IN-HOME SETUP ENCLOSURE ANALYSIS

Hermann’s Tortoise (T. hermanni boettgeri) enclosure.

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V 2.11.22

Tomaskas Ltd

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The details provided in this document are based on professional opinion and sole use, and the document contains both scientific information as well as opinion. Other people may have different results.

REASONS FOR VISIT

Tomaskas Ltd, was invited to attend and report on an enclosure in November 2022. The overall aim was to survey certain enclosure and produce a report based on the findings. Some recommendations have also been made where appropriate.

This assessment was carried out and this report prepared by Tomaskas Ltd, and data analysis was aided by the Reptile Lamp Database which is courtesy of Dr. Sarina Wunderlich – who is independent and not associated with Tomaskas Ltd.

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TERMINOLOGY USED

As with many things, there may be more than one correct or colloquial way to describe the same item. There may also be common terms used that may not be correct in everyday usage. I've tried to remain consistent throughout the document so that if I refer to a specific part of an item, you as the reader will know with confidence which part I'm referring to. I'm only human though, and there may be mistakes.

FIXTURE/UNIT

This refers to a lighting unit as a whole. This can consist of the main body, as well as any lamps in use. An example of this could be a "Baskzone" or a "Lightwave", or simply a "T5 ballast"

BASKING

This refers to a behaviour of sunbathing in natural or artificial light.

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BASKZONE

This refers to a specific brand of Infrared heater. This brand is not always used, but it has become somewhat of a proprietary eponym for “Infrared heater” or “patio heater” in zoos.

LAMP/BULB

This refers to a specific part of a lamp fixture. This is the part that is often replaceable and usually emits Visible Light and sometimes UVB and or Infrared. Usually refers to a classic screw-in lightbulb, a fluorescent tube, or an R7 halogen.

LED UNIT

This refers to a lighting unit as a whole that is made up of light emitting diodes. Often used for general lighting of an area.

POWER DENSITY (PD)

This refers to a reading in Watts per square metre in certain wavelengths.

INFRARED (IR)

IR is the term given to a section of the electromagnetic spectrum on certain wavelengths. It is invisible to humans. The range is so vast that it has been split into subcategories. Some of these wavelengths (IRA or sometimes “Near IR”) are associated with “deep heating” of skin and organs, whereas others (IRC or sometimes “Far IR”) are associated with general warming of the air and generally aren’t suitable for “basking”. This document does not aim to educate about

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this specifically, and further reading is readily available online. By continuing, it is presumed that you have an understanding of IR – including the differences between short wavelength (Near) IR (IRA) and long wavelength (Far) IR (IRB and IRC).

UVI

This is shorthand for Ultra Violet Index. UVI is a standardised measurement for the appropriate wavelengths of radiation associated with essential biological processes involving the synthesis of Vitamin D3 – it is often used as a measure of solar UV radiation at the Earth's surface in terms of potential damage to the skin and the eye. The higher the UVI, less time it takes for harm to occur. This document does not aim to educate about this biological process specifically, and further reading is readily available online. By continuing, it is presumed that you have an understanding of UVI and its relevance to these tests. UVI is not to be confused with UVB. UVI is not to be confused with the Ferguson Zones.

UVB

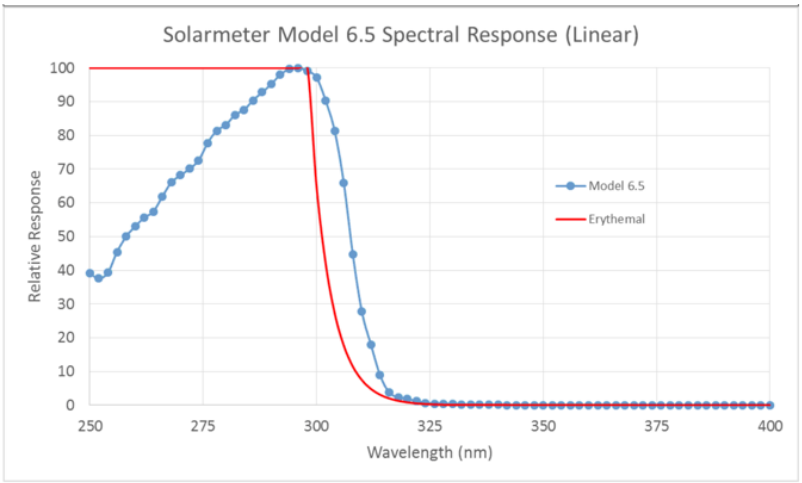
UVB is the term for part of the electromagnetic spectrum on certain wavelengths, generally between 280 and 320nm. This document does not aim to educate about this specifically, and further reading is readily available online. By continuing, it is presumed that you have an understanding of UVB – including the differences between terrestrial (solar) UVB, which is around 295-320nm, and the more dangerous non-terrestrial (non-solar) UVB, which is from 280nm to around 295nm.

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TESTING METHODS

EQUIPMENT

In order to ensure that results are as true and comparable as possible, we have used standardised measuring devices for the tests. We have used a SolarMeter 6.5 for measuring UVI. The spectral response of this broadband meter is shown below. On this graph, "Erythemal" refers to the action spectrum for the UV Index, since this is derived directly from the action spectrum for skin reddening ("erythema") under UVB.



