SOLARMETER, ITS USE AND LIMITATIONS

A dive into the Solarmeter 6.5 from Solar Light Company LLC, its history, and its use in the care of exotic animals.

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Tomaskas Ltd

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REASONS FOR WRITE UP

Exotic animal keeping, specifically reptile keeping, has come a long way even in the last 10 years. Zoos, pet owners, and rescue centres around the world are investing in new equipment in order to help them make informed decisions about what products to purchase.

Perhaps the most talked about piece of equipment that frequents online forums, articles, and scientific journals is the Solarmeter 6.5 (or 6.5R).

This device is relied upon to ensure that UVB-emitting lamps are up to standard (this undefined 'standard' is something I will touch on in this document).

As much as I feel that this device is useful, and has possibly saved the lives of countless animals, I wonder if the community is truly aware of what it does.

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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.

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

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and or Infrared. Usually refers to a classic screw-in lightbulb, a fluorescent tube, or an R7 halogen.

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, the 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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RARE UVB

This is NOT an agreed scientific term. I have used it in this document to help to make a point of just how little UVB appears in nature in the range of 290-295nm.

This range is so minimal in “normal” daylight, that it is really only detectible on the brightest parts on Earth, in the peak of full sun. So few of commonly kept species expose themselves to this range of wavelengths.

Because of this, I am using the term “Rare UVB” to illustrate the fact that producing these wavelengths with a lamp *could* be seen as unnecessary.

SM6.5

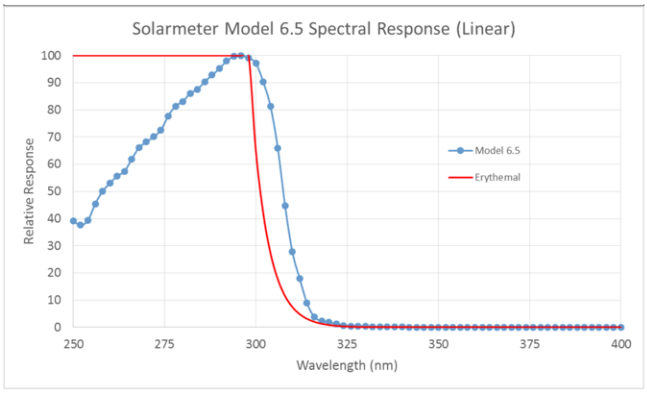
This is shorthand for Solarmeter 6.5.

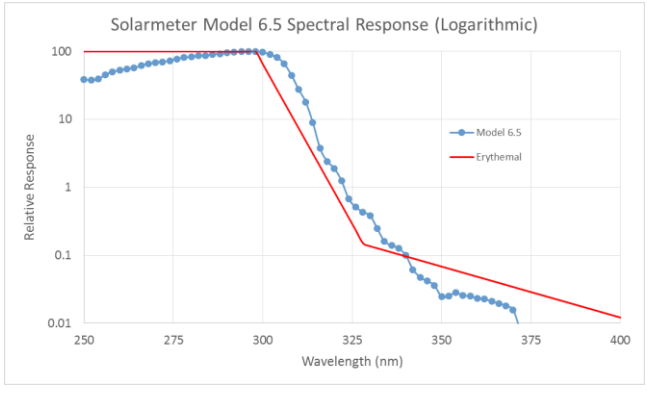
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TESTING METHODS

EQUIPMENT

I have of course used a Solarmeter 6.5 in my many tests. 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. The Solarmeter 6.5 is identical to the Solarmeter 6.5R in spectral response and general use.





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

The distances mentioned 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 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 UV?

A FOREWORD

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.

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

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"feel-good factor"). UVA stimulates nitric oxide production within cells, causing increased blood supply to the skin and reducing blood pressure.

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.

UNDERSTANDING UVB AND ITS PLACE

It's important to recognise that UVB is itself a man-made term. In nature, UVB in itself is not a "sole thing", it's a small part of a much greater spectrum.

We, as keepers, often read that UVB is essential for Vitamin D3 synthesis. We're told that reptiles in the wild use UVB to help them grow. And that's true, but that's not a complete picture.

UVB can be very dangerous, even deadly. And a part of what we call UVB isn't even found in nature most of the time.

Below, I've tried to make a visual representation of the breakdown of UV wavelengths and their placement in nature. Wavelengths are based on international standards, but some countries have different definitions. For the sake of this document, the precise wavelength definitions don't matter.

