ZooMed ReptiSun UVB/LED New Gen2 :
Lamps on test, following a pilot study demonstrating normal vitamin D3 levels synthesized during 10 month trial with bearded dragons.

Report by Frances M Baines

Introduction: The Pilot Study

Fluorescent lamps are increasingly being replaced by LEDs, owing to energy-saving policies and concerns about their mercury content. A pioneering study by Cusack *et al*., in 2017, demonstrated successful cutaneous vitamin D3 synthesis in reptiles under a prototype UVB-emitting LED lamp created by ZooMed Laboratories Inc. From 2019 onwards, a number of lamp manufacturers launched ranges of UVB-emitting LED products “for reptiles”. These are now widely available, many being sold direct to the public from Chinese companies via Amazon, eBay and similar international outlets. ZooMed Laboratories Inc. launched its own product, the ZooMed ReptiSun UVB/LED 9 watt, 13-LED UV-emitting LED bar, in 2021.
To date, UV LED products have not taken a hold in the marketplace, no doubt in part due to the proven effectiveness of quality T5-HO UVB fluorescent lighting, along with the high cost of UV-emitting LEDs. There have also been concerns about their effectiveness and occasional reports of UVB ‘burns’ and eye damage from some of the Chinese exports. A detailed study of 18 different products, including spectral analysis, was published by Wunderlich et al. (2023). The spectra of all 18 UVB-LED lamps had little similarity to the solar UV spectrum. Some lamps emitted short-wavelength, non-terrestrial radiation known to cause acute photo-kerato-conjunctivitis. All lamps were lacking significant output in the range 315 nm – 335 nm, essential for natural self-regulation of cutaneous Vitamin D3 synthesis, preventing overproduction. The authors expressed concerns that the use of these lamps might create a serious risk of hypervitaminosis D and called for long-term animal studies, measuring serum vitamin D3 metabolites, to assess this risk.

To date, the only company to have completed such a study is ZooMed Laboratories, Inc. following development of their ReptiSun UVB/LED into the New Gen2 lamp, with the addition of new UVA diodes specifically to provide output in the 315 nm – 335 nm range.
I was consulted before the trial, in 2024, regarding methodology and the appropriate blood tests to be undertaken. I had no further input into the trial, although on its completion in September 2025 I received a copy of the blood test results and had the opportunity to discuss them with several leading veterinarians and scientists as well as the ZooMed team.
The results for this very small pilot study, an in-house trial with a small number of bearded dragons in ZooMed’s own facilities, remain confidential. However I have obtained permission to report that the results from the trial were very promising. Initially, all dragons were healthy but blood tests revealed mild vitamin D insufficiency. The trial then compared dragons under ZooMed ReptiSun T5-HO 10.0 UVB lighting with dragons under the New Gen2 lamp, both groups under lamps providing UVI 4.0 in the basking zone. At the end of the 10-month trial, all dragons in both groups had very much improved vitamin D3 levels, serum 25(OH)D3 up to the high levels reported for wild, free-living bearded dragons in Australia. Serum and ionised calcium levels and levels of the active metabolite, 1,25$(OH)_2$D3 were also normal in both groups. **There was no evidence of hypervitaminosis D** and all dragons remained healthy throughout the trial.
The ZooMed team are planning further, larger-scale trials, the results of which I hope they will consider publishing, as this is ground-breaking research.

Fig. 1

Introduction: The Lamp Tests

Two ZooMed ReptiSun UVB/LED Gen2 18watt lamps were supplied by ZooMed Laboratories, Inc., 3650 Sacramento Drive, San Luis Obispo, CA93401, USA. (Figure 1). The lamps are 21-LED UV-emitting LED bars, each with 4 x UVB LED, 5 x UVA LED, 12 x 6500K LED, specified as 18 watts, 500 lumen, CRI 96, CCT 6500K.
The lamps were given reference numbers BZUVB1 and BZUVB2.

For testing, each lamp was placed in a simple E27 ceramic lamp holder and mounted horizontally at one end of a test bench, such that the lamp's beam spread across the bench, enabling meter readings and spectra to be collected perpendicular to the lamp and an iso-irradiance chart plotted in a horizontal plane over the bench.
The lamps were operated on UK line voltage (nominally 220 -240v). The recordings were made after a one hour warm-up time in each session, with the sensor positioned at right angles to the axis of the lamp, at the midpoint of the lamp array. Meter readings were taken at one-inch and 5cm increments from the lamp surface. Spectrometer recordings were made at a standard distance of 20cm from the lamp surface.

Both lamps performed normally during the trials.
Lamp BZUVB1 had a minor manufacturing defect; the lamp failed to receive a stamping process during the end of assembly, in which a dimpled 'punch' secures the metal screw base to the plastic housing. Although this did not result in any problems with lamp operation or create an electrical hazard, it did result in the metal base coming loose during the removal of the lamp from the fixture after testing. This defect has been reported to the manufacturer and was said to be an isolated occurrence.

No long-term testing has been performed.

Recordings include:
- Spectrograms (Ocean Optics Inc. USB2000+ spectrometer with UV-B fibre-optic probe with cosine adaptor)
- UV Index (UVB in the biologically active range of wavelengths) (Solarmeter 6.5R UV Index meter)
- Total UVB - 280 - 320nm (Solarmeter 6.2 broadband UVB meter)
- UVC (Solarmeter 8.0 broadband UVC meter)
- Visible light output (SkyTronic LX101 model 600.620 digital lux meter)
- Electrical consumption (Prodigit power monitor model 2000M-UK)

