LED-Lamps and Reptiles

Dr. rer. nat. Dipl. Phys. Sarina Wunderlich
www.lichtim-terrarium.de

UVB LED Lamps are available now

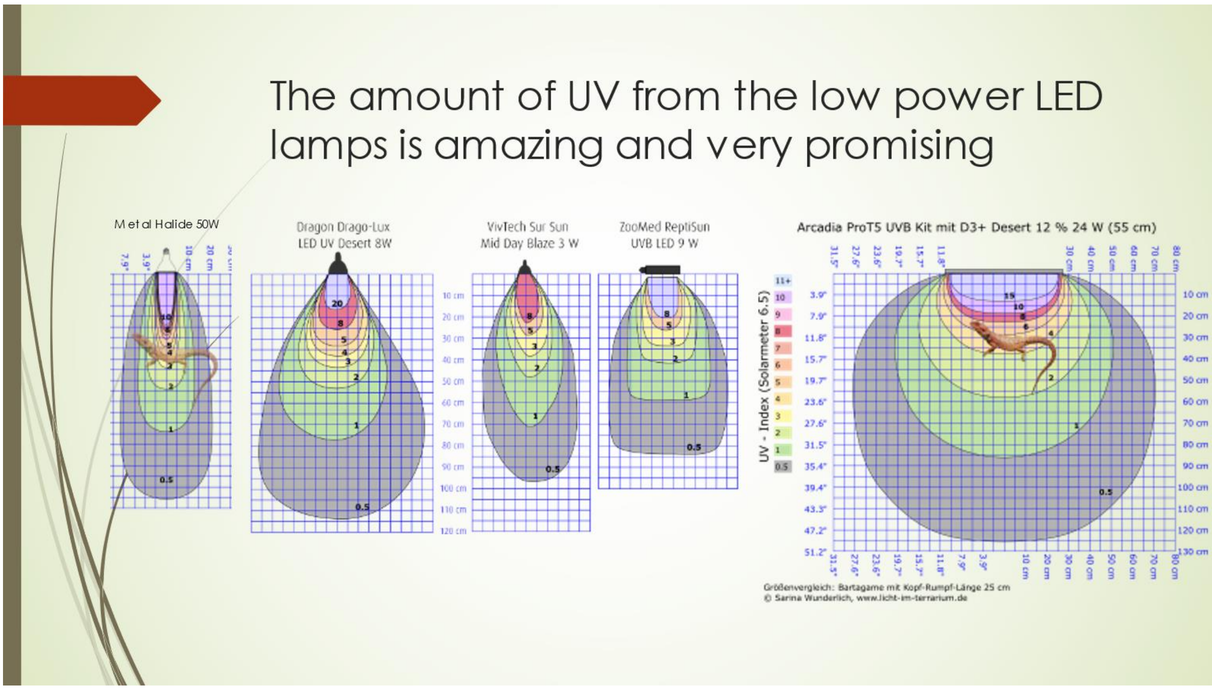
I will start with the UVB LEDs because I think you here are most excited about them.

These are lamps that I have tested during the last year.

Currently the UVB LED lamps are either small reflector lamps with E27 screw fitting that can be used like any standard lamp.

ZooMed and ReptileSystems have horizontal bars with E27 screw fitting.

The lamps are very low wattage. Only between 3 Watts and 13 Watts.



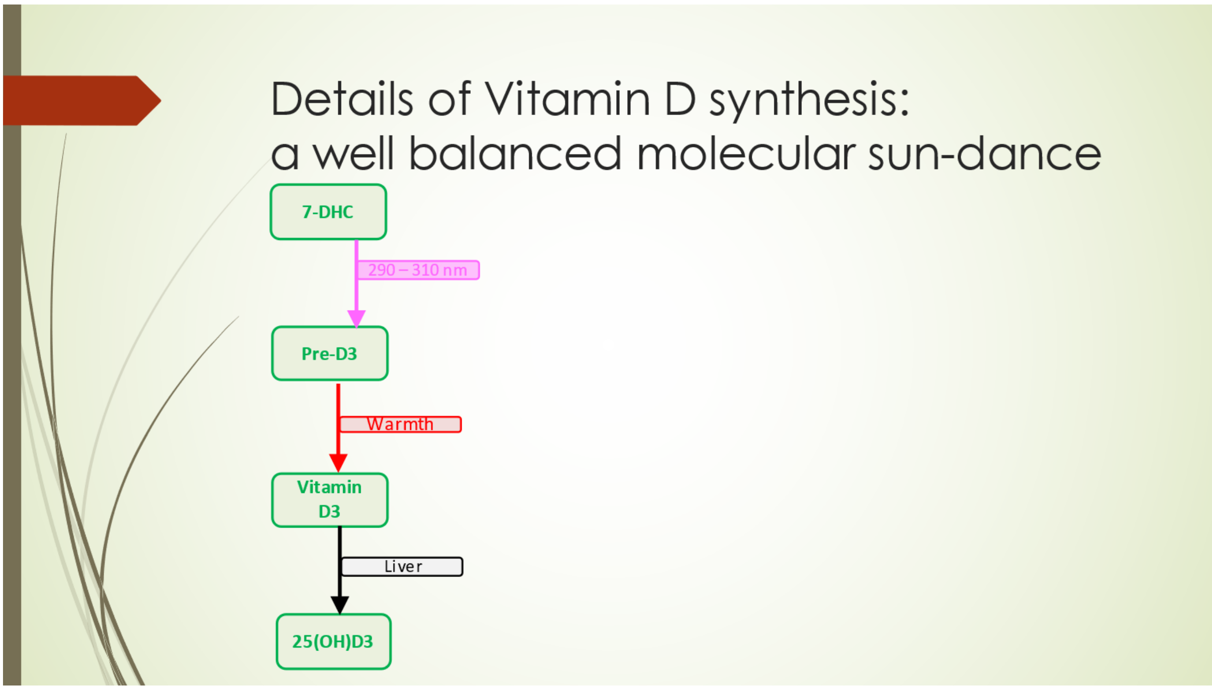
The amount of UV from the low power LED lamps is amazing and very promising.