UVC	UVB			UVA
100 - 280nm	280 - 289nm	290 - 295nm	296 - 319nm	320 - 399nm
Unnatural	Unnatural	Rarely seen in nature	Natural	Natural

(not to scale)

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As you can see from the chart, UVB consists of both natural and unnatural radiation. And to make matters even more confusing, some of the wavelengths are technically natural, but are so rarely seen on the Earth's surface that they are often considered unnatural for the sake of animal keeping.

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A (VERY) BRIEF HISTORY

THE ORIGINAL DEVICE

Electrical engineer Steve Mackin invented the Solarmeter in 1990. He started making meters by hand, at home, and set up his own company, Solartech Inc., to sell what became known as the Solartech Model 5.0 total UV (A+B) meter.

The UV Index was first recognised internationally a few years later, as a measure of the intensity of sunlight and tanning lamps in terms of their ability to cause skin redness (erythema). Steve then developed the Solarmeter 6.5 UV Index Meter, launched in 1996.

On his retirement in 2015, he sold Solartech Inc. to Solar Light Company, who took over production of his Solarmeter range. The Solarmeter 6.5 is one of many meters made. The meters each specialise in different sections of the electromagnetic spectrum, and are generally referred to as “broadband meters”, or “radiometers”.

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The meter is handheld, and consists of a simple button and screen. The user points the meter at a source of light, presses the button, and is presented with a UVI reading.

The meter is calibrated for use with sunlight, and with lamps having a similar spectrum – in the UVB range – as sunlight.

Since the meter's sensitivity response is close to the action spectrum for Vitamin D3 synthesis as well as that for erythema, its readings from lamps of this type can be taken as an indication of the ability of the light to enable Vitamin D3 synthesis.

DR. GARY FERGUSON

The Ferguson Zone system was originally developed by Dr Gary Ferguson and his team of herpetologists at Texas Christian University. They used the Solarmeter 6.5 to determine the daily UV exposure available in different microhabitats inhabited by 15 species of lizards and snakes occupying a range of ecological niches.

DR. FRANCES BAINES, AND THE UV TOOL PROJECT

Following on from work with Dr Gary Ferguson, in 2012, the Reptile and Amphibian Working Group of the British and Irish Association of Zoos and Aquaria (BIAZA) set up a UV Focus Group, with Dr. Frances Baines as co-ordinator.

They built on Ferguson's research, to produce a document known as the UV Tool. They collected reports and advice from herpetologists, zookeepers and specialist keepers worldwide about the microhabitats and basking behaviours of a total of 254 species of reptiles and amphibians, and allocated Ferguson Zones to each.

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This Tool was published in the peer-reviewed Journal of Zoo and Aquarium Research in 2016. It has proven useful worldwide as a guide to safe but effective UVB provision to reptiles in captivity. Various outlines of the Ferguson Zones and their use have appeared in numerous articles and even veterinary textbooks in subsequent years.

The Solarmeter 6.5 has also provided a means of "visualising" the output of UVB-emitting lamps by plotting their UVI gradients as the beams spread from the lamp. These "iso-irradiance charts" developed by Dr. Baines are now being created by other herpetologists and researchers, and are proving helpful to reptile keepers worldwide.

THE NEW DEVICES

Following the success of the work from scientists and researchers, Solar Light Company launched the Solarmeter 6.5R. This device is the exact same meter, rebranded for the use of reptile keepers and has some extra information on the Ferguson Zones included.

Popular brands have since commissioned "skins" from Solar Light Company. They are all the exact same meter, with different labels.

At the time of writing, there are 6 skins, shown below. Picture courtesy of Dr. Frances Baines.



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MAIN USES OF THE SOLARMETER

LAMP MONITORING

Most people find the device very easy to use – just point and click.

When buying a UV lamp for their pet, keepers want to be able to monitor its output and decay in UVB output over time. The Solarmeter 6.5 enables a keeper to keep a simple track of this decay – and ensure that they are maintaining the appropriate UVI for their animals.

Often, keepers assume that they are monitoring the quality of the UVB for their animals, but this is not the case, as will be discussed later.

The same is true for many zoos, pet shops, and even manufacturers. The very device that people buy for their pets is used by zoos around the world to monitor the aging of lamps on birds, apes, and even elephants!

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PROFESSIONAL TESTING

The meter has been utilised by professionals in laboratory and field-based testing for some time now. It has appeared as the instrument of choice for UV measurement in an increasing number of peer-reviewed papers.

