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Evidence-based practice

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

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Abstract

Guidance is almost non-existent as to suitable levels of UV lighting for reptiles and amphibians, or how to achieve satisfactory UV gradients using artificial lighting. The UV-Tool is a working document that seeks to address this problem, by considering the range of UV experienced by each species in the wild. The UV-Tool contains an editable and expanding database of the microhabitat requirements and basking behaviour of reptile and amphibian species, as derived from field studies, or inferred from observed behaviour in captivity. Since an animal's UV-B exposure is determined by its behaviour within its native microhabitat, estimation of its natural range of daily UV-B exposure is then possible. The current version of the UV-Tool assigns 254 species to each of four 'zones' of UV-B exposure (Ferguson zones) based upon UV-index measurements. Once the likely UV requirement of any species of reptile or amphibian is ascertained, the next step is to plan safe but effective UV gradients within the captive environment. To do this requires knowledge of the UV spectrum and output of the lamps to be used. The UV-Tool therefore includes test reports and UV-index gradient maps for commercially available UV-B lighting products, and a guide to selection of appropriate lamps for use in vivaria and in larger zoo enclosures. There are reports on 24 different products in the current version of the UV-Tool. This document has been compiled by members of the British and Irish Association of Zoos and Aquaria (BIAZA) Reptile and Amphibian Working Group (RAWG) with contributions from zookeepers and herpetologists from the UK and abroad. Further input is welcome and encouraged.

Introduction

The provision of UV lighting to captive reptiles and amphibians is widely recommended (e.g. Rossi 2006; Carmel and Johnson 2014; Tapley et al. 2015). However, guidance as to suitable levels of UV-B for different species, and how to achieve satisfactory UV gradients, is almost non-existent. The aim of this project is to create a working document that can be used as a guide to suitable UV lighting for all reptiles and amphibians kept in captivity. The project was initiated by the UV Focus Group of the British and Irish Association of Zoos and Aquaria (BIAZA) Reptile and Amphibian Working Group (RAWG).

Every aspect of the life of a reptile or amphibian is governed by its daily experience of solar light and heat – or the artificial equivalent, when it is housed indoors. All wavelengths from infra-red to ultraviolet (UV) may be utilised by these animals, and are received in amounts that depend upon their microhabitat and their daily activity patterns. Ultraviolet is a normal component of sunlight. It is subdivided by wavelength; natural sunlight consists of a short-wavelength fraction, UV-B (290–320 nm) and a longer-wavelength fraction, UV-A (320–400 nm).

UV-A from around 350 nm is within the visual range of many reptiles and amphibians, which use it in recognising conspecifics and food items (Govardovskii and Zueva 1974; Moehn 1974; Fleishman et al. 1993; Honkavaara et al. 2002); its provision within the spectrum is therefore very important.

Short-wavelength UV-B (290–315nm) enables the conversion of 7-dehydrocholesterol (7DHC), a sterol in the skin, to pre-vitamin D_3. In skin this undergoes a temperature-dependent isomerisation into vitamin D_3, which is metabolised by the liver and subsequently by the kidney into the vital endocrine hormone calcitriol, controlling calcium metabolism. It is also metabolised into calcitriol intracellularly throughout the body, where in mammals it has been shown to perform multiple autocrine and paracrine functions, controlling transcription of as many as 2000 genes that influence functions as diverse as growth, insulin production and the immune system (Hossein-nezhad and Holick 2013). Overproduction of vitamin D_3 is prevented by the conversion of excess pre-vitamin D_3 and vitamin D_3 into inert photoproducts by UV-B and short-wavelength UV-A (range 290–335nm), effectively making this natural process, in sunlight, self-limiting (MacLaughlin et al. 1982; Webb et al. 1989). Although most research on vitamin D_3 has been carried out on mammals, studies conducted on other taxa indicate that vitamin D pathways are similar in most terrestrial vertebrates (Holick et al. 1995; Bidmon and Stumpf 1996; Antwis and Browne 2009).

As well as its role in enabling and regulating cutaneous vitamin D synthesis, UV has direct effects upon skin, which include modulation of the cutaneous immune system, strengthening of skin barrier functions and increasing pigment formation. It also stimulates production of beta endorphins, giving sunlight its ‘feel good’ factor, and induces nitric oxide production, which has localised protective effects (Juzeniene and Moan 2012). Solar UV is also an effective disinfectant (McGuigan et al. 2012) that can destroy bacteria, fungi and viruses on the surface of the skin.

Excessive exposure to UV must, however, be avoided. High doses and/or exposure to unnaturally short-wavelength UV from artificial sources can result in eye and skin damage, reproductive failure or even the death of amphibians (Blaustein and Belden 2003) and reptiles (Gardiner et al. 2009), and in mammals, can lead to the formation of skin cancers (Soehnge 1997). Squamous cell carcinomas have been reported in captive reptiles but the significance of their association with the use of artificial UV lighting is as yet undetermined (Duarte and Baines 2009; Hannon et al. 2011).

Species vary widely in their basking behaviours or lack of them (Avery 1982; Tattersall et al. 2006; Michaels and Preziosi 2013), their skin permeability to UV radiation (Porter 1967; Nietzke 1990) and in their response to UV-B in terms of vitamin D_3 production (Carman et al. 2000). These behavioural and morphological characteristics optimise their UV exposure for vitamin D synthesis and the other beneficial effects of sunlight, whilst simultaneously minimising the risk of UV damage, but these adaptations are only relevant for the solar irradiation they experience in their native microhabitat. Thus it would seem very important to match the solar UV spectrum as closely as possible, and to recreate the levels of irradiance found in this microhabitat, when providing reptiles and amphibians with artificial lighting.

In nature the levels of UV irradiance at any one location vary continuously, unlike the situation in a typical vivarium, in which a UV-B-emitting lamp is either on or off. The greatest determinant of irradiance is the solar altitude – the height of the sun in the sky – because at low solar altitudes the rays must pass through a thicker layer of atmosphere, which selectively absorbs and scatters shorter wavelengths. Under clear skies, the solar UV-B levels rise from zero at dawn, to a maximum around noon, then fall again to zero at sunset (e.g. Michaels and Preziosi 2013). Clouds scatter and absorb all wavelengths, and may greatly reduce irradiance. However, meteorological data cannot be representative of conditions within a microclimate. At any time of day, sunlight also interacts with features in the animal’s environment such as trees, rocks, plants and water, creating superimposed gradients of heat, light and UV extending from full sunlight into full shade. Reptiles and amphibians perceive these gradients and may use light intensity as a cue for thermoregulation (Sievert and Hutchison 1988, 1989, 1991; Hertz et al 1994; Dickinson and Fa 1997) and in some cases for UV photoregulation (Manning and Grigg 1997; Ferguson et al. 2003; Karsten et al. 2009). The animal’s response will determine its exposure within these gradients. Variation in behaviour creates enormous differences in UV exposure between species, ranging from mid-day full-sun baskers to nocturnal and crepuscular animals, which may receive the majority of their ultraviolet exposure from small amounts of daylight reaching them in their diurnal retreats.

The creation of similar superimposed heat, light and UV gradients using UV-B-emitting lamps, often in combination with other sources of heat and light, is possible because their irradiance is proportional to the distance from the lamp. The task requires knowledge of (1) the range of irradiance appropriate for the species and (2) the gradients created by individual lighting products, which may be used individually or in combination to produce the desired effect.

The range of irradiance appropriate for the species

Research on this topic is in its infancy, even with regard to human beings. There is hardly any scientific data to back the recommendation of any particular level of UV-B for any particular species. Until very recently, no practical methods existed for recording ambient UV-B in the microhabitat of free-living reptiles and amphibians. However, Ferguson et al. (2010) reported the UV exposure of 15 species of reptiles in the field during their daily and seasonal peak of activity, using the unitless UV index (UVI), as measured with a Solarmeter 6.5 UV Index meter (Solartech Inc., Harrison Township, Michigan, USA), and demonstrated that knowledge of the basking/daylight exposure habits of any species enables a reasonable estimation of likely UV exposures to be made. They allocated species into four sun exposure groups or ‘zones’, which have since been designated ‘UV-B Zones’ or ‘Ferguson zones’ (Carmel and Johnson 2014; Ferguson et al. 2014). For each zone, a range of figures was given for the mean voluntary UVI exposures calculated from all readings (Zone Range), and for the maximum UVI in which the animals were encountered. The Ferguson zones are summarised in Table 1.

Any species can be assigned to one of the four zones based upon its basking behaviour. The authors suggest that a suitable UV gradient may then be provided in the captive animal’s environment using these figures as a guide. Such a gradient should enable the animal to self-regulate its exposure from zero (full shade) to the maximum indicated for that zone, which would be provided at the animal’s closest access point to the lamp.

Table 1. The Ferguson zones, summarised from Ferguson et al. (2010). Species are grouped into four zones according to their thermoregulatory behaviour and microhabitat preferences, with the UVB reference guidelines determined from average irradiance of randomly encountered individuals in the field.

	Characteristics	Zone range UVI	Maximum UVI
Zone 1	Crepuscular or shade dweller, thermal conformer	0–0.7	0.6–1.4
Zone 2	Partial sun/occasional basker, thermoregulator	0.7–1.0	1.1–3.0
Zone 3	Open or partial sun basker, thermoregulator	1.0–2.6	2.9–7.4
Zone 4	Mid-day sun basker, thermoregulator	2.6–3.5	4.5–9.5

The gradients created by individual lighting products

The suitability of any light source is governed by two main features: its quality (the spectrum) and quantity (the irradiance received by the animal). The template for the ideal spectral power distribution is the solar spectrum, under which life evolved and to which all life on the planet's surface is adapted. Direct comparisons of lamp spectra with the solar spectrum are therefore required.

With regard to quantity, the irradiance at any given distance from a lamp is a function of the output of the lamp and the way the light is distributed, i.e. the shape of the beam. For example, a fluorescent tube that radiates a diffuse, relatively low level of UV-B from its entire surface will produce a very different UV-B gradient and basking opportunity than a mercury vapour spot lamp that emits a very narrow beam of intense UV-B light only a few centimetres across. The use of various lamp reflectors, shades or luminaires can also dramatically affect the shape of the beam and the intensity of UV at any given distance. It is therefore important to plot an iso-irradiance chart for each lamp, to assess its effectiveness. However, in previous studies the irradiance from UV-B lamps has usually been measured at standard distances from the lamp, regardless of the lamp type and the shape of its beam (Gehrmann 1987; Gehrmann et al. 2004b; Lindgren 2004; Lindgren et al. 2008).

