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MATING BEHAVIOR AND BREEDING OF THE BLUE TREE MONITOR, *VARANUS MACRAEI* IN AN IN-COUNTRY FACILITY IN INDONESIA: A PRELIMINARY NOTE

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ABSTRACT

The Blue tree monitor, *Varanus macraei* Böhme & Jacobs, 2001 is a tree monitor species favored by reptile keepers. Successful captive breeding was reported from hobbyists and zoos in Europe shortly after its scientific description. Meanwhile, commercial farming to supply international demands has been progressing in Indonesia. However, such successful ex-situ breeding efforts have not yet been documented or published in Indonesia thus far. Therefore, in this, study we describe for the first time the mating behavior and reproduction of a *V. macraei* couple in an in-country outdoor facility, which is a common husbandry practice for monitor lizard breeders in Indonesia. The male started to approach the female at the beginning of the dry season, in May, with the female showing defensive behavior towards the male, both before mating and after laying eggs, pointing to a seasonal reproductive behavior. Monitor lizards were observed being active during the daytime. Eggs were laid by mid-July 2020. Two of the six eggs laid were revealed to be fertile and hatched after about 23 weeks (5.6 months). The two hatchlings were reared in an indoor enclosure, but only one survived, which showed to be a male.

Key words: diurnality, dry season, *Hapturosaurus*, outdoor husbandry, reproduction

INTRODUCTION

The Blue tree monitor, *Varanus macraei* is an island-endemic species known only from Batanta Island, Indonesia and the islets nearby (Fig. 1). Even before its scientific description, local hunters used to search for these lizards on the island of Ayemi, which lies about 5 km off the eastern coast of Amdui Village on Batanta, where these hunters still reside (Arida et al., 2021). Since its discovery on Ayemi in the late 1990s, the Blue tree monitor has shown up in the pet trade. Only several years later, the Blue tree monitor was described as a distinct species (Böhme & Jacobs, 2001). *Varanus macraei* belongs to the tree monitors distributed in the Raja Ampat Islands, for which the subgenus *Hapturosaurus* was erected recently (Bucklitsch et al., 2016). So far, this species has been exported to Japan, Korea, United Arab Emirates, and the USA (Bennett, 2015). The species continues to be sourced following the ongoing demands of exotic reptile pets and is among the top-four varanid lizard species found in European zoos (Ziegler et al., 2016).

