



Care and Reproduction of the Elegant Habu, *Protophrops elegans* (Gray 1849), at the Saint Louis Zoo

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The Charles H. Hoessle Herpetarium at the Saint Louis Zoo (Missouri, USA) houses an extensive number of Old World pitvipers (Viperidae: Crotalinae). Particular emphasis is placed on species in the genus *Protophrops*, many of which are rarely maintained or bred in zoological settings. Among these species is the Elegant or Sakashima Habu (*Protophrops elegans*). As of June 2025, the global reported zoo population of this snake was limited to the Saint Louis Zoo and two other institutions (ZIMS Species Holdings 2025).

Protophrops elegans is native to the Ryukyu Islands of Japan (Guo et al. 2016). The species occurs throughout much of the Yaeyama Archipelago within the Sakishima Islands group (Keegan and Yoshino 1959; Goris and Maeda 2004). In addition, *P. elegans* was introduced to southern Okinawa Island (Goris and Maeda 2004) and now occurs at high densities around Itoman City (Ota et al. 2004). These islands are subtropical, with a warm climate (mean annual temperature ~24 °C) and abundant rainfall (> 2000 mm annually) from seasonal monsoons and typhoons (Somiya 2015).

This species demonstrates remarkable plasticity in environment and behavior, and can be found in habitats from montane forests to lowland areas, but they most frequently are observed near human habitations or heavily overgrown areas, such as bamboo groves (Keegan and Yoshino 1959; Goris and Maeda 2004). These snakes are active primarily at night (Keegan and Yoshino 1959). Despite being considered a largely terrestrial species, individuals do exhibit arboreal activity (Keegan and Yoshino 1959; Goris and Maeda 2004).

Minimal information is available on the life history traits and ecology of *P. elegans* in nature. An oviparous species, females lay 5–13 eggs per clutch (Goris and Maeda 2004) usually in the summer (Keegan and Yoshino 1959). The venom of *P. elegans* is myotoxic and appears to be specialized for targeting reptilian skeletal muscle (Aird et al. 2015), suggesting a natural diet focused primarily on lizards. However, individuals also are known to eat frogs, small mammals, birds, and eggs (Keegan and Yoshino 1959; Goris and Maeda 2004).

Previous research on *P. elegans* has consisted largely of studies conducted in the context of human health. In humans, bites from this species are medically significant. Reported symptoms include severe local hemorrhaging, edema, and necrosis (Keegan and Yoshino 1959; Nozaki et al. 1974). However, while envenomations cause substantial morbidity, they seldom result in death (Goris and Maeda 2004).

Due to the limited representation of *P. elegans* in zoological institutions, little information is available regarding care and reproduction of this species. We herein provide a detailed account of the husbandry, environmental conditions, and reproductive strategies employed at the Saint Louis Zoo to achieve a successful breeding of *P. elegans*, contributing valuable insights into the management of this rarely housed species.

Methods and Results

Husbandry.—Detailed safety policies and emergency procedures for venomous reptiles, including *P. elegans*, have been developed and refined at the Saint Louis Zoo. Staff involved in the care of venomous reptiles are highly trained and act in strict accordance with these protocols. All venomous reptiles are housed in secure enclosures and maintained using approved handling and husbandry methods.

The Saint Louis Zoo acquired two individuals of *P. elegans* from a reputable animal importer in March 2018. These individuals, which originated in a facility in Russia, were reported to be hatchlings from 2017. This age was supported by their small size upon arrival, as the male and female were 31 g and 29 g in body mass, respectively. The snakes were isolated for a 120-day quarantine period before being moved to the Herpetarium. Initially, the pair were individually housed in a small custom-built snake rack system with an ambient temperature of approximately 22 °C. A localized hot spot of 31 °C was created using heat tape controlled by a VE-200 proportional thermostat (Vivarium Electronics/Reptile Basics Inc., High Point, North Carolina, USA) under one half of

each enclosure in the rack. Each snake was fed pinky (~2–3 g in mass) or fuzzy (~4–6 g) laboratory mice (*Mus musculus*) 1–2 times per month.

By June 2019, the mass of the male had increased to 108 g, whereas that of the female had grown to 132 g. At this stage, the snakes were transferred to another section of the Herpetarium that allowed for controlled seasonal temperature changes. The snakes were individually housed in a snake rack with enclosures measuring 40.5 x 56 x 14 cm. Each enclosure was furnished with a 5–8 cm deep substrate layer made from hardwood bark mulch, cypress mulch, coconut coir, sand, sheet moss, and leaf litter. Hide areas were provided using rectangular reptile-specific hide boxes (Vivarium Electronics/ Reptile Basics Inc., High Point, North Carolina, USA) and cork bark slabs. The environmental parameters of the snakes were cycled to simulate natural seasonal variations (Table 1). Prey offerings ceased prior to the onset of cooler conditions in mid-September, and the snakes were periodically soaked to ensure proper hydration and to aid in defecation. In mid-April, the snakes resumed feeding. The snakes were given appropriately-sized frozen/thawed whole *M. musculus* or quail chicks (*Coturnix* spp.) and typically ate the equivalent of one small *M. musculus* (~7–13 g in mass) every 2–3 weeks.