A hand-held broadband meter is a practical instrument for measuring both solar UV irradiance in the field and lamp irradiance indoors. However, different brands and models of broadband UV-B meters (range 280–320 nm) will have different spectral responsivity. Unless they are specifically calibrated for the spectral power distribution of a particular lamp, each meter may give a different reading from that lamp at any given distance (Gehrmann et al. 2004a). In addition, only a very narrow band of shorter wavelengths in the UV-B range (295–315 nm) contribute to vitamin D_3 synthesis; measurements including irradiance from longer wavelengths may be misleading as to the effectiveness of a lamp.

Unlike broadband UV-B meters, which respond to the entire range of UV-B wavelengths, the Solarmeter 6.5 UV Index meter (Solartech Inc., Harrison Township, Michigan, USA) used by Ferguson et al. (2010) has strong filtration of the longer wavelengths, resulting in a spectral responsivity with a 96% overlap to the CIE pre-vitamin D_3 spectrum (CIE 2006) from 290 to 400 nm (S. Wunderlich, pers. comm.). This enables a reasonable estimate of the vitamin D-synthesising potential of sunlight and any artificial source. The readings are displayed in the unitless UV index, which is beneficial for interpretation as it is a well known measurement of 'sun strength' as determined by human erythema, which has a similar, but not identical, action spectrum (CIE 1998) to the pre-vitamin D_3 spectrum. The Solarmeter 6.5's spectral response falls about halfway between the two (Schmalwieser et al. 2006). When its UVI measurements were compared with data provided by a Bentham spectrometer, a very accurate sensor used for UV measurements, deviations of only ±5% were found, which are within the range commonly expected for scientific instruments (de Paula Corrêa et al. 2010). This meter is therefore suitable for measuring the irradiance from sunlight and from a lamp at specific distances, and for plotting the shape of the lamp's beam, to create an iso-irradiance chart.

Methods

A database was compiled of basic information on each species of reptile and amphibian held by the authors' current institutions. Each species was assigned to a Ferguson zone based on an assessment of its basking behaviour, derived from published or personal studies made in the field if possible, but if not, from observations of the animal's behaviour in captivity. Further information on the animal's natural microhabitat and thermal requirements was added, to assist the keeper in choosing appropriate lamp combinations for creating a suitable lighting and heating gradient within the enclosure. The database included the following information:

- Species (Latin name, common name)
- Biome (Major biome or Terrestrial Ecoregion as defined by Olson et al. (2001) and adopted by the World Wildlife Fund (WWF 2015)
- Ferguson zone
- Photoperiod
- Winter treatment, if any (cooling, brumation or hibernation)
- Basking zone temperature (substrate surface temperature)
- Daytime ambient (air) temperature (summer and winter)
- Night ambient (air) temperature (summer and winter)
- Microhabitat, including specialist requirements added as 'comments'

A selection of 24 widely available UV-B-emitting lighting products was fully tested by one of the authors (FB). The lamps were switched on for 15 hours per day until a total of 105 hours was completed before testing, approximating the industry standard 'burning-in' period of 100 hours (IESNA 1999).

All measurements were carried out with the lamps in simple fixtures, with no shades or reflectors, above a test bench, after a 30-minute warm-up period. Recordings included:

- Spectrograms (Ocean Optics USB2000+ spectral radiometer with a UV-B compatible fibre-optic probe with cosine adaptor: Ocean Optics Inc., Dunedin, FL 34698 USA)
- UV Index (Solarmeter 6.5 UV Index meter: Solartech Inc., Harrison Township, MI 48045 USA)
- Total UV-B: 280–320nm (Solarmeter 6.2 broadband UVB meter: Solartech Inc., Harrison Township, MI 48045 USA)
- UV-C (Solarmeter 8.0 broadband UVC meter: Solartech Inc., Harrison Township, MI 48045 USA)
- Visible light output (SkyTronic LX101 model 600.620 digital lux meter: SkyTronic B. V., Overijssel, Netherlands)
- Electrical consumption (Prodigit power monitor model 2000M-UK: Prodigit Electronics, New Taipei City, Taiwan)

For those lamps emitting UV-B in appropriate wavelengths for vitamin D_3 synthesis, as indicated by their spectral analysis, an iso-irradiance chart mapping the UV index gradient was constructed according to a method described previously (Baines 2015). The ability of each lighting product to provide irradiances within the UV index ranges appropriate to each Ferguson zone was documented and guidelines drafted regarding methods of lamp choice.

The species database, lamp test results and guidelines were compiled into a draft Excel document. This was distributed to the wider BIAZA RAWG community and to a small number of herpetologists and private keepers with specialist knowledge. All recipients of the draft document were requested to submit reviews of the UV-Tool and data for additional species held in their collections, including references to their source material where appropriate. The first draft was distributed in December 2012, listing 190 species from the five zoological collections to which the co-authors were affiliated. Between January 2013 and October 2015 contributions were received from a further nine institutions and ten individual contributors, bringing the total up to 254 species of reptiles and amphibians. This is still a working document. The database has been updated at regular intervals, and is currently in its tenth edition, available for download from the Internet (BIAZA RAWG 2015). New reviews, corrections and submissions are welcomed.

Table 2. Assessment of 24 lamps used in reptile husbandry. Operating ranges also respect safe minimum distances. Fluorescent lamps emitting less than UVI 0.5 at 15cm are not considered to be suitable as the sole source of UVB even for Zone 1 species.

				Ferguson zones which can be covered using the lamp (depending upon distance)			
				Zone 1	Zone 2	Zone 3	Zone 4
Company name	Brand name	Sample in this report	Date sample purchased	using shade method	using shade method	using sunbeam method	using sunbeam method
Fluorescent tubes							
A) T8 (1" diameter) tubes							
Arcadia	Natural Sunlight Lamp 2% UVB	60cm 18W	2008	with reflector			
Arcadia	D3 Reptile Lamp 6% UVB	60cm 18W	2008	✓	with reflector		
Arcadia	D3+ Reptile Lamp 12% UVB	60cm 18W	2008	✓	✓	with reflector	
Narva	BioVital T8	60cm 18W	2009	×			
ZooMed	Reptisun 2.0/ Naturesun	60cm 18W	2008	×			
ZooMed	Reptisun 5.0/ IguanaLight	60cm 18W	2005	✓	✓		
ZooMed	Reptisun 10.0	60cm 18W	2011	✓	✓	with reflector	
B) T5 (16mm diameter) tubes							
Arcadia	T5 D3 Reptile Lamp 6% UVB	55cm 24W	2011	✓	✓	with reflector	with reflector
Arcadia	T5 D3+ Reptile Lamp 12% UVB	55cm 24W	2011	✓	✓	✓	✓
ZooMed	Reptisun 5.0 UVB T5-HO	55cm 24W	2012	✓	✓	with reflector	with reflector
ZooMed	Reptisun 10.0 UVB T5-HO	55cm 24W	2012	✓	✓	✓	✓
Mercury vapour lamps							
Arcadia	D3 Basking Lamp	100W	2012	✓	✓		
Arcadia	D3 Basking Lamp	160W	2012	✓	✓		
ExoTerra	Solar Glo	125W	2012-2013	✓	✓	?	
ExoTerra	Solar Glo	160W	2012-2013	✓	✓		
MegaRay PetCare	Mega-Ray	100W	2014	✓	✓	✓	✓
MegaRay PetCare	Mega-Ray	160W	2014	✓	✓	✓	✓
Osram	Ultravitalux	300W	2005-2011	✓	✓	✓	✓
ZooMed	Powersun	100W	2012-2013	✓	✓	✓	
ZooMed	Powersun	160W	2012-2013	✓	✓	✓	✓
Metal halide lamps							
Iwasaki EYE	Color Arc manufactured prior to 2011	150W	2009-2010	✓	✓	?	
Iwasaki EYE	Color Arc manufactured after 2011	150W	2009-2010	×			
Lucky Reptile	Bright Sun UV Desert	35W	2012	✓	✓	✓	✓
Lucky Reptile	Bright Sun UV Desert	50W	2008	✓	✓		

Results

Species database

The entries to date (254 species) are listed in full in the Appendix. The contributors for each species and their recommended reading and reference lists are not included owing to space limitations, but are present in the UV-Tool Excel working document available online (BIAZA RAWG 2015). Further contributions are still being sought, and the BIAZA RAWG Focus Group intends to edit and expand the database as more information becomes available.

UV-B lamp test results

Table 2 lists the lamps that were included in the trial, and summarises their ability to provide irradiances within the UV index ranges appropriate to each Ferguson zone, at practical distances beneath the lamp. Figure 1A–C graphs the UVI irradiances of individual lamps at increasing distances from the surface of the lamp, with the UV index meter positioned perpendicular to the lamp, directly beneath its central point. Figures 2 and 3 are examples of iso-irradiance charts and spectra for four distinct types of UV-B-emitting lamp: a standard-output T8 (25 mm