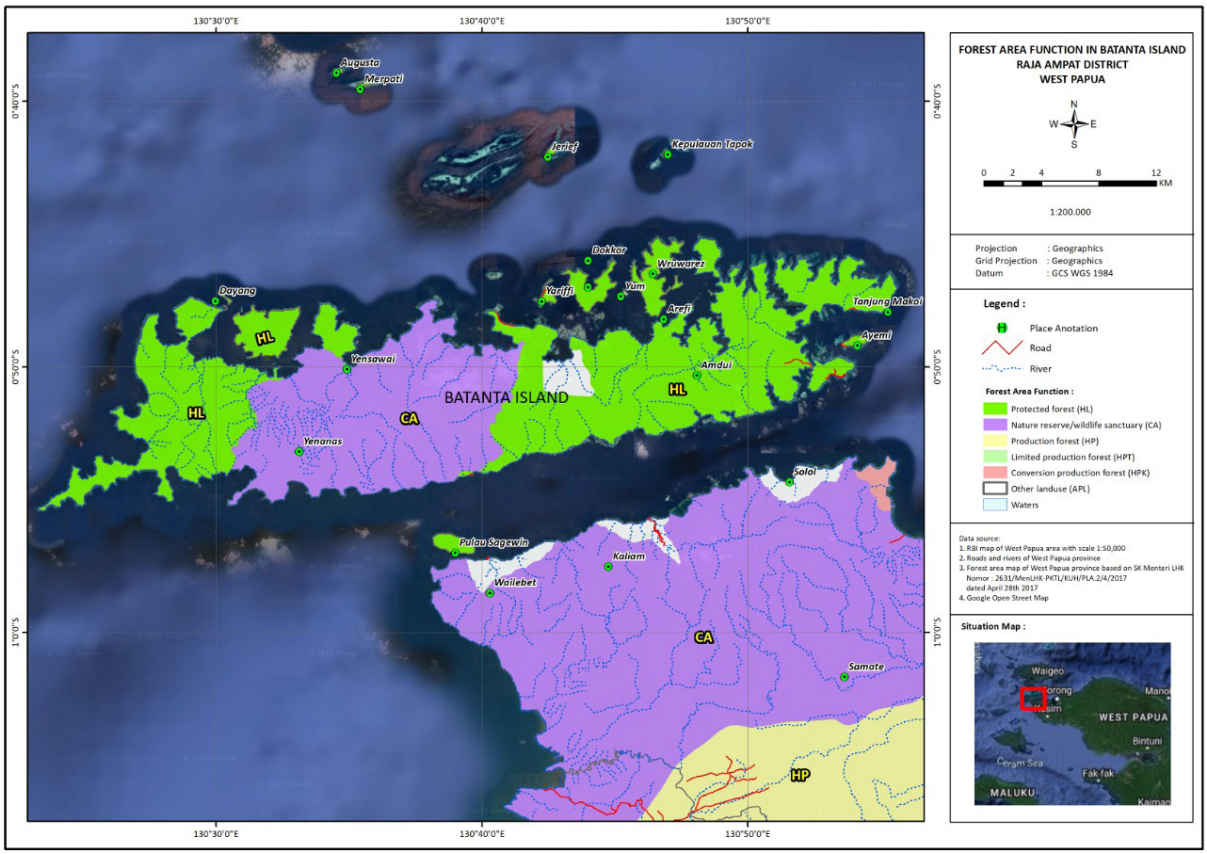

Figure 1. Topographic map of Batanta Island with land use categories set by the Indonesian Ministry of Forestry and Environment.

After the trade of the species into European countries, first breeding successes were reported from private indoor facilities and subsequently published by Jacobs (2002), Dedlmar (2007), Moldovan (2008), and Schneider (2016). Captive breeding also succeeded in zoos in Europe, with their founders having been derived from governmental confiscation events (Ziegler et al., 2009; Rauhaus et al., 2014). Most traded individuals arriving in Europe were sourced from Indonesia. Both private and public zoo collections were most likely wild-caught specimens due to unsubstantiated reports of breeding, ranching, or farming from Indonesia (Bennett, 2015).

At that time, published captive breeding reports were only available from *Varanus macraei* maintained in Europe and North America (Bennett, 2015). However, farming of *Varanus macraei* for the purpose of export had been already initiated as early as 2003 and is still continuing (B. Soetanto, pers. comm.). Nonetheless, wild-caught individuals can still be made available upon request among the amateur reptile keeper community in Indonesia (B. Rahmanto, pers. obs).

Little is known about the reproduction of many monitor lizards in their natural habitats, in particular in Indonesia, as many species have secretive habits and / or are difficult to find, let alone to observe. Here, studies on captive individuals held under natural conditions can help to better study and understand the reproductive biology of a given species. Thus herein we provide for the first time insights into the reproductive behavior of Blue tree monitor lizards in an in-country outdoor facility in Indonesia.

Figure 2. a. Adult, **b.** hatching, and **c**. hatchlings of *Varanus macraei* in a commercial reptile farm in West Java, Indonesia (Photos: E. Arida (a), B. Soetanto (b,c)).

MATERIALS AND METHODS

Observations of the mating behavior of a couple of *Varanus macraei* were casually conducted at a private facility in Banjarbaru, South Kalimantan, Indonesia from May 2020 to July 2020 between 9:00 and 17:00 local time (WITA = Central Indonesian Time Zone).

The pair of *V. macraei* observed during this study was obtained in 2018 from an anonymous reptile hobbyist, who claimed both adult individuals were wild-caught. The female was received on March 2nd and the male about one month later, i.e., on April 10th. Both lizards showed no injuries except for a slight irritation on their tips of the snout, probably resulting from rubbing during transport / interim keeping. Both individuals were adults (see Table 1).