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To allow for full spectrometry, a calibrated FLAME Spectrometer from Ocean Optics was used alongside their flagship software – OceanView.

Room temperature measurements were taken with equipment from the owner, as well as ambient temperatures with a "laser thermometer".

A Dr Meter LX1330B was used to manually determine LUX values. This is a good indicator of the "amount" of Visible Light in a measured space.

Power Density was measured with an ISM400 unit from RS. This device responds to wavelengths ranging from 400nm to 1100nm (Visible Light and some IRA).

Where appropriate, FLIR thermal imaging cameras were used, alongside the relevant software to standardise colour palettes across images.

The distances were determined using a Stanley tape measure, or a laser measure. All distance measurements are rough guides and not exact figures.

METHODS

Spectrometer readings were taken in line with standard processes.

The Reptile Lamp Database, created by Dr. Sarina Wunderlich, was utilised for some technical analysis and graph making – the database itself uses the data from the spectrometer to create usable and easy-to-read graphs.

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WHY DO WE NEED LIGHT?

A BRIEF UNDERSTANDING OF LIGHT

Explaining the definition of light in a few sentences is a near-impossible task, but here I've tried my best.

The sun produces a huge amount of energy, and this is irradiated towards Earth. This energy is utilised by life on Earth in many ways. We categorise this energy into sections such as "Ultraviolet", "Visible Light", and "Infrared". These can then be subcategorised further, such as Ultraviolet being split into "UVA" and "UVB" etc.

These categories, when put together in their natural proportions, is called "full spectrum light".

When talking about light in this document, I'm referring to the entire natural spectrum in its natural proportions. To help facilitate this and avoid confusion, I've referred to the section of the spectrum that is visible to humans as "Visible Light".

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OUR EYES PLAY TRICKS

It is worth noting that an area may appear bright to our eyes – and sometimes even to a camera. This is not a suitable tool for measuring the brightness of a room or space.

We generally measure levels of Visible Light in Lux. It is wavelength specific but not power density specific. Lux itself is only valid for Visible Light, but is a very good proxy when measuring sunlight for all other natural wavelengths.

All vertebrate eyes work this basic same way – the pupil dilates in order to compensate for low-light situations.

NATURAL LEVELS OF VISIBLE LIGHT

In open sunlight with some shaded areas, the space in which this enclosure aims to replicate, one would expect to read a range of light levels from around 60,000 to around 100,000 Lux in most places. This could exceed 120,000 Lux in the height of the day.

It is therefore reasonable to expect that the natural exposure levels are made available in captivity, from a high point exceeding 100,000 Lux, down on a gradient to the low-hundreds in more shaded areas.

However, 100,000 Lux is easily achieved in sunlight outdoors in the UK, but difficult to supply in an indoor setting. Levels such as 40,000-60,000 Lux (equivalent to daylight from a cloud-covered sky or to shaded areas) could be achieved by using appropriately-positioned LED floodlights over the desired basking area or adding specialised Metal Halide lamps. This is the aim for indoor basking areas.

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NATURAL EFFECTS OF IR

Studies show that the Near IR portion of sunlight provides the primary stimulus during the day to the majority of cells in the body – impacting over 60% of the cells in an adult and 100% of the cells in a foetus and in young.

The body, when under natural sunlight, has developed mechanisms to gather and localise Near IR in the most sensitive areas of the body; including blood vessels, the brain, and even a foetus.

Scientists propose that Near IR stimulates the body to release any excess antioxidants in cells – the cumulative effects of this antioxidant reservoir are to enhance the body's ability to locally deal with conditions throughout the day. Antioxidants continually mop up free radicals within the cells that are generated by energy production, sunlight, pathogens, etc., and so maintain cell health.

Near IR (Infrared-A and Infrared-B) appear in natural sunlight in significant proportions.

THE ROLE OF UV

Ultraviolet, or UV, is the most energised of the natural solar wavelengths, and life on Earth has evolved to utilise this free energy in every way possible.

The effects of UV are widely known and have been vastly documented.

The best-known of these is the role of UVB in enabling cutaneous Vitamin D3 synthesis. Adequate levels of Vitamin D3 are vital for calcium uptake from the gut and maintaining calcium levels throughout the body, vital for the continuing function of muscles, including the heart and gut, as well as for bones, for growth and for reproduction.

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Vitamin D3 also plays a vital role in supporting the immune system, fertility, the nervous system, and the brain.

However, UV itself –in levels experienced by animals in their native habitat – also has beneficial effects. UVB is a skin surface disinfectant, killing bacteria, viruses and fungi. It stimulates the skin's immune system, pigment formation, and beta-endorphin synthesis (sunlight's "feel-good factor"). UVA stimulates nitric oxide production within cells, causing increased blood supply to the skin and reducing blood pressure.

Not only that, but many animals can see UVA. This opens up an entire world of unknowns for us as humans – unable to truly "see through the eyes" of other animals. Not providing this part of the spectrum in its natural proportions in captivity could be seen as a disservice to those animals – not dissimilar from removing the colour "blue" from our own human vision.

The value of species-appropriate levels of UV, in full spectrum lighting, to animals housed indoors is being increasingly appreciated in zoos worldwide. The science is still in its infancy but practical applications are producing some remarkable changes in animal behaviour and health.