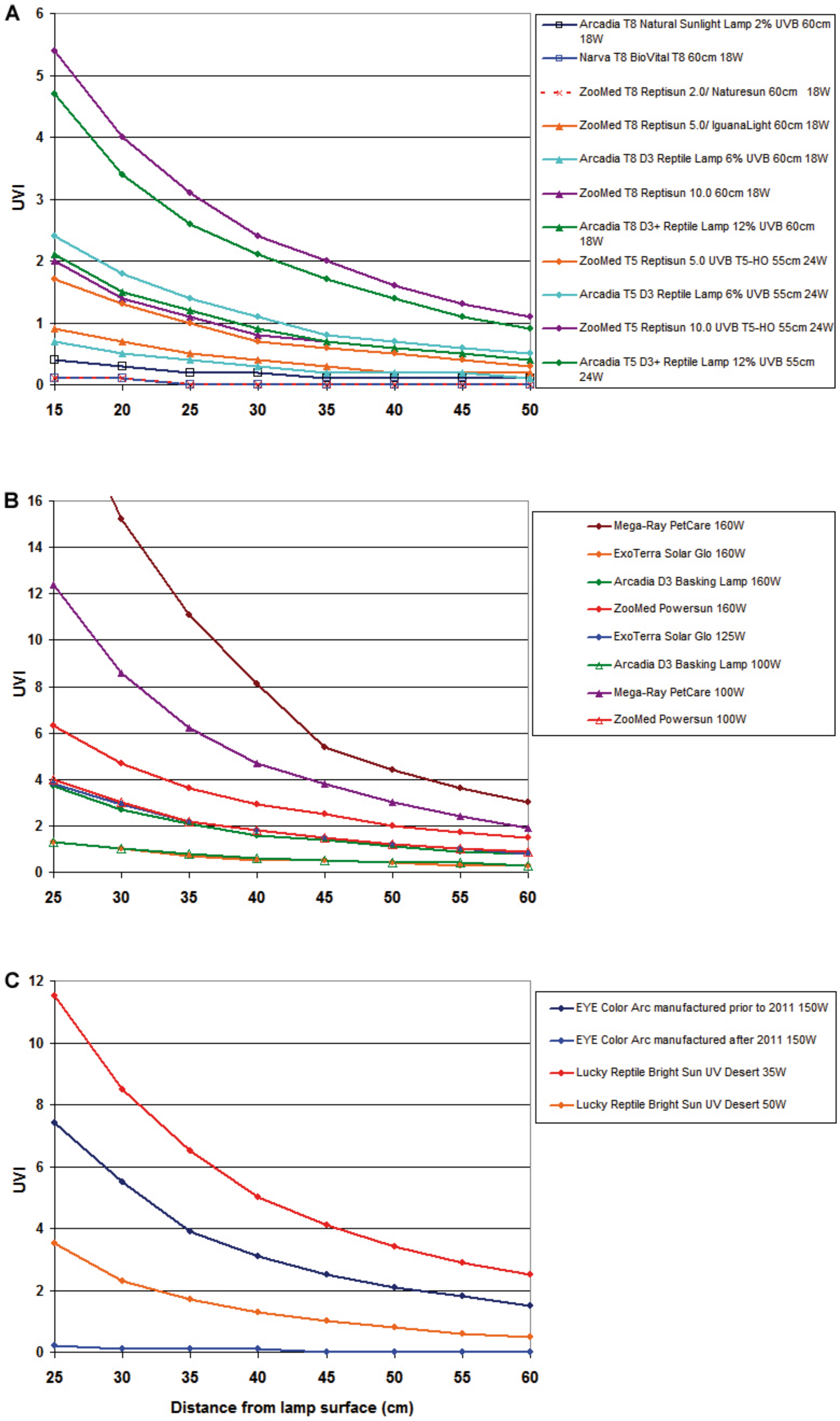


Figure 1. UV Index irradiance recordings. (A) UVB-emitting fluorescent tubes (T8 and T5 versions); (B) mercury vapour lamps; (C) metal halide lamps.

diameter) fluorescent tube, a mercury vapour lamp, a metal halide lamp and a T5 (16 mm diameter) High-Output (T5-HO) fluorescent tube fitted with an aluminium reflector. Each of the full lamp test results for all 24 lamps are accessible from links on the same website page from which the Excel working document may be downloaded (BIAZA RAWG 2015), as well as from links within the UV-Tool itself. New lamp test results will be added to this website, and their links will be added to the working document, as they become available.

Discussion

Lamp test results

The UV output of lamps sold for use with reptiles and amphibians varies enormously, not just from different types of lamp, but also from different brands with similar specifications. Although only one lamp from each brand was tested in this trial, previous tests (FB, unpublished data) have shown that considerable differences may exist between individual lamps of the same brand and

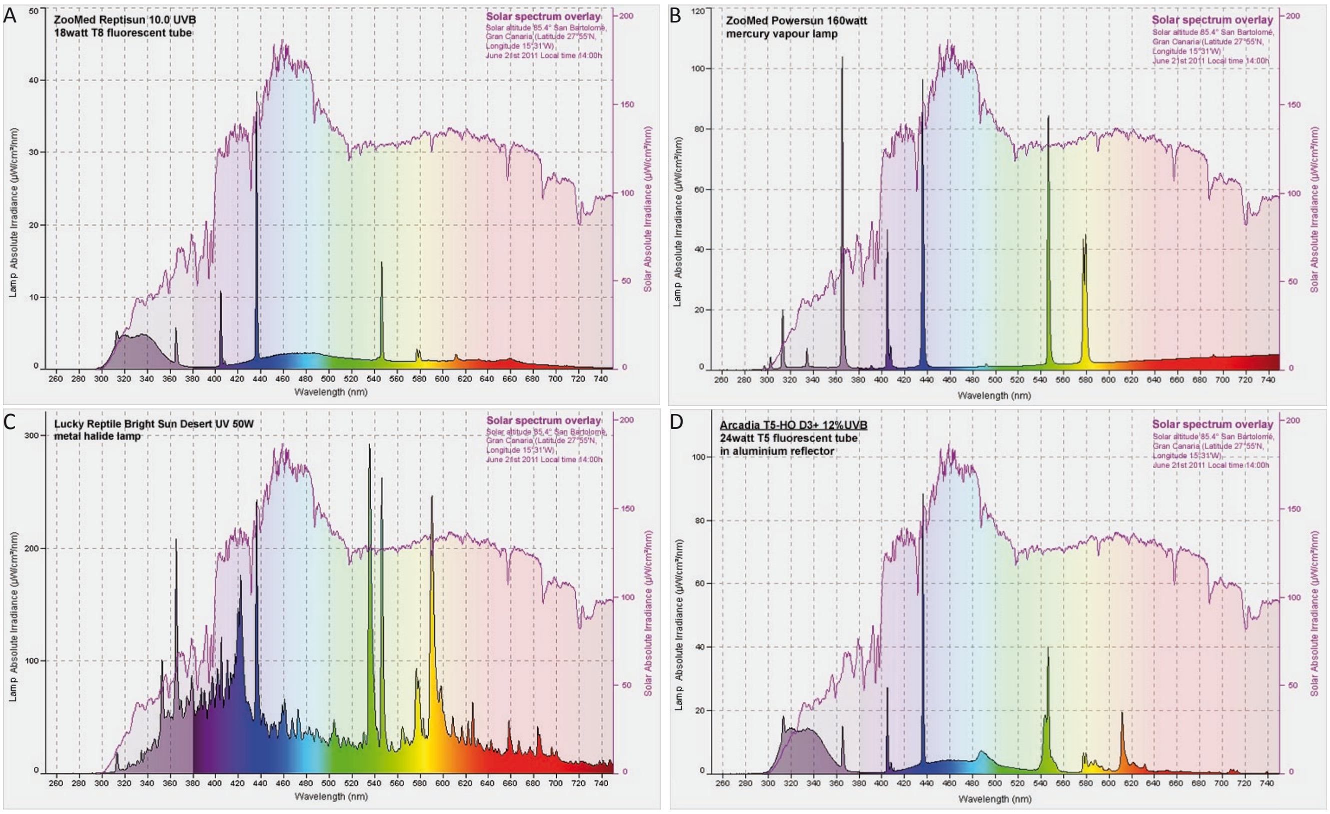


Figure 2. Full ultraviolet and visible light (UV-VIS) spectrum of samples of four types of UVB lamp. A mid-day solar spectrum with the sun close to the zenith (Solar altitude 85.4°) is overlaid onto each chart - but note the different irradiance scales. This enables comparison of the spectral power distribution of the lamp with that of natural sunlight, which has a completely continuous spectrum from a threshold around 295nm. (A) UVB-emitting fluorescent tube (T8 version): ZooMed Reptisun 10.0 UVB 18watt T8 fluorescent tube. Distance 10cm. (B) Mercury vapour lamp: ZooMed Powersun 160watt lamp. Distance 30cm. (C) Metal halide lamp: Lucky Reptile Bright Sun Desert UV 50watt lamp. Distance 30cm. (D) UVB-emitting fluorescent tube (T5 version): Arcadia T5-HO D3+ 12%UVB 24watt T5 fluorescent tube in aluminium reflector. Distance 10cm.

specifications. This may be due to small differences in manufacture such as internal positioning of lamp elements, thickness of glass or coatings, etc., but the UV-B output may also vary with external factors such as fluctuations in the voltage of the electrical supply and the ambient temperature. UV-B output also decays with use, primarily due to solarisation of the glass envelope under UV bombardment, but also due to chemical changes in phosphors or halide mixtures or the blackening of glass from sputtering from ageing electrodes. Ideally, lamp output should be monitored regularly. Most products decay only slowly, however, after the initial ‘burning-in’ period. Included in the full lamp test results are measurements taken from seven of the UV-emitting fluorescent tubes from Arcadia (Arcadia Products plc., Redhill, UK) and ZooMed (ZooMed Laboratories Inc., San Luis Obispo, USA), each lamp representing a different brand, put into use for at least a full year (4000 hours of use at 10–12 hours per day). After burning-in for 105 hours, the mean reduction in UVI, from new, was 12.6% (range 6–23%). At the end of 4000 hours the mean reduction in UVI, from new, was only 39.9% (range 30–48%). These results suggest that some brands may not need replacement for at least one year. Not all products have similar longevity. For example, one brand sold by a different manufacturer showed a reduction in UVI of 64% from new after only 1000 hours’ use – about three months at 10–12 hours per day. This product was therefore rendered ineffective at any practical distance after only three months (FB, unpublished data).

Spectral analysis reveals that none of the lamps in this trial emit harmful non-solar UV-B radiation (<290 nm). All of the lamps emit at least some UV-B in the range required for vitamin D_3 synthesis, although the so-called ‘full spectrum’ fluorescent tubes, Narva Biovital (Narva Lichtquellen GmbH, Brand-Erbisdorf, Germany), ZooMed NatureSun (ZooMed Laboratories Inc., San Luis Obispo, USA), and the Iwasaki EYE Color Arc metal halide lamp manufactured after 2011 (Iwasaki Electric Co. Ltd., Tokyo, Japan), emit insignificant amounts except at extremely close range.

Iso-irradiance charts

The iso-irradiance charts enable comparison of the UV gradients between different lamps and reveal important differences in the surface area beneath the lamps that receives any specified irradiance. For example, as indicated in Table 2, both the Arcadia T5 D3+ Reptile Lamp 12% UV-B fluorescent tube (Arcadia Products plc., Redhill, UK) and the Lucky Reptile Bright Sun Desert 50watt metal halide lamp (Import Export Peter Hoch GmbH, Waldkirch, Germany) are able to produce a gradient suitable for a Zone 2 animal at a safe distance. However, the iso-irradiance charts for these lamps indicate that the fluorescent tube fitted with a reflector provides a UV index range between 0.5 and 1.0 across an area over 130 cm in diameter at a distance of 85 cm (Figure 3D), whereas the same zone of irradiance under the metal halide lamp is achieved at 45 cm, but the footprint is less than 25 cm in diameter (Figure 3C). The practical uses for these two lamps will therefore be very different. Effective UV coverage needs to be at least as wide as the whole body of the animal.