I was really astonished how much UV is coming from these little lamps.

If you have a look at this 8 W lamp it gives off more UV than a 50 W metal halide lamp

and also compared to a 24W arcadia T5 this is a lot.

But … its not only about the strength of UV.

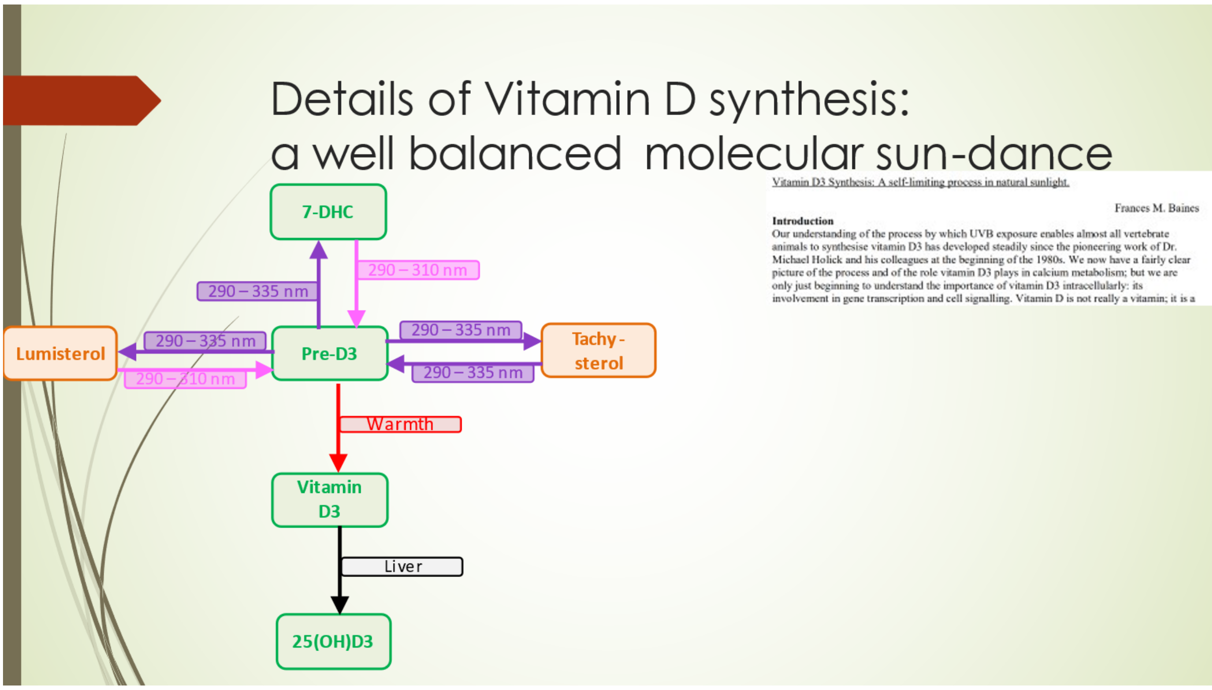


I guess everyone is familiar with this part of the vitamin D3 synthesis in skin:

7 DHC is converted to pre-vitamin D3 when it absorbs UV.

In the warm skin it then further converts to Vitamin D3 and goes to the blood stream.

But that is only half the story.