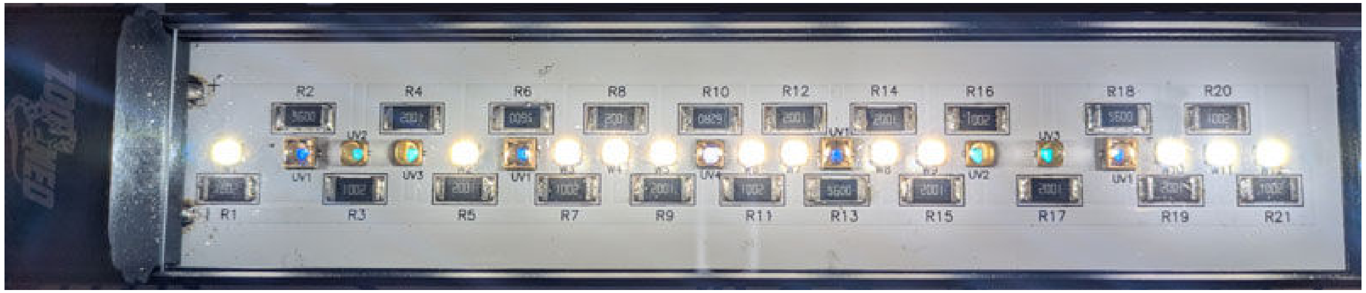
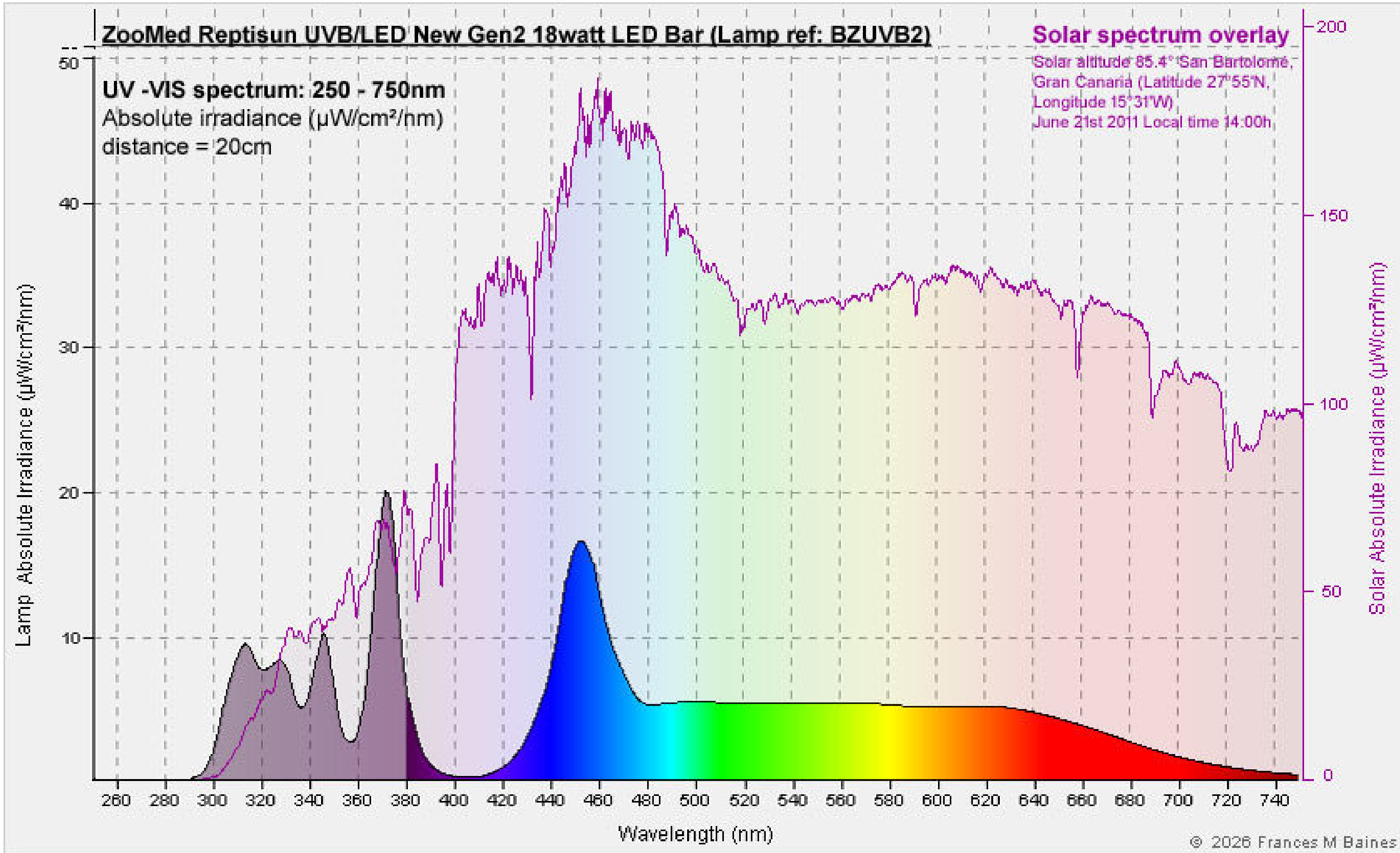


Fig. 2: Photographs from a camera with limited sensitivity to UV reveal the UVA and UVB-emitting diodes glowing in "false colour" blue and green. They are labelled UV1 (4x blue), UV2 and 3 (4x green) and UV4 (1x colourless, in a near-central position), spaced out between the 12 "white" LEDs.

Spectrum - UV plus Visible Light

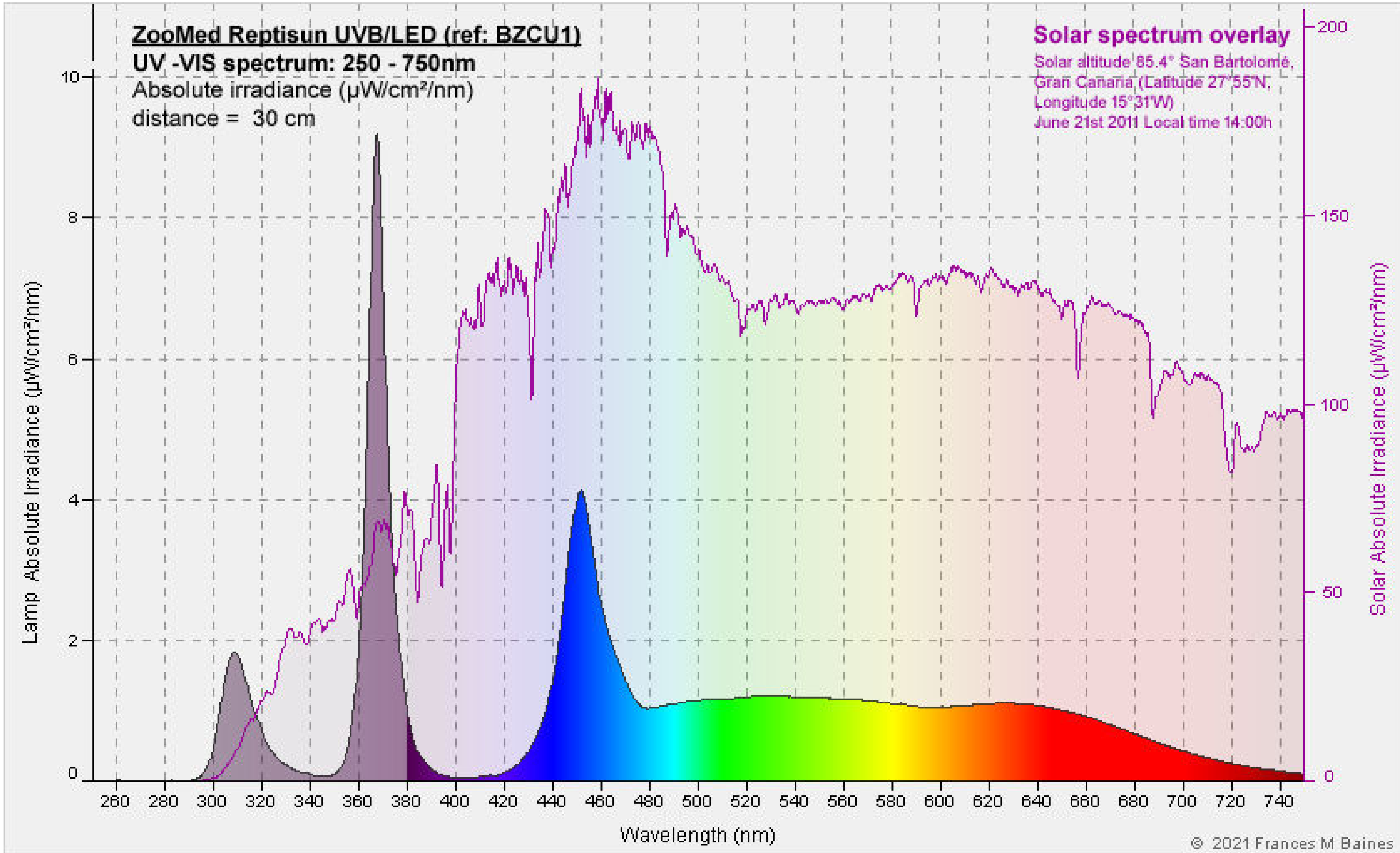
The full ultraviolet and visible light (UV-VIS) spectrum from lamp ref. BZUVB2 recorded at 20cm, is shown in Figure 3 (below). The spectral power distribution (SPD) of lamp BZUVB1 is essentially identical, omitted for clarity. A mid-day solar spectrum with the sun close to the zenith (Solar altitude 85.4°, location San Bartolomé, Gran Canaria, June 21st 2011 Local time 14:00h) is overlaid on the chart below (but note the different irradiance scales). This enables comparison of the SPD of the lamp with that of natural sunlight, which has a continuous spectrum from a threshold around 295nm.