Table 1. Body measurements of the *V. macraei* couple observed in this study

individual	Snout-Vent Length (cm)	Tail Length (cm)	Total Length (cm)
male	29.00	90.00	119.00
female	27.50	83.00	113.00

Initially, both monitor lizards were housed separately for quarantine and to acclimatize to the new environment. After one month, both monitor lizards were kept together in one facility (the male was transferred to the enclosure of the female).

Both enclosures for maintaining the lizards measured 90 cm x 80 cm x 180 cm (length x width x height) in size and were placed outdoor, thus lizards were exposed directly to the natural environment. Enclosure side walls consisted of mesh wire (5 mm mesh size), whereas the top consisted of a shading net and the rest of solid roof material. Natural soil served as the substrate. A wooden box (17 cm x 21 cm x 25 cm) was provided as shelter, and a cylindrical bucket (d= 18 cm, h= 20 cm) with cocopeat was provided as a nesting site. Other furniture consisted of, e.g., dead tree branches, plants for climbing and hiding, and a water bowl.

Hatchlings were kept indoors in a plastic container with perlite as substrate at room temperature of about 29.0°C for two months. The surviving lizard was then moved to a larger plastic container measuring 27.0 cm x 20 cm x 9.5 cm and provided with cocopeat and a cut of a tree branch. This lizard is also kept indoors up until now.

The animals were fed with farmed Dubia cockroach, *Blaptica dubia* of about 10 g - 12 g (10 individuals) offered three times a week in the morning or afternoon. One boiled quail egg was given once a week besides other supplementary diets, i.e House crickets, *Acheta domesticus*, as well as commercial multivitamin and calcium powder.

Climatic parameters in the enclosure were measured using a thermo-hygrometer, with an average temperature range of 28.27°C–29.33°C and humidity range of 76.12%–78.44% during the observation period. Monthly average rainfall data were obtained from the official website of the Climatic Station Level I of Banjarbaru City, Stasiun Klimatologi Kelas I Banjarbaru (https://banjarbarukota.bps.go.id/indicator/151/120/), which shows relatively low figures, i.e., 138 mm, 218 mm, and 62.40 mm respectively for May 2020, June 2020, and July 2020.

Behavioral events were observed daily from a distance of about 300 cm, with the observer being hidden behind a metal shield. Data were recorded in a logbook, which were used to generate a chronological table of mating sequences.

RESULTS

Reproductive Behavior

Reproductive activity of the kept pair was documented to begin by the end of May 2020, at the beginning of the dry season. The male lizard was flicking its tongue in a jerking movement over the female's back, after approaching her from the rear side. This tongue-flicking behavior was observed for two consecutive days, after which the male initiated copulation on Day 3. The female was always moving away during the period of approach and showed more so swiftly when the male began to copulate. However, actual copulation was only observed for the first time after such an approach on Day 7 (Table 2.).

Copulations were observed within a time span of four days and always started during daylight with a duration of up to two hours for each session (Fig. 3). Lizards moved in pairs from one spot in the enclosure to another while kept maintaining their copulating positions, mostly upright against the mesh wire. Such positioning during the mating period has been reported to be commonly observed for tree monitors in commercial breeding facilities, including *Varanus macraei* (Fig. 3, right).

Table 2. Chronology of mating behavior of Blue tree monitor in an outdoor enclosure

day	date	male behavior	female behavior	time, position
1	May 25th, 2020	approach	move away	09:00–17:00, vertical
2	May 26th, 2020	approach	move away	09:00–17:00, vertical
3	May 27th, 2020	approach	flight	09:00–17:00, vertical
4	May 28th, 2020	approach	flight	09:00–17:00, vertical
5	May 29th, 2020	approach	flight	09:00–17:00, vertical
6	May 30th, 2020	approach	flight	09:00–17:00, vertical
7	May 31st, 2020	copulation	copulation	starting 14:00, vertical
8	June 1st, 2020	copulation	copulation	starting 11:05, vertical
10	June 3rd, 2020	copulation	copulation	starting 12:30, vertical
11	June 4th, 2020	copulation	copulation	starting 16:10, horizontal
12-48	June 5th - July 11th 2020	normal	normal	09:00–17:00
49	July 12th, 2020	normal	nest digging	11:00- 15:00, body in/tail out
50	July 13th, 2020	normal	nest digging	11:00- 15:00, body in/tail out
51	July 14th, 2020	normal	nest digging	11:00- 15:00, body in/tail out
52	July 15th, 2020	normal	egg laying	overnight, in the nest