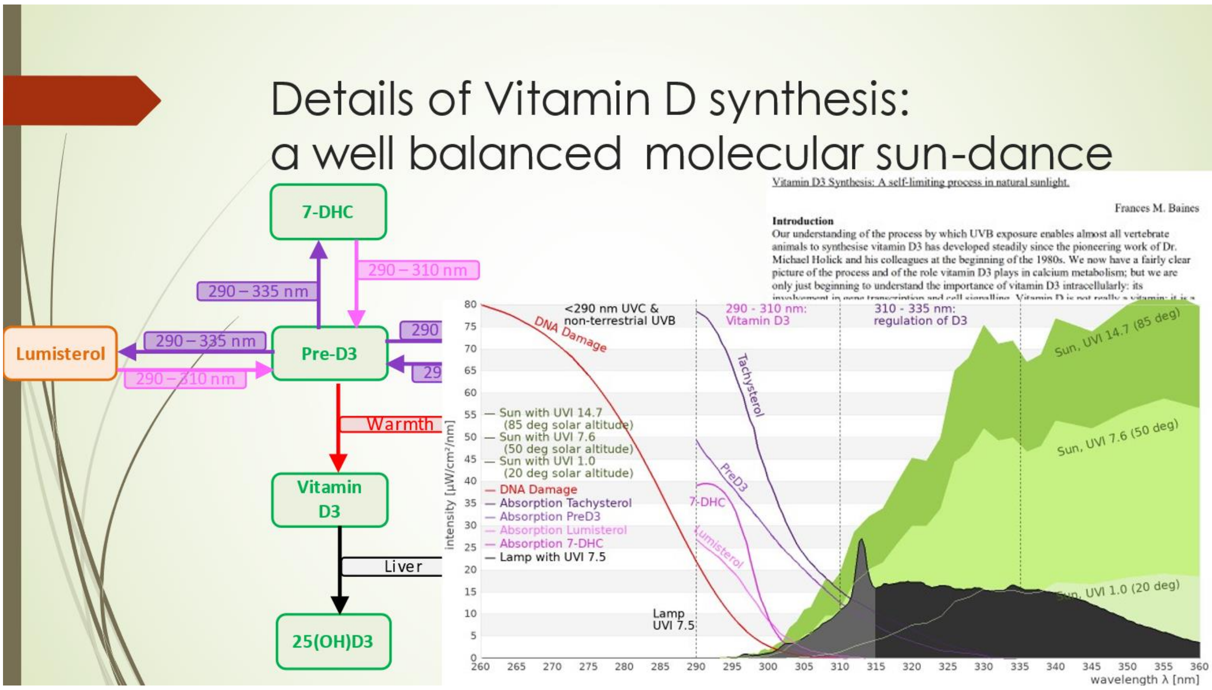
The PreD3 molecule can also absorb another UV photon of longer wavelength and convert back to 7DHC.

Or to Lumisterol and Tachisterol.

Both Lumisterol and Tachysterol can themselves absorb UV and convert back to pre D3.

I don't want you to memorize this chart, I just want you to understand, that it is a well balanced molecular dance where only a few of the 7 DHC molecules end up as Vitamin D3.

If you want to read more, Frances Baines has made a wonderful little pdf entitled "Vitamin D3 synthesis: A self-limiting process in natural sunlight".



The absorption spectra of all those molecules have been measured already in the 1980s.

We know that 7DHC and Lumisterol only can use the shortest wavelengths below 310 nm.

PreD3 and Tachysterol however also use the longer wavelengths up to 335 nm.

The shorter wavelengths are more likely to convert the molecule to Vitamin D3 and the longer wavelengths are more likely to convert the molucule to any of the other three substances.

