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Growth and Feeding Response in Python regius in Ambient Temperature vs. Hot-Spot

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Growth and Feeding Response in *Python regius* in Ambient Temperature vs. Hot-Spot Husbandry

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Introduction

Python regius, also known as the ball python or the royal python, is one of the most popular reptiles in the pet trade and has been heavily imported, kept, and bred in captivity since 1976 (Toudonou 1). This species has adapted to life in captivity extremely well making it one of the most popular reptiles in the reptile trade. It is one of the first reptiles many reptile enthusiasts own. It is a frequently used species for educating the public in zoos and other facilities. Some of the main reasons that *Python regius* has maintained its popularity in the reptile trade are that they are extremely docile, willing to feed on prey items that are easy to obtain, reach sexual maturity quicker than many other python species, breed very easily in captivity, and do not require a large enclosure (Stieb). There are two husbandry methods for keeping *Python regius*, in a room set at a constant ambient temperature, and in an enclosure that's back end has a belly heat hotspot and the temperature gradually decreases towards the front of the enclosure. But does one of these husbandry methods, hotspot vs ambient temperature, promote faster growth in *Python regius* and/or create a stronger feeding response?

This species also displays a wide variety of color and pattern mutations that many people in the pet trade find desirable. These mutations are referred to as “morphs” and can cause *Python regius* to become almost any color, excluding green, blue, and red, and have extremely busy patterns or even no pattern at all. Many breeders and hobbyists wish to combine these color and pattern mutations to get specific colored/patterned snakes that are more visually appealing. Some of these pattern and color mutations are highly sought after and can be sold for very high prices. Usually *Python regius* morphs will sell for around $1,000 each, however individuals have been sold for $37,000 and higher (Stieb). The market for ball python morphs is increasing as more and more new mutations are being discovered every year attracting new owners and giving breeders and hobbyists ball python genetics to invest in (Stieb).

The number of people keeping and/or breeding these pythons for profit has steadily grown over the last decade, and will probably continue to increase as more people see their variability (Stieb). They also make good pets as they are quiet, very docile, usually tolerant with handling, require a small enclosure, and they come in so many colors and/or patterns that there is something for everyone. However, all husbandry specifics must be met, such as temperature and humidity, or they can be quite difficult to get to feed (Stieb). Tens of thousands of *Python regius* are hatched and sold internationally in captivity every year (Stieb). As the number of ball pythons in captivity rises, it is important to investigate all the different options of captive husbandry and see if one promotes faster growth and a stronger feeding response.

The large majority of ball pythons breeders, hobbyists keepers, pet owners, zoos, and other facilities keep *Python regius* in an enclosure with a temperature gradient and hotspot. A small number of larger ball python breeders, and zoos keep *Python regius* in enclosures with an ambient temperature and no hotspot or temperature gradient (Stieb). A large number of the population of captive *Python regius* could be affected if one of these two husbandry methods proved to promote an increase in feeding responses and/or promote quicker growth. Breeders would be enticed to change their husbandry method if another proved to increase feeding response and/or growth because they could breed and sell their offspring quicker, and reach project goals quicker. However, if one of the husbandry methods produced a stronger feeding response that would likely cause anyone with a ball python(s) to consider switching to that husbandry method (Stieb). This could positively impact the lives of tens of thousands of captive ball pythons since *Python regius* are known to be finicky eaters and can seasonally decide not to eat while searching for a mate. They may also refuse to feed if husbandry parameters are not exactly correct. In many cases captive *Python regius* will only feed on one or two preferred prey

items. *Python regius* has been known to refuse food to the point of emaciation and even death. Being able to increase the odds of *Python regius* feeding constantly would relieve a lot of stress from those who keep them, and promote healthier snakes (Stieb).

Almost all people who keep or breed *Python regius* keep them in enclosures with a temperature gradient of around 23℃ in the front and a belly heat hot spot of 32℃. However, the temperature at the front of the enclosure should be kept closer to 26.6℃, but since most people keep their *Python regius* in a room temperature environment, the front of the enclosure will most likely be lower than what is optimal. A few keepers house ball pythons in a room with a higher ambient temperature of 31℃. At this temperature *Python regius* do not need a temperature gradient and can thrive comfortably (Stieb). However, the ambient temperature husbandry method is not as widespread because it requires more power to heat an entire room, more expensive equipment to maintain a steady temperature, and causes a hot, uncomfortable environment for people to be in when working with their snakes.

Python regius must be kept in an enclosure with little to no direct light. These snakes are nocturnal and can easily get stressed by the presence of a heat/night time lamp. A constant humidity level of 60% - 75% is best for ball pythons (De Vosjoli). If the humidity level gets too low it can cause dehydration and trouble shedding. Misting ball python enclosures is dangerous as it can cause spikes in humidity levels which have been linked to respiratory illnesses (Stieb). Choosing a substrate for *Python regius* can help increase or decrease humidity depending on the choice. Paper products, and shredded aspen bedding, can be used to lower humidity, where cypress mulch, and coconut husk can be used to increase humidity (Stieb). They can be very shy and prefer smaller enclosures where they can remain hidden in hides, behind clutter such as fake plants, or in nontransparent enclosures.

Breeders of *Python regius* are careful to closely monitor a snake's mass in grams before breeding. Length is not as important as mass for breeding. Most breeders will wait for a male ball python to be around 10-12 months old and around 700 grams before breeding him. Females have to be larger before breeding, around 18-24 months old and 1400 grams. The sooner they reach these weights the sooner breeders can start breeding them as long as the snake is healthy and feeding (Stieb). Although a ball python may reach a weight at which it can begin to reproduce, it may not be sexually mature yet (Toudonou 2).

Python regius are fed every 7-14 days, except babies that can be fed every 5 days. Most *Python regius* feed on live or frozen then thawed rats, and mice in captivity with rats being the preferred prey item to feed since they are larger so less prey items are needed to feed adults. However, some keepers feed African soft furred rats which are a prey item ball pythons feed on in the wild. African soft furred rats are not as tame as domestic rats and mice, but many breeders say they can cause an increased feeding response from picky eaters (Stieb). However, *Python regius* has been known to only feed on a select few prey items. They may take a new prey item offered to them, but then that could be the only prey they will accept moving forward.

In the wild *Python regius* takes refuge in termite mounds during the day and emerges at night to hunt small mammals and birds (De Vosjoli 43). They are nocturnal and are rarely seen out during the daylight. *Python regius* will also prey upon any mammal or bird that ventures into these termite mounds.

The climate where *Python regius* is found is mainly a tropical savannah. *Python regius* are occasionally found in the arid steppe habitat to the north, and the arid desert habitat north of the steppe in Sub-Saharan Africa. However, the majority of *Python regius* are found within the tropical savannah (see Figure 1 and Figure 2). They are very rarely found in the arid desert (De

Vosjoli 2). Temperatures in these areas can reach a maximum of 38℃ and a minimum of 18℃. However, temperatures are normally within 28℃ - 32℃ throughout the seasons. Humidity in this area is typically between 80% - 100% in the morning, and 60% - 70% in the afternoon (Nicholson).