Fig. 3



The individual LED spectra can be identified by their peak irradiances. The UVB LEDs have a peak wavelength of 313nm; the UVA LEDs peak at 327nm, 345nm and 371nm. The blue LEDs driving the phosphor for the white light are at 450nm. The total visible light output is very low in proportion to the UV output in comparison with the solar spectrum. There is an obvious gap in the upper UVA and purple wavelength range, and a deficit in the red waveband. The “white light” LEDs used in this lamp are a standard type used widely in products manufactured for household lighting. Nevertheless, this is a very significant advance from the UV spectrum of the original ZooMed ReptiSun LED/UVB launched in 2021 (Figure 4, below) in which there was a single UVB peak at 308nm (four UVB LEDs) and another at 367nm from a single UVA LED, resulting in a very different SPD from sunlight, with a conspicuous absence of long-wavelength UVB and short-wavelength UVA, which are involved in the control of cutaneous vitamin D3 synthesis.

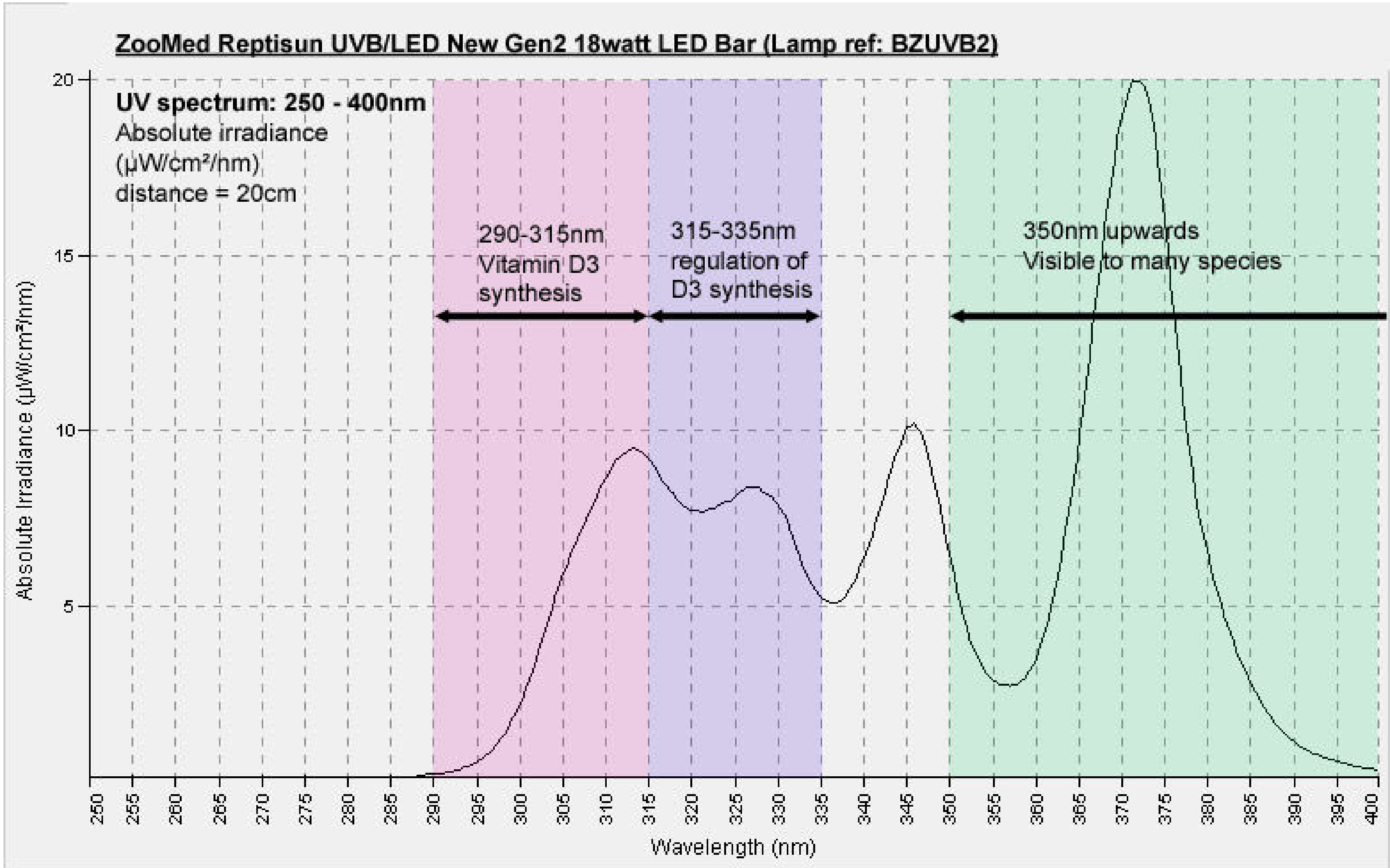
Fig. 4 : Previous version of ZooMed ReptiSun UVB/LED (2021) for comparison



Spectrum - UV in more detail

Figure 5 (below) shows the UVB (280-320nm) and UVA (320 – 400nm) ranges for the New Gen2 lamp in more detail.

Fig. 5



The UVB LEDs do not emit any UVC and the threshold wavelength is 290nm, with only insignificant output below about 295nm. This threshold is similar to sunlight, but the lamp has a much greater proportion of its total UVB below 315nm, as clearly shown in Figures 4 and 5.

The lamp does, however, emit significantly more long-wavelength UVB (above 315nm) and short-wavelength UVA (320 – 335nm), than its predecessor owing to the introduction of two sets of mid-range UVA diodes. The purpose of adding these diodes is to produce a more "sunlike" spectrum, which prevents excessive vitamin D3 synthesis by shifting the equilibrium of the photoproducts towards production of lumisterol, tachysterol and the transformation of excess pre-D3 back to 7-DHC. Absence of wavelengths from 315 - 335nm is likely to result in a higher pre-D3 yield than would be predicted by the UV Index, which could in theory lead to oversupply of vitamin D3 and possibly an eventual hypervitaminosis.

However, this is still very different from sunlight in which the UV irradiance in these wavelengths greatly exceeds that of the total UVB.
The proportions of UVB: UVA: Visible light are 6.7 : 23.6 : 69.7, (irradiance in $\mu W/cm^2$) in contrast to those of very strong sunlight: 0.8 : 12.6 : 86.5 (data from reference spectrum for 85-degree altitude sun).