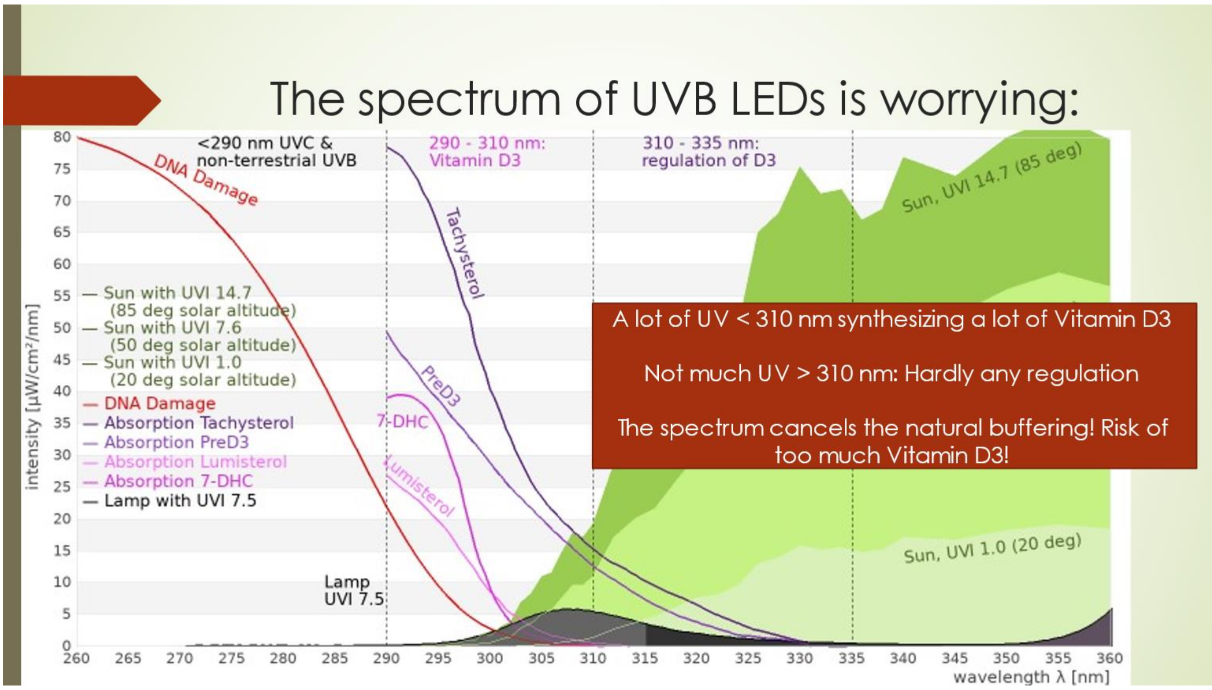
So we can say that 290 – 310 nm is responsible for the generation of Vitamin D3

and 310 – 335 nm is responsible to prevent a vitamin D3 overdose.

If you now look at the solar spectra:
There are three spectra, one very weak early morning sun with UV-index 1, one strong summer sun with UV index 7.6 and a extreme sunlight with UV 14.7.

All of these solar spectra have much more UV in the regulatory part of the spectrum.

And then this graph also shows the spectrum of a **good fluorescent lamp**.
Between 290 nm and 315 nm the spectrum follows exactly the solar spectrum.
There could be a bit more in the range 310 – 335 nm, but its okeyish.

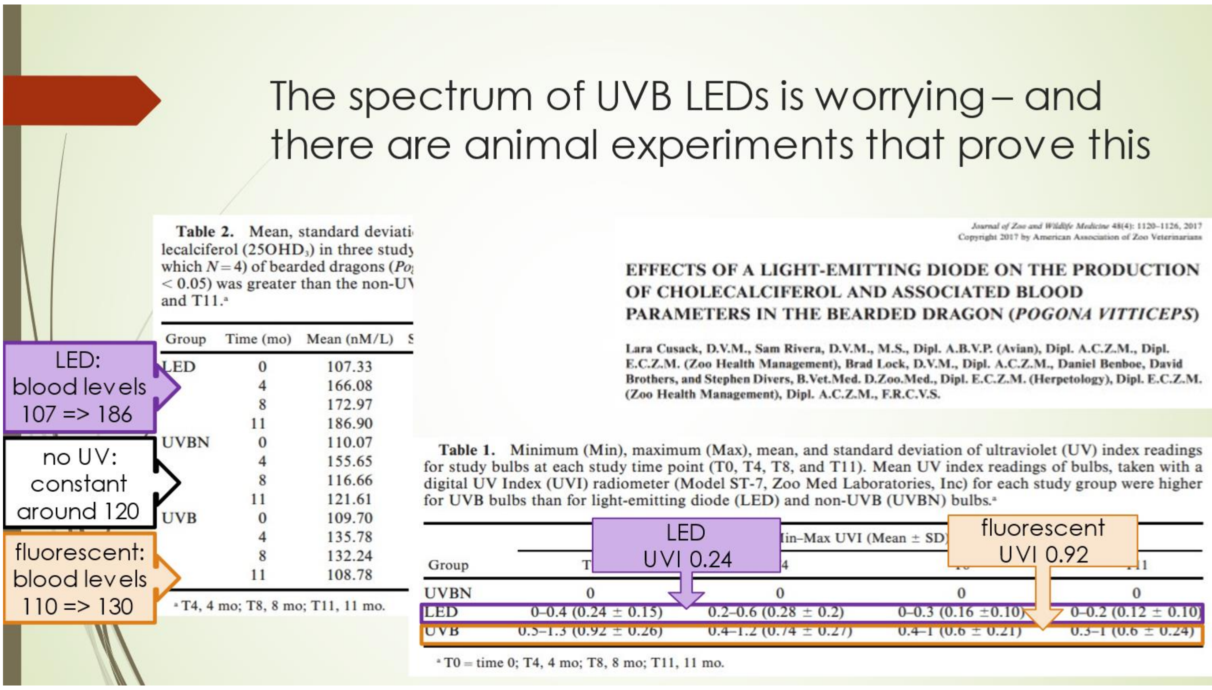


Now, if we compare that to the spectrum of a LED:
You see that LED has more intensity in the wavelengths below 300 nm than has the most intense sunlight.
We know that these wavelengths are most damaging to DNA and the skin.