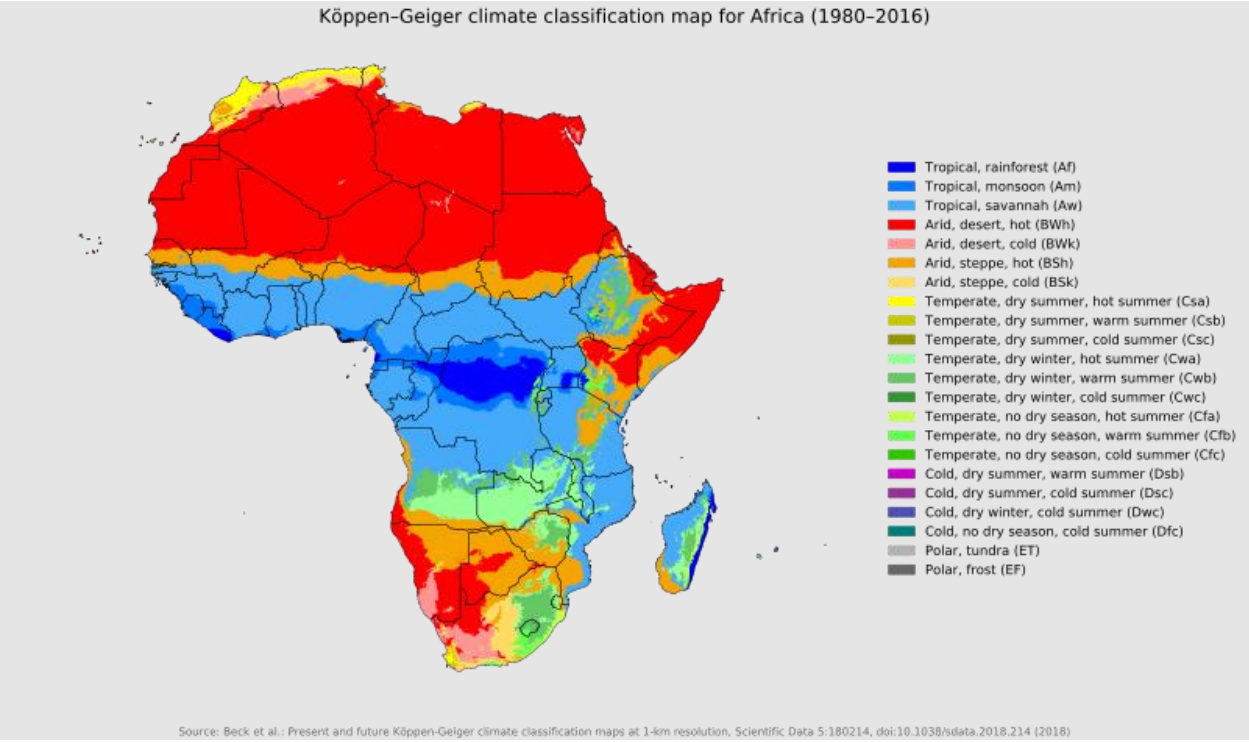


Figure 1. Beck, H.E., Zimmermann, N. E., McVicar, T. R., Vergopolan, N., Berg, A., & Wood, E. F. *Köppen–Geiger climate classification map for Africa."Present and future Köppen-Geiger climate classification maps at 1-km resolution". Nature Scientific Data*, 6 Nov. 2018, https://commons.wikimedia.org/wiki/File:Koppen-Geiger_Map_Africa_present.svg

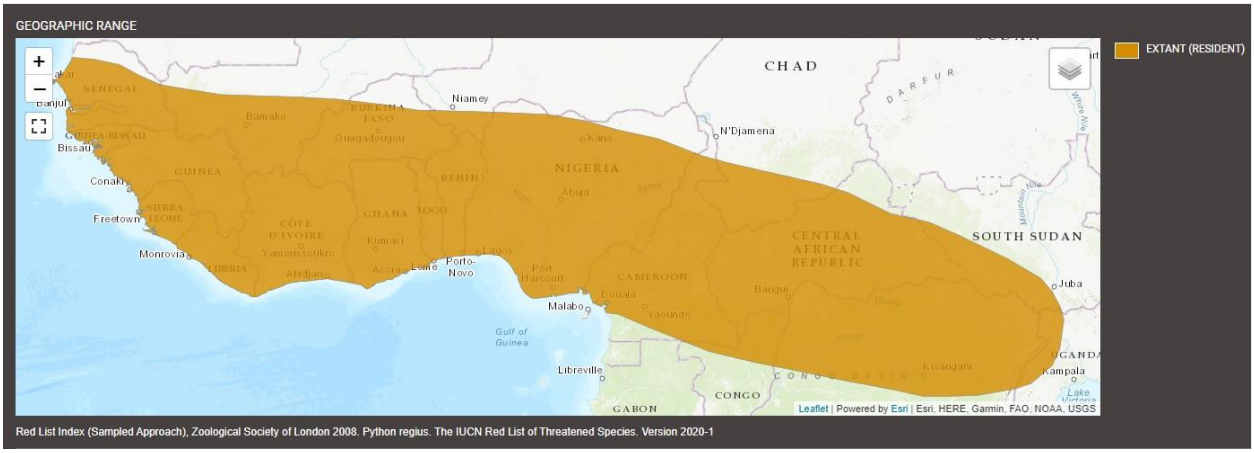


Figure 2. Auliya, M., Schmitz, A. 2010. "*Geographic Range". The IUCN Red List of Threatened Species* 2010: e.T177562A7457411. https://dx.doi.org/10.2305/IUCN.UK.2010-4.RLTS.T177562A7457411.en. Downloaded on April 30, 2020.

Python regius kept on belly heat typically have a hot spot of 32℃ in the back of the enclosure, but the front of the enclosure may range in temperature from 23℃ - 27 ℃. This means the hotspot husbandry method has a gradient of temperatures that may change throughout the seasons as the room temperature changes. This temperature range does allow *Python regius* to have more options thermoregulating than in ambient room temperature. However, since *Python regius* spend most of their time in termite mounds in the wild they would spend most of their life in a place with a very stable temperature and humidity.

Ambient temperature is a method of husbandry that closely mimics the natural environment of *Python regius* much better. A small amount of the total number of captive ball pythons are kept in these conditions. It is more common for only bigger breeders to keep *Python regius* in ambient temperature conditions, where pet owners and hobbyists tend to keep their ball pythons on heat tape.

