Cortes et al. 2014; Pyron and Burbrink 2012; Title et al. 2024), and their dietary habits vary greatly in composition and hunting strategies (Colston et al. 2010; Vitt and Vangilder 1983; Wan et al. 2025). Arboreal snakes, such as Boidae and Colubridae, constitute approximately 17% of snake diversity and are mostly distributed in tropical regions (Harrington et al. 2018; Uetz et al. 2025). The majority of arboreal species found in the Neotropics belong to the Colubridae family, which are often generalists preying on reptiles, mammals, or amphibians (Harrington et al. 2018). Variations in diet are known to be influenced both by prey availability and phylogenetic patterns (Wells 2007), but the foraging ecology of canopy-dwelling species remains relatively overlooked, mostly due to the difficulty in accessing arboreal environments (Martins and Oliveira 1998; Moore et al. 2021). Therefore, opportunistic reports are key for a better understanding of snake trophic ecology and the evolutionary interactions between predators and prey (Griesbaum et al. 2023; Santana et al. 2019).

Amphibians, including treefrogs (Hylidae), are an important part of snake diets throughout their life cycle (Bellini et al. 2015; Hartmann et al. 2009; Vitt and Vangilder 1983). While some treefrog species mate and reproduce in terrestrial water bodies (Dias-Silva et al. 2021), others rely exclusively on arboreal pools, known as phytotelmata (Schlippe-Justicia et al. 2025). These microhabitats are often considered safer breeding sites than larger water bodies, as they reduce exposure to many aquatic and terrestrial predators. While some invertebrates and carnivorous tadpoles of certain poison frog species prey on amphibian larvae inside phytotelmata (Caldwell and De Araújo 1998; Fincke 1999; Rojas 2015), remarkably little is known about predation pressures originating from outside the pool. Observations

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of non-resident predators in phytotelmata are extremely rare, leaving a major gap in our understanding of the selective pressures acting on canopy-breeding frogs.

In the Neotropics, several arboreal frog species belonging to the Dendrobatoidae and Hylidae families, rely on phytotelmata for breeding (Fouilloux et al. 2021; Maguire 1971). At the Nouragues Nature Reserve in French Guiana, located in the eastern part of the Guiana Shield, at least three hylid species: *Trachycephalus resinifictrix* (Goeldi, 1907), *Trachycephalus hadroceps* (Duellman and Hoogmoed, 1992), and *Osteocephalus oophagus* Jungfer and Schiesari, 1995 rely on tree cavities for breeding (Gaucher 2002; Jungfer and Weygoldt 1999; Schiesari et al. 2003). During the reproductive season, males call from suitable pools at night to attract females and mating pairs engage in amplexus before laying egg clutches in the water. Despite their similarities in reproductive strategies, each species occupies preferred phytotelmata types along a vertical gradient (Fouilloux et al. 2021). In addition, *O. oophagus* and *T. hadroceps* provide parental care by egg-feeding their tadpoles (Gaucher 2002; Jungfer and Weygoldt 1999). Although predation avoidance is proposed to be the main evolutionary drive for breeding in small pools (Maguire 1971), very little information is available on predation pressures in these habitats.

The Common Green Racer *Chlorosoma viridissimum* (Linnaeus, 1758) is a diurnal arboreal snake widely distributed across the Amazon basin and the Guiana Shield (Cunha and de Nascimento 1983; Entiauspe-Neto et al. 2018) but information on its habitat, behaviour and diet is scarce (Chávez-Arribasplata et al. 2016). Early reports on *C. viridissimum* described adults preying on bats and squirrels, while juveniles preyed on lizards and frogs (Jorge and Simões 2018; Lozorio 2025). There is only one report on the presence of the snake in a *T. resinifictrix* phytotelmata, with no clear predation sign (Martins and Oliveira 1998). Given the fundamental trophic role of anurans in the ecosystem, it is important to investigate predator–prey interactions (Griesbaum et al. 2023).

Here, we report several independent observations of juvenile *C. viridissimum* diving into arboreal pools to hunt treefrog tadpoles. To our knowledge, these observations provide the first evidence of underwater hunting in an arboreal snake species. Importantly, they suggest that juvenile snakes may exploit a previously unrecognised aquatic resource and that tadpoles are a component of *C. viridissimum* diet, reflecting either ontogenic foraging flexibility or behavioural specialisation. More broadly, these observations reveal a novel predation pressure for arboreal tadpoles and highlight the importance of opportunistic records for advancing our understanding of predator–prey interactions.