The sexes of the snakes were confirmed via probing in December 2022. At this time, the mass of the male was 348 g and that of the female was 322 g. In late March 2023, the snakes were paired with the intention of breeding. They were transferred to a 20-gallon aquarium (76 x 30 x 33 cm) equipped with two hide boxes (18 x 24 x 6 cm). An overhead halogen light bulb (39 W) was provided for heat, with the bulb controlled by a timer to maintain the same ambient photoperiod as in their previous housing. This setup allowed for a localized basking spot with a maximum temperature of 31 °C to ensure the necessary thermal gradient to support the physiological needs of the snakes during the breeding season. Over the following months, the pair were only separated for weighing. Snakes were observed regularly but not continuously during this period. They appeared to exhibit a strong tendency to cohabitate, as they were seen spending extended periods in the same hide box. Although copulation was never

observed, the close physical proximity of the individuals suggested that they had ample opportunities for mating.

On 19 June 2023, the female entered a pre-ovulatory shed cycle at a mass of 377 g. She was separated from the male on 23 June. On 9 July, she laid a clutch of eleven eggs. All of the eggs were laid under a hide box filled with long dead grasses for nesting material. The temperature of the nesting site was 24 °C and it was on the side of the enclosure with higher humidity, opposite the basking spot. Following oviposition, the body mass of the female was 258 g. The female was coiled on the eggs when first discovered (Fig. 1).

Incubation.—The eleven eggs were collected from the female’s enclosure for artificial incubation. Nine of the eggs were firmly adhered to one another. This cluster was left intact to avoid damage to the eggs, which precluded individual measurements of some eggs. For the eight measured eggs, mean length was 35.5 ± 3.3 mm (32–40 mm) and mean width was 21.5 mm (20–25 mm). The mass of the entire clutch was 105 g, resulting in a relative clutch mass (i.e., total mass of the clutch divided by the post-partum mass of the female) of 0.407. All of the eggs were placed in a container filled approximately halfway with a 1:1 ratio of vermiculite to reverse-osmosis water. Eggs were placed directly onto the vermiculite so that the bottom third of each egg’s surface was in contact with the substrate (Fig. 2). A MyTemp Mini thermo-electric incubator (Model H2200-HC, Benchmark Scientific, Sayreville, New Jersey, USA) set at 25 °C maintained a constant temperature throughout incubation. On day 17 of incubation, one of the eggs in the cluster began to darken and collapse, indicating that it was not viable. However, because of its position, removing the egg would have risked damaging adjacent eggs. Therefore, it was left attached to the group. This egg was the only one that did not hatch. Nine of the remaining eggs hatched on 7 September 2023 after a 60-day incubation period (Fig. 3). The last egg pipped the next day, and the hatchling fully emerged from the egg on 9 September.

Hatchlings.—To reduce the potential for injuries to snakes or staff during handling and restraint, the hatchlings were measured using a minimally invasive digital method (Astley et al. 2017). Hatchlings were photographed individu-

Table 1. Seasonal cycling schedule for Elegant Habus (*Protophthrops elegans*) at the Saint Louis Zoo.

Time Period	Temperature (°C)	Photoperiod on:off (h)	Basking light	Misting Frequency (per week)
Mid-November–mid-March	10.0	8:16	off	~1x
Mid-March–mid-April	18.3	8:16	on	~2x
Mid-April–late May	21.1	9:15	on	~2–3x
Early June–mid-September	23.3	12:12	on	~2–3x
Mid-September–Mid-October	18.3	9:15	on	~2x
Mid-October–Mid-November	15.5	8:16	off	~1x



Figure 1. Female Elegant Habu (*Protobothrops elegans*) found coiled around eggs after oviposition under a hide box at the Saint Louis Zoo. Photograph by Rachel Boehm.



Figure 2. The arrangement of Elegant Habu (*Protobothrops elegans*) eggs in an incubation container at the Saint Louis Zoo (left) and candling one of the eggs to monitor development (right). Photographs by Rachel Boehm.



Figure 3. A hatchling Elegant Habu (*Protobothrops elegans*) emerging from an egg at the Saint Louis Zoo. Photograph by Justin Elden.

ally within 24 hours of hatching, and the resulting images were analyzed using ImageJ version 1.54e (Schneider et al. 2012). The hatchlings ($n = 10$) had a mean total length of 253.1 ± 7.8 mm, mean snout-vent length of 209.5 ± 6.0 mm, mean tail length of 43.6 ± 3.1 mm, and mean body mass of 7.82 ± 0.36 g (Table 2). All were initially housed individually on moistened paper towels in $35 \times 20 \times 22$ cm plastic Kritter Keeper® terrariums (Lee’s Aquarium & Pet Products, San Marcos, California, USA), until their first ecdysis which occurred 3–6 days after hatching. The ambient temperature of the enclosures was 23–25 °C.