We see that there is a lot of UV below 310 nm, so this lamp will synthesize a lot of Vitamin D3.

And there is not much UV between 310 and 335 nm. So we can expect hardly any regulation of the Vitamin D3 synthesis.

This spectrum cancels the natural buffing system.
All of nature’s inventions to exclude a Vitamin D3 overdose are overwritten.
There is a risk that this lamp will cause far too much Vitamin D3.



This so far has been theory.
But there are also some studies.
It has been measured how much Vitamin D is produced in the skin after exposure to UVB from LEDs.

I have picked this one: „Effects of a light-emitting diode on the production of cholecalciferol and associtated blood parameters in the bearded dragon“.

Three groups of bearded dragons were kept with different UV and the blood levels were checked for almost one year.
There was one group with no UV at all

one group with fluorescent light and UV-Index 0.92

and one group with LED with UV index 0.24

These are extremely low UV levels. Usually UV-Index 3-7 is recommended for bearded dragons. You would not expect any good blood levels from that.

But the result is a surprise.

The blood levels of the fluorescent group only rose a little bit,

the animals stayed deficient, as expected.

But the blood levels of the LED group rose to normal levels and kept rising all the time.

The spectrum of UVB LEDs is worrying – and there are animal experiments that prove this

Almost non-existent UVI (0.24) lead to high Vitamin D3 blood levels

What would happen with UVI 3– 7, as usually recommended for bearded dragons?

Severe risk ofhazardous, uncontrolled vitamin D3 synthesis!

Vitamin D3 overdose can be mistaken as Vitamin D3 deficiency

Table 2. Mean, standard deviati
lecalciferol (25OHD$_3$) in three study
which $N = 4$) of bearded dragons (Po
< 0.05) was greater than the non-U
and T11.[a]

Group	Time (mo)	Mean (nM/L)
LED	0	107.33
	4	166.08
	8	172.97
	11	186.90
UVBN	0	110.07
	4	155.65
	8	116.66
	11	121.61
UVB	0	109.70
	4	135.78
	8	132.24
	11	108.78

[a] T4, 4 mo; T8, 8 mo; T11, 11 mo.

LED: blood levels 107 => 186

no UV: constant around 120

fluorescent: blood levels 110 => 130

Tabl … for study bulbs at each study time point (T0, T4, T8, and T11). Mean UV index readings of bulbs, taken with a digital UV Index (UVI) radiometer (Model ST-7, Zoo Med Laboratories, Inc) for each study group were higher for UVB bulbs than for light-emitting diode (LED) and non-UVB (UVBN) bulbs.[a]

Group	T	4		1
UVBN	0	0	0	0
LED	0–0.4 (0.24 ± 0.15)	0.2–0.6 (0.28 ± 0.2)	0–0.3 (0.16 ±0.10)	0–0.2 (0.12 ± 0.10)
UVB	0.5–1.3 (0.92 ± 0.26)	0.4–1.2 (0.74 ± 0.27)	0.4–1 (0.6 ± 0.21)	0.3–1 (0.6 ± 0.24)

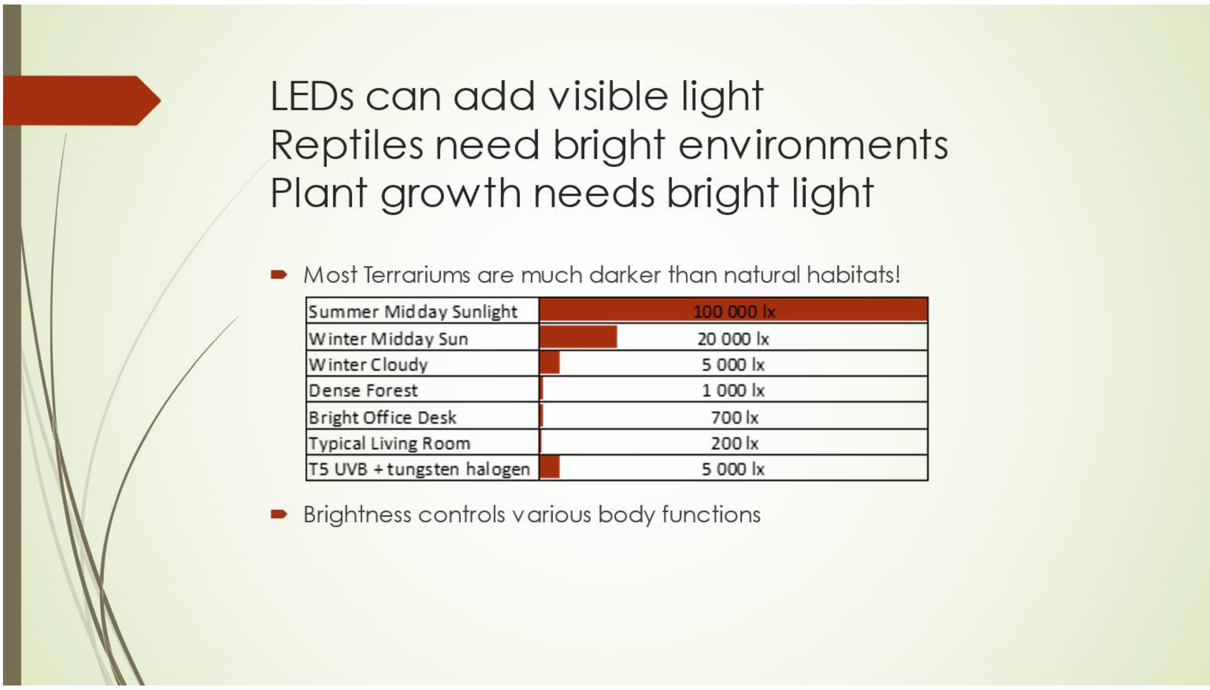
[a] T0 = time 0; T4, 4 mo; T8, 8 mo; T11, 11 mo.