2 | Methods

2.1 | Treefrog Breeding Sites Surveys

The study was carried out in the primary lowland rainforests of the Nouragues Nature Reserve, French Guiana near the Camp Pararé (4°02′N, 52°41′W, WGS84) of the CNRS Nouragues Ecological Research station (local sunrise between 06:15–06:30 and sunset between 18:30–18:36). We report direct observations and remote camera recordings from one artificial pool and two natural breeding sites recorded in 2010 and 2025, respectively. Observations were part of a larger project investigating the ecology and behaviour of phytotelm breeding frog communities across wet (generally, December to July) and dry seasons (generally, August to November; Gottsberger and Gruber 2004). The predation observations were recorded during the wet season. Phytotelmata were located by following calls produced by *T. resinifictrix*, *T. hadroceps*, and *O. oophagus* during night surveys to identify potential trees with arboreal pools. When necessary and feasible, we used a single rope canopy access system to find and access the phytotelmata. In the same area, an artificial pool was monitored as a pilot experiment to further study the behaviour of phytotelm breeding frogs.

2.2 | Pool Characteristics and Monitoring

2.2.1 | Artificial Pool A

In May 2010, we equipped one artificial pool (54 m a.s.l.) (hereafter "Artificial pool A") used for breeding by *T. resinifictrix* adults with a passive infrared sensor camera (Wingscapes Digital Timelapse Camera PRO), recording 30 s video every minute in time-lapse mode (Figure 1a). The artificial pool was a cylindrical concrete container 40 cm tall and 28 cm wide in diameter placed on the ground and that could contain a maximum volume of ~25 L in water.

2.2.2 | Natural Pool A

On the 20th of March 2025, we set up a surveillance camera (Wyze Cam v4, Wyze Labs Inc.) on an arboreal pool (70 m a.s.l.) (hereafter "Natural pool A") occupied by seven *T. hadroceps* tadpoles. The pool was located 23 m above ground level and measured 9 cm, 8 cm and 36 cm in length, width and depth respectively (Figure 1b). The site can hold ~2.5 L of water. We monitored the phytotelm for treefrog behaviour using a pixel-change detection system, which allows for video captures of a wide range of animals, including ectotherms (Lynch et al. 2025; Goolsby et al. 2023; McGaugh et al. 2019). We equipped the camera with a 32GB SD card and a power bank (Galeces model LC100, 25000 mAh/92.5 Wh) secured in a dry bag around a main branch. This setup allowed autonomous recording for 48 h after which the battery and SD card were replaced.

2.2.3 | Natural Pool B

Direct observations were made opportunistically in April 2025 during visual encounter ground surveys at one low arboreal pool (70 m a.s.l.) (hereafter "Natural pool B") occupied by *T. resinifictrix* and *O. oophagus* tadpoles (Figure 1c). The pool was located at 47 cm height, and was 53 cm long, 42 cm wide and 52 cm deep, which resulted in ~115 L in water capacity.

2.3 | Data Description

For each event, we report the timing and duration of predation events, number of prey caught, and descriptions of hunting

FIGURE 1 | Photographs and video-stills showing pool sites (left column), predation instances (middle column) and study species (right column). (a) Artificial pool A, (b) Natural pool A, (c) Natural pool B, (d) *C. viridissimum* hunting underwater in Artificial pool A, (e) *C. viridissimum* eating a *T. hadroceps* tadpole in Natural pool A, (f) *C. viridissimum* hunting underwater mouth parts open in Natural pool B (g) full-body photograph of *Chlorosoma viridissimum*, (h) *T. resinifictrix* tadpoles in turbid water of Natural Pool A.

behaviours. The number of prey caught was determined by visually counting the instances when the snake had the tadpole in its mouth; we did not do any gut content analysis.

3 | Results

During the rainy seasons of 2010 and 2025, we recorded four independent predation events by *C. viridissimum* on treefrog tadpoles at three different breeding sites ranging from ground-level to high arboreal pools. In all cases, we observed a different *C. viridissimum* juvenile snake present inside a phytotelm, which we could differentiate based on unique head colour patterns.

3.1 | Camera Recordings

3.1.1 | Artificial Pool A

On the 21st of May 2010 at 14:14, we captured several clips of a juvenile *C. viridissimum* in Artificial pool A that was regularly used by *T. resinifictrix* for breeding (Video S1 and Data S1). In this instance, we could observe the underwater hunting strategy more precisely: the individual repeatedly tried to catch prey with an open mouth (Figure 1d). Overall, several predation attempts were recorded over a total duration of 17 min until 14:33. However, we could not confirm any successful captures.