RELATIONSHIP TO HORMONES

Light, the entire natural spectrum, is used for more than just vision, warming, and synthesising Vitamin D3.

For example, Visible Light is an unconscious indicator of season and time of day. So-called "non-visual perception" is widely studied in human medicine, and even in social science.

Processes involving non-visual perception are completely unconscious, but very important, Melanopsin is just one photopigment used in this process, and is present in the retina of the eye and is extremely

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sensitive to Visible Light, in particular the blue wavelengths which appear at the first light of dawn and increase in intensity towards mid-day, before tapering towards sunset. The times of their appearance and cessation, and their intensity, set circadian rhythms and activity levels.

UV, Visible Light, and Infrared are all involved in stimulating the neuroendocrine network in the body.

There are numerous hormones that are widely associated with exposure to light; Corticosterone (a key component of the immune system), Melatonin (often cited as the "sleep hormone"), Serotonin (widely associated with mood stabilisation, well-being, and happiness pathways), and Dopamine (known to play a role in mood) are just a few!

Because of the intricacy of the relationship between light and hormones, without bright light - in the full natural spectrum - symptoms such as lethargy can be seen in humans.

If low light levels continue, in humans we see this is clearly and directly linked to Seasonal Affective Disorder (SAD) – this is a mental disorder often associated with (but not solely reliant on) hormonal imbalances. It is known that more light helps to treat SAD, however one of the continued symptoms of SAD is that once an individual develops it, they then lose the drive to seek out more light at all. This is where therapeutic light must be provided.

In order to avoid similar hormonal imbalances in animals, providing as close to natural levels of light, in their natural proportions, would be beneficial for the animals. This includes UV and IR.

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TARGET LEVELS FOR THIS SPECIES

Based on best practice guidelines for this species or for animals that fill a similar ecological niche, the UV Tool, and my professional opinion, the target levels for this enclosure are:

UVI – 3.0 – 5.0 in basking areas, with a gradient down to zero elsewhere.

Lux – 40,000 in basking areas, with a gradient down to low hundreds elsewhere.

IR heater Power Density – up to 250-310W/m² in basking areas, to ensure adequate short-wavelength Infrared.

These levels should be in a wide enough space to cover the animals completely whilst basking.

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AREA TESTED

This report on the enclosure covers one area.

JUVENILE HERMANN'S TORTOISE ENCLOSURE

This is a rectangular shaped enclosure indoors. There are 3 animals, approximately 6 months old at the time of the analysis.

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HERMANN'S TORTOISE ENCLOSURE

DESCRIPTION

This is a decently sized space for young tortoises. The enclosure is a modified "rodent hutch" for indoor use. It has a plastic base with a metal cage overhead. It is approximately 120cm long, 60cm wide, and 60cm tall.

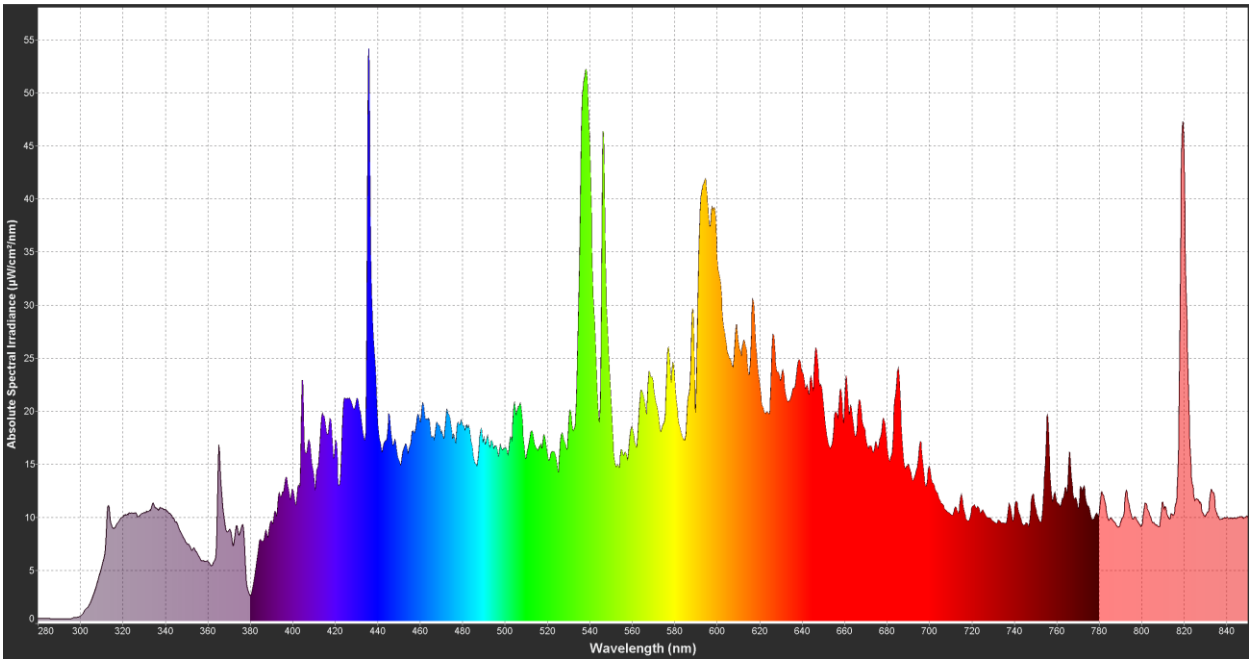
There is a designated basking area, consisting of 3x 24W T5 fixtures and lamps, 1x 70W Metal Halide (Philips), and a small heater (Reptile Systems Gold Infrared).