Mercury vapour and metal halide lamps emit significant infrared radiation as well as UV and visible light. When creating a thermal gradient, just as with a UV gradient, the whole of the animal’s body must fit within the optimum upper temperature zone. For

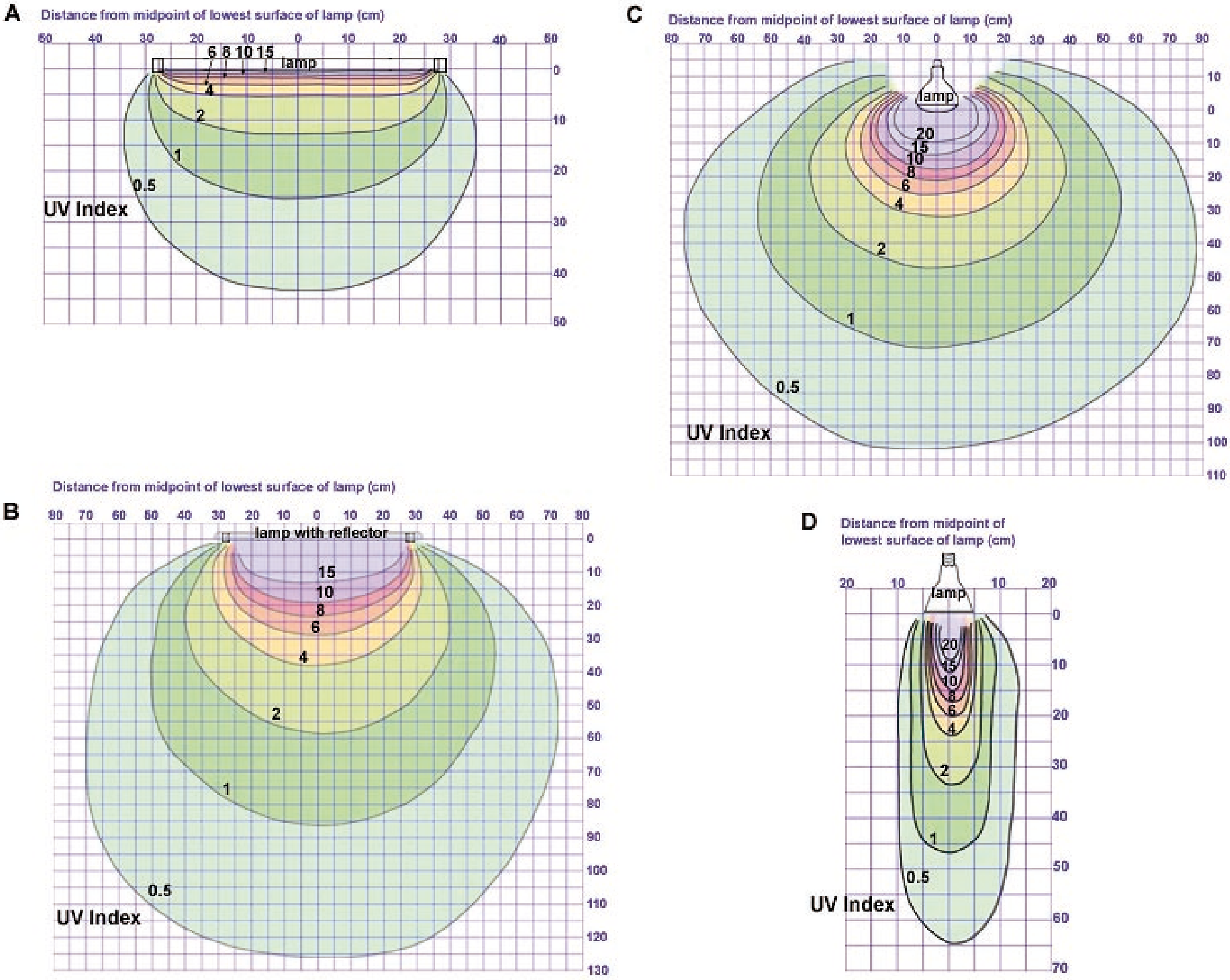


Figure 3. UV Index iso-irradiance charts for samples of four types of UVB lamp. These charts are for the lamps with spectra illustrated in Figure 2. (A) UVB-emitting fluorescent tube (T8): ZooMed Reptisun 10.0 UVB 18watt T8 tube. (B) Mercury vapour lamp: ZooMed Powersun 160watt lamp. (C) Metal halide lamp: Lucky Reptile Bright Sun Desert UV 50watt lamp. (D) UVB-emitting fluorescent tube (T5): Arcadia T5-HO D3+ 12%UVB 24watt T5 fluorescent tube in aluminium reflector.

basking species, this means creation of a basking area in which appropriate UV, visible light and infrared radiation cover the entire body of the animal. Lamps with wide flood-type beams or multiple lamps above the basking zone are often necessary.

When lamps are installed in enclosures, any shades and reflectors, mesh guards, even nearby objects such as branches and foliage will affect light and UV distribution. Iso-irradiance charts are no substitute for in-situ measurements; they are merely guides to aid lamp selection.

Using the Ferguson zones

Figure 4 summarises the zone ranges recorded by Ferguson et al. (2010) and illustrates the way in which we propose they might be used to create suitable UV gradients for any species based upon its thermoregulation behaviour.

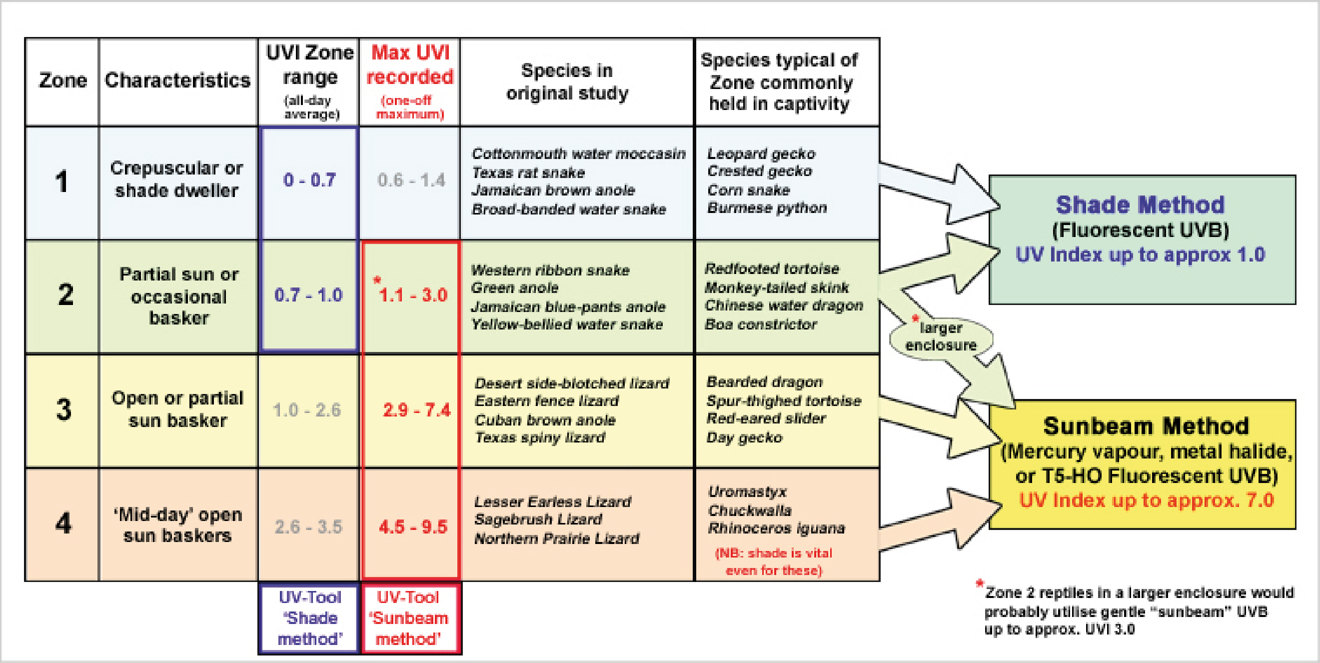
Ferguson et al. (2010) provide two sets of figures:

1. 'Zone ranges': all the UVI readings for the microhabitats at the time and place the reptiles were found were averaged. For example, the average exposure of crepuscular or shade dwelling species fell in the range between UVI 0 and 0.7, the 'partial sun or occasional baskers' were in a range from 0.7 to 1.0, and so on. This figure might be considered a suitable 'mid-background' level of UV for the species in question.
2. 'Max UVI recorded' refers to the highest UVI that the reptiles from each zone were found to occupy in this study. Obviously this figure might reflect a 'one-off' exposure – a single reptile found out in mid-day sun – but it gives an estimate of the maximum levels this type of animal might encounter naturally. This might be considered as a guide as to the upper acceptable limit for the UV gradient to be provided in captivity.

We suggest that a suitable UV gradient, chosen to match the zone to which the reptile or amphibian is allocated, may then be provided in the captive animal's environment, enabling the animal to self-regulate its exposure. A full range of UV levels may be provided, from zero (full shade) to the maximum suggested by the zone assessment (at the closest point possible between the animal and the lamp). We have used the information from the Ferguson et al. (2010) study as a basis for our suggestion that there are two ways of supplying UV to reptiles and amphibians kept indoors in captivity.