The long-wavelength UVA peaks at 371nm with a broad emission spectrum which will be strongly visible in the blend of light seen by reptiles, although it is such a comparatively powerful radiation that it is conceivable that it might give the "white" light a UVA-coloured cast to reptile eyes. The effect of the relative lack of light between about 380 and 430nm on the colour perception of reptiles is unknown. However, these wavelengths are difficult to supply adequately with any conventional lighting. Metal halides are the most successful source for reptile-visible light including long-wavelength UVA.

To summarize, it can be seen that:

- The lamp does not emit hazardous UVC, or UVB in the non-terrestrial UVB wavelengths.
- Compared to sunlight, a greater proportion of its output is below 300nm. The risk of DNA damage is therefore greater than for natural sunlight.
- Compared to sunlight, a greater proportion of the total UV emission is between 300 – 320nm, hence greater photobiological activity is to be expected. There is a risk of "sunburn" and photo-kerato-conjunctivitis following over-exposure.
- There is significant UVB in the wavelengths which enable vitamin D3 synthesis in skin.
- The proportion of UV from 315 – 335nm, important for natural prevention of excessive D3 synthesis, is higher than the previous version of this lamp (and higher than many of its current UVB LED competitors) although still lower than natural sunlight.

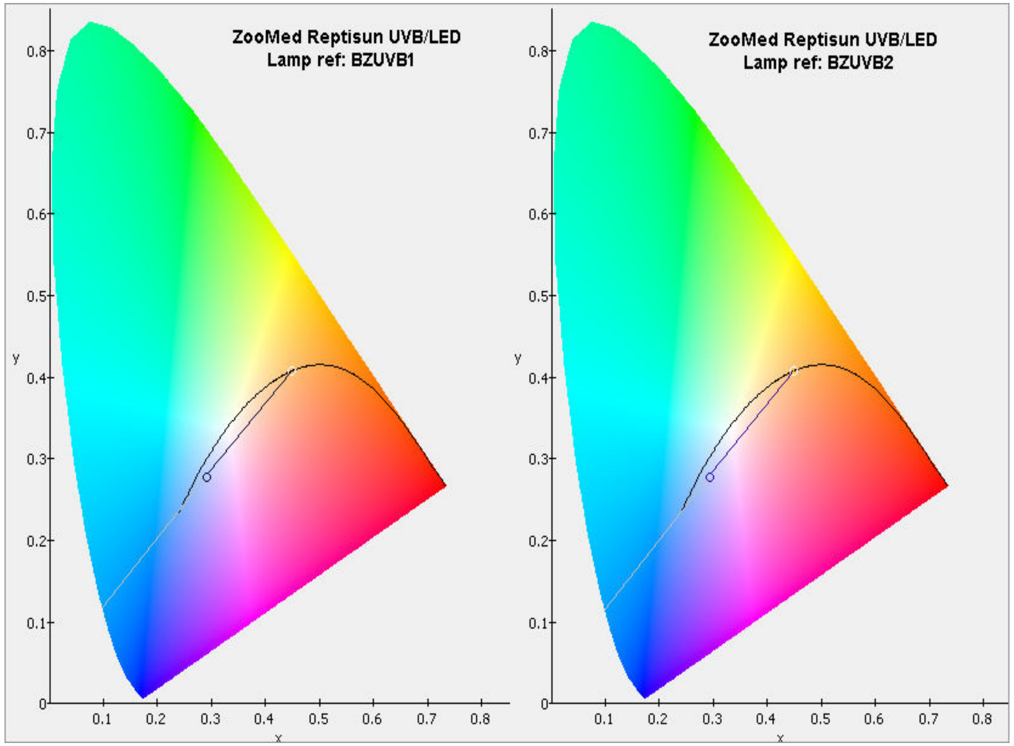
Colorimetry

Colour analysis performed on the spectral data gave the results shown below (Figure 6). The colour analysis chart provides an estimate of the Colour Rendering Index (CRI) and Corrected Colour Temperature (CCT) for the lamp. The colour of the light is not quite close enough to the Planckian locus to be within the range required for accurate calculation of the Colour Rendering Index (CRI) and Corrected Colour Temperature (CCT) by the spectrometer software. This is indicated by the entry: $DC<5.4^{E-3}$ = FALSE. Even so, the software provides an estimate based upon the data provided. According to this calculation, the lamp has a good colour rendering index (CRI 90), and almost all colours are rendered very well, except for strong red (as indicated by CRI R9), since red light is not well represented in the spectrum of "white" LEDs which use a phosphor, as do these.

The colour temperature is estimated to be between 9200 – 9400K, which is slightly more "blue" than daylight as seen by the human eye and very different from the advertised 6500K. There is no formula yet for calculating how these lamps render colour to a reptile or bird's eye, however.

Fig. 6: Colorimetry	ReptiSun UVB/LED (BZUVB1)	ReptiSun UVB/LED (BZUVB2)
CRI Ra	**91.0**	**89.7**
CRI R1	86.7	84.3
CRI R2	92.4	90.4
CRI R3	92.7	94.7
CRI R4	91.8	89.7
CRI R5	89.1	87.0
CRI R6	87.8	86.8
CRI R7	99.0	97.8
CRI R8	88.9	86.9
CRI R9	61.0	54.1
CRI R10	89.5	85.6
CRI R11	88.8	86.7
CRI R12	70.2	71.9
CRI R13	87.9	85.3
CRI R14	95.0	95.7
CRI R15	82.4	79.5
CRI DC	1.54E-2	1.69E-2
$DC<5.4^{E-3}$	false	false
CCT	**9365K**	**9235K**

Fig. 7.



The spectrometer software also creates a Chromaticity Chart for each spectrum (Fig.7, above right). The chromaticity coordinates are given by the dark blue circle; the arc represents the Planckian locus (the chromaticity coordinates of a perfect 'black body' radiator at all temperatures). The co-ordinates are close to the arc, resulting in the high CRI, and the "blue" higher colour temperature is also visualised. However, these colours are only relevant to the human eye. The colour space of reptilian vision is very different, since it includes UVA. It must not be assumed that this light looks white to a reptile.

Broadband Meter Readings

The “quality” of its light, as indicated by its spectrum, is only one factor in predicting the usefulness of a lamp. The “quantity” of UVB must also be assessed. Therefore the intensity of the UV at different distances must be measured. This is done using broadband UV meters.

