Captive husbandry and breeding of *Gonyosoma boulengeri*

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ABSTRACT - The rhino rat snake *Gonyosoma boulengeri* is a medium-sized arboreal colubrid snake from southern China and northern Vietnam. Captive specimens maintained at the Zoological Society of London presented little difficulty in husbandry and were found to breed between March and June. A clutch of 9 eggs were laid on the 16 May 2008 and a clutch of 8 eggs were laid on 4 July 2013, following manipulation of the captive environment to reflect natural seasonality for this species. Post-laying incubation temperature was maintained at a constant 28.0 ˚C and lasted 52 days for the 2008 clutch and 57 days for the 2013 clutch. All individuals from the 2013 clutch had sloughed their skin for the first time by 10 days post-hatching, and five of the six fed, subsequent to sloughing, by 20 days post-hatching.

INTRODUCTION

The rhino rat snake *Gonyosoma boulengeri* is a medium-sized arboreal colubrid snake from southern China and northern Vietnam (Hecht et al., 2013; Nguyen et al., 2009; Zhao, 2006). On the dorsal surface adult *G. boulengeri* are coloured lime to olive-green with white and black stippling around some scales; ventrally this species is off-white. Juveniles are grey-brown on the dorsal surface and off-white on the ventral surface. With increasing maturity this colour shifts from brown to green, potentially reflecting a shift in habitat preference as shown in other species (Wilson et al., 2007). Both adults and juveniles have a dark stripe running along the upper labial scales from the snout through the eye to the angle of the jaw. A notable feature of this species is the elongated, pointed, rostral appendage (Fig. 1).

Throughout its range this species is closely associated with riparian forested areas and often found close to water in mountainous regions (Orlov et al., 2000; Hecht, et al., 2013; Schuchmann, 2011). Both subtropical and tropical lowland and montane forest are known to be inhabited (Hecht et al., 2013). From non peer-reviewed documents written by private keepers, captive *G. boulengeri* are reported to spend large amounts of time in water, especially as juveniles. This species is not commonly encountered in nature but is known to occur in several protected areas within Vietnam (Hecht et al., 2013; Miskovic & Ziegler, 2013). *G. boulengeri* is known to be both diurnal and nocturnal, and is known to feed on small mammals and birds in the wild (Hecht et al., 2013). This species was assessed by the IUCN as Least Concern in 2012 (Rao et al., 2012).

From a search on the Zoological Information Management System (ZIMS) and several online interest groups *G. boulengeri* was assessed to be relatively common in captivity, both in the private and professional sectors. However, so far, published peer-reviewed data on husbandry and reproduction are lacking. The first reported breeding in a European zoo took place in 2008 in ZSL London Zoo. This was followed five years later in 2013 by this institution's second breeding of the species. The primary purpose of this paper is to provide information on captive care and breeding of this species at ZSL London Zoo. Additionally there are no published records of juvenile growth rates which this study does provide. Knowledge of captive requirements and breeding triggers is essential to be able to maintain an *ex-situ* population over more than one generation, whether this is for conservation purposes, education, research or in a private collection. Therefore this report seeks to disseminate this information to the wider herpetological community.

Figure 1: Adult male *G. boulengeri* at ZSL London Zoo (© Daniel Kane, ZSL London Zoo)

MATERIALS AND METHODS

Study Individuals

Study animals consisted of two different pairs of *G. boulengeri*; one pair during 2008 and another pair during

2013. During the 2013 breeding the male snake was nine years and ten months old, of St Louis Zoo progeny, and weighed 299g at the time of breeding. The female snake was of unknown origin but had been in captivity four years and eleven months, and weighed 373g at the beginning of the time of breeding. Data on adult snake weights and ages are lacking for the pair from the 2008 breeding.

Captive care

Records in 2008 do not allow for robust descriptions so data from the 2013 breeding at ZSL London Zoo has been used for description and analysis in this paper.

Both snakes were individually-housed, off-show, in neutrally-coloured plastic Herptek vivaria measuring 90 x 60 x 90 cm. The vivaria were furnished with chipped bark substrate and an arboreal environment was created with branches of varying diameter, texture, and thickness. This provided multiple spatial, thermo and photo-gradients for the animals to choose from. Additional cover was provided with both artificial and live plants, including palm fronds (*Sabal* sp.) and bromeliads (*Guzmania* sp.). On the floor of each enclosure a hide box containing damp sphagnum moss was provided to all *G. boulengeri*.