LED UVI 0.24

fluorescent UVI 0.92

Summary UVB LEDs

- Do **NOT** use them now!
- The current spectrum is worrying, likely causing Vitamin D3 overdose
  - Vitamin D3 overdose can look similar as vitamin D3 deficiency!
  - Spectrum can be improved technically, but that needs time
- Many aspects are very promising
  - Broad spread of the light, suitable for larger animals
  - Long life span
  - Easy to use lamps (E27, no external ballast, small, lightweight)
  - No mercury (environment, legislation, no health risk when breaking)
- I expect that in 10-20 years time LEDs will replace other UVB lamps



Now to my second parts. What about standard white LEDs without UVB.

They can add visible light.

Reptiles need bright environments. And also plant growth needs bright light.

Most terrariums are much darker than natural habitats.

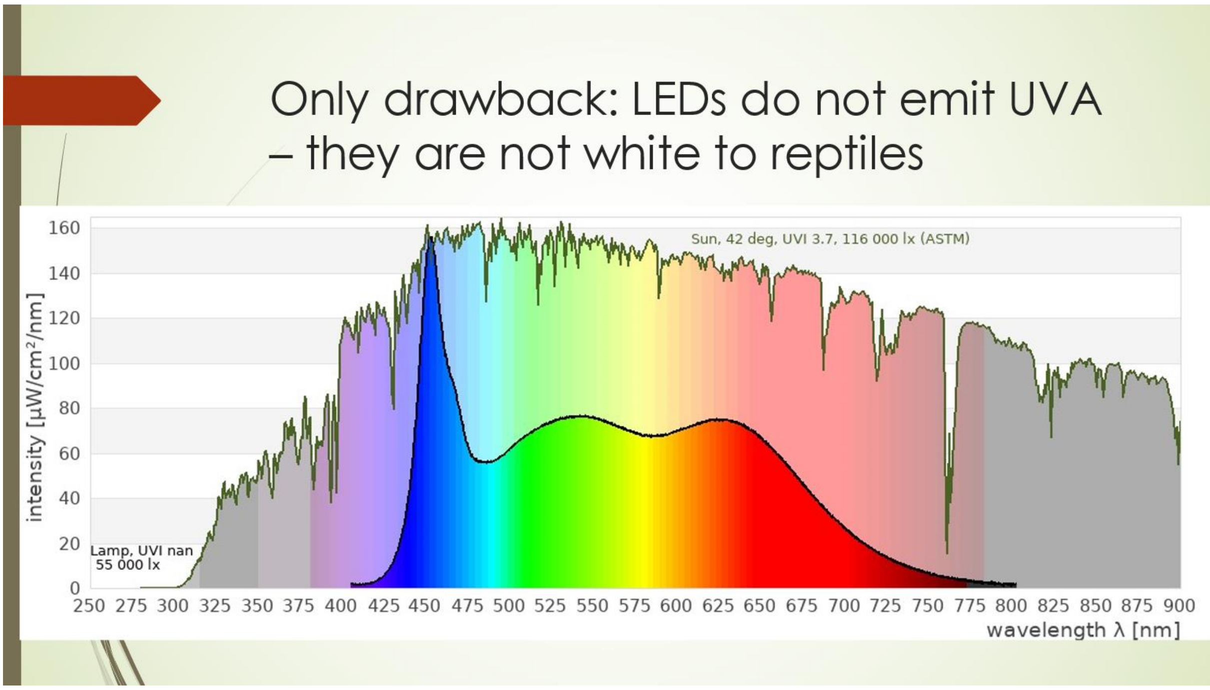
Typically summer midday sunlight reaches more than one hundred thousand lux.