'Shade' and 'sunbeam' methods

The 'shade method' provides low-level background UV over a large proportion of the animal's enclosure using the zone ranges as a guide to appropriate ambient UV, with a gradient from the



Zone	Characteristics	UVI Zone range (all-day average)	Max UVI recorded (one-off maximum)	Species in original study	Species typical of Zone commonly held in captivity
1	Crepuscular or shade dweller	0 - 0.7	0.6 - 1.4	*Cottonmouth water moccasin* *Texas rat snake* *Jamaican brown anole* *Broad-banded water snake*	*Leopard gecko* *Crested gecko* *Corn snake* *Burmese python*
2	Partial sun or occasional basker	0.7 - 1.0	*1.1 - 3.0	*Western ribbon snake* *Green anole* *Jamaican blue-pants anole* *Yellow-bellied water snake*	*Redfooted tortoise* *Monkey-tailed skink* *Chinese water dragon* *Boa constrictor*
3	Open or partial sun basker	1.0 - 2.6	2.9 - 7.4	*Desert side-blotched lizard* *Eastern fence lizard* *Cuban brown anole* *Texas spiny lizard*	*Bearded dragon* *Spur-thighed tortoise* *Red-eared slider* *Day gecko*
4	'Mid-day' open sun baskers	2.6 - 3.5	4.5 - 9.5	*Lesser Earless Lizard* *Sagebrush Lizard* *Northern Prairie Lizard*	*Uromastyx* *Chuckwalla* *Rhinoceros iguana* (NB: shade is vital even for these)
		UV-Tool 'Shade method'	UV-Tool 'Sunbeam method'		

Shade Method
(Fluorescent UVB)
UV Index up to approx 1.0

Sunbeam Method
(Mercury vapour, metal halide, or T5-HO Fluorescent UVB)
UV Index up to approx. 7.0

*Zone 2 reptiles in a larger enclosure would probably utilise gentle "sunbeam" UVB up to approx. UVI 3.0

Figure 4. UV index estimates based upon the Ferguson zones. Columns 1 to 5 of the table identify the characteristics of each zone as presented by Ferguson et al. (2010). The original 15 species of reptiles studied in their natural habitat in Jamaica and south and west USA are shown in column 5. In the column 6 are examples of species commonly held in captivity, assigned to Ferguson zones based upon their known basking behaviour. Arrows link animals from each zone to either shade or sunbeam methods of UV provision as proposed in the BIAZA UV-Tool (2012) and indicate typical lamp types suggested for each method.

highest zone range value close to the lamp, to zero in the shade. This would seem to be the method of choice for shade-dwelling animals and occasional baskers, i.e., those in zones 1 and 2. Most amphibians, snakes and crepuscular lizards have been allocated to these zones. Fluorescent T8 (26 mm diameter) UV-B tubes create low levels of UV irradiance, similar to those found in outdoor shade on a sunny day, over a relatively large area close to the tube, with a gradient to zero at greater distances from the lamp. They would therefore appear to be particularly suitable for the shade method in small enclosures and vivaria, where the maximum UVI required would be no higher than UVI 0.7–1.0. In larger enclosures, high output T5 (T5-HO) (16 mm diameter) UV-B fluorescent tubes may be used, as these can be positioned further from the animals, to achieve the same low UVI at animal level.

The 'sunbeam method' is designed to provide a higher level of UV for species known to bask in direct sunlight. The aim is to provide UV levels in the basking area that are similar to those experienced by a wild animal in direct sunlight in its natural habitat during a typical early to mid-morning basking period. This is the time when most basking species absorb solar radiation for long periods. In the tropics and sub-tropics, in open sunlight on clear days between 8.30am and 9.30am local time, the UV index is typically in the range UVI 3.0–5.0 (FB, unpublished data). This higher level needs to be restricted to the basking zone (simulating a patch of sunlight) with a gradient to zero into shade. This method would seem appropriate for animals in zones 3 and 4, many of which are diurnal reptiles, and for some partial sun/occasional baskers from zone 2. Some mercury vapour lamps, metal halide UV-B lamps and high output T5 (T5-HO) UV-B fluorescent tubes (16 mm diameter) can produce much higher levels of UV-B than T8 fluorescent tubes, up to levels typical of natural sunlight. These lamps can be positioned to irradiate a brightly illuminated basking zone with appropriate levels of UV-B for the entire photoperiod, so that suitable UV exposure occurs whenever the animal chooses to bask. We suggest that 'Max UVI recorded' should be a guide to the maximum permitted for each zone, with the exception of zone 4. Although some zone 4 reptiles have been observed basking at UVI 9.5 or above (Ferguson et al. 2010, 2014), even these spend the majority of their basking time in the early morning and late afternoon, when levels are around UVI 3.0–5.0. It follows that the most appropriate levels for zone 4 animals, too, will be in this range. We suggest that for safety, UVI 7.0–8.0 should be considered the absolute maximum UVI at reptile level for zone 4 reptiles under artificial sources of UV-B, since the UV spectrum from artificial lighting is not the same as from natural sunlight.

If keepers do not have access to a UV index meter, the iso-irradiance charts and irradiance tables to which the UV-Tool is linked may be used to identify suitable distances at which appropriate levels for both 'shade' and 'sunbeam' methods are achieved by different lamps.

Special considerations: nocturnal species

Traditionally, it has been assumed that nocturnal and crepuscular species do not require UV lighting because their lifestyle precludes exposure to daylight, and/or they obtain all the vitamin D_3 they require from their diet. Although carnivores may obtain sufficient vitamin D_3 from the bodies of their prey, the natural diets of insectivores are unlikely to provide any significant amounts of the vitamin (Finke and Oonincx 2014), making cutaneous synthesis the most likely primary source.

More than 60 years ago, reports were collected of supposedly nocturnal reptiles experiencing at least some exposure to daylight, either by occasional daytime forays or by incidental exposure to light in their sleeping places (Brattstrom 1952). House geckos, *Hemidactylus frenatus* and *H. turcicus*, are often seen in daylight around dusk and dawn (FB, pers. obs.) and *Tarentola mauretanica* can regularly be seen basking in the sun for periods throughout the day (MG, pers. obs.). Without evidence from 24-hour observational field studies, it cannot be assumed that any nocturnal species receives no sunlight at all. Many snakes, such as the black ratsnake (*Pantherophis obsoletus*) vary their diel patterns of activity depending upon ambient temperatures, increasing diurnal activity in the cooler months (Sperry et al. 2013).

It has been speculated that crepuscular species may synthesise vitamin D_3 by emerging into sunlight at dusk and dawn. However, when the sun is close to the horizon, the atmosphere filters out almost all the UV-B wavelengths required for vitamin D_3 synthesis; species which can benefit from such low levels of UV need skin with very high UV transmission. Some nocturnal geckos, for example, fit into this category. Short wavelength UV-B has been shown to be transmitted through the full thickness of skin of the nocturnal gecko *Coleonyx variegatus* to a depth of 1.2 to 1.9 mm, in stark comparison with diurnal species such as the desert lizard *Uta stansburiana*, in which transmission was restricted to between 0.3 and 0.9 mm (Porter 1967). In the same study, Porter found that the skin transmission of seven species of snake reflected their behaviour, such that the highest transmission was seen in the most completely nocturnal species, and the lowest in diurnal species, with crepuscular snakes in between. This suggests one way in which low levels of UV-B may enable adequate vitamin D_3 synthesis in nocturnal species. Carman et al. (2000) demonstrated that the skin of the nocturnal house gecko *Hemidactylus turcicus* can synthesise vitamin D_3 eight times more efficiently than skin from the diurnal desert lizard *Sceloporus olivaceous* – suggesting that this is an adaptation either to lower levels of available ultraviolet light in its microhabitat, or to very short exposure to higher levels, during brief day-time emergences from shelter.

Leopard geckos (*Eublepharis macularius*) synthesised vitamin D_3 when exposed to low-level UV-B; 25-hydroxyvitamin D_3 levels in exposed animals were 3.2 times higher than controls receiving only dietary supplementation (Wangen et al. 2013). Crepuscular snakes such as the corn snake, *Elaphe guttata*, have also been shown to synthesise vitamin D_3 in the skin when exposed to low levels of UV-B from fluorescent lamps (Acierno et al. 2008).

Mid-day UV-B filtering into the daylight sleeping places of nocturnal animals may also be sufficient to enable adequate cutaneous synthesis. As far as we are aware, no published field studies exist recording the ambient UV-B in the daytime location of inactive nocturnal animals. However, UVI meter readings between UVI 0.1 and 1.2 have been recorded beside leaf-tailed geckos (*Uroplatus* sp.) sleeping in daylight against tree trunks in Madagascar (L. Warren, pers. comm.)

The vitamin D_3 requirement of some nocturnal species may be low; passive absorption of dietary calcium by vitamin D-deprived leopard geckos, for example, appears to be effective enough to prevent metabolic bone disease (Allen et al. 1996). However, the paracrine and autocrine functions of vitamin D_3 are independent from calcium metabolism; more research is needed to assess the full effects of vitamin D deficiency.

To summarise, some nocturnal animals clearly do have the ability to synthesise vitamin D_3 in their skin, and this would occur naturally whenever they were exposed to daylight. So there would seem to be no reason to withhold provision of full spectrum lighting, provided that they are able to spend the daylight hours in an appropriate retreat, with access to a UV-B component suitable for a shade-dwelling or crepuscular species (i.e. Ferguson zone 1).

Hypopigmentation

Extra consideration is required when planning lighting for albino and hypomelanistic specimens of any species, regardless of the zone allocation of that species. Melanin strongly absorbs UV radiation. A lack of skin and eye pigmentation therefore increases the transmission of radiation into the body (Solano 2014). Such animals are often popularly reported to be more sensitive to UV and visible light (e.g. Dell'Amore 2007), and may be at increased risk of UV-induced skin damage and cancer (Duarte and Baines 2009). They are therefore likely to need much reduced exposure levels. Fortunately adequate vitamin D_3 synthesis should still be possible despite lower UV exposure, since reduced melanin pigment allows more UV-B to enter the epidermal cells.

Ontogenetic changes

Consideration should also be given to any ontogenetic changes in microhabitat and/or behaviour when allocating species to Ferguson zones. Amphibians with both larval and adult life stages are obvious examples, but juvenile reptiles of many species also live more cryptic lifestyles than the adults, inhabiting more sheltered microhabitats with relatively less ambient UV. A well-known example of this is the Komodo dragon (*Varanus komodoensis*); juveniles are arboreal, whereas adults are ground-dwellers foraging across open savanna as well as in woodlands (Auffenberg 1981). More fieldwork is needed to identify differences in the UV exposure of immature animals, to determine whether they need a different Ferguson zone allocation from that of adults. Estimating juvenile requirements was outside the remit of this project, but these might usefully be added to the UV-Tool in the future.

General cautions

In applying these guidelines to the provision of UV lighting, some general cautions must be emphasised.

Firstly, this is a very simplistic assessment, with very wide interpretations possible. This is intentional; the concept is designed to enable creation of wide, safe UV gradients combined with heat and light gradients, enabling reptiles and amphibians to photoregulate and thermoregulate simultaneously, throughout the day. This requires the sources of UV, visible light and infrared radiation to be positioned close together, simulating sunlight, and creating a basking zone at least as large as the whole body of the animal. Multiple lamps may be required in some cases; the effects are additive for all wavelengths, so overlapping beams must be used with caution. It also requires provision of adequate space and shelter, away from the lamps, for suitable gradients to form. Provision of shade is vital for all species, regardless of their Ferguson zone. Even zone 4 reptiles must have a UV gradient falling to zero in shelters away from the light. All guidelines to date are still very experimental; the exact UV requirements of reptiles and amphibians are still largely unknown, and it is vital to monitor the animals' responses and record results.

Secondly, basking temperatures and ambient temperatures must be suitable, to ensure basking behaviours – and therefore UV exposure times – are natural, neither abnormally short nor prolonged.