About 40 days since the first observed mating, the female apparently started to dig out substrate in the nesting bucket (Fig. 3.b). She went into the nest with her tail hanging out of the bucket during the day between 11:00 and 15:00 and came back out in the late afternoon to stay overnight in its shelter box (Fig. 3.a). She repeated this behavior for three days before finally laying six eggs and burying them in the cocopeat. She stayed close to the nesting bucket for about four days, during which she showed defensive behavior towards the male. The female was generally docile while together in the enclosure with the male, except during the few days after laying eggs.

After mating was over, both lizards showed normal behavior, including basking, preying on insects provided in the enclosure, drinking from the water bowl, and moving about once in a while. Lizards seemed to be resting in one position apart from one another for an extended time during the daylight, suggesting a passive nature.

Figure 3. The pair of *Varanus macraei* observed mating in vertical position in their outdoor enclosure (left) and a pair of Blue tree monitor mating in an outdoor enclosure of a commercial reptile farm (right, Photo: T Wahyu).

Reproduction

Two of the eggs were fertile and four others were infertile. The fertile eggs were 42 mm x 20 mm and 45 mm x 22 mm with 12 g and 13 g of mass, respectively, when measured a couple of days after deposition. Both eggs hatched on December 20th, 2020 after 158 days of incubation indoors and at room temperature. Our incubator was simply a plastic box with perlite substrate placed on a shelf indoors (Fig. 4.a). The temperature in the incubator ranged between 28.0 °C - 30.0 °C and humidity was 95%.

Total lengths of hatchlings were 25.5 cm (SVL=10.0 cm) and 27.5 cm (SVL=10.5 cm) (Fig. 4.a). Body mass at hatching was 11 g and 12 g, respectively. One of the two hatchlings has been growing up to 78.5 cm in total length (SVL=20.5 cm, tail=58.0 cm) during the writing of this manuscript and was revealed to be a male based on palpation (Harlow, 1996) of the base of the tail (Fig. 4.b). Unfortunately, the other lizard was found dead after surviving for two months in the plastic container (Fig. 4.a).

Figure 4. a. Neonates of *V. macraei* at hatching and **b.** a grown-up lizard of the two neonates at 18-month old.

DISCUSSION

The onset of the mating period for the Blue tree monitor seems to follow the monsoonal dry season, i.e., between May and October annually. The male's approach was relatively long for about one week and continued with mating for a few days afterward. During this period (e.g., in the years 2018–2020), monthly average rainfall was generally below 200 mm except for June 2020, i.e., 218 mm (https://banjarbarukota.bps.go.id/indicator/151/120/). This observation is consistent with the mating season for Blue tree monitor in commercial reptile farms in West Java, Indonesia, i.e., around May and June every year (T. Wahyu, pers. comm.). We consider

the parallel breeding season for our lizards and those in the commercial farms due to some similarities in the settings of enclosures, which are placed open-air (Fig. 5). Thus, lizards follow natural breeding cycles in the generally uniform climatic parameters across the lowlands in Indonesia. Our finding on seasonal mating seems to be justified by a finding of a gravid female in June 2007 on Batanta Island (Del Canto, 2013).

Figure 5. a. Outdoor enclosure setting used in our study**, b, c**. those of commercial farms in West Java.