UV Index Recordings

Recordings of the output of the lamps made with the Solarmeter 6.5R UV Index meter, at 5cm increments from the lamp surface with the sensor positioned at right angles to the axis of the lamp, aimed at the midpoint of the lamp array, are shown in Figure 8 (below). The spectral response of this meter is similar to the action spectrum for vitamin D3 synthesis, and so readings from this meter are used to estimate the potential of the lamp to enable vitamin D3 synthesis. (NB. Measurements were taken to 60cm distance with lamp ref. BZUVB1 and extended to 100cm distance with lamp ref. BZUVB2)

Fig. 8. UV Index (Solarmeter 6.5 readings)

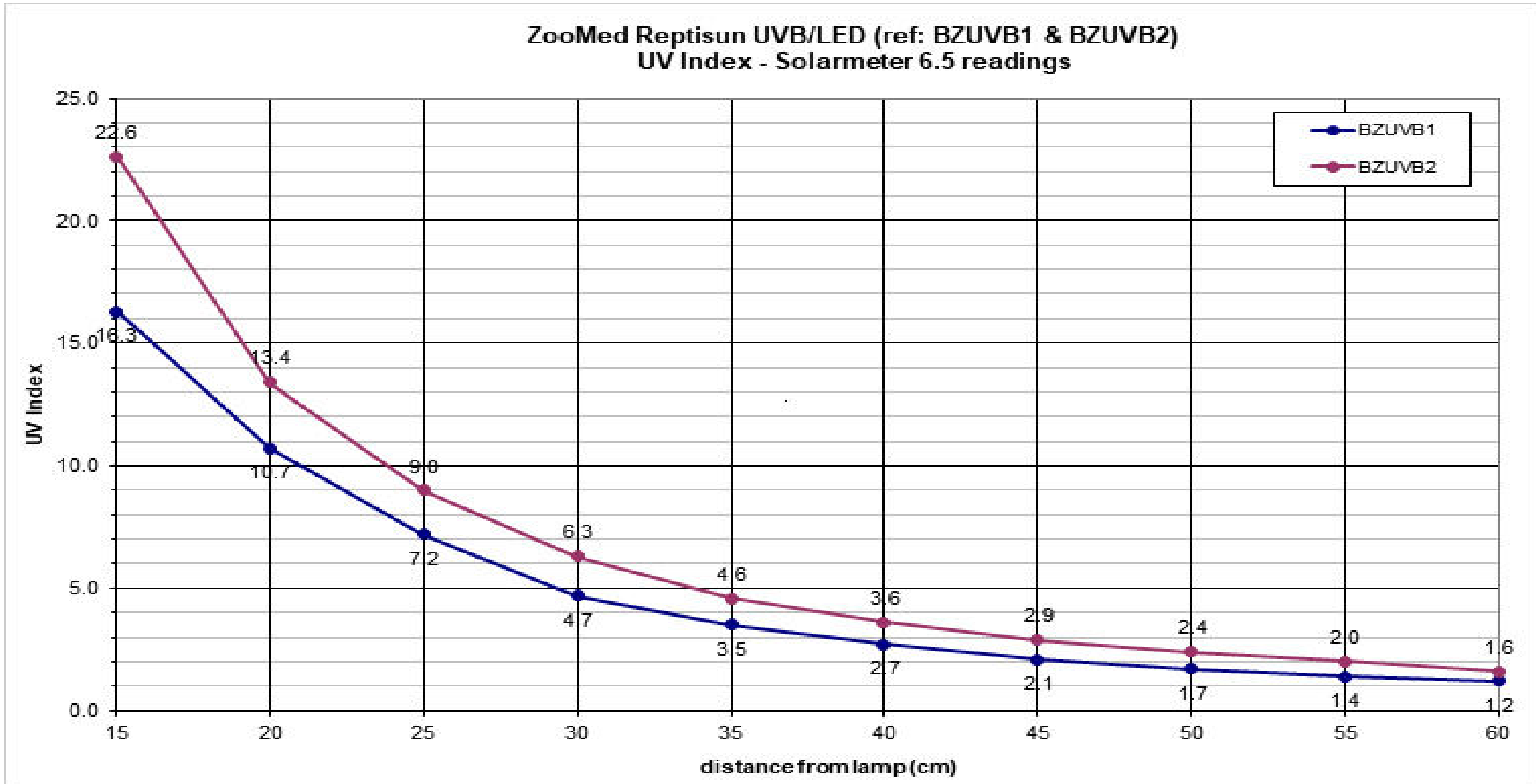
	Distance from lamp surface (cm)																	
	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
ReptiSun UVB/LED (BZUVB1)	16.3	10.7	7.2	4.7	3.5	2.7	2.1	1.7	1.4	1.2	-	-	-	-	-	-	-	-
ReptiSun UVB/LED (BZUVB2)	22.6	13.4	9.0	6.3	4.6	3.6	2.9	2.4	2.0	1.6	1.4	1.2	1.0	0.9	0.8	0.8	0.7	0.6

These readings suggest that as long as the use of UV Index is a safe guide, these lamps can be used to provide UVB to species with low requirements (e.g. Ferguson Zone 1, blue shading) at distances of 55-65cm or more.
Occasional baskers (Ferguson Zone 2, green shading) require a basking zone at 40 - 60cm distance with a gradient to zero into shade.
Full sun baskers (Ferguson Zones 3 and 4, yellow and orange shading) require a basking zone 25 – 30cm below the lamp, with a gradient to zero into shade.
Even the most sun-tolerant reptiles should not have access closer than 25 - 30cm as the UVI becomes too strong for safety at close range.
Figure 9 (below) charts the UV Index readings from the same lamp using imperial measurements (inches).

Fig. 9. UV Index (Solarmeter 6.5 readings)

	Distance from lamp surface (inches)																	
	6	**8**	**10**	**12**	**14**	**16**	**18**	**20**	**22**	**24**	**26**	**28**	**30**	**32**	**34**	**36**	**38**	**40**
ReptiSun UVB/LED (BZUVB1)	16.1	10.4	7.0	4.5	3.4	2.6	2.0	1.7	1.4	1.2	-	-	-	-	-	-	-	-
ReptiSun UVB/LED (BZUVB2)	22.8	13.3	8.9	6.3	4.5	3.9	2.8	2.3	1.9	1.5	1.4	1.2	1.0	0.9	0.8	0.7	0.6	0.6

Figure 10 (below) shows the UV Index with increasing distance in graphical form from 15cm to 60cm distance.



Comparison with figures published by ZooMed

The ZooMed instruction leaflet supplied with the lamp has a table labelled as an Application Chart giving recommended distances for Ferguson Zone categories. These are also printed on the box. These are cited in the table below (Fig. 11.) along with the widely-recommended UVI ranges for the Ferguson Zones, and the readings measured in this study at the distances stated.

Fig. 11. ZooMed "Application Chart" in comparison with Ferguson Zone ranges and UVI measurements from this trial (lamp BZUVB2)

Ferguson Zone	Established Ferguson Zone ranges for max UVI in basking zone	**ZooMed Recommended Distances: Without Screen Cover**	Measured UV at closest match to those distances	**ZooMed Recommended Distances: With Screen Cover**	Estimated UVI at closest match to those distances (with 35% UV block)	Examples of species (listed on box)
Do Not Use	>UVI 8.0	1 - 8 ins (2 – 20 cm)		1 – 7 ins (1 – 18 cm)		
4	**UVI 8.0 – 4.5** ("Target" UVI 4.5 – 5.0)	9 - 15 ins (23 – 38 cm)	**UVI 13.4 – 4.6** (20 – 35 cm)	8 – 13 ins (20 – 35 cm)	**UVI 8.7 – 3.0** (20 – 35 cm)	Bearded dragon Uromastyx Haitian curlytail lizard Marginated & Sulcata tortoises
3	**UVI 7.0 – 3.0** ("Target" UVI 4.0)	16 – 24 ins (41 - 61cm)	**UVI 3.6 – 1.6** (40 – 60 cm)	14 – 21 ins (35 – 53 cm)	**UVI 3.0 – 1.3** (35 – 55 cm)	Green iguana Painted turtle Panther & Veiled chameleons Day gecko
2	**UVI 3.0 – 1.0** ("Target" UVI 2.0)	25 - 31 ins (63 – 79 cm)	**UVI 1.6 – 0.9** (60 – 80 cm)	22 – 26 ins (56 – 66 cm)	**UVI 1.3 – 0.6** (55 – 65 cm)	Green anole Eastern Box turtle Water dragon
1	**UVI 1.4 – 0.6** ("Target" UVI 1.0)	32 – 40 ins (81 - 102cm)	**UVI 0.9 – 0.6** (80 – 100 cm)	27 – 36 ins (68 – 91 cm)	**UVI 0.6 – 0.5** (70 – 90 cm)	Crested gecko Corn snake Leopard gecko Dart frog