Dr. Frances Baines, Dr. Sarina Wunderlich and I have each independently undertaken professional work testing commercial products, including prototypes for various manufacturers and distributors, and consulting on the use of UVB lighting, using this meter to measure UVI.

Others in the general hobby have also utilised the meter to create their own iso-irradiance charts.

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THE LIMITATIONS

CALIBRATION

Firstly, it is very important that every user of the meter is well aware of the calibration of their device. Accuracy is stated to be ± 10%. This means that individual meters should give a reading within 10% of the value which would be determined by the NIST calibrated master meter used in its calibration, when it is used with lamps having a spectrum similar to that used in its calibration.

In short, a lamp of this type may be emitting UVI 4.0. One Solarmeter may read 4.4 and another may read 3.6. Both meters, in this instance, are working as intended.

This is well within standards seen in other industries. It should always be taken into account by anyone testing lamps for personal or professional use. It is also worth noting that when the spectrum of a lamp is very different from that to which the meter is calibrated then results from any broadband meter will vary in their accuracy and reliability.

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SENSOR PLACEMENT

Perhaps the biggest limitation of the meters is the placement of the sensor. Although a reasonable position, it does make measuring UVB lamps a problem in many cases.

Consider measuring a basking surface at the base of a vivarium, say for a leopard gecko. In this hypothetical situation, the keeper places their meter in the enclosure at the basking area and gets a reading of UVI 1.8.

But, in actuality, they've not collected a reading of the UVI that their gecko would be getting. They've actually measured the UVI approximately 7cm away from the gecko's back (assuming the gecko is 3cm "tall")

Some people have made adjustments to their meters to try to circumvent the limitation. The concept behind these adjustments is to allow users to place the meter at "animal level" more easily.

Some images can be seen below. Tomaskas does not recommend making any changes to a Solarmeter, as doing so could affect the readings provided, and could damage the delicate filter assembly and wiring as well as voiding any warranty.







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NO 'HOLD' FEATURE

Users have reported issues with the lack of a "HOLD" feature on the device. In order to get an accurate reading, a user must be able to see exactly what the screen says whilst pressing the button down and *also* pointing the sensor at the intended location.

This can be difficult in some situations. Users should be very aware of this limitation when using the device.

THE SENSITIVITY OF THE SOLARMETER 6.5

The Solarmeter 6.5 is most sensitive in the range around 295-305nm, but remains relatively sensitive as low as 250nm – which is well into UVC territory.

Here is the same chart as earlier, but I have added a row for indicating, as simply as I possibly can, the sensitivity level of the Solarmeter 6.5 at different wavelengths.

UVC	UVB			UVA
100 - 280nm	280 - 289nm	290 - 295nm	296 - 319nm	320 - 399nm
Unnatural	Unnatural	Rarely seen in nature	Natural	Natural
Fairly sensitive	Very sensitive	Most sensitive	Very sensitive	Not very sensitive

(not to scale)

Under normal use, in sunlight, this sensitivity won't be a problem. The areas in which the meter is sensitive are dictated by the natural order – i.e. the meter is a good indicator of UVI when used under sunlight.

The reason for this sensitivity comes from the meter's original purpose – to provide a reading based on erythema (skin reddening when exposed to UV light). For this purpose, the meter is ideal.

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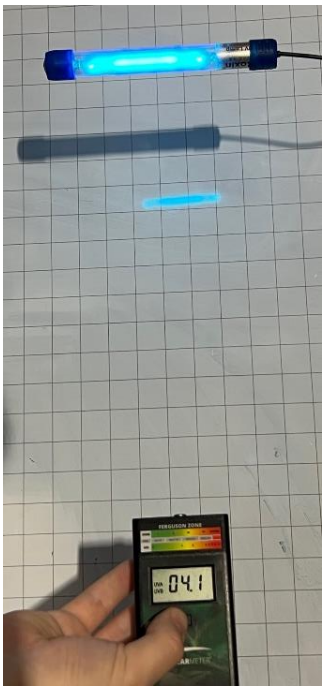
THE PROBLEM WITH THE SENSITIVITY RESPONSE

This means that the meter is only *truly* valid for measuring the UVI from the solar spectrum (or lamps with a similar spectrum). It can only be used as an *indicator* of UVI for lamps with very different spectra.