There is a tiny amount of sunlight through a nearby window, as well as some additional light from the room. We collected data from the basking area.

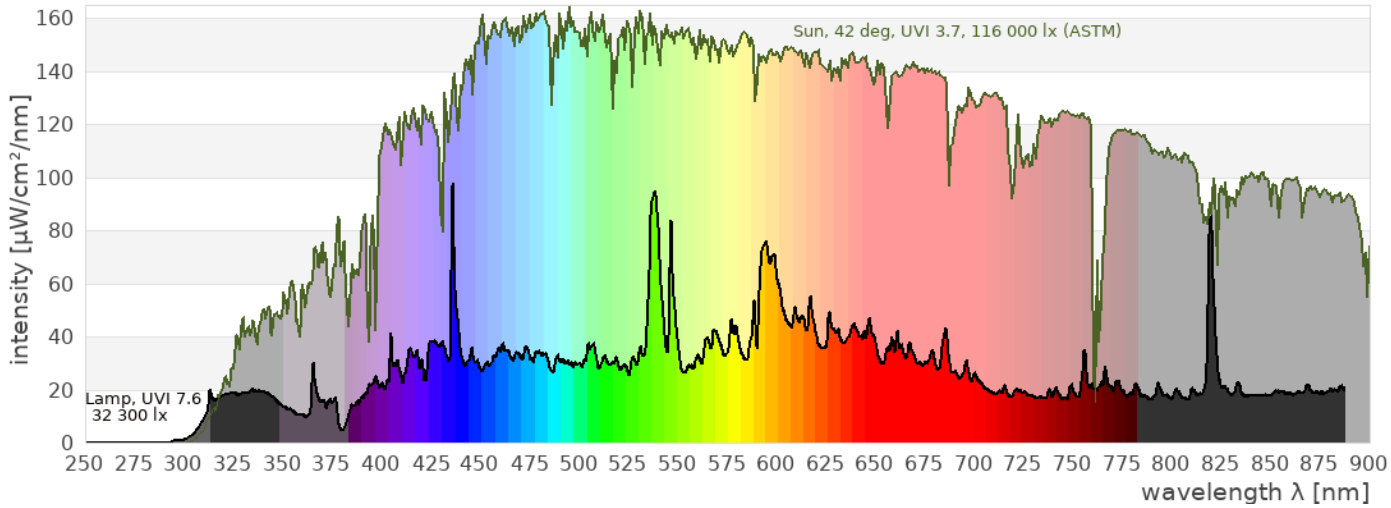
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SPECTRAL ANALYSIS – BASKING AREA

A visual representation of the spectral reading is below.



Below is a chart showing the light in the basking area compared to sunlight. The spectral plot of the light in the room has been up-scaled (to approx. UVI 7.6) in order to be visually comparable to sunlight for the sake of analysis. The total light levels are far below that of daylight, but the spectrum does approximate sunlight very well.



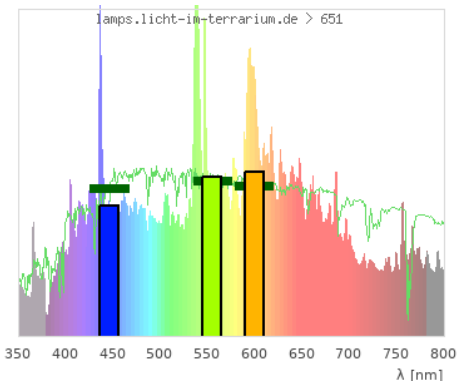
Graph created using Reptile Lamp Database - Courtesy of S. Wunderlich

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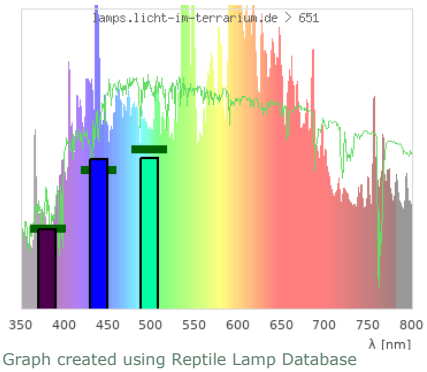
The spectral reading shows clearly that the majority of the light in this area is produced by the Mercury Vapour Bulbs (the appearance of “spikes” on the spectrum are indicative of this). The spectrum was collected facing directly up.

Below is a chart showing excitation of the 3 “cone” visual photoreceptors used in human vision, as they would be stimulated by the spectrum in this enclosure. The coloured vertical bars show the cone stimulation level; the short green horizontal bars show the equivalent stimulation by natural sunlight. The chart gives a visual representation of how well colour is rendered by humans.

