

Husbandry and reproduction of the eastern indigo snake, *Drymarchon couperi* (Holbrook, 1842)

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Introduction

The eastern indigo snake, *Drymarchon couperi* is the largest species of snake in North America reaching a total length of 2.61m (Connant & Collins, 1991). *D.couperi*'s current species range is across Southern Georgia and Florida (Deimer & Speake, 1983) but formerly ranged across Alabama, Georgia, Mississippi, South Carolina and throughout Florida (Speake, 1993). *D.couperi* is a uniform bluish black or gunmetal black, both dorsally and ventrally. Red/orange colouration is often present on the chin, sides of the head, and throat (Moler, 1992). A wide variety of habitats is used by this species including; sandhills, oak scrub, sand pine scrub, mangrove swamps, wet prairies and pine flatwoods. Gopher tortoise, *Gopherus polyphemus* burrows play a central role in the ecology of *D.couperi* as refugia during the winter months (Deimer & Speake, 1983; AZA Snake Tag, 2011). According to the IUCN Red List (2023) the conservation status of *D.couperi* is Least Concern with a decreasing population trend. However, in

the United States, *D.couperi* is listed as threatened under the U.S Fish and Wildlife Service (U.S Fish and Wildlife Service, 1998)

Methods

1.1 *D.couperi* were used in the breeding project. The males' age was unknown but possibly an old individual as had begun to develop cataracts in both eyes. Specimen weighed 3431g. The female was seven years old and was obtained by the author a couple of months after hatching. Specimen weighed 2441g. Both specimens were captive bred. These were the final weights taken on 28 November 2019 before the breeding attempt. Specimens were housed individually in 180 x 90 x 50 cm Herptek vivariums (Figure 1). Zoo Med 100w Repti Basking Spot Lamps were used for heating and two bulbs were placed next to each other to allow a larger basking area. This was controlled by a Habistat Dimming Thermostat. UVB was provided by using an Arcadia UV Flood 55w which was placed next to the basking bulbs. Branches the same



Figure 1. Enclosure for female *D. couperi*.

circumference of the snake were used for climbing opportunities. Cork bark tubes were used for hides. Fine-grade orchid bark chipping was used for substrate at a depth of 6-8cm. Dried bamboo leaves were used to provide extra hiding areas and water was provided in a ceramic water bowl.

Ambient daytime temperature ranged from 25-28c. The basking temperature was 30-32c. Night temperatures were between 18-20c. A photoperiod of 14/10 (light/dark) was implemented from April – October and 10/14 from November – March. UVI 2.5-3 was recorded (Solarmeter 6.5) and measured from a position equivalent to the dorsum of a basking *D. couperi*. Humidity was maintained at 55-65 % RH but occasionally reached 90 % RH after spraying the enclosure with warm tap water every two – three days

Feeding was sporadic but usually occurred every

two – four weeks. Specimens were fed day-old chicks, adult mice, weaner rats, trout and quail of appropriate size. Adult quail had their wings removed for ease of consumption. Food was readily accepted by both specimens during the cooling period but smaller amounts were given e.g two chicks instead of the usual five-six.

From the beginning of November 2019, the photoperiod was gradually reduced over a 14 day period from a 14/10 (light/dark) cycle to a 10/14 cycle using a standard Materplug mechanical 24hr timer. Ambient temperature was gradually reduced by 1c every two days to coincide with the change in daylight hours. Ambient temperatures were reduced to 23-25c. Basking temperature was reduced to no higher than 30c and night temperatures were reduced to 12-14c. Humidity was still maintained at 55-65 % RH but spraying the enclosure decreased to once per week.

On 19 December 2019, the male *D. couperi* was observed moving around the enclosure and appeared restless. Sperm was observed smeared over the branches and water bowl. The female was also moving around her enclosure and appeared more active than normal. It was decided to introduce the male to the females' adjacent enclosure at 09:30 (table 1). As the male was introduced,

Table 1. Record of events from introduction of adult indigo snakes to oviposition of eggs.