The meter certainly can't be used as a measure of a lamp's safety for use with animals. And although it has never been advertised as such, and professionals have never stated as such, the general hobby appears to have developed the mindset that the meter can be used as a lamp safety detector. Users need to be very aware of the fact that the device cannot be used to determine lamp safety.

It can also not be used as a sole method of determining an appropriate distance between a lamp and an animal. This can *only* be done where the lamp in question has otherwise been thoroughly tested, independent of the manufacturer, and has proven efficacy and safety for its intended use.

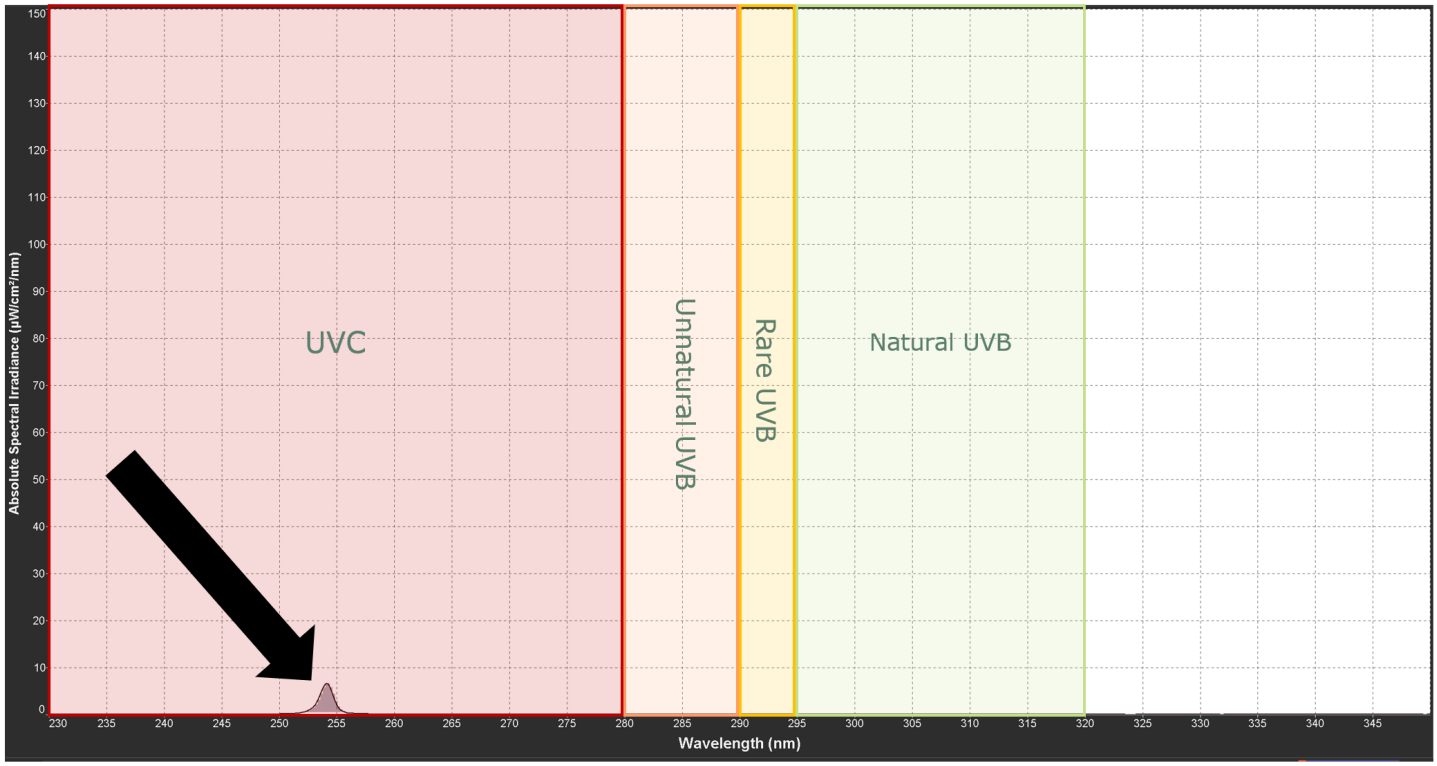
This can be demonstrated easily. Here I took a UVC sterilising lamp – something that kills cells and should NEVER be used on an animal – and measured it with a Solarmeter 6.5R.



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You can see that the meter indicates that we're seeing a UVI of 4.1 at a distance of 30cm. That's perfect for a bearded dragon, in theory. Had I relied on just the Solarmeter 6.5 for this test, it's entirely plausible that I could have used this lamp on my beardie.