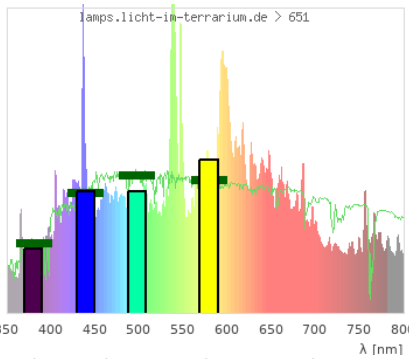


Graph created using Reptile Lamp Database - Courtesy of S. Wunderlich

Below are the same charts showing excitation of the “3 cone” visual photoreceptors used by some reptiles and birds (left), and the same for “4 cone” visual photoreceptors used by other species of reptile and birds (right), as they would be stimulated by the spectrum in this enclosure. The coloured vertical bars show the cone stimulation level; the short green horizontal bars show the equivalent stimulation by natural sunlight. The chart gives a visual representation of how well colour is rendered by different species of reptile or bird.



Graph created using Reptile Lamp Database
Courtesy of S. Wunderlich



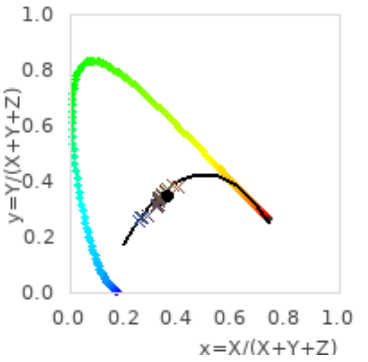
Graph created using Reptile Lamp Database
Courtesy of S. Wunderlich

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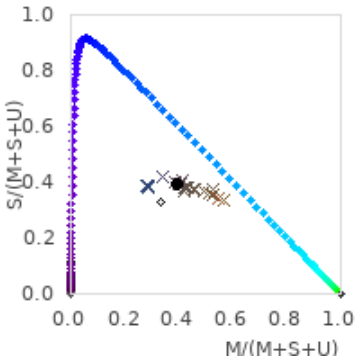
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Below are readings and a representation of the colour rendering factors for the basking area, for human vision (set by CIE). And I have also included the colour space chart for human vision (left) as well as theoretical colour space for reptiles (right).

Cat.	CCT (Kelvin)	CRI(a)	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	DC<5 .4E-3
Ref.																		
Val.	4400K	94.8	99.1	98.1	89.7	95.1	99.0	96.5	92.9	88.3	70.9	90.6	96.6	95.5	98.8	93.3	96.4	FALSE

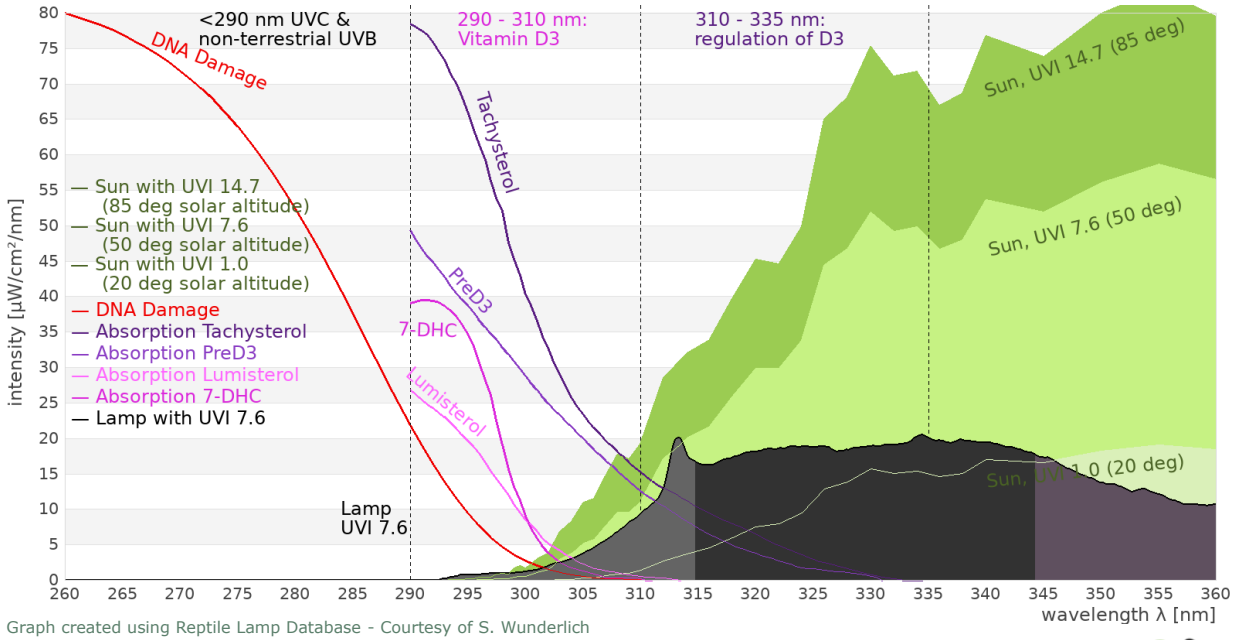


Graph created using Reptile Lamp Database
Courtesy of S. Wunderlich



Graph created using Reptile Lamp Database
Courtesy of S. Wunderlich

The chart below shows the UV portion of the spectrum (the spectral plot is again up-scaled to UVI 7.6 in order to be visually comparable to sunlight for the sake of analysis) alongside the action spectra for the Vitamin D3 Synthesis and DNA damage.