The majority of *Python regius* in captivity are being kept on a hotspot husbandry method which is not the environment ball pythons are found to be in while in the wild. However, housing *Python regius* in ambient temperature husbandry methods is much more similar to the stable temperature they would be exposed to in the wild while living in termite mounds. I came across no articles, reports, or research documents on if a study regarding ball python growth and/or feeding response between ambient and hotspot husbandry methods had been written. It is notable that a few of the bigger breeders that have switched from hotspot husbandry methods to ambient temperature methods, have stated they witnessed snakes grow more quickly in ambient temperatures. However, no proof was provided (Stieb). These findings could impact how most

captive *Python regius* are kept if one of these husbandry methods did show evidence of promoting faster growth and/or feeding response. It is beneficial for breeders and hobbyists to get their snakes up to breeding size as quickly as possible so they can further their projects and make enough profit to support their ball pythons. The possibility that a husbandry method may prove to create better feeding response is very exciting since *Python regius* can refuse to feed for extended periods of time. Finding a way to increase the chances that picky eaters consistently eat would reduce a lot of anxiety that many ball python owners experience, and most importantly, it could greatly increase the health, and quality of life, of tens of thousands of captive *Python regius*.

Methods

For this experiment twenty *Python regius* will be purchased and separated into two groups of ten. Group "A" will be the *Python regius* kept on ambient husbandry methods, group "H" will be the *Python regius* kept on hotspot husbandry methods with a temperature gradient. Most, if not all of these pythons, will be unrelated to ensure that genetics will not play a part in one group growing quicker or slower than another or one group having a stronger feeding response. Groups of ten will be used since this number of hatchlings is close to the average clutch size of *Python regius*.

One group of ten hatchling ball pythons will be put into a room with an ambient room temperature of 30 °C. While the other group of ten ball python hatchlings will be placed in a room at 30 °C and on insulated heat tape set to 32 °C as a hotspot. Each of these groups will be kept in identical conditions. The only difference between how the two groups will be kept, is how the heat will be controlled.

Humidity will be kept between 60%-70%. Three large electric humidifiers will consistently be used to keep the humidity from spiking. Each hatchling ball python will be kept in the same lab rodent carriers. They will have to be refilled every other day to keep the humidity levels consistent. These opaque rodent cages will give the hatchlings a lot of security. They will be kept on paper towel substrate, and the enclosures will be kept in a closed room with no windows to prevent direct light. Each *Python regius* hatchling will be provided the same size water bowl and a small hide for extra security.

The ambient temperature will be controlled by a heater that will have a Lux WIN100-A05 programmable outlet thermostat attached, to ensure the heater is constantly running . This thermostat will keep the room's ambient temperature at 30 °C within a degree of certainty.

The *Python regius* hatchlings will be fed live rats every Monday. The prey will stay in each enclosure for up to an hour before being removed to give each hatchling ample time to decide to feed. The rats will be added and removed, if they were not eaten, at the same time for every hatchling.

Before each feeding, every rat will have its weight recorded, and a record will be kept of which rat was fed to which snake, before being offered to a ball python. Hatchlings will receive rats that are similar in size because they come from the same litter(s), but rats will be fed randomly to ball python hatchlings. However, some individuals may have to be given smaller meals at the beginning of the experiment due to some ball pythons being runts and only being able to feed on smaller prey for the first week or two of their lives. All rats used in this experiment will be from a single private rattery. The rats used as prey will be picked from 3-4 litters and will be mixed together. This ensures that each group will be fed a mixture of rats from each litter. Mixing the litters between the groups will make sure that no groups are growing

faster/slower due to some litters being more nutritious. After an hour, the hatchling *Python regius* will be checked on to see if they ate and the data will be recorded.

On Fridays the hatchlings will have their snout-vent length recorded in millimeters using a ruler. The mass of each hatchling *Python regius* will be recorded in grams using a scale on this day as well. All cleaning will be done on Fridays to ensure that any handling that may stress the hatchlings, does not occur on Mondays when they are scheduled to feed. This possible stress could otherwise keep them from feeding on Monday. Water changes will still be done on Monday if needed. Humidity will be measured with a hygrometer on Fridays, and the temperature of the front and back of each enclosure will also be taken on Friday by using a laser heat gun.

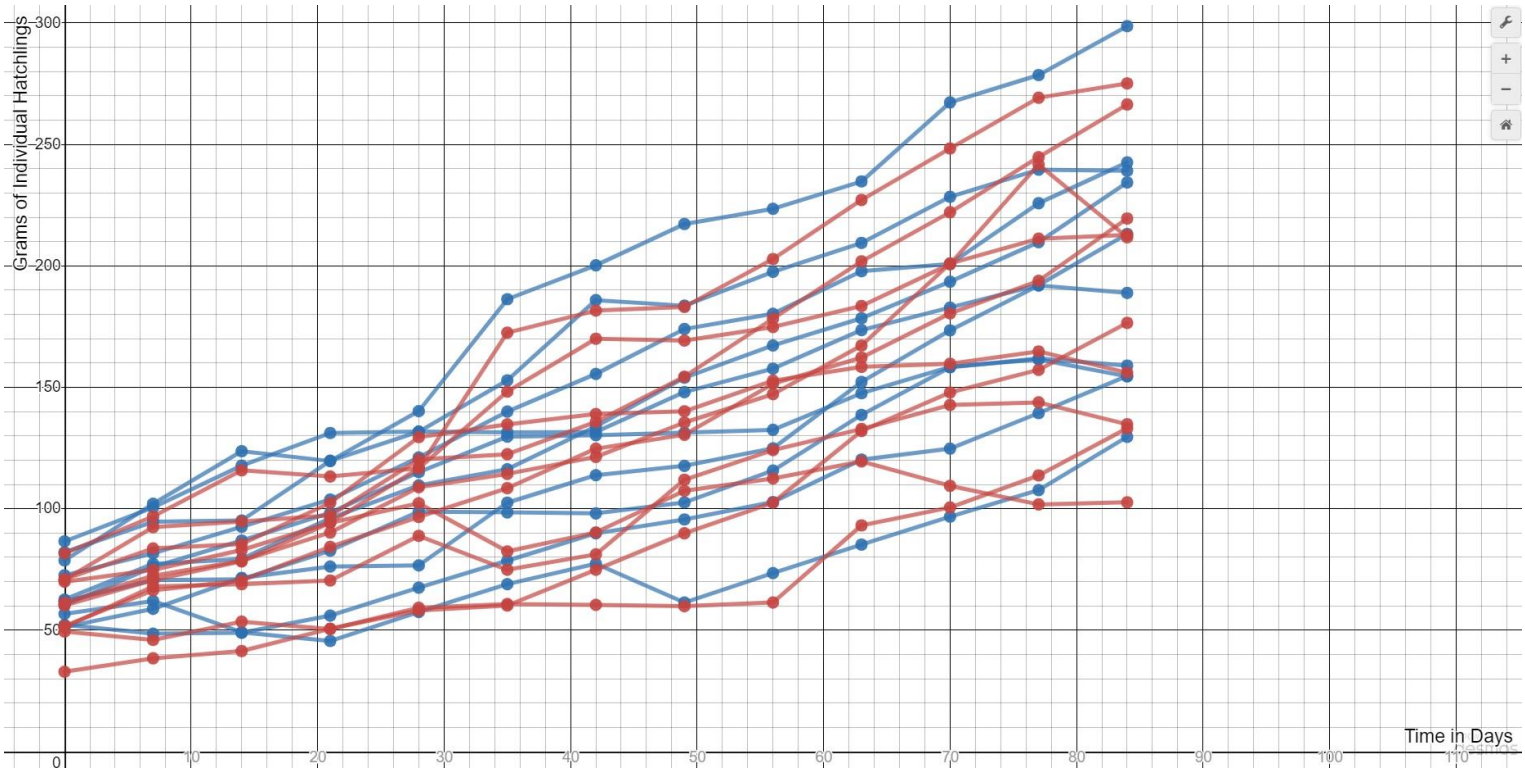
Data will be collected for a minimum of three months to ensure all hatchlings have had time to grow and have been given plenty of opportunities to feed. This will make sure enough data on growth and feeding response has been collected. After the experiment is finished, data will be looked at to determine growth in both the ambient temperature group, “A’, and the growth in the hot spot group, “H”. The data will also be examined to see if one group of ball pythons ate more readily than the other group. Any other findings the data may provide will be mentioned as well.