Unfortunately, as can be seen from the above figures, the UVI ranges at the suggested distances do not correlate well with the Ferguson Zones. If used with no mesh screen, the **Zone 4** species should be no closer than 30-35 cm / 12-14 inches (UVI 6.3 – 4.6) and with a 35% screen, the minimum distance needs to be around 25 cm / 10 inches (UVI 5.9).

However **Zone 3** species cannot quite reach the target of UVI 4.0 in the basking zone at even the minimum suggested distance. With no screen, they need to be a little closer than the suggested 41 cm / 16 inches; with a 35% screen block they need to be 30 cm / 12 inches distance (UVI 4.1)

Zone 2 species fail to reach the target of UVI 2.0 at the suggested distances, with or without a screen in the way; with no screen, it would be achieved with a 55 cm / 22 inch gap; with a screen, they would need to be 45 cm / 18 inches below the screen (UVI 1.9).

Zone 1 species need a gap of about 80 cm with no screen, and 60 cm with a 35% screen block, to achieve a safe maximum target around UVI 1.0 in the basking zone. Greater distances do provide acceptable levels, however, up to 90 - 100 cm distance (i.e. down to UVI 0.6 in the basking zone). The distances needed between the lamp and the reptile for safety, for Zone 1 and Zone 2 species, are so great that it would appear that the lamp is unsuitable for use with these reptiles in most commercially-available terrariums (60cm or less in height). Arboreal species in particular require basking zones only a very short distance below the mesh, since they readily climb up to almost the top of the terrarium. Lamps with a much lower UVB output are needed for use in these situations.

Iso-Irradiance Chart

Iso-irradiance charts give a clear picture of the UVB gradient in terms of the width of the beam across the basking zone. Figure 12 (right) was plotted for the ReptiSun LED/UVB lamp BZUVB2 after 2 hours of use.

The individual UVB LEDs have narrow beams which overlap and create a single beam with an almost symmetrical pattern created by their interaction.

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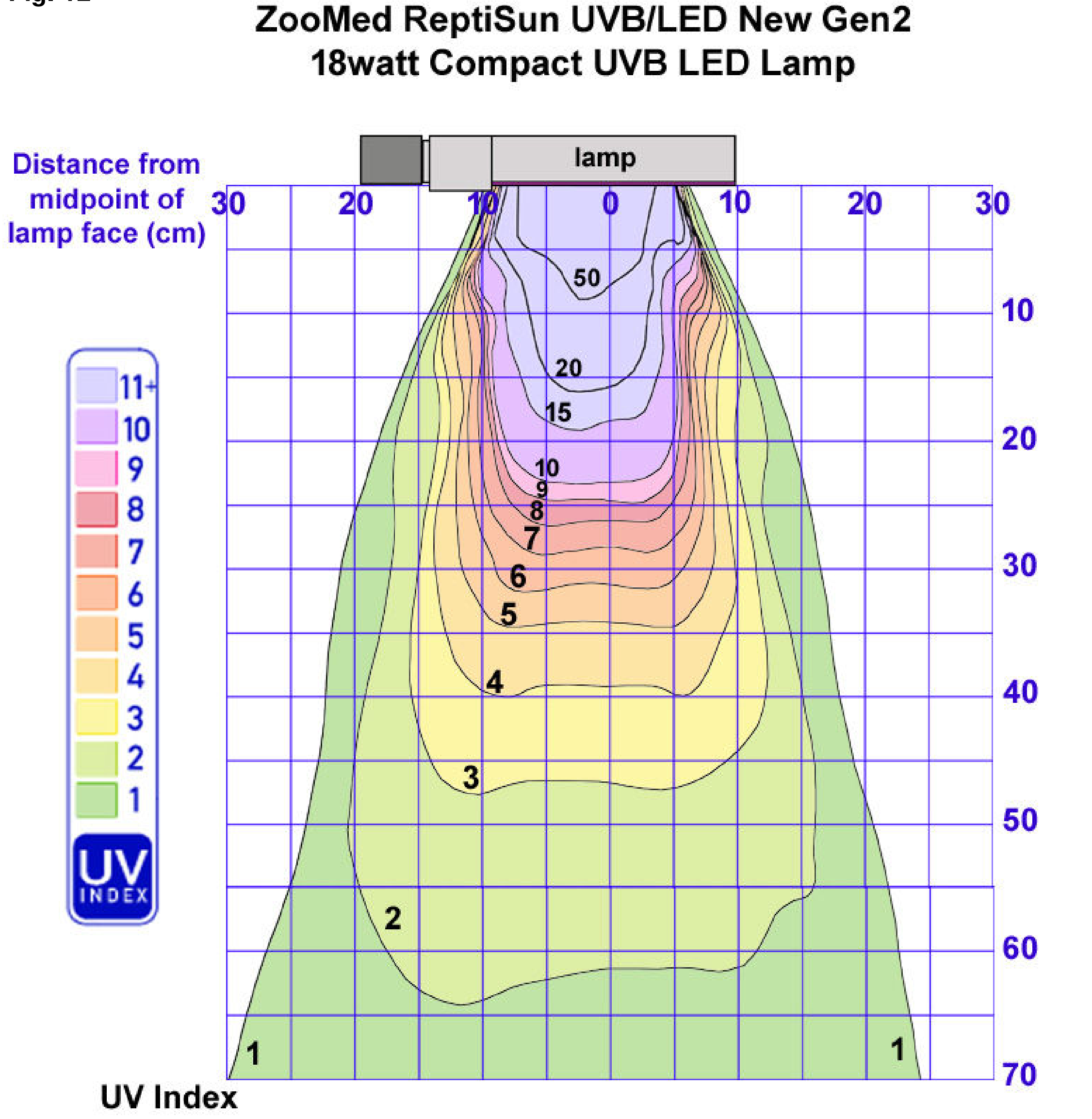
Fig. 12



UV Index iso-irradiance diagram (spread pattern) of lamp ref. BZUVB2 tested 19.02.2026 after 24hrs burn

Total UVB - 280 - 320nm

For some years now, measurement of the total UVB range (in µW/cm²) using another broadband meter, the Solarmeter 6.2, has become popular. For this reason, these measurements are routinely included in all reports.
The total UVB output of the lamp is shown in the table below (Figure 13).