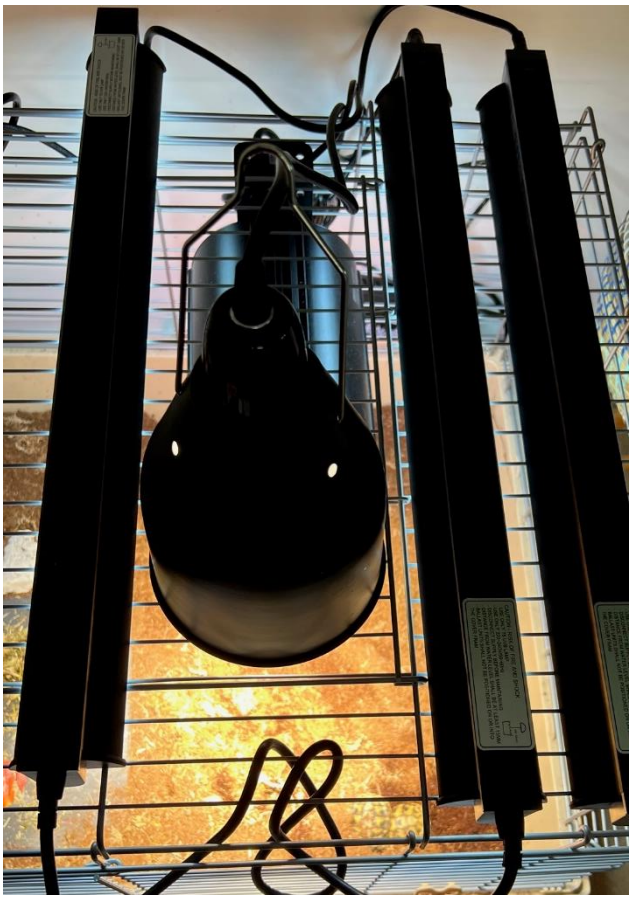
Graph created using Reptile Lamp Database - Courtesy of S. Wunderlich

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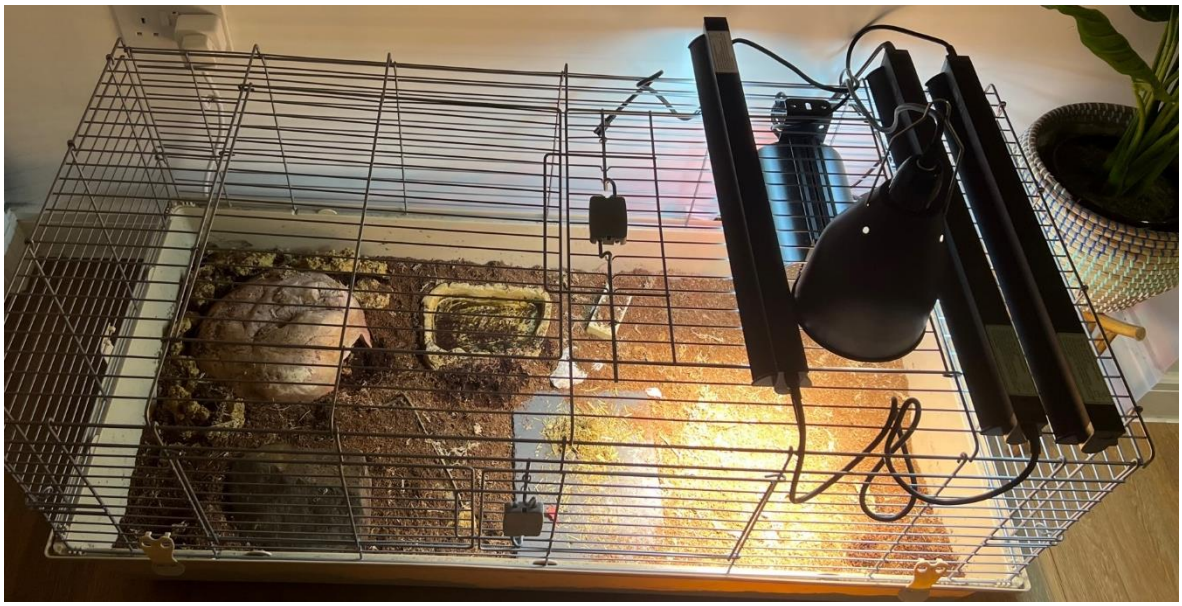
PHOTOGRAPHS

Here are some images of the areas of interest.