A husbandry method that helps hatchling ball pythons grow quicker with the same amount of food, will change the husbandry practices of *Python regius* in zoos, private collections, and those kept as pets. This could benefit not only the lives of the ball pythons, but also those that are caring for them since the snakes may eat easier in one or the other conditions. It also may help breeders make healthier, faster growing, mutated ball pythons that could breed quicker for them.

Results

Growth in grams from day 0 to day 84 was compared between the two groups of *Python regius* hatchlings. *Python regius* hatchlings in both groups grew in a similar linear fashion. Both groups had similar growth spurts and drops in mass, likely due to defecation. Neither the hotspot husbandry group or the ambient temperature group grew slower or quicker than each other in grams (Figure 6).

Figure 6.Grams of Individual Hatchlings vs Time in Days. The red represents *Python regius* hatchlings kept on hotspot husbandry methods, blue represents *Python regius* hatchlings



kept on ambient temperature husbandry methods. Every line represents an individual ball python as they grew from day 0 to day 84.

When the growth in grams between the two groups of *Python regius* hatchlings was compared, group “A” did grow more in grams from day 0 to day 84 at an average of 134.93 grams. Group "H" grew an average of 128.84 grams from day 0 to day 84 (Table 1). This growth was calculated by taking each group’s individual hatchlings growth in grams from day 0 to day 84 and finding the average for each group. However, this data does not compensate for different sized prey items or feeding frequency from day 0 to day 84.

Group A Snake IDs	Total Growth in Grams	Group H Snake IDs	Total Growth in Grams
A1	72.87g	H1	195.67g
A2	131g	H2	83.68g
A3	169.95g	H3	42.39g
A4	152.57g	H4	83.56g

A5	102.45g	H5	193.5g
A6	219.95g	H6	143.62g
A7	94.2g	H7	151.36g
A8	97.04g	H8	141.79g
A9	137.59g	H9	167.76g
A10	171.69g	H10	85.03g
Average Growth:	134.931g	Average Growth:	128.836g

Table 1. This depicts the total body mass gained for each *Python regius.* The total grams gained was then averaged for each group. An average of total body mass gained for both groups "A" and "H" is given at the end.

Between the two groups of hatchling *Python regius*, group "A" kept in ambient husbandry methods, and "H" kept in hotspot husbandry, there was no group that grew faster in grams from day 0 to day 84. Both groups had very similar growth in grams. The growth was calculated by taking the total growth in grams, divided by the total grams eaten. This would compensate for any *Python regius* hatchling(s) that ate more or less often than others, and also any differences in prey size. *Python regius* hatchlings in group "A" gained a body mass on average of 49.42% from day 0 to day 84, while hatchlings in group "H" gained a body mass on average of 49.08% from day 0 to day 84 (Table 2).

Group A Snake IDs	Total Growth in Grams/Total Grams Eaten	Group H Snake IDs	Total Growth in Grams/Total Grams Eaten
A1	0.3650618706g	H1	0.6058457442g
A2	0.4538839997g	H2	0.4863419737g
A3	0.6870275296g	H3	0.1529220779g
A4	0.5075177966g	H4	0.356758603g
A5	0.451401128g	H5	0.631898635g

A6	0.5506872637g	H6	0.6613556824g
A7	0.3559821631g	H7	0.5555514773g
A8	0.3831786772g	H8	0.4711570413g
A9	0.5411389916g	H9	0.6448587353g
A10	0.6457667281g	H10	0.3416505947g
Average Growth:	0.4941646148g	Average Growth:	0.4908340565g

Table 2. This depicts the percentage of prey eaten to the body mass gained for each *Python regius.* The total grams of prey eaten was divided by the total growth in grams for each individual snake. An average percentage of prey eaten to the body mass gained by both groups "A" and "H" is given at the end.

For both groups "A" and "H" of *Python regius,* the amount of grams eaten showed a positive correlation to the growth in grams (Figure 3). Ball pythons hatchlings from both groups are tightly clustered around the lines of best fit provided for each group. With *Python regius* hatchlings housed in ambient temperature husbandry methods showing very linear growth to grams of prey eaten.

