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Short Note
Reproduction of the Red-headed Krait (*Bungarus flaviceps*) in Captivity

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The Red-headed Krait or *Bungarus flaviceps* Reinhardt, 1843 is one of three species of the genus *Bungarus* Daudin, 1803 (kraits) known in Thailand. This snake is very beautiful with its coloration of red or orange head and tail. Its body is iridescent black or bluish black with the enlarged vertebral scales forming the predominant vertebral ridge. The belly is white. This snake is inoffensive and nocturnal, mainly feeds on skinks and other snakes. It is terrestrial and oviparous[1]. Its reproductive profile has been rarely reported. Two wild-caught gravid females of *Bungarus flaviceps* were brought to the snake farm of Queen Saovabha Memorial Institute in 2000 – 2001. The deposition and hatching of their eggs were observed. Two successful hatchings by artificial incubation were achieved as follows:

Reproduction of the Red-headed Krait (*Bungrus flaviceps*)

A wild-caught female (No.1) *Bungarus flaviceps* was brought from southern Thailand on November 21, 2000 to the snake farm of Queen Saovabha Memorial Institute. She was kept in a 40 x 60 x 30 cm plastic box. She was fed once a week with live or frozen and thawed *Enhydris enhydris* and *E. plumbea*. On December 5, 2000, she laid a clutch of four fertile and one infertile eggs (clutch no. 1). The width, length, and weight of the eggs were measured (Table 1),

TABLE 1. Female and egg sizes of Red-headed Krait (*Bungarus flaviceps*)

Female no.	Size of Postparturiant female			No. eggs	Egg size		
	SVL (cm)	Tail length (cm)	Body mass (g)		Width (cm)	Length (cm)	Weight (g)
1	106.0	19.0	165.5	4	2.1 ± 0.1 (2.0-2.3)	4.9 ± 0.1 (4.8-5.0)	9.7 ± 0.3 (9.4-10.0)
2	115.5	19.0	241.4	6	2.0 ± 0.1 (1.9-2.0)	4.2 ± 0.2 (3.9-4.3)	9.6 ± 0.3 (9.4-10.0)
				10	2.0 ± 0.1 (1.9-2.3)	4.5 ± 0.4 (3.9-5.0)	9.6 ± 0.2 (9.4-10.0)

FIGURE 1. On February 26, 2001, one hatchling from clutch No. 1 emerged after 84 days of incubation.

and then artificially incubated at the room temperature of 30-32 ˚C and 60-70 % of humidity in the day time[2]. The size of the female measured after egg deposition was recorded as follows: 106.0 cm. snout-vent length, 19.0 cm. tail length, and 165.5 g. of body mass (Table 1). On February 26, 2001, one hatchling emerged after 84 days of incubation (Fig. 1). Its size was 30.0 cm. snout-vent length, 5.0 cm. tail length, and 8.5 g. of body mass. The newborn of any snake species generally eat the first meal after shedding. This *B. flaviceps* newborn shed its skin on day seven after hatching. Then it was offered meals of frozen and thawed *E. enhydris* neonates but, unfortunately, all were refused. Therefore the young snake was successfully assisted in its feeding several times but it died on 18 April 2001 at the age of 51 days.

On July 31, 2001, a female *B. flaviceps* (No. 2) was captured from the same habitat in southern Thailand. She laid six fertile eggs on September 2, 2001 (clutch no. 2, Fig. 2). The size of female No. 2 was measured after egg deposition and was recorded as 115.5 cm. snout-vent length, 19.0 cm. tail length, and 241.4 g. of body mass (Table 1). All six eggs were measured and artificially incubated at the room temperature of 26-27˚C and 60 % of humidity in the day time (Table 1). The weight of this egg clutch was measured on November 5 and 20, 2001 (Table 2). Six

TABLE 2. Egg weights during incubation period and hatchling weights of Red-headed Krait *(Bungarus flaviceps)* (clutch no. 2)