A bright office desk is around seven hundered lux.

A terrarium with a T5 UVB and a tungsten halogen lamp with around five thousand lux might look bright compared to that.

But its nothing compared to summer sunlight.

So LEDs can help there. And again there is a but …



The only drawback of LED is: They do not emit UVA. What means, that they are not white to reptiles.

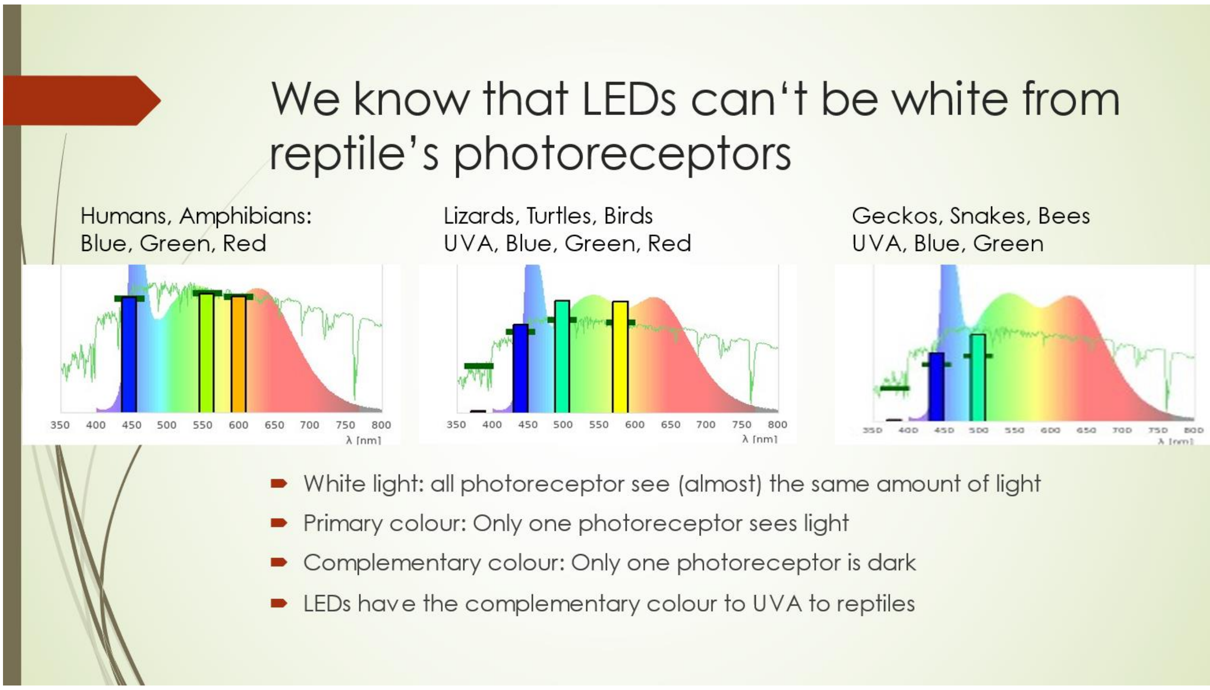
Let‘s have a look at the spectrum of a standard high quality LED.

It has a peak in the blue from the primary blue LED and then a broad peak from one or in this case two phosphors.

There is no light below 420 nm.

This is the case in every single LED, no matter what the Colour Rendering Index or Correlated Colour Temperature is.

Sunlight in contrast has plenty of UVA.



We know that the LEDs can’t be white to reptiles from the reptile’s photoreceptors.

Humans and also Amphibians have three photoreceptors, blue, green, and red.

The LEDs spectrum is tuned, so that all see almost the same amount of light.

Lizards and Turtles, as well as Birds have a fourth photoreceptor in the UVA.

This UVA receptor does not perceive light from an LED, because the LED does not emit UVA.

And then there are geckos, snakes, and bees that have tree photoreceptors, UVA, blue and green.

Again here, the UVA photoreceptor does not see light.

There is a convention to call light white, when all photoreceptors see almost the same mount of light.

This is a universal concept. You might have heard of white noise, where all the frequencies, that a human ear can perceive have almost the same intensity.

And we call a colour a primary colour, when only one photoreceptor sees light.

For example if only the red cone in our human eye sees light, we perceive this as red.