Grams Eaten Vs Growth in Grams

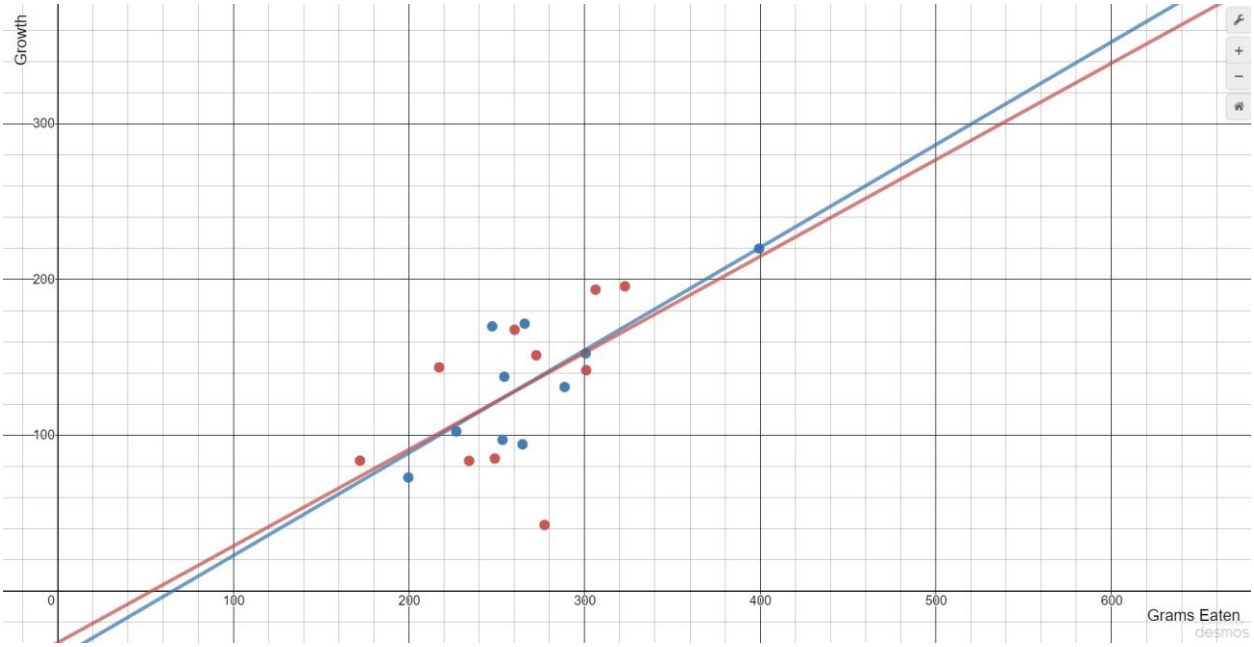


Figure 3. Grams eaten vs growth in grams. The red represents *Python regius* hatchlings kept on hotspot husbandry methods, blue represents *Python regius* hatchlings kept on ambient temperature husbandry methods.

When a closer look at the consistency of growth between the two groups was taken, group "A" grew at a very linear rate usually starting after the first meal or two. Group "H" did not grow in the same linear fashion (Figure 5). In group "A" individual hatchlings growth was so predictable it could be closely calculated by using y=mx+b, where y is weight, m is growth per day, x is day, and b is the estimated starting weight. This could be done because the r^2 values for group "A" averaged 0.94, meaning that these values were extremely linear. The r^2 values for group "H" were still high at .90, but not nearly as predictable as group "A" (Table 3).

Consistency of Growth vs Number of Prey Eaten

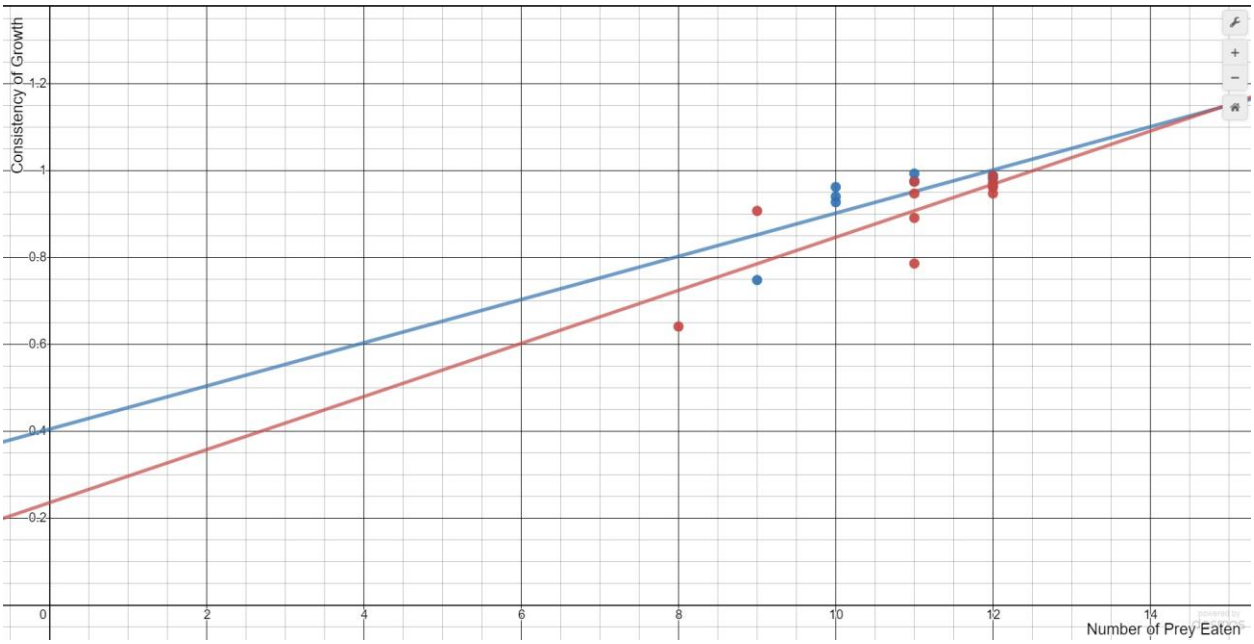


Figure 5. Consistency of Growth vs Number of Prey Eaten. The red represents *Python regius* hatchlings kept on hotspot husbandry methods, blue represents *Python regius* hatchlings kept on ambient temperature husbandry methods.

Group A Snake IDs	r^2	Group A Snake IDs	r^2
A1	0.748	H1	0.961
A2	0.976	H2	0.786
A3	0.993	H3	0.641
A4	0.983	H4	0.907
A5	0.962	H5	0.974
A6	0.983	H6	0.947
A7	0.927	H7	0.9717
A8	0.94	H8	0.947
A9	0.965	H9	0.988
A10	0.989	H10	0.891
Average r^2:	0.9466	Average r^2:	0.90137

Table 3. This depicts the r^2 of each hatchling *Python regius* in both groups. The average r^2 for each group was calculated at the end.

When the growth in body length measured in millimeters was looked at, both groups "A" and "H" grew in a very similar fashion, especially from day 0 to day 21. From day 21 to day 84 both groups had individual *Python regius* hatchlings that grew more quickly or more slowly than others (Figure 7). Neither the hotspot husbandry group or the ambient temperature group grew slower or quicker than each other in millimeters.