Thirdly, lamps should always be positioned above the animal, so the shape of the head, and upper eyelids and eyebrow ridges when present, shade the eyes from the direct light.

Fourthly, all lamps present an electrical risk, and many also present the risk of thermal burns and UV burns if the animal can approach too closely. All bulbs should be inaccessible to the animals; wire guards may be necessary. Wide wire mesh should be chosen where possible, to maximise light and UV transmission (Burger et al. 2007).

Finally, ordinary glass or plastics must not be placed anywhere between the lamp and the animal, as these normally block transmission of all UV-B. Some high-transmission glass and specialised UV-transmitting acrylics will, however, allow a certain proportion through, although even these materials selectively block shorter UV wavelengths. Spectral analysis conducted by one of the authors (FB, unpublished data) indicated that 3 mm UV-transmitting acrylic (Clear Sunbed Grade UV-T Perspex Acrylic Sheet: Bay Plastics Ltd., North Shields, UK) permitted 80.9% transmission of UV-B at 300 nm. UV-transmitting twin-wall acrylic roofing panels (Plexiglas Alltop SDP16: Evonik Industries AG, Essen, Germany) permitted 58.8% transmission at 300 nm. For comparison, a 4 mm sheet of high-transmission, low-iron glass (Planibel Clearvision Glass: AGC Glass Europe, Louvain-La-Neuve, Belgium) transmitted 16.9% of UV-B at 300 nm, compared to only 0.4% transmission through ordinary 4 mm window glass.

Summary

Very few field studies have been conducted on the natural UV exposure of reptiles and amphibians. However, an estimation of a suitable UV range for any species may be made using knowledge of its typical basking behaviour and its microhabitat. In indoor enclosures, careful positioning of UV lamps enables creation of a UV gradient within this range, which can be incorporated into full spectrum lighting to simulate sunlight.

The BIAZA RAWG UV-Tool is a working document in which species are allocated to UVI ranges (Ferguson zones) according to their basking behaviour. Information is also provided regarding suitable temperature gradients, photoperiod and microhabitat, to assist construction of the photo-microhabitat. UV-B lamps vary widely in output and beam characteristics, but links to lamp test results are available in the UV-Tool. Lamp choice will depend primarily on the Ferguson zone of the animal, which determines the required UV gradient, and the size of the enclosure, which determines the distance at which the lamp can be placed. Final positioning of the lamp (or lamps) is determined by using a UV index meter; if no meter is available, the charts and figures published in the test results may be helpful if the same lamps are being used.

Since this is a working document, we encourage submission of new species data to the database, and updates of lamp test results are planned.

Definitions

Irradiance is the radiant power received by a surface per unit area. The units are microwatts per square centimetre (μW/cm²).

Illuminance is the total luminous flux received by a surface per unit area. This is a measure of the apparent brightness of an illuminated area to the human eye. It is calculated from the product of the spectral irradiance (μW/cm² per nanometre of wavelength) with the human luminosity function, which represents the eye's response to different wavelengths. This weighting is required because human brightness perception is wavelength-dependent. The unit is the lux. Since animal eyes have different spectral sensitivities, it is only a crude estimate of the brightness perceived by any non-human species, but equivalent luminosity functions for reptile and amphibian species are lacking.

The UV index (WHO 2002) is an international standard measurement of the intensity of human erythemally-active (sunburn-producing) UV radiation. It is calculated from the product of the spectral irradiance (μW/cm² per nanometre of wavelength) and the human erythemal action spectrum across the range of UV wavelengths. This weighting is required because shorter UV wavelengths are much more damaging than longer wavelengths. The UV index is unitless.

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Appendix: Microhabitat assessment

Key

Biome
WWF major terrestrial biomes: 01 Tropical and Subtropical Moist Broadleaf Forests; 02 Tropical and Subtropical Dry Broadleaf Forests; 03 Tropical and Subtropical Coniferous Forests; 04 Temperate Broadleaf and Mixed Forests; 05 Temperate Coniferous Forests; 06 Boreal Forests/ Taiga; 07 Tropical and Subtropical Grasslands, Savannas and Shrublands; 08 Temperate Grasslands, Savannas and Shrublands; 09 Flooded Grasslands and Savannas; 10 Montane Grasslands and Shrublands; 11 Tundra; 12 Mediterranean Forests, Woodlands and Scrub; 13 Deserts and Xeric Shrublands; 14 Mangroves.

Thermoregulatory behaviour
Ferguson zones:
1 - crepuscular or shade dweller; 2 - partial sun/ occasional basker; 3 - open or partial sun basker; 4 - mid-day sun basker.

Winter treatment:
Cooling: The temperature is reduced for a period, usually co-incident with winter. The animal reduces activity and feeding may cease, but it does not necessarily go into an extended, torpid state.
Brumation: The animal becomes torpid for a period which may last weeks. Co-incident with winter.
Hibernation: The animal undertakes preparation and goes in to a torpid state for an extended period - duration in months. Physiological changes occur within the animal. Co-incident with winter and seen mostly in animals of northerly latitudes.
Aestivation: The animal becomes torpid for a period of days or weeks. Co-incident with hotter weather.

Photoperiod (as usually given in captivity)
Tropical - 12h all year; Subtropical - 13:11h summer:winter; Temperate - 14:10h summer:winter

Microhabitat
A - Fossorial; B - Leaf litter; C - Forest floor; D - Rocks, crevices or burrows; E - Foliage or shrubs; F - Grassland or savanna; G - Semi-arboreal; H - Arboreal; I - Riparian or wetlands; J - Aquatic.

							Day – ambient (air) temperature (°C)		Night – ambient (air) temperature (°C)		
Scientific name	Common Name	Biome	Ferguson Zone	Photoperiod	Winter treatment (if any)	Basking zone – Substrate surface temperature (°C)	Summer	Winter (if different)	Summer	Winter (if different)	Microhabitat
Crocodilia											
Caiman crocodilus	Spectacled Caiman	1	2–3	13:11		30–35	25–30		24–26		I
Crocodylus mindorensis	Philippine crocodile	1	2–3	12:12		31–36	26–30		24–25		IJ
Crocodylus moreletii	Morelet's Crocodile	1	2	13:11		30–35	25–30	23–25			J
Osteolaemus tetraspis	Dwarf Crocodile	1	2–3	12:12		35	25		>20		I
Paleosuchus palpebrosus	Cuvier's Dwarf Caiman	1	2–3	13:11		30–32	25–30		24–26		I
Rhynchocephalia											
Sphenodon punctatus	Cook Strait Tuatara	4	3	14:10	Hibernation	30	13–20	12–17	12–15	6–9	D

							Day – ambient (air) temperature (°C)		Night – ambient (air) temperature (°C)		
Scientific name	Common Name	Biome	Ferguson Zone	Photoperiod	Winter treatment (if any)	Basking zone – Substrate surface temperature (°C)	Summer	Winter (if different)	Summer	Winter (if different)	Microhabitat
Squamata: Lacertilia											
Acanthosaura capra	Two-horned Mountain Horned Dragon	1	1	13:11	Cooling	30–32	23–28	18–22	18–22	14–18	G
Acanthosaura lepidogaster	Rough-bellied Mountain Horned Dragon	1	1	13:11	Cooling	30–32	23–28	18–22	18–22	14–18	G
Anolis carolinensis	American Green Anole	4	2	14:10	Cooling	30–35	25–30	18–20	20–25	10–15	EG
Anolis grahami	Jamaican Blue-pants Anole	1	2	12:12		30–35	25–30		20–25		EGH
Anolis lineatopus	Jamaican Brown Anole		1	12:12		25–30	25–30		20–25		EG
Anolis roquet summus	Martinique Anole	1	2	13:11		34–36	25–27	24–26	20–24	18–22	H
Anolis sagrei	Cuban Brown Anole		3	12:12/13:11		30–40	25–30		20–25		EG
Basiliscus plumifrons	Plumed Basilisk	1	2	12:12		30–35	25–30		24–26		CEI
Brachylophus bulabula	Fiji Banded Iguana	1	1–2	12:12		30–32	27–32		20–25		H
Bronchocela cristatella	Bornean bloodsucker/Green Crested Lizard	1	3	13:11		30–32	26–30		20–24		EH
Brookesia superciliaris	Brown Leaf Chameleon	1	1	12:12		30	21–26		15–20		E
Calotes versicolor	Oriental Garden Lizard, Eastern Garden Lizard, Bloodsucker		3	12:12		40	25–30	22–26	22–25	20–22	DEG
Calumma parsonii	Parson's Chameleon	1	3	12:12/13:11		30–35	20–30	20–30	15–26	15–24	EH
Celestus warreni	Giant Hispaniolan Galliwasp	2	2	13:11		35–45	26–28	24–26	24–26	21–23	ABD
Chamaeleo calyptratus	Yemen Chameleon	13	3	13:11		35–40	25–35		23–25		EH
Chamaeleo melleri	Meller's Chameleon	2	2	13:11	Cooling	29–32	25–37	17–27		10	H
Chameleo trioceros quadricornis	Four Horned Chameleon	1	2	13:11		32	20–30		15–20		H
Chlamydosaurus kingii	Frilled Lizard		3	13:11		40	30	28	25–27	23–25	GH
Corucia zebrata	Prehensile or Monkey-tailed Skink	1	2	12:12		30–35	27–29	25–27	23–25	20–23	H
Crotaphytus collaris	Collared Lizard	04/05/ 10/13	3–4	14:10	Brumation / Hibernation	40–48	25–32	25–30; 10–15 (Brumation)	20–26	18–22; 5 (Brumation)	DF
Ctenophorus nuchalis	Central Netted Dragon	08/13	3–4	13:11/14:10	Cooling	40–45	30–35	26–30	24–28	20–22	DEFG
Ctenosaura bakeri	Utila Iguana	14	4	13:11		40–50	30–35	30–32	24–28	22–25	H
Ctenosaura palearis	Guatemalan Black Iguana	13	3	12:12		40–45	25–33		23–25		H
Cyclura cornuta cornuta	Rhinoceros Iguana	7	4	13:11		40–50	30–35	28–32	25–28	22–25	DF
Cyclura nubila	Cuban Rock Iguana	7	4	13:11		40–50	30–35	28–32	25–28	22–25	DF
Cyclura nubila caymanensis	Cayman Brac Iguana/ Sister Isles Iguana	02/07	3	13:11		40	28	26	21	20	D
Cyclura nubila lewisi	Grand Cayman Iguana/ Blue Iguana	02/07	3	13:11		40	28	26	21	20	D