But, confirming this with an analysis of the spectrum makes it clear just how dangerous the lamp really is. The area of interest is marked with a black arrow.



This tiny amount of UVC was all it took to generate a relatively high UVI at 30cm away. There was no measurable UVB present, but a UVI of 4.1 was still achieved.

Meanwhile, this amount of UVC is also enough to cause serious skin damage and is highly carcinogenic, even with short exposure times.

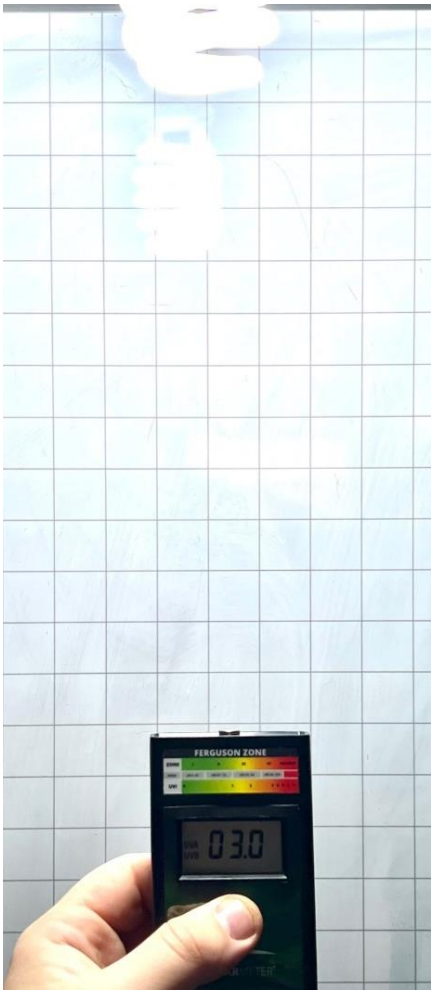
That might sound like an unrealistic example, as people tend not to buy UVC lamps expecting them to be safe. However, I've ran some very similar quick tests on lamps that are on sale as "reptile" lamps and are easily accessible.

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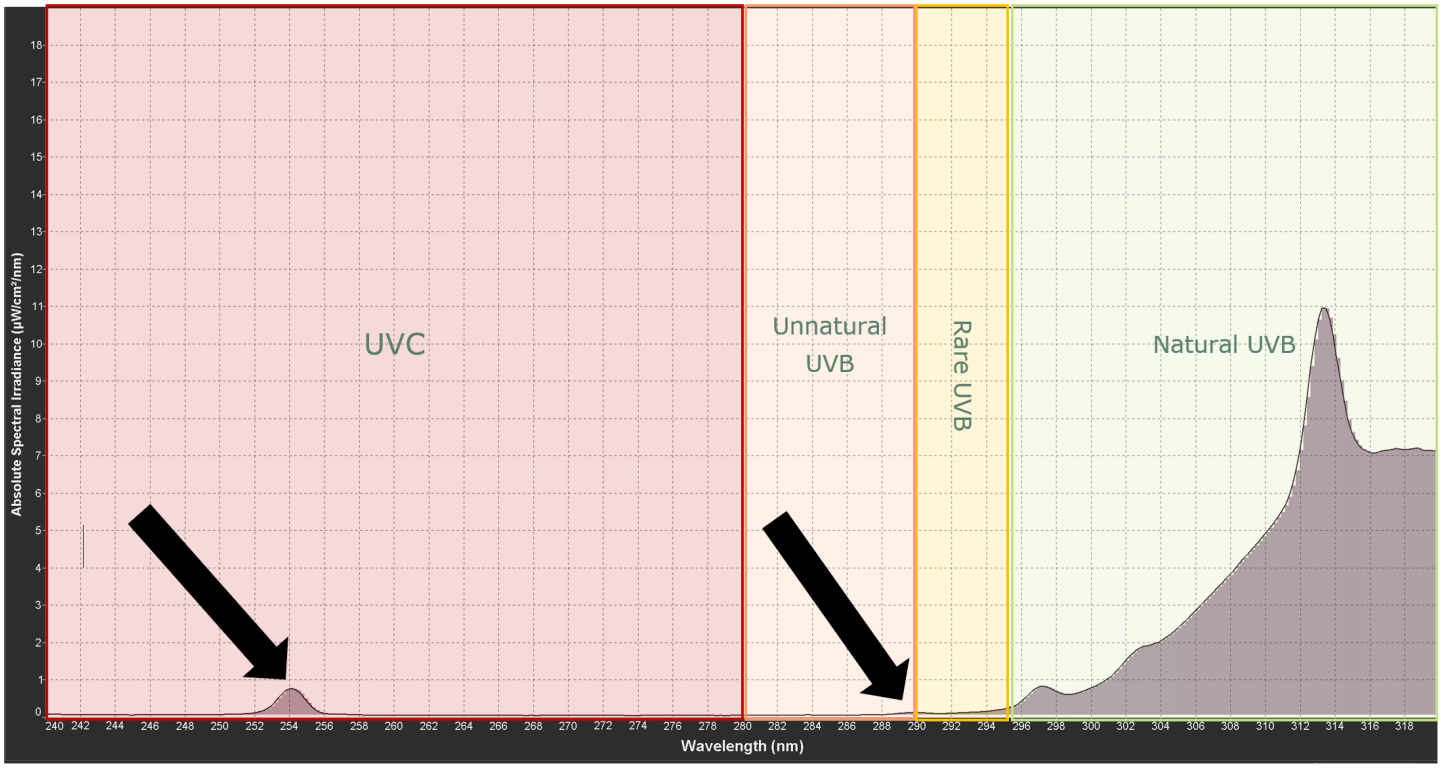