Millimeters of Individual Hatchlings vs Time In Days

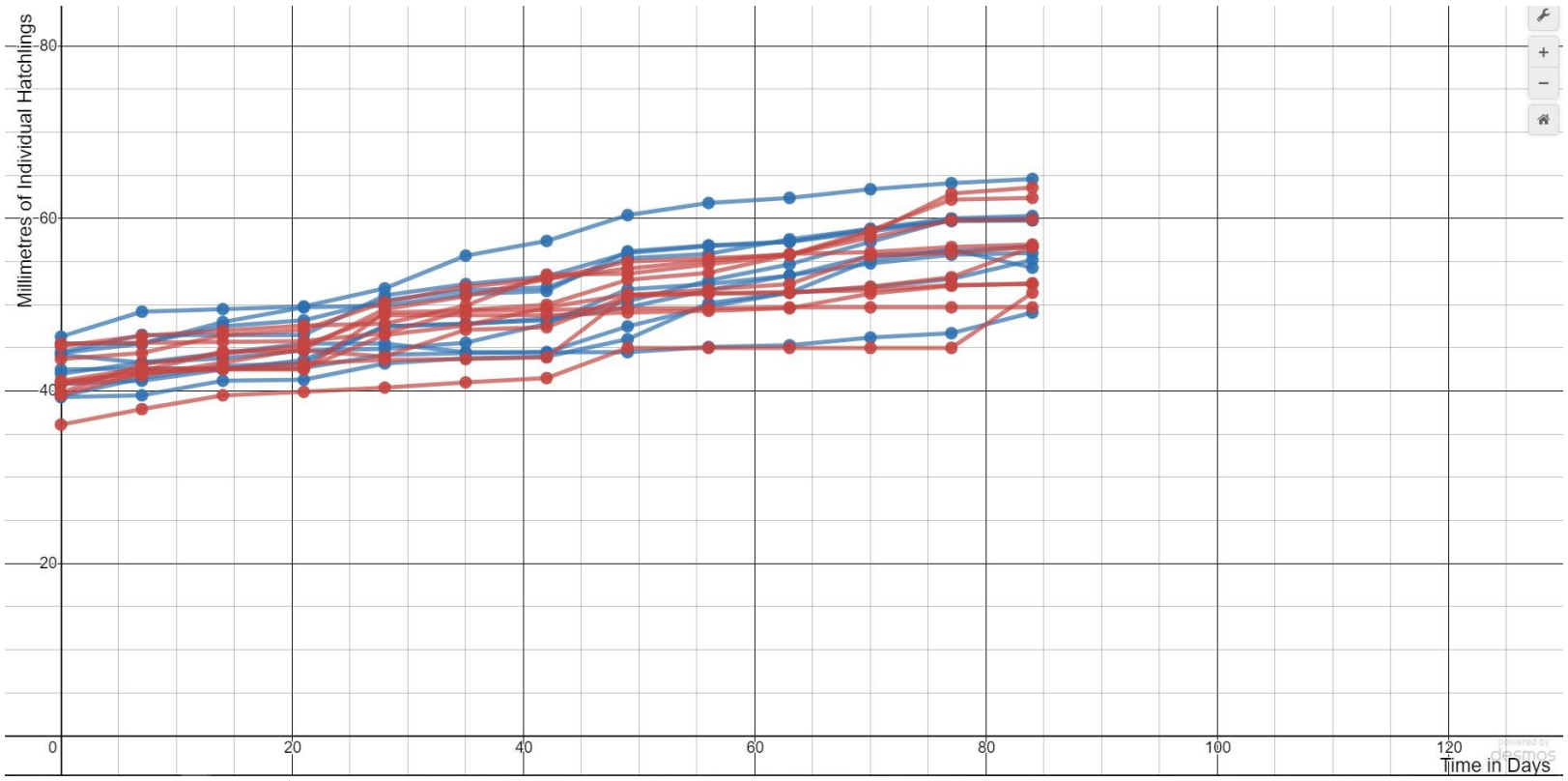


Figure 7. Millimeters of Individual Hatchlings vs Time in Days. The red represents *Python regius* hatchlings kept on hotspot husbandry methods, blue represents *Python regius* hatchlings kept on ambient temperature husbandry methods. Every line represents an individual ball python as they grew from day 0 to day 84.

There was very little difference in the total growth between the ambient temperature husbandry method group and the hotspot husbandry method group. Group "A" grew an average

of 14.7mm from day 0 to day 84, while group "H" grew an average of 14.33mm from day 0 to day 84 (Table 4). However, this data does not compensate for different sized prey items or feeding frequency from day 0 to day 84.

Group A Snake IDs	Total Growth in Snout Vent Length in Millimeters	Group A Snake IDs	Total Growth in Snout Vent Length in Millimeters
A1	6.6mm	H1	16.2mm
A2	15.4mm	H2	12.7mm
A3	15.3mm	H3	10.2mm
A4	14.8mm	H4	11.2mm
A5	10.1mm	H5	17.2mm
A6	18.3mm	H6	15.3mm
A7	19.2mm	H7	12.8mm
A8	16.6mm	H8	16.2mm
A9	15.9mm	H9	15.7mm
A10	14.8mm	H10	15.8mm
Average Growth in Snout Vent Length in Millimeters[2]:	14.7mm	Average Growth in Snout Vent Length in Millimeters:	14.33mm

Table 4. This depicts the total growth in millimeters of each hatchling *Python regius* in both groups. The average growth in millimeters for each group was calculated at the end.

There was a positive correlation between the grams of prey eaten and the length in millimeters a *Python regius* grew. Neither the hotspot husbandry group or the ambient temperature group grew slower or quicker than each other in millimeters. Both groups "A" and "H"'s length in millimeters increased, but did not increase at a predictable rate (Figure 4),

meaning the hatchlings did not grow with a strong enough r^2 to be able to possibly predict their length from previous measurements.

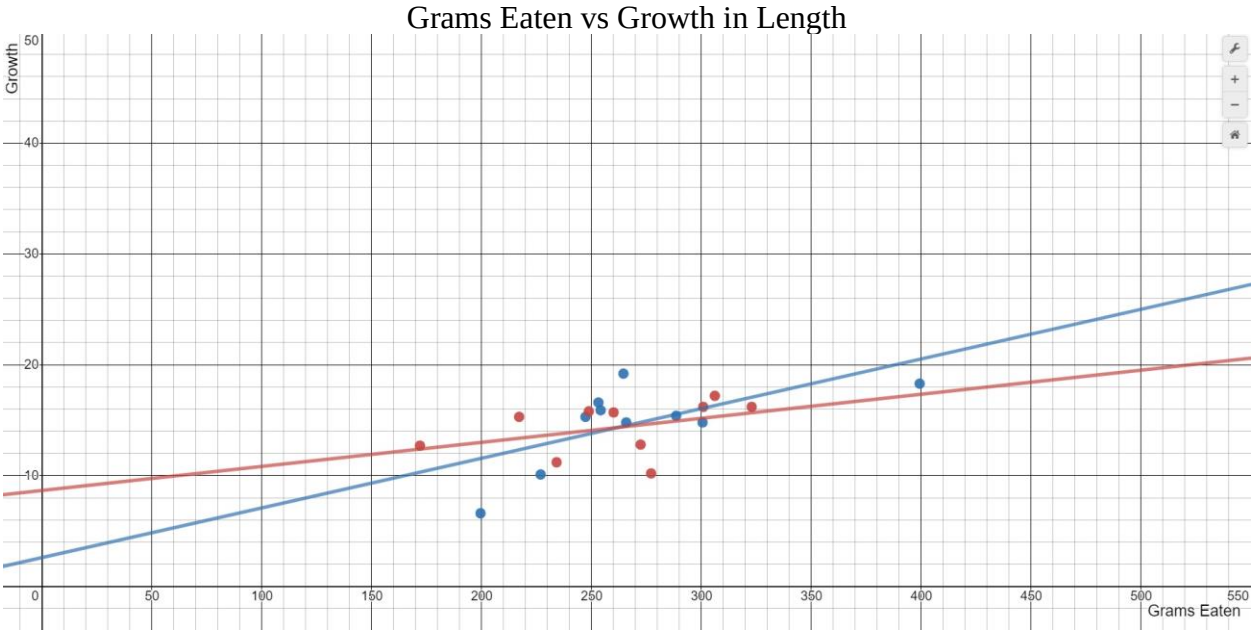


Figure 4. Total grams of prey eaten vs total growth in length. The red represents *Python regius* hatchlings kept on hotspot husbandry methods, blue represents *Python regius* hatchlings kept on ambient temperature husbandry methods.