Servicing these vivaria consisted of removing soiled substrate and faecal matter, providing fresh water daily and spraying vivaria with water to create a daily humidity fluctuation from around 50% daily minimum to 99% daily maximum. Snakes were frequently observed drinking from the water sprayed onto their bodies and water bowls were generally around 6 cm in diameter and filled to 4 cm in depth. Throughout the active period of the year, including the months between March and December, each snake was offered small defrosted rodents warmed to room temperature every 7-10 days. The nest box was checked when the female displayed swelling in the mid-region of the body, which could indicate being gravid, or after she had spent extended periods of time within it. Checking of environmental parameters with a Precision Gold N85FR non-contact thermometer and a Solarmeter 6.5 UV meter was performed when necessary, such as after a lamp had been changed. UV basking lamps above each enclosure, including Arcadia 80W and Arcadia 12% T5, were provided throughout the year to allow the snakes to regulate their exposure to UV, visible light and heat, as is normal documented behaviour for many reptile species (Baines et al., 2016).

Inferences from climate data in this species' natural range were used to inform captive management. The temperature in the rooms the snakes were housed in was programmable and controlled by built-in air-conditioning units. Ambient temperature in the vivaria during summer 2012 ranged from 28.0 ˚C, dropping to 24.0 ˚C during the night. On 8 January 2013 the breeding pair of *G. boulengeri* was moved to a separate room for brumation. For the duration of the brumation period the snakes were not offered food. In this room the daytime maximum temperature was incrementally reduced over a seven-day period from 26.0 ˚C during the day down to 25.0 ˚C during the day, and from 25.0 ˚C overnight down to 18.0 ˚C overnight. A small bask spot of around 30.0 ˚C to 34.0 ˚C was provided in each vivaria during this time which is where the highest level of UVB was available. The UV index, a unitless measure of UVB irradiation (see explanation in Michaels & Preziosi (2013)) provided to the snakes was in the region of 0-3 over the whole year. During the brumation period the time the basking lamps were on was reduced from 8am – 8pm to 10am - 4pm to mimic the snakes' natural annual photoperiod more closely. Additionally, light levels through the large windows where the snakes were cycled would fluctuate throughout the year which may have aided in the cycling of these animals.

To conclude the brumation period, on 5 March 2013, daytime temperatures in the rooms where *G. boulengeri* were housed were increased from 25.0 ˚C to 26.0 ˚C and night time temperatures were increased from 18.0 ˚C to 25.0 ˚C. Immediately after this date, whilst the two individuals were housed separately, they were each offered their first post-brumation mouse feed. The male *G. boulengeri* fed on 6 March and the female refused feed. The female did not feed until 25 April 2013. Specimens were mixed in an on-show exhibit on 30 March until 19 July, after the female had laid her eggs. This exhibit measured 160 x 145 x 180 cm and was furnished with branches and live plants, similar to the off-show set-up but on a larger scale. During this time mating behaviour was not observed between this pair and could have taken place during the day or overnight.

Outside the breeding period of March to July the snakes were housed singly. This housing system may lead to reduced levels of stress in female snakes once they are separated from amorous males. Males may also benefit from being housed singly, as males of certain species of snake will refuse food in the presence of an adult female of the same species around the breeding season (Daltry et al., 1998; Goiran et al., 2013; Tetzlaff et al., 2015).

RESULTS

Captive Breeding

Based on the husbandry regime outlined above, a pair of *G. boulengeri* were bred during 2013 at ZSL London Zoo. A single infertile egg was found in the enclosure on 1 July 2013; three days subsequent to this on 4 July 2013 a further 8 eggs were found in the nest box placed in the enclosure. The eggs were removed and artificially incubated in a plastic box half-filled with a 1:1 water:vermiculite medium by weight at a constant 28.0 ˚C. Five eggs had hatched by the morning of 30 August 2013, after 57 days, followed the next day by the 6th individual hatching after 58 days incubation. The two remaining eggs did not hatch.

Prior to this, on 16 May 2008, a clutch of nine eggs was laid by a female. Records held on ZIMS do not show any notes on environmental changes recorded in the male or female snakes' enclosure although they do state that possible mating was observed on 1 April 2008. However, as this pair was inside a hide box at the time they were not unduly disturbed. Eggs were incubated on a 1:1 water:vermiculite mix by weight, at a constant

28.0 ˚C. The first two eggs had pipped by 7 July 2008, 52 days after laying, and by 8 July 2008 a total of three snakes had emerged from their eggs.