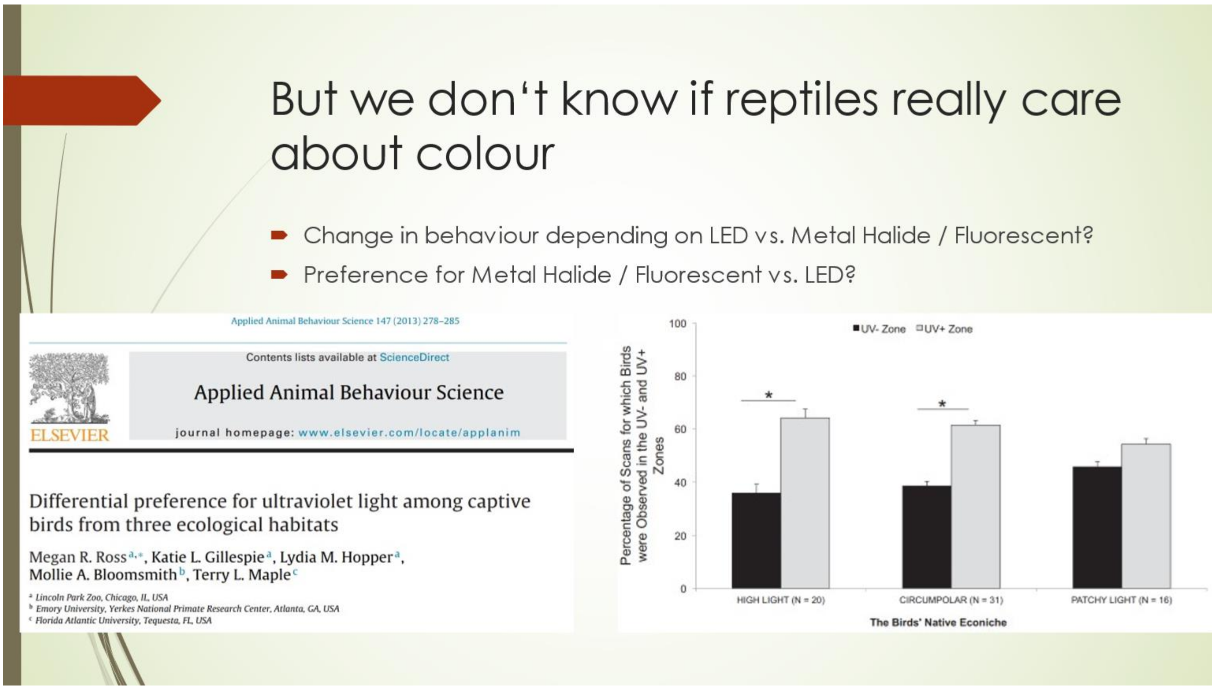
I am keeping it very simple her due to the lack of time. If you are a photographer you might know that there are more details to this.

And we call light a complementary colour to that primary colour, if only one photoreceptor is dark.

For humans, if only the green and the blue cone see light, the light is cyan. The complementary colour to red.

So for LEDs, where only the UVA photoreceptor stays dark, the light has the complementary colour to UVA to reptiles.

Perhaps it looks something like cyan to them.



So, we can be certain, that LEDs are not white to reptiles. But we currently do not know, if they care about that.

To my knowledge there is no study that investigated if reptiles change their behaviour when they are kept under LED light compared to real full spectrum lamps like metal halides or fluorescent lamps with UVA.

There is also no study that investigates if reptiles show a preference when they are able to chose between a terrarium with LED and one with full spectrum light.
The anecdotes do not give a clear picture.

There are a few studies on birds, some of them show a clear preference of birds for the half of their aviary where UV fluorescent lamps were used.

But sadly we do not know if reptiles care for colour. If they don't that's fine and makes our lives much easier. But I would prefer that to be studied before we all switch to LED lighting.

Summary

LEDs for visible light

- Reptiles benefit from bright light
- Standard LEDs do not emit UVA – they can not be white to reptiles and must have a strong colour
- Reptiles are effectively colour-blinded, when LEDs are used
- Birds show a preference for light sources with UVA
- No studies on reptile behaviour are available, no obvious negative effects have been seen so far.
- LEDs are likely safe to use, but do not replicate sunlight, even with good CCT and CRI (only valid for human eye)
- Alternatives: Lamps with balanced spectrum:
  - Metal halide lamps
  - Fluorescent lamps with special UVA phosphor (gold standard Sylvania Activa F172; UVB-lamps have mainly short-wavelength UVA, not visible to reptiles)

UVB LEDs

- Do **NOT** use them now!
- The current spectrum is worrying, likely causing Vitamin D3 overdose
  - Vitamin D3 overdose can look similar as vitamin D3 deficiency!
  - Spectrum can be improved technically and be made like sunlight, but this needs some engineering time.
- Many aspects are very promising
  - Broad spread of the light, suitable for larger animals
  - Long life span
  - Easy to use lamps (E27, no external ballast, small, lightweight)
  - No mercury (environment, legislation, no health risk when breaking)
- I expect that in 10-20 years time LEDs will replace other UVB lamps