Between groups “A” and “H” of hatchling *Python regius*, group “A” kept in ambient husbandry methods, and “H” kept in hotspot husbandry, there was no group that grew faster in millimeters from day 0 to day 84. Both of the groups grew similarly from day 0 to day 84. The growth in length was calculated by taking the total growth in millimeters divided by the total grams eaten. This would compensate for any *Python regius* hatchling(s) that ate more or less often than others and also any differences in prey size. *Python regius* hatchlings in group “A” gained a body length on average of 5.44% from day 0 to day 84, while hatchlings in group "H" gained a body length on average of 5.6% from day 0 to day 84 (Table 5).

Group A Snake IDs	Total Growth in Millimeters/Total Grams Eaten	Group H Snake IDs	Total Growth in Millimeters/Total Grams Eaten

A1	0.03306447573	H1	0.05015945753
A2	0.05335735569	H2	0.07381146112
A3	0.06185066904	H3	0.0367965368
A4	0.04923158805	H4	0.0478182905
A5	0.0445012337	H5	0.05616876755
A6	0.04581758093	H6	0.07045496408
A7	0.07255687401	H7	0.04698109745
A8	0.06554787759	H8	0.0538313285
A9	0.06253441359	H9	0.06034979819
A10	0.05566630308	H10	0.06348441016
Average Growth:	0.05441283714	Average Growth:	0.05598561119

Table 5. This depicts the percentage of prey eaten to the body length gained for each *Python regius.* The total grams of prey eaten was divided by the total growth in millimeters for each individual snake. An average percentage of prey eaten, to the body length gained, by both groups "A" and "H" is given at the end.

All *Python regius* had 12 opportunities to feed during this experiment. To see if either group "A" on ambient temperature husbandry or group "H" on hotspot husbandry had a stronger feeding response, the average number of prey eaten between the two groups from day 0 to day 84 was compared. However, both groups averaged the same number of prey items consumed during day 0 to day 84 (Table 2).

Group A Snake IDs	Total Prey Eaten	Group H Snake IDs	Total Prey Eaten
A1	9	H1	12
A2	11	H2	11
A3	11	H3	8
A4	12	H4	9

A5	10	H5	11
A6	12	H6	12
A7	10	H7	12
A8	10	H8	11
A9	12	H9	12
A10	12	H10	11
Average Number of Prey Eaten:	10.9	Average Number of Prey Eaten:	10.9

Table 2. This depicts the number of prey eaten between the hatchlings in groups "A" and "H".

The humidity for this experiment was as high as 87% and got as low as 55%. However it usually stayed within the 70's from day 0 until day 84 (Table 6).

Day:	Humidity:
0	73%
7	73%
14	71%
21	76%
28	87%
35	75%
42	70%
49	77%
56	72%
63	74%
70	68%
77	55%
84	57%

Table 5. This depicts the percentage of humidity each *Python regius* was exposed to.

Temperatures for this experiment varied between the two different husbandry methods, and the front and back of enclosures. The front of the enclosures in both groups had lower temperatures than the back of the enclosures. The average temperature in enclosures where hatchling ball pythons were housed in hotspot husbandry was 27.71°C towards the front, and 29.73°C towards the back of the enclosures. The average temperature in enclosures where hatchling ball pythons were housed in ambient temperatures was 28.27°C towards the front, and 28.37°C towards the back (Table 6).

Group A Snake IDs	Average Front Temperature in °C	Average Back Temperature in °C	Group H Snake IDs	Average Front Temperature in °C	Average Back Temperature in °C
A1	29.23°C	29.70°C	H1	28.39°C	29.92°C
A2	29.02°C	29.80°C	H2	28.25°C	30.00°C
A3	29.14°C	29.38°C	H3	28.28°C	30.38°C
A4	28.85°C	28.60°C	H4	28.10°C	30.10°C
A5	28.4°C	28.55°C	H5	27.58°C	29.55°C
A6	28.25°C	28.02°C	H6	27.28°C	29.45°C
A7	27.92°C	27.90°C	H7	27.56°C	29.42°C
A8	27.68°C	27.48°C	H8	27.28°C	29.56°C
A9	27.39°C	27.35°C	H9	27.28°C	29.52°C
A10	26.85°C	26.96°C	H10	27.12°C	29.35°C
Average Temperature in °C for Group A	28.27°C	28.37°C	Average Temperature in °C for Group H	27.71°C	29.73°C

Table 5. This depicts the average temperature each *Python regius* was exposed to. The averages for each group were then calculated.

Discussion

My results show that *Python regius* housed in either hotspot husbandry methods, or ambient temperature methods, showed little to no difference in growth in grams from day 0 to day 84. Both group "A" and Group "H" grew linearly in grams and in a very similar mannar. There were instances where individual hatchlings would have growth spurts and then lose some weight the next week. This is likely due to the ball python defecating the remainder of a previous meal. There was a positive correlation between grams of prey eaten and grams of mass gained. Ball python hatchlings in group "A" did gain a little more mass than those in group "H". But this does not closely reflect a realistic representation of growth from day 0 to day 84. A better way to calculate growth in grams that compensates for meals that some ball python missed and/or variation in prey size, is to take the total grams in prey eaten divided by the total growth in grams. This more closely reflects the total percent of body mass gained. *Python regius* in group "A", ambient temperature, gained an average of 49.42g of body mass. *Python regius* in group "H", hotspot temperature, gained an average of 49.08g of body mass. Neither hotspot husbandry methods or ambient temperature husbandry methods improved the growth rate in grams of *Python regius.*

My results show that *Python regius* housed in either hotspot husbandry methods, or ambient temperature methods showed little to no difference in growth in millimeters from day 0 to day 84. Growth in length was slower than growth in mass, but it was still linear. Both groups "A" and "H" gained length at a very similar rate, especially from day 0 to day 21. Past this point and until day 84, both groups still gained length at a similar rate. There was a positive correlation between the amount of grams of prey eaten and the amount of millimeters the hatchlings grew.