Egg	Egg weight (g)			Hatchling weight(g)
no.	Sep 2, 2001	Nov 5, 2001	Nov 20, 2001	Nov 22, 2001
1	9.4	11.8	10.6	7.4
2	9.8	12.0	10.8	7.8
3	9.4	12.0	11.0	7.6
4	9.4	11.0	9.8	7.4
5	9.4	10.8	9.6	7.2
6	10.0	12.2	11.2	7.8

neonates hatched successfully on November 21-22, 2001 with the incubation period of 81-82 days. The neonatal size was 28.9 ± 0.8 cm (range = 28.0-29.8 cm) from snout to vent length, 33.9 ± 0.8 cm (range = 33.0-34.9 cm) of total length, and 7.5 ± 0.2 g (range = 7.2-7.8 g) of body weight. The neonates were kept separately in 15 x 23 x 13 cm plastic boxes. Room temperature was maintained at 26-27 ˚C and 60-70 % of humidity in the day time. The juveniles shed their skin on days 7-10 after hatching but they did not accept any offered food. The young snakes were assisted in their feeding several times but they died at the following ages: 2 at 19 days, 1 at 93 days, 2 at 95 days, and 1 at 115 days.

Characteristics of juvenile of the Red-headed Krait (*Bungrus flaviceps*)

The coloration of the juveniles of *Bungarus flaviceps* was investigated and they were similar to those described by Soderberg, 1973. The head is red with a pointed, elongated black mark extending from the nape along the interparietal suture to the frontal shield. The supralabials are red, whereas the infralabials and throat are yellow or yellowish-white. The body is iridescent black or bluish black but becomes red anterior to the tail and the tail is entirely red. The ventral surface is black. The ventral coloration anterior to the tail and the subcaudal area of the tail is yellowish orange to red.

There is a white line created by a series of small white dots that extends from the nape along their vertebral ridge to the red area anterior to the tail. This line of small dots does not appear in the red area anterior to the tail nor does it appear on the tail. There is also a relatively solid white line extending from just behind the neck along the first two or three dorsal body scale rows to the red area anterior to the tail where it terminates and does not extend on to the tail.

Discussion

This reproductive profile is presumably the first report of a successful artificial incubation of eggs and hatching of *Bungarus flaviceps.* The number of eggs deposited from the two wild mated females was 4 and 6 eggs, respectively, and the egg size was 2.0 ± 0.1 cm (range = 1.9-2.3 cm) in width, 4.5 ± 0.4 cm (range = 3.9-5.0 cm) in length, and 9.6 ± 0.2 g (range = 9.4-10.0 g) in weight (Table 1). Though the size of female no. 1 is smaller than female no. 2, egg size of the first clutch is slightly bigger

FIGURE 2. Female *B. flaviceps* (No. 2) laid six fertile eggs on September 2, 2001.

than that of the second clutch. If reproductive effort is defined as the ratios of clutch weight (C= mean egg weight multiplied by clutch size) to body weight of postparturiant female (B= gravid weight minus embryo or egg weights), C:B of these two females is constant with increasing body size[3,4]. In this point, the clutch size is positively correlated with female body size of which larger female generally produces larger clutch[3,5].

The incubation period (egg deposition to the completion of the hatching of all variable eggs) varied from 81 to 84 days when artificially incubated within a temperature range of 26- 27˚C (clutch no. 2) to 30-32˚C (clutch no. 1). The high temperature of 30-32 ˚C might affect the development of embryos resulting in the low percentage of hatching in egg clutch no. 1. The duration of embryonic development in nature is affected by temperature[6]. Moreover the embryos of tropical squamates need to be incubated at temperatures as close as possible to those occurring in their natural environments. Table 2 presents the gradual increase in egg weights during 65 days of artificial incubation and declines within 15 days before hatching. These may explain each stage of embryonic development in body size and mass. The gestation of elapid snakes usually takes

about two months. For example, in *Naja oxiana* gestation lasted 67-69 days[2,7,8]. The breeding season of *B. flaviceps* in the wild can be estimated by subtracting two months from the times of egg deposition which takes place in September through December. Therefore the breeding season or mating in *B. flaviceps* occurs approximately in July through October. This can be the time period for breeding trials in captivity in the future.

Food refusal in newly obtained snakes can be the result of missing natural stimuli or the presence of unnatural physical conditions. Wild-caught adult *B. flaviceps* are often difficult to acclimate and generally have refused food in captivity at QSMI snake farm. Therefore the survival period in captivity at QSMI snake farm is five months on average. The first female in this report survived for seven years and 172 days which is the longest survival of *B. flaviceps* in captivity at QSMI snake farm. She was fed a diet of live or frozen and thawed *E. enhydris* and *E. plumbea* every 1-2 weeks. The second female survived only for 100 days. The high mortality rate observed in *B. flaviceps* newborns may be attributed to feeding difficulties and/or stress factors resulting from unnatural environment condition in captivity.

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