Date	Action
19 – 23 December 2019	Male introduced to female for breeding.
10 January 2020	Female showing signs of being gravid.
26 February	Increased basking behaviour from the female.
14 March	Pre oviposition slough.
4 April	Restless behaviour from female looking for appropriate place to lay eggs.
7 April	Oviposition with a clutch of 11 eggs laid.

he immediately pursued the female around the enclosure. Rapid tongue flicking was observed by the male. The female reduced the speed of her movements which allowed the male to nuzzle the dorsal side of the head. Rhythmic undulating movements were observed ventrally by the male. At 10:10, the female became stationary and this allowed the male to attempt copulation. More of the same reproductive behaviours were observed for another ten minutes until copulation was observed at 10:20am. Copulation lasted for 28 minutes. At 11:00, both specimens were slowly moving around the enclosure. Tongue flicking had also slowed in the male and the general reproductive observations had ceased. It was decided to remove the male at 11:15.

On 23 December 2019, the male was introduced to the females' enclosure due to increased activity.

Reproductive behaviour was observed similar to the previous introduction. Specimens were together between 10:15 – 16:00 but were not fully observed during this time. Copulation was not observed.

On 10 January 2020, specimen was believed to be gravid for the first time. Slight swellings noticed in the latter third of the body when the specimen was observed moving around the enclosure. Feeding continued every 7-10 days and consisted of three - four chicks.

On 26 February 2020, specimen was observed basking and moving the latter third of its body under the heat bulbs, which was clearly distended showing the skin between the scales. External body temperature measured 29.6c using a Ketotek laser temperature gun.

On 1 March 2020, temperatures and photoperiod gradually returned to normal over a 10-day period. During this time, the female remained hidden away inside a cork bark tube and was observed to be in slough. Specimen sloughed on 14 March. After sloughing, a thick layer of damp sphagnum moss was added in the middle of the enclosure with a semi-circle piece of cork bark laid on top large enough for the snake to hide under.

8 March - 2 April 2020, female was observed spending the majority of time coiled up in the pile of sphagnum moss and would also be observed basking in the morning for short periods (<60mins) before retreating back to the moss hide. Specimen was never observed basking in the afternoon.

On 4 April 2020, restless behaviour was observed with the specimen continually moving around the enclosure with such force that branches and hides were being displaced and bark mulch ended up in the water bowl. This behaviour continued until the morning of the 7 April where the specimen was discovered coiled around 11 eggs in the sphagnum moss (Figure 2). The eggs were rough in texture (Figure 3) and did not adhere to each other.

All 11 eggs were transferred to two separate plastic air-tight containers measuring 30x20x15cm. Six

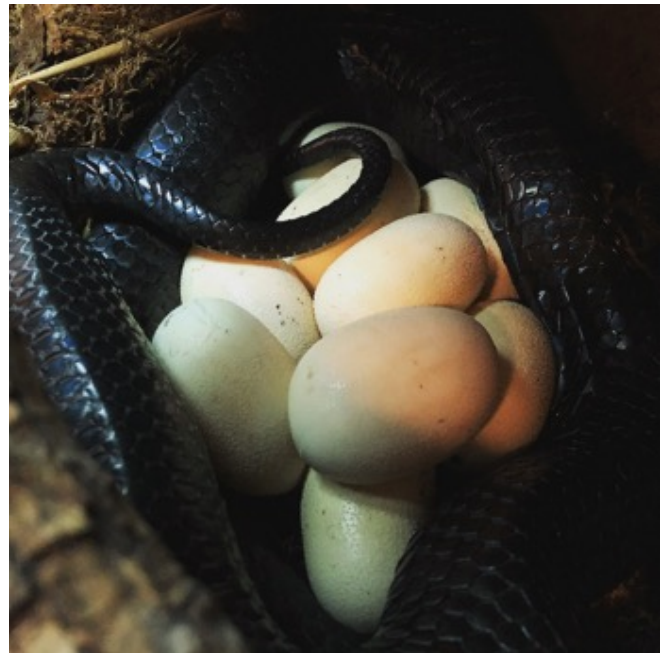


Figure 2. Female laying clutch of eggs.



Figure 3. Rough texture of a *D.couperi* egg.

eggs in one and five in the other. 3cm of Hatch Right incubation medium was added to the base of both boxes and egg crate was placed on top of the incubation medium (Figure 4). The eggs were placed on top of the egg crate and damp sphagnum moss was added around the eggs. Eggs were



Figure 4. Egg set up ready for incubation.

incubated in a neonatal incubator (Vickers Medical Model 79 Servo) and set to 26.8c. The container lid was lifted off for a few second every 2-3 days to allow gaseous exchange. Excess water vapour was removed from the lid.