In addition, on the 12th of March 2010 at 05:04, an adult Banded Cat-eyed Snake (*Leptodeira annulata*) was recorded visiting Artificial pool A (Data S2). This semi-arboreal and nocturnal species displayed a similar hunting behaviour to that of *C. viridissimum*. The snake was seen exploring the pool surface before trying to capture tadpoles with half of its body submerged at 05:07.

3.1.2 | Natural Pool A

On the 30th of March 2025, we recorded one juvenile *C. viridissimum* hunting *T. hadroceps* tadpoles inside the Natural Pool A (Video S1 and Data S3). The entire predation event lasted approximately 50 min, during which the camera captured a total of 22 min of footage. The snake slowly approached the arboreal pool at 17:12 before diving into the pool. After spending 101 s underwater, the individual returned to the surface with the first tadpole in its mouth and ingested it (Figure 1e). Throughout the predation event, the snake repeated the same sequence of behaviours: hunting underwater, surfacing either to rest before a new predation attempt or to consume captured prey. We could not clearly identify the underwater hunting behaviours due to the pool's turbidity. The snake performed a total of nine dives and successfully captured individual tadpoles in five instances. The average dive duration was 120 s (range between 26 and 196 s). The last successful hunting attempt occurred at 17:52 and the snake left the pool at 18:04, leaving a single tadpole alive.

3.2 | Direct Observations

3.2.1 | Natural Pool B

On the 15th of April 2025, we surveyed the Natural Pool B known to contain *T. resinifictrix* and *O. oophagus* tadpoles. From 17:52 to 18:25, we observed a juvenile *C. viridissimum*, approximately 20 cm long, inside the water. We immediately recorded and documented its behaviour with a camera (OM-1 system, M Zuiko 60 mm macro lens) (Video S1 and Data S4). The snake continuously dived and re-emerged from the water with its mouth open (Figure 1f). We suspect that the snake caught some tadpoles, as it adjusted its fangs on several occasions, but we did not clearly observe capture or handling of prey. After half an hour of active underwater hunting, the individual left the pool, at which point we took identification pictures.

On the next day at 15:23, we identified a different juvenile individual of *C. viridissimum* underwater in the same pool. The snake was not hunting upon arrival, so we attempted to take identification and observational pictures while it was hiding underwater (Kodak Pixpro, WPZ2). Our approach may have disturbed the individual, as it remained still inside and around the pool for at least an hour. We saw the snake in the pool at approximately 17:00 for the last time before leaving the site.

4 | Discussion

4.1 | Underwater Hunting in an Arboreal Snake

We provide the first report of underwater hunting behaviour in a primarily arboreal snake—*C. viridissimu*m. Specifically, we observed and described *C. viridissimum* diving inside phytotelmata multiple times to prey on tadpoles of *T. hadroceps, T. resinifictrix* and *O. oophagus*. While aquatic snake species are known to feed on anuran larvae (Di Pietro et al. 2020; Durso et al. 2013; Eisfeld et al. 2021), Leong et al. (2009) have first speculated that arboreal snakes also prey on frog tadpoles (based on attempted predation of *Hylarana erythraea* (Schlegel, 1837) tadpoles in a pond by *Dendrelaphis pictus* (Gmelin, 1789)) without reporting direct observation of predation. *Chlorosoma viridissimum* hunting successfully in phytotelmata is surprising and physiologically challenging for at least two reasons. First, for visual predators like *C. viridissimum* hunting underwater can be very challenging because of the low light and high-water turbidity of many phytotelmata (Fouilloux et al. 2022). Second, spending a prolonged period of time underwater is more likely to be seen in an aquatic adapted species. However, other arboreal snake species, such as the Malabar Pit Viper (*Craspedocephalus malabaricus* (Jerdon, 1854)), have also been observed to spend long periods of time under water (~20 min), in a shallow stream and concrete water tank on ground (Bhaisare and Pelling 2015). This raises further questions about the apnoea (temporary cessation of breath) capabilities in non-aquatic snakes adding more support to the idea that prolonged apnoea might not be restricted to aquatic species (Aubret 2004).

4.2 | Diet Specialisation in Juvenile Snakes

Chlorosoma viridissimum is a predator that feeds on diverse prey across taxa depending on its ontogeny (Lozorio 2025; Martins and Oliveira 1998). Across our four independent observations of tadpole predation by *C. viridissimum*, the snake involved was consistently a juvenile. Prey choice in snakes is constrained by the predator's body size and shifting energetic requirements (Barends and Naik 2023; Manjarrez et al. 2013; Shine and Wall 2007). Therefore, tadpoles of canopy-dwelling treefrogs may represent optimally sized prey for smaller juveniles. Additionally, Martins and Oliveira (1998) and Lozorio (2025) reported an apparent shift in prey type from ectothermic to endothermic prey during the ontogeny of *C. viridissimum*. Taken together, these patterns support our speculation that juvenile *C. viridissimum* may show a preference for preying on tadpoles, with this preference likely fading as individuals increase in size. Although adults of *C. viridissimum* have also been documented to forage in phytotelmata (Martins and Oliveira 1998), their broader gape and diet breadth suggest that tadpoles may be a more profitable resource specifically for smaller juvenile snakes.