Fig. 13. Total UVB µW/cm² **(Solarmeter 6.2 readings)**										
	Distance from lamp surface (cm)									
	15	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**55**	**60**
ReptiSun UVB/LED (BZUVB1)	265	195	133	95	69	53	42	34	28	23
ReptiSun UVB/LED (BZUVB1)	320	205	142	104	78	59	47	39	32	28

Relative Photobiological Activity

A simple, "rough-and-ready" estimation of the photobiological activity of the light emitted by a lamp can be made by comparing its total UVB output with that of natural sunlight when the UV Index of both is the same. It is only a crude estimation because broadband meters have a fixed sensor response affected by differing spectral power distributions. Moreover, different batches of Solarmeters (of either the 6.2 or 6.5) have slightly different spectral responses, so the actual ratios will vary between different Solarmeter pairs. However, this estimation has proven invaluable in the field, for detecting lamps with a dangerously high proportion of their output in the very low UVB wavelengths. This "Solarmeter 6.2 UVB : 6.5 UVI ratio" is unitless.
Paired readings with the current author's two meters, taken in sunlight across a wide range of solar altitudes and weather conditions in the UK, USA and Australia give a UVB : UVI ratio of between 35 : 1 and 60 : 1, depending upon solar altitude and degree of cloud cover. The higher the sun is in the sky, the greater is the proportion of short-wavelength UVB, and hence the lower the ratio.
When the solar UV Index is 3.5, the ratio is approximately 50 : 1; when it is 13.0, the ratio is 35 : 1. These figures are within the normal range for tropical sunlight at 8:30am and noon, respectively.
The following result was obtained by regression analysis of paired readings across measured distances from 15 – 60cm with these same two meters:

ReptiSun UVB/LED (BZUVB1) UVB : UVI = 17.4 : 1
ReptiSun UVB/LED (BZUVB2) UVB : UVI = 14.8 : 1

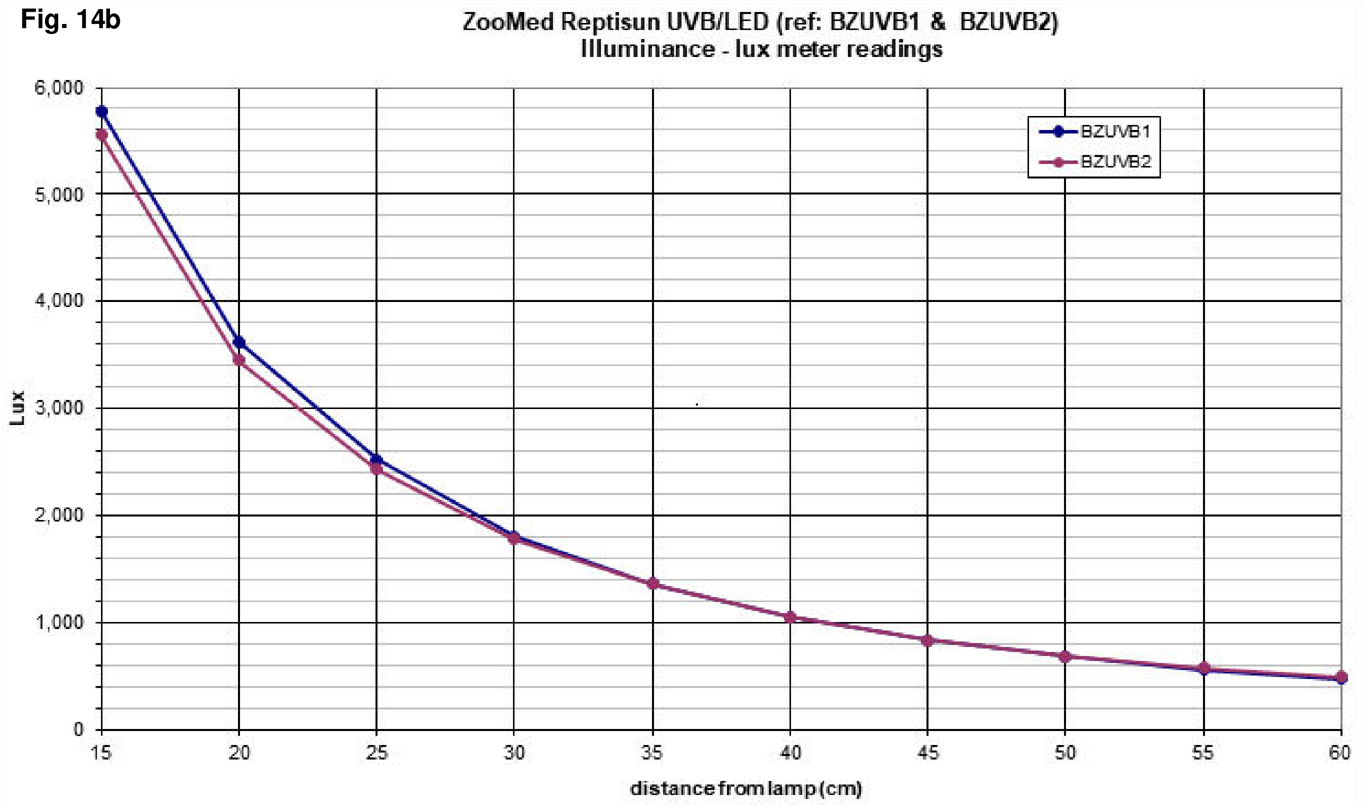
This result is what would be expected, given the spectral analysis of the lamps. The ratio is lower than seen from mid-day tropical sunlight, confirming that the light from the lamp has a much greater proportion of its UVB in the shorter UVB wavelengths than an overhead mid-day tropical sun. In simple terms, these lamps emit "strong" UVB and great care must be taken to avoid over-exposure even when UV Index readings seem within acceptable limits for the species.
However, most lamps which have in the past caused photokeratitis and "sunburn" to skin have been demonstrated to have UVB:UVI ratios less than 12:1 and to emit shorter wavelengths than sunlight, i.e., below 290nm.

Visible light output

Recordings taken with the SkyTronic LX101 model 600.620 digital lux meter from the two UVB/LED are shown in Figures 14a and b (below)

Fig. 14a. Illuminance (lux)										
	Distance from lamp surface (cm)									
	15	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**55**	**60**
Reptisun UVB/LED (BZUVB1)	5,780	3,620	2,520	1,800	1,360	1,050	834	682	559	476
Reptisun UVB/LED (BZUVB2)	5,550	3,450	2,430	1,780	1,360	1,050	838	688	577	493

Fig. 14b



For comparison, direct solar readings only five minutes after sunrise reach 3,000 – 5,000 lux. In clear weather, mid-day direct solar readings of 120,000 to 150,000 lux are often seen. It is obvious that alone, the visible light from the UVB/LED (e.g. 1,800 lux at 30cm) is not sufficient for illuminating any basking zone. Brighter light with a continuous spectrum needs to be combined with the UVB/LED in the basking zone, to create a "patch of sunlight". An incandescent "basking lamp" -necessary in any case, since the UVB/LED emits no short-wavelength infrared (IR-A) – will make a small but important contribution to the visible light; additional bright visible light from either a metal halide or a stronger "white" LED floodlight aimed at the basking zone would complete the "sunlight simulation" for many basking species.