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							Summer	Winter (if different)	Summer	Winter (if different)	
Dipsosaurus dorsalis	Desert Iguana	13	3	13:11	Cooling	50	25–35	15–25	20–25	10–15	D
Dracaena guianensis	Northern Caiman Lizard	1	2	13:11		30–35	25–28		24–26		I
Egernia cunninghami	Cunningham's Rock Skink	4	3–4	14:10	Cooling/ Brumation	35–40	28–32	24–28; 12 – 15 (Brumation)	20–24	18–20; 4–8 (Brumation)	D
Eublepharis macularius	Leopard Gecko	13	1	14:10	Cooling	32	25–29	15–20	20–24	10–15	D
Eumeces schneideri	Berber Skink	13	3	12:12	Cooling	40	25–30	20–25	20–25	10–15	D
Furcifer pardalis	Panther Chameleon	01/02	3	12:12/13:11		35–40	25–30	24–28	18–24	18–24	EH
Gecko gecko	Tokay Gecko	01/02	1	12:12		35	30		25		H
Gerrhosaurus major	Sudan Plated Lizard	7	3	12:12/13:11	None / Cooling	35–40	25–30	10–20	20	5–15	DF
Gonocephalus bellii	Bell's Forest Dragon	1	2	12:12		32	26–29		22–24		H
Gonocephalus doriae	Angle-headed Dragon	1	2	12:12		32	26–29		22–24		H
Gonocephalus grandis	Angle-headed Dragon	1	2	13:11	Cooling	30–32	26–30	20–24	20–24	16–20	H
Heloderma horridum exasperatum	Rio Fuerte Beaded Lizard	2	2	13:11		35–40	28–32	26–28	24–26	20–22	DFG
Heloderma suspectum	Gila Monster	04/13	2–3	13:11	Cooling	34–37	24–30	10–12	20–25	9–10	D
Hemisphaeriodon gerrardii	Pink-Tongued Skink	01/04/07	2	13:11		35	25–30	20–25	20–25	20	AG
Holbrookia maculata	Lesser Earless Lizard	8	4	14:10	Brumation	30–40	25–30	10–15		10–15	F
Iguana delicatissima	Lesser Antillean Iguana	2	4	13:11		40–50	30–35	28–32	25–28	23–25	GH
Intellagama (Physignathus) lesueurii	Australian Water Dragon	1	2	14:10	Brumation	35	25–30	20–25	20–25	10–15	I
Lacerta agilis	Sand Lizard	4	3	14:10	Hibernation	ambient UK temps	ambient UK temps		ambient UK temps		DF
Laemanctus serratus	Serrated Casque-headed Iguana	1	4	13:11		35–40	30–32		24–26		EH
Laudakia stellio brachydactyla	Painted Dragon (Starred Agama spp)	13	3–4	14:10	Brumation	30–40	25–35	5–15	10–20	5–15	DE
Leiocephalus carinatus	Curly Tail Lizard	13	3	13:11	Cooling	40–50	30–35	27–30	23–25	20–22	DE
Leiolopisma telfairi	Round Island Skink	7	4	14:10		35–40	27–32	24–28	24–26	20–24	BDEFG
Lepidothyris (Riopa) fernandi	Fire Skink	1	2	12:12		35	25–30		20–25		A
Lophognathus temporalis	Striped Water Dragon	2	3	12:12		35–45	26–30	24–28	22–24	18–22	G
Lygodactylus williamsi	Electric blue day gecko / Turquoise dwarf gecko	7	2–3	12:12		30–32	26–28	22–24	20–22	20	EH
Nactus coindemirensis	Lesser Night Gecko	7	1	14:10		28–32	24–27	20–23	22–24	18–20	BD
Oeudura castelnaui	Northern Velvet Gecko	7	1	12:12		None	28–30	25–27			H
Ophisaurus apodus	Scheltopusik	08/04/12	2	14:10	Brumation	30 –35	24–28	2–6	16–22	2–6	ABCEF

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							Summer	Winter (if different)	Summer	Winter (if different)	
Phelsuma klemmeri	Yellow Headed Day Gecko	2	3	13:11		30–35	25–30		23–25		EH
Phelsuma madagascariensis grandis	Giant Day Gecko	1	3	13:11		30–35	25–30		23–25		EH
Phelsuma standingi	Standing's Day Gecko	2	3	14:10	Cooling	35–45	30–35	25–28	25–30	22–25	H
Phrynosoma cornutum	Texas Horned Lizard	08/13	4	14:10	Brumation	30–40	30–35	10–15	20–25	10–15	EF
Physignathus cocincinus	Asian Water Dragon	1	2–3	13:11	Cooling	30–40	26–28	22–24	20–22	18–20	EGI
Plica plica	Spiny-headed Tree Lizard	1	2–3	12:12		33	28	20	28	20	EGH
Pogona vitticeps	Inland Bearded dragon	07/08/ 12/13	3–4	13:11/14:10	Cooling/ Brumation	40–45	25–30	25–30; 15–20 (Brumation)	20–25	20–22;10–15 (Brumation)	EFG
Rhacodactylus auriculatus	Gargoyle Gecko	1	2	12:12		29	25–29		20–25		H
Rhacodactylus ciliatus	Crested Gecko	1	1	14:10	Cooling	28	25–28	19–23	23–25	16–20	H
Rieppeleon brevicaudatus	Bearded Pygmy Chameleon	01/10	2	12:12		25	18–20		11–16		BEH
Sauromalus ater	Chuckwalla	13	4	14:10	Brumation	50	24–30		18–20		D
Sauromalus hispidus	Angel Island Chuckwalla	13	4	13:11	Cooling	50	30–35	25–30	25–30	15–20	D
Sceloporus consobrinus (Louisiana USA)	Eastern Fence Lizard	4	3	14:10	Brumation	30–40	25–30	10–15	20–25	10–15	EG
Sceloporus graciosus	Sagebrush Lizard	05/13	4	14:10	Brumation	30–40	25–30	5–10	15–20	5–10	DE
Sceloporus olivaceus	Texas spiny lizard	8	3	14:10	Brumation	35–40	27–33	10–15	20–25	10–15	EGH
Sceloporus serrifer cyanogenys	Blue Spiny Lizard	7	4	14:10		35–40	28–35	24–28	24–26	20–22	DG
Smaug (Cordylus) giganteus	Sungazer, Giant Girdled Lizard	10	4	14:10	Brumation	35	20–30	10–15	15–20	5–10	CF
Tarentola mauritanica	Moorish Gecko	12	2	14:10	Cooling	30–32	27		22		D
Teratoscincus scincus	Wonder Gecko	13	2	14:10	Brumation / Hibernation	35	25–30	15–20	20–25	10–15	D
Tiliqua nigrolutea	Southern or Blotched Blue-tongued Lizard	4	2–3	14:10	Cooling/ Brumation	35–40	26–30	22–28	18–22	18–20	BCDF
Tiliqua rugosa	Shingleback Lizard	04/08/ 12/13	2–3	13:11/14:10	Cooling	35–40	28–32	24–28	20–24	18–22	DF
Tiliqua scincoides	Eastern Blue-tongued Lizard	04/07/ 08/12	2–3	13:11/14:10	Cooling	35–45	28–32	18–28	20–24	14–20	DEF
Tribolonotus gracilis	Crocodile Skink	1	1	12:12		28–32	23–28		23–25		ABCI
Trioceros jacksonii	Jackson's chameleon	1	2–3	12:12		36	24–25		16–17		EH
Tupinambis merianae	Black-and-White Tegu	01/02/04/ 07/08	3	13:11	Brumation	35–40	25–30	5–20	20	5–10	ABCF

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							Summer	Winter (if different)	Summer	Winter (if different)	
Uromastyx aegyptia	Egyptian Uromastyx / Mastigure/ Dab Lizard	13	4	14:10	Cooling	45–50	30–38	25–30	20–25	18–20	DF
Uromastyx geyri	Saharan Uromastyx / Spinytailed Lizard	13	4	12:12	Cooling	45–50	28–35	20–25	16–18	10–18	DF
Uromastyx ornata	Ornate Uromastyx	13	4	14:10	Cooling	40–50	30	30	20	20	AD
Uroplatus henkeli	Henkel's leaf-tail gecko	01/02	1–2	12:12	Cooling	25–28	23–25	21–23	18–20	17–19	EH
Uroplatus phantasticus	Satanic Leaf Tailed Gecko	1	1	14:10	Cooling	None	20–25	16–20	18–20	15–18	BEG
Uta stansburiana stejnegeri	Desert Side-blotched Lizard	13	3	14:10	Cooling	30–40	25–30	18–20	20–25	10–15	DE
Varanus beccarii	Black Tree Monitor	1	3	12:12		40–50	28–35	28–30	23–26	21–23	H
Varanus cumingi	Philippine Water Monitor	01/14	3	12:12		31–36	26–30		24–25		CGI
Varanus exanthematicus	Bosc Monitor, Savannah Monitor	07/09	3–4	13:11	Cooling	55–65	30–40	28–35	23	23	ADFI
Varanus glauerti	Kimberley Rock Monitor	7	3	12:12		35–40	25–30	22–25	20–24	18–23	DF
Varanus komodoensis	Komodo Dragon	7	4	12:12		45	30–32	30–34	24–26	25–28	FG
Varanus macraei	Blue Tree Monitor	1	2	12:12		35–40	28–32	26–30	24–26	22–25	H
Varanus prasinus	Emerald Tree Monitor	1	2	12:12		35–40	28–32	26–30	24–26	22–25	H
Varanus salvadorii	Crocodile Tree Monitor	1	2	12:12		35–40	26–32		22–26		H
Varanus spenceri	Spencer's goanna	7	3–4	13:11	Cooling	40	30–32	28	25–28	18–20	DF
Varanus timorensis	Timor Monitor	2	3	12:12		40–50	30–35	28–30	23–26	21–23	G
Varanus varius	Lace Monitor	04/07/08	3	12:12		34–36	28–30	25–27			CFG
Squamata: Serpentes											
Acrantophis dumerili	Dumeril's Boa	2	2	13:11	Cooling	40–45	30–35	25–30	24–28	22–25	C
Antaresia childreni	Children's Python	7	1–2	12:12/13:11	Cooling	40–45	28–35	25–30	25–28	20–25	CDFG
Antaresia stimsoni orientalis	Stimson's Python	13	1	13:11/14:10	Cooling	32	28–30	25–28	25–28	20–24	DF
Aspidites ramsayi	Woma python	13	1–2	13:11/14:10	Cooling	32	28–30	25–28	25–28	20–24	ADF
Bitis gabonica	Gaboon Viper	1	1	12:12	Cooling		29–30	25–26	28–29	23–24	BC
Bitis nasicornis	Rhinoceros Viper	1	1	12:12	Cooling		29–30	25–26	28–29	23–24	BC
Boa constrictor	Boa Constrictor	01/02	2	13:11	Cooling	28–30	24–30	20–26	18–24	16–22	BCEG
Boiga dendrophila melanota	Banded Mangrove Snake	1	2	13:11		30–35	26–28	24–26	24–26	22–24	G
Bothriechis schlegelii	Eyelash Viper	1	1	13:11		30–35	27–30	25–27	24–26	20–22	EH
Candoia carinata	Solomon Island Boa	1	1	13:11		32	26		22		CDE