Mean average egg dimensions from the 2013 clutch were 42.5 x 21.0 mm. Mean average weight of the eggs in this clutch was 5.59 g. Eggs ranged from 48.0 x 21.0 mm to 38.0 x 22.0 mm. The mean average size of each egg in the 2008 clutch was 39.8 x 20.1 mm, and the mean average weight of the eggs in this clutch was 7.49 g. Eggs in this clutch ranged from 44.6 x 19.0 mm to 35.9 x 18.9 mm.

Juvenile Care

Hatched specimens were set up in individual transparent plastic tanks with vented lids, which measured 37 x 22 x 25cm. A heat mat was placed underneath the back of each enclosure, covering approximately one third of the floor space, and an Arcadia 6% T5 UV-B emitting strip light was placed along the top. UV index reading of the tanks was 0-3.4 and temperature ranged from 25.2˚C to 27.4˚C. Each enclosure had a small water bowl and two plastic hides filled with moss to provide a warm and a cool retreat. Some branching with leaves was added to provide a more natural environment for the snakes. Small pinkie mice were offered on tweezers once every 7 – 10 days while the snakes were small. As the snakes grew the size of the food item offered was increased proportionately to the size of the snake, keeping roughly equal to the maximum width of the snake's body.

Juvenile Growth Rates

Figure 2. below illustrates the weight changes of juvenile *G. boulengeri* bred at ZSL London Zoo. Three specimens are still maintained in the living collection of ZSL London Zoo, and the other three were transferred to a private individual which is why their zoo records only date as far as May 2014.

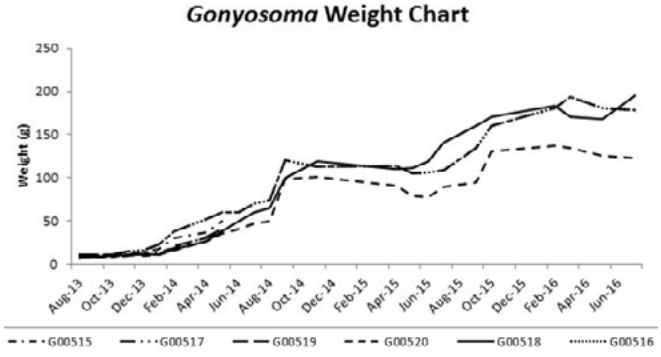

Figure 2. Growth rates for the six *G. boulengeri* hatched at ZSL London Zoo in 2013. Records for three animals stop in May 2014 as they were transferred out of ZSL's collection at this point.

DISCUSSION

G. boulengeri have been found to be relatively hardy in captivity, with only a few individuals maintained in ZSL's collection presenting difficulty. Two main issues were noted with this species; a reluctance to feed, and skin issues marked by discolouration and abnormal scale shape. Both issues were exhibited by only a few specimens in the collection and did not appear to be linked. The causes for both issues remain unknown. Regarding natural feeding behaviour of this species there is evidence from the wild that *G. boulengeri* are crepuscular or nocturnal and one animal has been recorded with a small bird in its stomach (Hecht et al., 2013). In ZSL's collection occasional night time feeds, for reluctant feeders, using warmed rodents or quail chicks were generally successful. In contrast to these few occasions the majority of snakes were consistent at accepting food presented during the day.

Wild data are lacking for longevity of *G. boulengeri* but in captivity this species is estimated to reach ages of 15-20 years typical of other medium-sized colubrids (Filippi & Luiselli, 2000). The oldest individual maintained at ZSL London Zoo during 2016 hatched in 2005, showing this species can reach ages of at least 11 years.

An analysis of institutional information from the ZIMS database, as of 29 July 2016, shows 47 institutions worldwide holding a total of 126 *G. boulengeri*. Worldwide, one European institution has bred this species in the last 12 months, producing 12 juveniles. From this analysis recent captive breeding in the zoo sector appears to be uncommon, as also generally seems to be the case in the private sector. It is unlikely that the lack of captive breeding of this species of snake is due to difficulty in doing so. Potentially, keeper time and zoo resources are being allocated to species assessed by the IUCN as being more threatened, or those species with a higher or more targeted conservation focus (Brooks et al., 2006). Ultimately, the reasons for the low-level of captive breeding of *G. boulengeri* are not fully understood.