After their first shed, the young snakes were housed on corrugated cardboard paper and provided with leaf litter, a small plastic hide box, and slender branches for perching. A thermal gradient of 22–31 °C was maintained with the heat

source under one half of each enclosure. The hatchlings were reluctant to start eating and required a weekly regimen of assist-feeding to ensure survival during the first three weeks of life. The snakes typically were offered heads of frozen/thawed hatchling Brown Anoles (*Anolis sagrei*) or pinky *M. musculus*. Before presentation, mouse heads were scented with a liquid of frozen/thawed *A. sagrei* organs blended in water. Self-feeding was observed on only rare occasions, and the only prey items voluntarily accepted were hatchling *A. sagrei* heads.

Discussion

The pattern of seasonal cycling described in this paper followed general parameters that were previously developed for other insular species of *Protobothrops* housed at the Saint Louis Zoo. This protocol proved effective in providing optimal husbandry conditions and resulted in the successful reproduction of these species (e.g., *P. tokarensis*; Elden et al. 2021). Based on this prior success, we assumed that the same approach would be suitable for *P. elegans*, given its similar geographic distribution, habitat, and ecology. Our results with *P. elegans* confirmed that seasonal cycling (e.g., controlled temperature fluctuations, photoperiod adjustments, and changes to other environmental conditions) can be applied within the framework of biologically-relevant husbandry to maintain healthy individuals and facilitate reproduction in this species.

Because little information has been published on reproduction in *P. elegans* (Goris and Maeda 2004), our work has yielded important data on the behavior and biology of this species, despite us reporting only a single breeding event. When the eggs were discovered, the female was coiled on the clutch. Observations of nest-guarding behavior by females of other species of *Protobothrops* have been reported in both captivity and nature (Elden et al. 2021; Miller et al. 2021, and references therein). The relative clutch mass of *P. elegans* in

Table 2. Measurements of hatchling Elegant Habus (*Protobothrops elegans*) at the Saint Louis Zoo.

Egg #	Hatching date	Total length (mm)	Snout-vent length (mm)	Tail length (mm)	Body mass (g)
1	7 September 2023	251	212	39	8.1
2	9 September 2023	262	217	45	8.1
3	7 September 2023	233	194	39	7.4
4	7 September 2023	257	210	47	7.5
5	7 September 2023	254	210	44	8.0
6	7 September 2023	251	208	43	7.5
7	7 September 2023	257	209	48	8.3
8	7 September 2023	258	212	46	8.0
9	7 September 2023	255	211	44	7.3
11	7 September 2023	254	213	41	8.0

the present study (0.407) was higher than the values of 0.217 and 0.333 recorded by Elden et al. (2021) for *P. tokarensis* and the estimates of 0.32–0.37 by Nishimura and Kamura (1994) for *P. flavoviridis*. However, this relative clutch mass is still within the range known for other oviparous snakes (Seigel and Fitch 1984).

In one of the few prior studies of reproduction in *P. elegans*, Nishimura and Kamura (2009) experimentally incubated eggs of the species at a range of temperatures. They were successful between 22–30 °C (hatching rates 66.7–84.6%), whereas no eggs hatched when incubated at 32.1 °C. In the present work, we incubated all of the eggs at a single temperature (25 °C) and obtained a high hatching rate (90.9%). Nishimura and Kamura (2009) also found a strong negative correlation between incubation temperature and the length of incubation. Although they did not include summary statistics for incubation period, Nishimura and Kamura (2009) provided algebraic and graphical representations of the relationship between temperature and length of incubation. Using the logarithmic regression equation presented in their paper, we calculated an incubation period of 55 days at 25 °C, which is 5–6 days earlier than our eggs hatched. However, our incubation length remained within the range of incubation times for this temperature recorded by Nishimura and Kamura (2009).

Protobothrops elegans is listed as Least Concern on the IUCN Red List of Threatened Species (Ota and Kidera 2018) and portions of the natural range of *P. elegans* are included in Iriomote-Ishigaki National Park (Somiya 2015), so no conservation interventions appear necessary for this species at this time. However, although *P. elegans* is currently considered common and inhabits protected areas, quantitative data on recent population trends and threats are lacking. Species that are endemic to islands, including snakes, often face greater risks of extinction (Lillywhite and Martins 2023). Also, herpetofauna endemic to the Ryukyu Islands of Japan are attractive in the international trade, making these species targets for poaching and wildlife trafficking (Janssen and Shepherd 2019). Our study demonstrates that reproduction of *P. elegans* in captivity is possible, allowing for sustainable captive populations that can reduce collection pressure in nature. *Protobothrops elegans* also could be used as a surrogate for related species, as successful husbandry techniques could be applied to species in need of further study or ex-situ conservation.

The ability of zoos and aquariums to house and observe species under controlled conditions provides valuable opportunities to collect data that often cannot be readily obtained in the field. Historically, snakes have been under-studied when compared to other vertebrate groups (Shine and Bonnet 2000). Therefore, zoos and aquariums can play important roles in increasing our understanding of snakes (Shiryaev et

al. 2007; Elden et al. 2021). We strongly encourage others working with snakes, particularly poorly known species, to publish their experiences in husbandry and reproduction.

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