UVC

The Solarmeter 8.0 broadband UVC radiometer measuring the UVC range (240 – 280nm), with filtering for extraneous UVA and UVB, gave zero readings at all distances. This is not surprising since UV LEDs have very restricted wavebands, and no UVC LEDs were used.

Electrical consumption

The electrical consumption of each lamp was measured at the time of testing, using a Prodigit power monitor (model 2000M-UK) with line voltage 237-240V (UK mains voltage).
The lamps (nominally 18 Watt) were operating at 12 Watts (22 VA, pf 0.55) drawing 0.09 amps at 240 volts. The power factor of only 0.55 means that the voltage and current waveforms are not in phase, so that although a lamp is running on only 12 watts, the apparent power is 22 watts and a higher current is drawn. This is normal with lamps of this type.

Discussion

UV LEDs, the solar spectrum, Vitamin D synthesis and more

The most important feature of any lamp used in animal husbandry must be that if used according to instructions, it is safe to put over an animal – safe for eyes, safe for skin, and safe for general long-term health.
The use of LED lighting itself is new to reptile husbandry, and yet it is widely replacing human lighting everywhere, from street lamps to desk lamps. The increased blue component is known to affect circadian rhythms in humans and other animals owing to its action on the brain via non-visual perception; however, since its use in reptile husbandry is largely restricted to daytime lighting, this is not normally considered to be a significant problem for the animals.
The situation regarding the use of UV LEDs is very different.
They are typically purchased "to enable vitamin D3 synthesis." Cutaneous vitamin D3 synthesis is a wavelength-dependent process, which evolved under natural sunlight. When UVB acts upon the natural cholesterol, 7-DHC, in the skin, a spectral power distribution and irradiance close to that of sunlight is needed to produce a natural balance of beneficial photoproducts, including pre-vitamin D3. Warmth causes pre-D3 to undergo thermal isomerization to vitamin D3, which then attaches to vitamin-D-binding protein and enters the bloodstream, to be carried away from the skin. Reptiles utilise the short-wavelength infrared from sunlight (IR-A) to provide the heat energy for this transformation in the upper layers of the skin. This is why the UV lamp needs to be used alongside incandescent "basking lamps" which emit the necessary IR-A.
It is also important to bear in mind that UVB and UVA have multiple effects on skin, apart from vitamin D synthesis, and that these, too, are wavelength-dependent effects. Beneficial ones, elicited by natural levels of exposure, include UVB upregulation of melanin synthesis, endorphin synthesis and modulation of the immune system, and UVA-induced anti-inflammatory effects, upregulation of antioxidant enzymes and production of nitric oxide, increasing blood flow to the skin and reducing blood pressure.
The spectrum must therefore be sunlike – and the irradiance similar to that to which the species would encounter in its natural microhabitat.
The UV LEDs currently available all have very short bandwidth – typically no more than about 20nm – and have a strong peak wavelength which gives a LED its name (e.g. 300nm LED, 450nm LED.) Reliable UV LEDs with good longevity are only available in a small number of nominal wavelengths at present. In addition, although the technology is advancing rapidly, most UVB LEDs are only available with a low output, necessitating multiple diodes of the same wavelength to build up a sufficient irradiance level in each part of the UV spectrum.

This makes it very difficult to recreate the sun's natural spectrum in the UV range, in which the irradiance increases with increasing wavelength. It requires juxtaposing a range of LEDs of steadily increasing wavelength, and the shorter UVA wavelengths are particularly difficult to reproduce.
The ZooMed Gen2 lamp is revolutionary in its use of short-wavelength UVA diodes. The blood test results from the small pilot study conducted by ZooMed are most encouraging, but the number of animals under the lamps was very small, and only from one species. *A full scale trial is now needed to confirm safety and efficacy across multiple taxa, and to demonstrate lamp reliability and longevity.*

UV Overexposure
Overexposure is almost always the result of the animal getting too close to the lamp, where irradiance may be dangerously high. When any artificial source of UV with unknown potential is used, animals should be monitored regularly for any sign of UVB damage to skin and eyes, since this is a symptom of acute over-exposure to high UV. The cornea (or spectacle of snakes and geckos) is usually affected first. Photo-kerato-conjunctivitis presents as an opacity or lesion on one or both corneas, causing intense pain. Affected animals will become immobile and depressed. Those with eyelids will keep the eyes permanently closed to reduce the pain. The eyelids often become swollen and their skin may appear burned. Fortunately, removing the UV source enables rapid healing in most cases. (See: Baines 2010). UVB does not penetrate the cornea; however UVA and visible light do, and intense radiation from these wavelengths may cause cataracts and retinal damage.
More severe UV overexposure causes UV radiation burns to the skin of the rest of the body as well. Milder burns resemble dysecdysis; more severe damage will form blisters and layers of dead skin which may slough. (See: Gardiner *et al.* 2009.)
Long-term exposure to abnormally high levels of UVA and/or UVB may predispose skin cells to undergo neoplastic changes, and skin cancers to develop. (See: Duarte and Baines 2009)
Damage due to overexposure is easily prevented by ensuring the animal cannot get closer to the lamp than the minimum recommended distance for exposure to a species-appropriate UV Index, and by ensuring that the lamp is out of the animal's line of sight, which usually means directly above the basking zone.

Lamp Longevity
This trial was carried out on new lamps with no measurement of decay in UVB output and can give no indication of the useful lifespan of these lamps. Long-term trials are required. Single-wavelength LEDs which do not succumb to overheating and are not subjected to abnormal electrical load may have very little further decay over the course of their lifetime, which depends upon the manufacturer's specifications. In this case, ZooMed claim a lifespan of "up to 4 years or 20,000 hours" for the UVB LEDs, printed on the packaging. No specific claim is made for the lifespan of the UVA or visible light LEDs.
"White" LEDs utilise a blue LED to activate a phosphor for the rest of the spectrum; this can degrade slowly, resulting in a reduction in light output. However, it is possible that their lifespan exceeds that of the UV LEDs. Unfortunately, because UV is invisible to us, it will not be possible to tell, without a UV meter, if or when the UV diodes fail. It is possible that their failure will not cut off the power supply to the rest of the lamp, in which case the lamp may appear no different to the human eye, but be emitting no UVA, or no UVB, or an altered spectrum with certain UV wavelengths missing, which could disrupt the vitamin D3 pathway in unpredictable ways. *This is an issue which urgently needs a solution to be found.*

Looking to the Future
With the phasing-out of lamps using mercury, and increasing concern with improving electrical efficiency, "general service" fluorescent tubes are to be banned from sale in multiple countries over the next two years. Eventually even "special use" fluorescent tubes such as those emitting UVB for use with reptiles will become obsolete and it seems likely that LEDs will take their place.
Lamps such as these UVB LEDs are a first major step in the right direction. If further steps are taken to prove them to be reliable, safe and effective, the future could be bright in more ways than one.

Author's note.

Individual lamps will vary in their UVB output, depending upon their original specifications and upon their age, the quality of the electrical supply, external temperature and doubtless, other factors. Only two lamps have been tested. To be certain that these are typical of their kind would require a much larger sample to be tested.
Because there will inevitably be differences between individual lamps, the charts for the lamps tested in this report should not be relied upon as an accurate guide to the exact output of all lamps of this type. Comments in this report reflect my personal opinions only.

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