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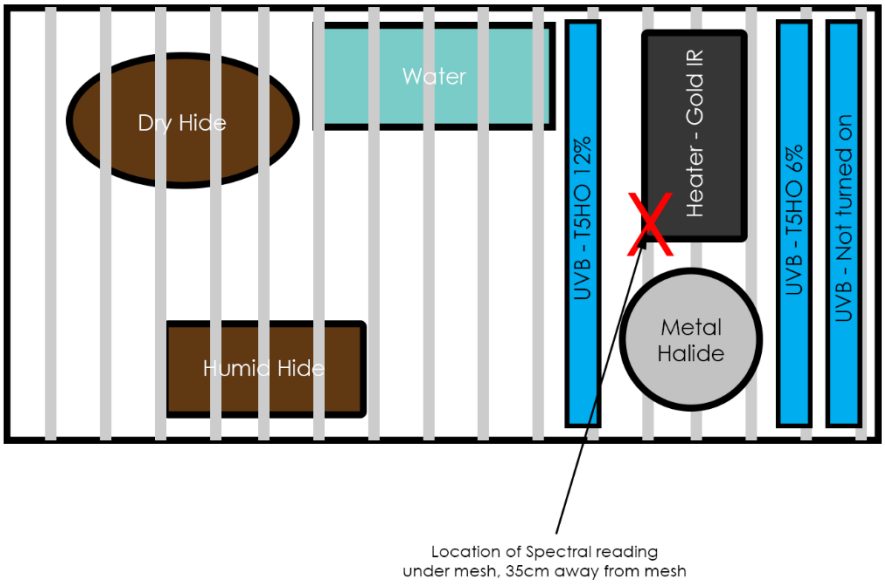




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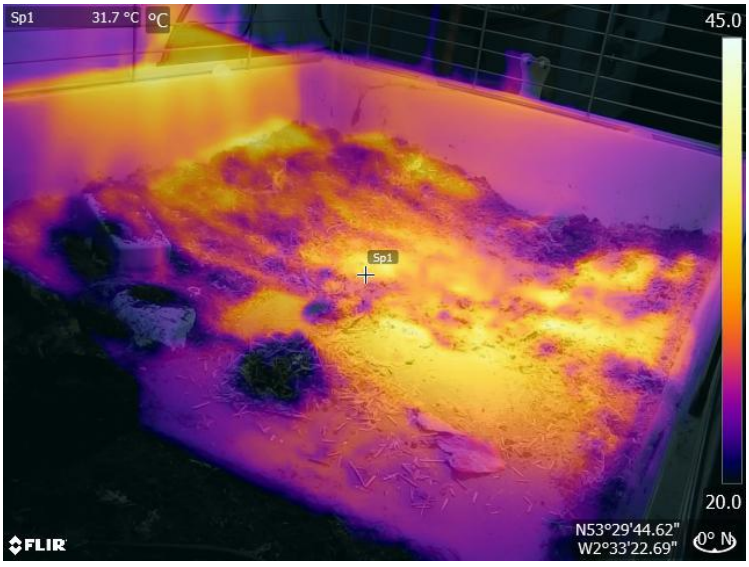
FLOOR PLAN

Below is a basic floor plan oof the area. Not to scale.



THERMAL IMAGING

Thermal imaging is provided here. Unless otherwise stated, the palette has been set to be between 20-45°C. In these instances, if an area is not illuminated, then it is colder than 20°C.



Basking area –Sp1 was approx. 32°C.

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OTHER READINGS – BASKING AREA

The illumination in the space ranges from approx. 25,000 Lux to approx. 55,000 Lux depending on the exact spot measured.

The power density in the area ranges from approx. 200W/m² to 290W/m² depending on the exact spot measured.

The UVI reading was between 3.6 and 4.8 depending on the exact spot measured.

The surface temperatures of the log ranged from 30°C-35°C depending on the exact spot measured.

FINDINGS

Despite the number of lights, the area is quite dimly lit with the exception of directly underneath the Metal Halide lamp.

Recommendations in the next section.

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COMMENTARY AND THOUGHTS

THE BASKING AREA

The colour rendering quality of the Visible Light in this area is very high, especially for reptile vision.

The animals have a range of access to different exposure levels of UVB; however, the enclosure is quite dim for most of the enclosure and basking area (with the exception of directly under the Metal Halide lamp). This lack of broad significant Visible Light provision may be a concern.

Whilst recognising the need to save energy where possible, it is recommended that the animals are provided with more overall light throughout the enclosure, consisting of a higher exposure to Visible Light and UVB for wider areas. The basking area should then increase the visible light exposure in order to remain brighter than the rest of the enclosure in proportion.

The IR in this area is satisfactory. The wide basking area provided by the Gold Infrared Unit plays a big part in this.

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There is a very good provision for UVA – something not often seen in an indoor enclosure. This is provided by the Metal Halide.

One of the T5 units was not turned on.

RECOMMENDATIONS AND PRODUCTS

The animals will be outdoors once the UK weather picks up.

Here is a short list of recommendations and possible products for this enclosure in the meantime. Other items and brands may be available.

In order to achieve the target levels Lux, some small upgrades to the basking area are recommended.

LEDs are recommended for the basking area. This could be done using some of the Arcadia Jungle Dawn LEDs, which have proven to be useful at other zoological institutions, and in the general herpetology hobby. 1x 34W Jungle Dawn LED would suit well in the dedicated basking area. This could be placed in the location which currently houses a T5 unit that is not turned on.

The lamps would need to be placed at the correct distance from the ground in order to provide the target levels. This could be done if the units are hung on chains, and an appropriate LUX meter is used to measure the amount of Visible Light in the area when placing the lamps.