Results

During oviposition, specimen retained an egg that was positioned 3-4cm from the base of the cloaca. 24hrs after oviposition, muscle contractions were observed on two occasions in the morning but the egg didn't appear to move closer towards the cloaca. On 9 April, specimen was restrained and the area palpated. It was determined that the egg

had not adhered to the oviduct and the author along with a colleague continued to gently massage the egg toward the cloaca. The egg was slightly moving when gentle force was applied but it wasn't possible to safely extract. Veterinary intervention was necessary and on 14 April, specimen was anaesthetised and a portion of the contents of the egg was removed via aspiration. The egg was then manually extracted with no invasive surgery. The egg was discarded. Specimen weighed 1608g post oviposition.

On 1st July 2020, after 85 days incubation, the first hatchling emerged from the egg (Figure 5). It was

noticed on inspection that one hatchling had two obvious caudal spinal kinks. All 11 eggs hatched and by 4th July 2020 (day 88), the final two hatched out. Hatchlings were weighed as they emerged with weights recorded between 34-49g. Hatchlings were weighed as they emerged with weights recorded between 34-49g.

Rearing of Hatchlings - Hatchlings were housed individually in contico containers measuring 55x40x15cm. Each container was furnished the same with fine orchid bark chippings, ceramic hide containing sphagnum moss in the base, ceramic water bowl and a thick layer of dried bamboo leaves. Temperature was kept at an ambient of 26c in the day with a maximum of 29c at the back of the container closest to the Habistat heat strip.



Figure 5. *Freshly hatched D.couperi.*

Temperature was controlled by a Habistat pulse proportional thermostat. Night temperature was between 20-22c.

Hatchlings sloughed six-eight days after emerging from the egg. First meals were given approx. seven days after sloughing. One defrosted day old (pinkie) mouse was offered to each snake and left at the entrance of the hide. Seven hatchlings fed for the first time and food was consumed after a few minutes being introduced. Uneaten food from the others was removed the next morning. Two hatchlings refused to feed after their first month and several attempts, therefore a day-old mouse was rubbed on some day old chick feathers. This enticed a feeding response with both hatchlings feeding normally after and no other scenting was necessary. After a successful feed on one day old mouse, feeding increased to two day old mice and after four weeks, one small mouse was offered and accepted. Hatchlings were fed every five-seven days. Occasionally chopped trout and salmon was offered but was only accepted by five individuals.

Discussion

During the writing of this paper, 13 eggs were incubated in 2021, 12 hatched and 13 eggs were incubated in 2022, 13 hatched. To the best of the author's knowledge, all specimens are still alive.

Hatchlings struggled to slough with RH <50%. Skin was often retained around the head, eyes and tail. This was remedied by spraying their habitats with warm water (20-25c) twice daily during the sloughing period.

The cause of the caudal kinks was detected in just one individual. Wines *et al*, (2015) suggested 26c to be optimal for incubating *D.couperi* eggs successfully. While this may be true, the author decided to lower the incubation temperature to 24.8 – 25c to prevent kinked spines in the hatchlings, higher incubation temperatures for prolonged periods often result in spinal kinks (Ross & Marzec, 1990). No spinal kinks were observed in any of the hatchlings following this temperature change. This also increased incubation time by up to 20 days.

No retained eggs or evidence of dystocia were observed during 2021 and 2022 reproductive successes. Invasive surgery to remove retained eggs can cause sterility in snakes resulting from scarring of the oviduct (Ross & Marzec, 1990). Where possible, it's advantageous (through veterinary intervention) to conduct less invasive procedures as discussed in this paper to allow specimens to continue to reproduce successfully.

With a loss of 833g post oviposition, the female

was visibly skinny but not emaciated. Specimen was fed weekly on smaller items of food including adult mice, day old chicks and chopped trout. Once specimen's weight exceeded 2000g, it was decided to continue the feeding schedule discussed earlier in this paper. This method continued in 2021 and 2022 with no issues to the female. Clutch size was at its largest in 2022 with 13 eggs.

A varied diet is important when maintaining healthy specimens. Wild *D.couperi* have been known to consume up to 48 different species of prey including snakes, tortoises, fish, birds, rodents and carrion (Stevenson *et al*. 2010). Using wild data is key to replicating a balanced diet and improving the overall nutrition needed to reproduce successfully on an annual basis.

D.couperi is currently maintained by 49 zoological institutions globally (ZIMS, 2023) Few collections outside of the Central Florida Zoological Park is currently breeding this species. Access to more peer reviewed husbandry and breeding notes may better inform other collections on best practice guidelines for reproducing this species successfully.

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