Above, we see a brand easily found online, NeoRep (Neo Reptile Products, a trading name of SP Archangel Ltd). The lamp is recommended for desert animals by the manufacturer. The lamp is reading a UVI of 3.0 at 30cm. This could be seen as suitable for quite a few commonly kept species, if only taking the UVI into context.



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Below is a simple spectral reading of some of the UV portion of the same NeoRep lamp. It is clear that the lamp emits unnaturally short-wavelength UVB as well as UVC – something that we wouldn't want to expose our animals to. The points of interest are marked with black arrows. The Solarmeter will detect this UVC as well as the UVB, and give a higher UV Index reading as a result – but this reading alone does not warn of the presence of the UVC.



UVC is deadly to all life on earth, and can be harmful even in small doses, and is used as a disinfectant for sanitary purposes in hospitals and other medical settings. It's something we definitely don't want near our animals, or indeed in our homes around our children and family.

But yet, if using the Solarmeter 6.5 alone, a user would otherwise not know of the dangers of lamps emitting UVC.

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IN CONCLUSION

STATEMENT

I see online in forums, Facebook groups, and in posts made by many pet stores, that the use of a Solarmeter 6.5 is an essential part of exotic animal keeping. This is partly true in many ways.

I have lost count of the number of times I've seen words to the effect of "the only way to see if a lamp is safe is to use a Solarmeter". Statements like that are just plain wrong.

The Solarmeter 6.5 is, in my opinion, only useful in the exotic keeping hobby and profession for the following:

- *Ensuring safe distances* ***of otherwise tried and tested and safe lamps.***
- *Monitoring UVB decay* ***of otherwise tried and tested and safe lamps.***
- *Professional testing for UVI (irradiance chart plotting).*

Anything outside of this remit, such as measuring an otherwise untested lamp, is dangerous and ill-informed.

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If a pet shop, or keeper, is offering a lamp testing service that relies solely on a Solarmeter 6.5, then this should be taken in the context discussed in this document – the test is incomplete and only provides a very limited perspective on the lamp being tested.

CAVEAT

This does not mean that the Solarmeter 6.5 is useless. The Solarmeter 6.5 is an invaluable tool for many users.

What this document aims to do is to educate and inform about the limitations of the Solarmeter 6.5. It is one of many tools that we have in our armoury – and plays an important part in professional testing, lamp manufacture, and general keeping around the world.

All keepers should be aware of the limitations of the meter in order to get the most out of the tool.

This is not an advertisement for Tomaskas Ltd. or the lamp testing facility and services offered. Other independent lamp testing options are available around the globe. Manufacturers should always utilise at least one completely independent testing service. Consumers should always refer to professional independent testing before purchasing a product that they haven't used before.

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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. Frances Baines has acted as a point of contact and consultancy for this document.

Dr Sarina Wunderlich has acted as a point of consultancy. More of Dr Wunderlich's in depth work on the Solarmeter can be seen here:
https://bit.ly/3TaPlkF
https://bit.ly/3hh5MhV
https://bit.ly/3Djxq5h

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COPY

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

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LITERATURE AND FURTHER READING

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