4.3 | Predators of Phytotelm-Breeding Frog Larvae

Predations on anuran larvae have been reported mainly by odonate larvae, other tadpoles (Mckeon and Summers 2004; Phuge et al. 2020; Rojas 2014) and in some cases mosquito larvae (*Toxorhynchites* sp.) (von May et al. 2009). Our observations from natural and artificial breeding sites describe a previously undocumented predation risk for phytotelm-breeding amphibians by arboreal snakes. The presence of arboreal snakes has been previously reported in phytotelmata occupied by tadpoles of *O. oophagus* (Jungfer and Weygoldt 1999), *T. resinifictrix* (Jungfer and Weygoldt 1999; Martins and Oliveira 1998) and *T. hadroceps* (PG pers. comm.), but none of these reports documented tadpole predation. Despite the challenges of low light and turbid waters (Fouilloux et al. 2022), phytotelmata may serve as effective foraging sites as they provide a confined space that increases snakes' ability to capture tadpoles. In addition, frogs reuse stable breeding sites across years (Schiesari et al. 2003), thereby providing reliable foraging sites for canopy predators.

In summary, we report novel underwater hunting behaviour in *C. viridissimum* and add *T. resinifictrix*, *T. hadroceps*, and *O. oophagus* larvae to its diet. Information about such predator–prey interactions in arboreal species is constrained by the difficulty of accessing the tree canopy as it requires specific skills, equipment, and expertise (Martins and Oliveira 1998; Moore et al. 2021). Other recent studies report predation attempts by snakes in arboreal habitats on bats (Aya-Cuero et al. 2019), birds (Mise et al. 2021), and frogs (Donnelly and Guyer 1994; Jung et al. 2020). Our observations contribute to the accumulating evidence that snakes are key predators in arboreal habitats. Natural history observations like those in our study describe previously uncharacterized behaviours, opening new avenues of research and encouraging additional study of canopy-dwelling species.

Author Contributions

Floriana Stanca: conceptualization (equal), data curation (equal), formal analysis (equal), investigation (equal), methodology (equal), writing – original draft (equal). **Shubham Soni:** conceptualization (equal), data curation (equal), formal analysis (equal), investigation (equal), methodology (equal), writing – original draft (equal). **Daniel Shaykevich:** data curation (supporting), formal analysis (supporting), investigation (equal), writing – review and editing (supporting). **Ugo Lorioux-Chevalier:** data curation (supporting), formal analysis (supporting), investigation (equal), writing – review and editing (supporting). **Paul Kesseler:** data curation (supporting), formal analysis (supporting), investigation (equal), writing – review and editing (supporting). **Lia Schlippe Justicia:** data curation (supporting), formal analysis (supporting), investigation (equal), writing – review and editing (supporting). **Philippe Gaucher:** data curation (supporting), formal analysis (supporting), investigation (equal), writing – review and editing (supporting). **Valentine Alt:** investigation (equal), resources (supporting), writing – review and editing (supporting). **Andrius Pašukonis:** conceptualization (equal), funding acquisition (lead), investigation (equal), methodology (equal), supervision (lead), writing – review and editing (equal).

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Ethics Statement

The study was approved by the local authorities at the study site (DGTM permit R03-2024-03-26-00001) and the scientific committee of the Nouragues Ecological Research Station (Notice No. 2024-12 communicated to A.P.). The study is also part of a partnership agreement between A.P. and the Nouragues Nature Reserve (partnership agreement No. 01-2019). We strictly adhered to the current French and European Union law and followed the Association for the Study of Animal Behaviour's (ASAB) Guidelines for the use of live animals in teaching and research (ASAB, 2023).

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

Video S1 is available within the Supporting Information of the paper. All video data supporting the observations of underwater hunting behaviours by *Chlorosoma viridissimum* can be accessed on Zenodo following this link: https://doi.org/10.5281/zenodo.18346364.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section. **Video S1:** ece373376-sup-0001-VideoS1.avi. **Data S1:** ece373376-sup-0002-DataS1.avi. **Data S2:** ece373376-sup-0003-DataS2.avi. **Data S4:** ece373376-sup-0004-DataS4.avi.