The average length in millimeters was calculated for both ball pythons in ambient temperatures, and ball pythons on hotspots. Both groups of hatchlings averaged almost the same amount of length grown from day 0 to day 84. Group “A” grew a total of 14.70 millimeters and group “H” grew a total of 14.33 millimeters. These numbers do not take into account the possibility that hatchlings could have missed a meal(s) and/or the variation in prey size. However, by dividing the total millimeters each snake grew by the total grams of prey it fed on, a more accurate percentage of growth in millimeters can be found that compensates for variation in prey size and/or any meals missed. The percentage of growth in millimeters that *Python regius* in ambient temperature husbandry, group “A”, grew was 5.44%. The percentage of growth in millimeters that *Python regius* in hotspot temperature husbandry, “H”, grew was 5.6% . Neither hotspot husbandry methods or ambient temperature husbandry methods improved the growth rate in millimeters of *Python regius.*

From day 0 to day 84 every *Python regius* had the chance to feed 12 times. The more a hatchling would feed would represent a strong feeding response and the less a hatchling would feed would represent a poor feeding response. The average number of prey items that were consumed was found for both group “A” and group “H” and then compared. *Python regius* in both ambient temperature husbandry and hotspot husbandry ate the same amount of prey as an average. Group “A” averaged 10.9 out of 12 prey items consumed, and group “H” averaged 10.9 out of 12 prey items consumed. There was no increase or decrease in feeding response from *Python regius* kept in either ambient temperature husbandry or hotspot temperature.

Growth in mass for *Python regius* kept in ambient temperature husbandry was found to be extremely linear. The r^2 values for group “A” averaged 0.94. This is a very high r^2 value showing an extremely linear growth in grams. This means that it is possible to use an equation to

closely predict the growth in grams for individual hatchlings after the first week or two of recording hatchling weights, prey weights, and feeds. The equation used to predict growth for hatchling *Python regius* kept in ambient temperature husbandry methods is, y=mx+b, where y is weight, m is growth per day, x is day, and b is the estimated starting weight. This is very important because ball python breeders use grams to track their snake's growth and each snake must reach a certain weight in grams before it can be bred. With this equation, ball python breeders could predict a hatching's growth in grams if the hatchlings are kept in ambient temperatures. This could give a breeder vital information on how long it may take a certain snake to reach an appropriate gram size in order for it to begin breeding. A breeder could also then determine which babies they hatch may grow quicker than their siblings. Therefore, the breeder may decide to keep a hatchling that is predicted to grow quicker than its sibling, since they would be able to breed that hatchling quicker. Although this data was only gathered for three months, this equation could be used to predict the weight of a hatchling for at least the first three months of its life. This may give ball python breeders an idea of what snakes are best to keep to further their projects and their monetary gain, and which to sell. *Python regius* kept in hotspot husbandry, group "H", did not grow at a predictable rate or in a rate as linearly as that of group "A".

Python regius kept in hotspot husbandry, had a nice temperature gradient with the front of the enclosure averaging 27.71°C, and the back of the enclosure averaging 29.73°C on the hotspot. Ball pythons kept in ambient temperature husbandry, had a very stable temperature throughout the enclosure that averaged 28.27°C in the front, and 28.37°C in the back. It should be noted that the first few ball pythons in each group had slightly higher temperatures from day 0 to day 84. This is because they were housed on a higher shelf of the rack than the other ball

pythons, and since heat rises, they were exposed to higher temperatures than the others of their group. A fan mounted on the ceiling pointing down could have been used to better circulate the air and ensure the temperature did not increase towards the ceiling. However, since both groups "A" and "H" had the same number of snakes affected by the higher temperatures it should not have skewed the data. But should this experiment be repeated, fans should be placed in the rooms to circulate warm air.

Humidity from day 0 to day 84 was not as stable as it should have been. There were two instances where it dropped into the 50's. While this is not dangerous for *Python regius* it is a large drop from where the humidity was normally sitting, in the 70's. This could have caused issues with feeding response from already picky eaters. However, since both groups were exposed to this change in humidity, it should not have affected the data. If this experiment is to be repeated, a different method of humidifying the room should be installed to ensure a much more constant humidity.

Summary and Conclusion

Twenty baby *Python regius* were split into two groups of ten. One group of ten was placed in a room with an ambient temperature of 30 °C, while the other group of ten ball python hatchlings was placed in the same room with the addition of insulated heat tape set to 32 °C as a belly hotspot. Very few if any *Python regius* were related in this experiment, which ensured that shared genetics did not cause some siblings to grow faster or slower than others in the experiment. Each hatchling had its weight in grams, and length in millimeters measured and recorded once a week. The temperature in the front and the back of the enclosure was recorded

once a week along with the humidity. Each ball python was fed once a week, 12 times total. The prey's mass in grams was recorded. Both successful, and unsuccessful feedings, were recorded.

Python regius did not grow any quicker in either mass or length while being housed in ambient temperatures, or on a hotspot with a temperature gradient. The hatchlings also ate the same number of prey averaged between the individuals in their group, meaning feeding response is not stronger or weaker in either ambient temperatures or on a hotspot with a temperature gradient. Neither husbandry method increased feeding response, meaning that neither method is better for the health or wellbeing of *Python regius*.

However, the growth in grams could be calculated for *Python regius* kept in ambient temperatures, since they grew at an extremely linear rate. This would allow ball python breeders to quickly see which ball pythons they hatched, may grow quicker than others. Ball python breeders would be more inclined to keep faster growing babies, since the quicker they grow in grams, the quicker they can reach a safe and acceptable weight in grams to be bred. This would expedite certain projects ball python breeders are working on, and increase income. However, although monitoring baby ball pythons in ambient temperature husbandry may provide a way to predict their growth, it is unlikely that this finding would cause many people to switch from hotspot husbandry methods to ambient temperature methods.

If this experiment was to be repeated again, a more sophisticated humidifier should be used to keep the humidity more constant. Fans should be placed in multiple levels in the ambient temperature room to ensure that the entire room is the same temperature. The data in this experiment could also be compared between males and females. This would provide data on if male or female ball pythons grew more or quicker in mass and length. For this experiment, I did not have access to a seperate room where the ambient temperature was the same as the room

temperature. This room temperature space would need to have the exact humidity, hotspot temperature, foot traffic, light, and other variables as the 30 °C ambient temperature room. I did not have another space that met these conditions or that could be altered to meet these conditions, so feeding response and growth in mass and length was not explored in ball pythons kept in a hotspot husbandry method with the front of the enclosure being room temperature. This would be important to explore because most *Python regius* kept on hotspot husbandry methods are kept in a space at room temperature, meaning the front of their enclosure is room temperature. While this is not ideal husbandry for the hatchlings, it is not dangerous and is the most common way *Python regius* are kept. There may be notable differences in the growth and feeding response of *Python regius* kept at room temperature than with those kept in a room that has its temperature at least 26.6°C. This should be explored.

However, there was no change in feeding response or increase in growth, of either mass or length, between *Python regius* kept on hotspot husbandry methods or those kept on ambient husbandry methods. A larger sample size may provide more accurate numbers. A sample size of 100 hatchlings, or roughly 10 clutches, in each group could provide more accurate data.

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