The zoo sector should not be reliant on wild-caught animals, and therefore needs access to self-sustaining captive populations in order to not have a negative effect on wild populations if a chosen species is to be exhibited. A net decrease in population size has already been demonstrated in other southeast Asian reptiles, including monitors (Nijman & Shepherd, 2009) and green tree pythons (Lyons & Natusch, 2011; Lyons & Natusch, 2013). Despite this not being the case with *G. boulengeri*, as current knowledge suggests there is no direct threat to this species from wild collection at this point, an IUCN assessment of Least Concern and no detectable trade issue with a species should not be an excuse for collecting animals from the wild without thorough justification. On a regional level, focussed collection planning can enable the number of captive-bred juveniles to not exceed the holding capability of the local collections so as to sensibly manage this species. In the zoo sector this species is currently managed by the European Association of Zoos and Aquaria (EAZA).

There are currently no peer-reviewed published data on the breeding season for wild *G. boulengeri*. The species is presumed to be a vernal breeder, as captive animals have bred in the warmer time period following cooler

temperatures over the preceding couple of months. The relative increase in temperature, rainfall and photoperiod throughout April and May in areas of southern China and Vietnam, as detailed in Nguyen et al. (2014), may be a trigger for this species to begin breeding in nature. However, it could well be the case that this species is able to breed throughout much of the year, as has been demonstrated with other colubrid snakes (Brown & Shine, 2002).

From reading information published by online interest groups available to the public, female *G. boulengeri* are reported to lay a single clutch of between 5-16 eggs, ranging from infrequently to annually. This potential plasticity reported from captivity is believed to have more to do with the environmental conditions under which the snakes were kept, rather than the species' reproductive ecology. It is also possible the nutrition plays a role in the reproductive ecology of this species, as has been reported in a European colubrid snake (Santos et al., 2005). Many female snakes do not initiate reproduction until body condition exceeds a vital threshold value (Aubret et al., 2002; Al-Sadoon, Kandeal & Al-Otaibi, 2013). Therefore, this species could have an annual breeding cycle typical of other tropical and sub-tropical colubrids (Brown & Shine, 2002) provided the correct resources are available. Indeed both male and female *G. boulengeri* have been shown to be capable of annual breeding in captivity, according to the ZIMS database, at the Birmingham Zoo in Alabama. Provided individuals of this species can remain at adequate levels of body condition throughout the year it is conceivable that an annual breeding season may exist in nature.

In terms of egg incubation duration of *G. boulengeri* in comparison to another species in the genus, *G. oxycephala* was recorded as having a longer incubation period for its eggs at approximately 132 days (Pickersgill & Meek, 1988) versus 52-57 days for *G. boulengeri* (this study). The same authors report a larger hatchling size of between 15.6g to 19.5g with a mean average 17.8g, in comparison to the hatchling *G. boulengeri* reported in this study, which ranged from 7.75g to 10.5g with a mean average of 8.61g. The shorter time for *G. boulengeri* incubation relative to *G. oxycephala* is roughly proportionate to the smaller mean average weight of hatchlings of the former species. This is despite a similar clutch size reported for both species and broadly similar adult size, therefore appearing to indicate higher maternal investment in reproduction in *G. oxycephala*. It is beyond the available data sets to meaningfully investigate this trend further.

This study was limited by sample size, as detailed data are limited to just the 2013 breeding where only a single pair of *G. boulengeri* was bred and six neonates were produced. As there was just one other successful breeding of this species to compare with, and on both occasions a very similar temperature, thermal and photoperiod cycling regime was used, we are unable to comment on whether or not our method was the most successful it could have been. In intervening years this species has not bred at ZSL, most likely due to a lack of seasonality for the animals maintained in the captive collection. It is hoped to repeat the breeding success of this species, under conditions more akin to those found in nature for this species, so that we are able to further our knowledge. Additionally, two of the eggs did not hatch; records indicate that one of the embryos died very late-term during development whereas there is no data on file regarding the other egg. It is possible that incubation conditions were not optimal for all eggs in the clutch despite the best available knowledge being followed (Köhler, 2005).

ACKNOWLEDGEMENTS

The authors would like to thank George Sunter, Grant Kother, Sebastian Grant and Zoe Bryant for their contribution to the care of these snakes. The authors wish also to thank Rob Challis for the loan of a female *G. boulengeri* which was bred from during this time.

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Accepted: 26 December 2016