Breeding season in farms in West Java may be extended to August, and the first eggs will be available for collection in the farms as early as September (A. Tasma, pers. comm.). However, in general, tree monitors may be bred twice a year for a commercial purpose but see Mendyk (2007) on egg deposition of up to four clutches during the course of a year. After laying their eggs, a female may be placed in a separate enclosure from the male for approximately five months (about 150 days) before releasing it back into the previous enclosure with the same male (B. Soetanto, pers. comm.). The next mating period takes place as early as in October or a month later in November, which is the beginning of mating season reported in European zoos, where enclosures are all set up under indoor conditions (Ziegler et al., 2009).

A five-month interval between two mating periods is thought conservative to allow females to regain body weight after oviposition. In the case of indoor captive breeding at Plzen Zoo in the Czech Republic, 95 days between two successive clutches of the same breeding pair were recorded as the shortest interval (Ziegler et al., 2009).

The Blue tree monitor couple in our study was observed to mate during the daylight, i.e.. late mornings to late afternoons, suggesting diurnality. Lizards were mating in vertical positions most of the time during observation, as reported in Dedlmar (2007) and Moldovan (2008), instead of in the horizontal position reported in Ziegler et al. (2009). However, the female seemed to lay

her eggs after sunset. She was observed to enter the nest in the late afternoon the previous day with a bulky abdomen and only came out the next day on the morning of July 16th, 2020, with a flat abdomen. Thus, we believe that eggs were deposited during the evening of July 15th, 2020.

The period of oviposition in our study was in the middle of the monsoonal dry season, about 43 days after the first copulation. This gestation period is beyond the range of those kept in indoor enclosures in the northern hemisphere, i.e., 25–35 days (Ziegler et al., 2009). It seems that our finding on oviposition in the dry season is in contrast to the findings observed in European zoos, where the majority of females were reported laying their eggs from October to March (Ziegler et al., 2009). Whether October to March was also a period of reduced rainfall on Batanta and the nearby islets, this notion remains to be substantiated. We suggest that the discrepancy in the periods of oviposition is probably due to some differences in the level of environmental controls. Indoor enclosures in the temperate regions are fully controlled, for example, in terms of temperature, UV exposure, and rainfall. In order for lizards to have optimized climatic conditions, those parameters need to be simulated to resemble their natural conditions. Conversely, lizards in outdoor enclosures in the tropics receive natural heat and UV directly from the sunlight as well as rainfall. Thus, the timing of oviposition in our observation may be influenced by reduced rainfall in the dry season in South Kalimantan. In this regard, the onset of mating was probably also influenced by naturally reduced rainfall. We consider that air temperature and humidity may not be the factors to cue for reproduction because these parameters are relatively stable throughout the year in the tropics.

The clutch size of our female lizard fell within the range reported in European captive individuals, i.e., 2–7 eggs (Ziegler et al., 2009). The two fertile eggs were hatching after 5.6 months or approximately 23 weeks in December, when rainfall was peaking in South Kalimantan and may coincide with natural factors such as the high abundance of invertebrate prey (James et al., 1992). However, hatchlings were kept together in a plastic container (Fig. 4.a) and placed in a closed room for better monitoring of their growth. The dimensions of eggs and hatchling sizes were similar to those reported in Europe, suggesting there was no effect of breeding time on reproductive outputs. We assume that there are factors such as nutrition that may have had some effects on the growth or behavior of hatchlings, but we do not have the data at the moment to account for it. Further research on diets may well be of importance for captive-bred individuals.

CONCLUSION

Our study is the first to report the captive reproduction of Blue tree monitor in Indonesia. We found several differences in the timing of reproduction between lizards kept outdoors in the tropics in Indonesia and those kept indoors in temperate regions in the northern hemisphere. Breeding seasons seems to start at different months in the year between the tropics and the temperate region, but it may only be because climatic factor such as rainfall was controlled or

non-natural for the indoor setting of enclosures. This difference in the start of mating seasons consequently affects the period for females to lay eggs. However, reproductive outputs, i.e., clutch size and size of neonates were similar for females kept in either captive setting. Thus, an advantage of outdoor captive breeding for tropical reptiles in the tropics is probably the greatly reduced costs of setting up enclosures with a suitable climate.

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