Tomaskas Ltd. would be available to attend and test any setup changes at the request of the owner. This could be done whilst changes are being made – thus maximising the value of a multi-disciplinary understanding from the owner and myself.

Lights should be checked regularly for faults, breakages, or output problems. A rota could be implemented to ensure that this is done. UVI can be measured with a Solarmeter 6.5. Visible Light can be

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measured with a Lux Meter. Power Density can be measured with an appropriate device, such as an ISM400.

MOVING FORWARD

I would be available, upon request, to attend if changes are being made to this enclosure. Doing this would be of benefit to the animals in the enclosure, as this would allow an active measurement of the changes, a professional oversight focusing on just the lighting, and the possibility for an updated report on the enclosure.

The owner is welcome to contact me through Tomaskas Ltd. for a phone call or on-the-fly advice any time.

Email: tom@tomaskas.co.uk

SPECIAL THANKS

Special thanks are in order for many friends, colleagues, and partners. I'd like to give a thank you to the following, but there are undoubtedly more that have not been named.

COLLEAGUES

Dr. Sarina Wunderlich has kindly allowed me to utilise her Lamp Database system to generate some technical graphs and datasets.

The pet owner allowed me access to the enclosure and was able to answer questions on the day.

COPY

Rebecca Baines MA conducted spellchecks and ensured that I was making sense. She also provided much needed coffee.

LITERATURE AND FURTHER READING

SCIENTIFIC PEER REVIEWED LITERATURE

MacLaughlin, J., Anderson, R. & Holick, M. F. (1982) - Spectral character of sunlight modulates photosynthesis of preVitamin D3 and its photoisomers in human skin. Science, 216 1001–1003.

Baines, F. M et al. (2016) - How much UV-B does my reptile need? The UV-Tool, a guide to the selection of UV lighting for reptiles and amphibians in captivity. Journal of Zoo and Aquarium Research, 4.

Ferguson, G. W. et al. (2010) - Voluntary exposure of some western-hemisphere snake and lizard species to ultraviolet-B radiation in the field: how much ultraviolet-B should a lizard or snake receive in captivity? Zoo Biology 29(3), 317-34.

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Kelber, A., Vorobyev, M. & Osorio, D. (2003) - Animal colour vision - behavioural tests and physiological concepts. Biological Reviews, 78 81–118.

G. Chen et al. (2017) - Mercury speciation by differential photochemical vapor generation at UV-B vs. UV-C wavelength. Spectrochimica Acta Part B 137, 1–7.

C. M. Lerche et al. (2017) - UVR: sun, lamps, pigmentation and Vitamin D. Photochem. Photobiol. Sci., 2017, 16, 291-301

Lindgren, J., Gehrmann, W. H., Ferguson, G. W. & Pinder, J. E. (2008) - Measuring Effective Vitamin D3-Producing Ultraviolet B Radiation Using Solartech's Solarmeter® 6.4 Handheld, UVB Radiometer. Bulletin of the Chicago Herpetological Society, 43 57–62.

Holick, M. F. (2016) - Biological Effects of Sunlight, Ultraviolet Radiation, Visible Light, Infrared Radiation and Vitamin D for Health. Anticancer Research, 36 1345–1356.

Kalajian, T. A., Aldoukhi, A., Veronikis, T.J., Persons, K.& Holick, M. F. (2017) - Ultraviolet B Light Emitting Diodes (LEDs) Are More Efficient and Effective in Producing Vitamin D3 in Human Skin Compared to Natural Sunlight. Scientific Reports, 7 11489.

Bellastella et al. (2014) - Opposite influence of light and blindness on pituitary–gonadal function. Front. Endocrinol.

Sarika Paul and Timothy M Brown (2019) - Direct effects of the light environment on daily neuroendocrine control. Journal of Endocrinology, 243:1.

Albers et al. (2019) - Blue light (λ=453 nm) nitric oxide dependently induces β-endorphin production of human skin keratinocytes in-vitro and increases systemic βendorphin levels in humans in-vivo. Free Radical Biology and Medicine 145 78-86.

Zimmerman and Reiter (2019) - Melatonin and the Optics of the Human Body. Melatonin Research.

Scott, R. K. et al. (2015) - Evolutionary transformation of rod photoreceptors in the all-cone retina of a diurnal garter snake. PNAS 113, 2.

Katti C, Stacey-Solis M, Coronel-Rojas NA and Davies WIL (2019) - The Diversity and Adaptive Evolution of Visual Photopigments in Reptiles. Front. Ecol. Evol. 7:35.

Grace, Michael S. (1997) - The visual system and non-visual photoreception. The Biology Husbandry, and Health Care of Reptiles. Lowell Ackerman, DVM, ed. Vol. I, pp. 325-341.

James K. Bowmaker (2012) - Evolution of the Vertebrate Eye. How Animals See the World: Comparative Behavior, Biology, and Evolution of Vision 23 441–472.

Tosini et al. (2001) - The circadian system of reptiles: a multioscillatory and multiphotoreceptive system. Physiology & Behavior 72 (2001) 461-471.

OTHER LITERATURE

Sinclair, Sandra (1985) - How Animals See: Other Visions of Our World. Croom Helm, London.

Dr Frances M Baines (2021) - Vitamin D3 Synthesis: A self-limiting process in natural sunlight.