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Cerastes cerastes	Horned Viper	13	2	13:11	Night cooling	30–35	25–30		24–26	20–22	DF
Corallus caninus	Emerald Tree Boa	1	1	12:12			26–30		24–26		H
Cryptelytrops albolabris	White Lipped Viper	1	1	13:11		30–35	25–30		24–26	20–22	EH
Dendroaspis angusticeps	Green Mamba	1	1–2	12:12		30–32	28–30	20–25			H
Dendroaspis polylepis	Black Mamba	7	1–2	12:12		30–32	28–30	20–25			EFG
Epicrates angulifer	Cuban Boa	2	1–2	12:12	Cooling		28–32	25–27			CG
Epicrates subflavus	Jamaican Boa	1	2	13:11		35–40	28–32	26–28	24–26	22–24	GH
Eunectes murinus	Green Anaconda	01/07	1–2	12:12		35–40	28–32		25–27		IJ
Gonyosoma oxycephalum	Red–tailed Ratsnake	1	2	13:11		30–45	26–32	24–28	22–26	20–24	H
Heterodon nasicus nasicus	Western Hognose Snake	08/10	2	14:10	Cooling / Brumation	28–30	24–30	14–18	20–24	14–16	ADEF
Lampropeltis triangulum campbelli	Pueblan Milksnake	2	1	13:11	Brumation	28–32	24–28	10–15	24–26	10–15	DF
Lampropeltis triangulum sinaloae	Sinaloan Milksnake	02/13	1	13:11	Brumation	28–32	24–28	10–15	24–26	10–15	D
Lampropeltis triangulum stuarti	Stuart's Milksnake	1	1	13:11	Cooling	30–35	24–28	22–25	20–23	18–21	C
Liasis macklotti savuensis	Savu Python	07/02	2	12:12		30–35	25–30		24–26		DEFG
Morelia amethistina	Amethystine Python	01/14	1–2	12:12		30–32	26–30		24–26		G
Morelia boeleni	Boelens Python	1	2	13:11	Cooling		24–28	20–24	18–22	15–20	E
Morelia bredli	Central Carpet Python/ Bredl's Python	13	2	13:11/14:10	Cooling	30–32	28–30	24–28	26–28	22–26	DEGH
Morelia spilota spilota	Diamond Python	4	3	14:10	Cooling	32	25–28	22–26	20–26	15–20	BCDEGH
Morelia spilota variegata	Top End Carpet Python	7	1–2	12:12		34–36	28–30	25–27			DEFG
Morelia viridis	Green Tree Python	1	1	12:12			26–30		24–26		H
Opheodrys aestivus	Rough Green Snake	04/08	1–2	13:11	Cooling	30	18–32	10–12	18–20	10–12	EHI
Orthriophis moellendorffi	Hundred Flower Snake	1	1	14:10	Brumation		22–25	12–17	18–20	12–17	D
Pantherophis guttatus guttatus	Corn Snake	7	1–2	13:11		31	24–26	19	20	16	EF
Protobothrops mangshanensis	Mang Mountain Viper	01/04/05	1–2	14:10	Brumation	22–28	23–25	17–19	17–19	9–12	BCD
Python brietensteini	Borneo Short–tailed Python	1	1	13:11			28–32		22–26		I
Python molurus bivittatus	Burmese Python	01/02	1	13:11			28–32		22–26		DF
Python regius	Royal Python	2	2	12:12	Cooling	35–40	28–30	27–29	24–26	22–24	CF
Python (Broghammerus) reticulatus	Reticulated Python	1	1	13:11			28–32		22–26		CGI

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Rhyncophis boulengeri	Rhinoceros Rat Snake	1	2	13:11	Cooling/ Brumation	30–35	25–29	20–25	21–25	15–20	EGH
Sanzinia madagascarensis	Madagascan Tree Boa	1	1–2	13:11	Cooling	40–45	30–35	25–30	24–28	22–25	EGHI
Thamnophis sirtalis tetrataenia	San Fransico Garter Snake	4	2	14:10	Cooling/ Brumation	30	22–28	16–20	18–24	14–18	I
Vipera berus	Adder	04/05/ 06/08	3	14:10	Brumation	30–35	18–24	2–6	10–16	2–6	BCDF
Chelonia											
Agrionemys horsfieldii	Horsfield's Tortoise, Russian Tortoise	08/10	3	14:10	Hibernation	35	25–30	5–10	20	14–18	G
Apalone mutica	Smooth Softshell	4	2–3	14:10	Hibernation	35	22–30	3–7		14–18	G
Apalone spinifera	Spiny Softshell	4	2–3	14:10	Hibernation	35	22–30	3–7		10–15	EG
Astrochelys radiata	Radiated Tortoise	7	3	14:10	Cooling/ None	35–50	28–32	26–30	24–28		EGH
Astrochelys yniphora	Ploughshare Tortoise	7	3	12:12		35–45	28–32	24–26	24–28		EG
Centrochelys (Geochelone) sulcata	Sulcata Tortoise, African Spurred Tortoise	13	3–4	13:11		45–50	30–35	28–30	25–28	18–22	H
Chelodina expansa	Broad– shelled Turtle	04/07/ 08/12	3	13:11/14:10	Cooling	35	28–30	24–28	22–24		EG
Chelodina longicollis	Common or Eastern snake–necked turtle	04/07/ 08/12	3	13:11/14:10	Cooling	35	28–30	24–28	22–24		CEI
Chelodina mccordi	Roti Island snake–necked turtle	1	2–3	12:12	Cooling	35–40	26–28	24–26	22–24		H
Chelonoidis denticulata	Yellow footed Tortoise	1	2	12:12	Cooling	28–32	25–28	22–24	22		EH
Chelydra serpentina	Common Snapper	4	2–3	14:10	Hibernation	35	22–30	3–7			E
Clemmys guttata	Spotted Turtle	4	3	14:10	Hibernation	35	20–25	3–7		20–22	DEG
Crysemys picta ssp.	Painted Turtle	4	3–4	13:11/14:10	Hibernation	35	20–30	3–10		15–24	EH
Cuora galbinifrons	Vietnamese/ Flowerback Box Turtle	1	1–2	12:12	Cooling	30–34	25–31	20–28	22–28	21–23	ABD
Cuora mouhotti	Vietnamese Keeled Turtle	1	2	14:10	Brumation	28–30	26–30	10–15	20–24		EH
Cuora trifasciata	Golden coin Box Turtle	1	2–3	12:12	Cooling	30–35	26–28	24–26	22–24	10	H
Cuora zhoui	Zhou's Box Turtle	1	2–3	12:12	Cooling	30	24–26	22–24	22–24		H
Emydura macquarii	Murray Short–necked Turtle	04/08/12	3	13:11/14:10	Cooling	35	28–30	24–28	22–24	23–25	GH
Emys orbicularis	European Pond Turtle	4	3	14:10	Hibernation	35	25–30	3–7	18	20–23	H
Geochelone carbonaria	Red Foot Tortoise	01/07	1–2	13:11		30–35	27–30	25–27	24–26	18–22; 5 (Brumation)	DF
Geochelone elegans	Indian Star Tortoise	01/02/ 07/13	3	12:12		30	20–25		20–25	20–22	DEFG
Geochelone gigantea/ Dipsochelys dussumieri	Aldabran Tortoise	13	2–3	12:12		35–45	29–31	22–25		22–25	H

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							Summer	Winter (if different)	Summer	Winter (if different)	
Geochelone nigra	Galapagos Tortoise	7	4	12:12		35–45	28–32	26–30	24–28		H
Geochelone pardalis	Leopard Tortoise	7	3	14:10	Cooling	40–50	28–32	26–30	24–28	22–25	DF
Geoemyda spengleri	Black–breasted Leaf Turtle	1	1	13:11	Cooling	30	24–26	22–24	22–24	22–25	DF
Glyptemys insculpulata	Wood Turtle	4	2	14:10	Hibernation	35	22–30	3–7		20	D
Graptemys ouachitensis	Ouachita Map Turtle	4	3–4	13:11/14:10	Hibernation	35	25–30	3–10		20	D
Graptemys pseudogeographica ssp	False, Mississippi, Northern Map Turtle	4	3–4	13:11/14:10	Hibernation	35	25–30	3–10		10–15	D
Heosemys spinosa	Spiny Turtle	1	1	12:12		35	25–30	24–26	24–26		I
Indotestudo elongata	Elongated Tortoise	1	2	13:11	Cooling	35–45	24–30	20–25	20–25	18–20; 4–8 (Brumation)	D
Kinixys belliana	Bell's Hingeback Tortoise	02/07	3	12:12		35	25–30		20–25	10–15	D
Kinixys homeana	Home's Hingeback Tortoise	01/07	1–2	12:12	Cooling	28–32	26–28	22–24	22	10–15	D
Kinosternon subrubrum	Eastern Mud Turtle	4	2–3	14:10	Hibernation	35	22–30	3–7		18–24	EH
Malaclemys terrapin	Diamond Back Terrapin	4	3	14:10	Hibernation	35	25–30	3–7			H
Malacochersus tornieri	Pancake Tortoise	7	2–3	12:12		30–32	28–30		22–25	5–15	DF
Mauremys leprosa	Mediterranean Pond Turtle	4	3	14:10	Brumation	35	25–30	14			H
Mauremys (Annamemys) annamensis	Annam Leaf Turtle	1	2–3	12:12	Cooling	30–35	26–28	24–26	22–24		H
Mauremys reevesii	Reeves Turtle	4	3	13:11	Brumation	35	25–30	12		16–20	H
Mauremys rivulata	Eurasian Pond Turtle	4	3	14:10	Brumation	35	25–30	14		20–22	DFG
Orlitia borneensis	Malaysian Giant Pond Turtle	01/02	2–3	12:12		26–28	25–30	23–26	23–25	9–10	D
Phrynops geoffranus	Side–neck Turtle	4	3–4	12:12		35	25–30		23–25	20	AG
Podocnemis unifilis	Yellow–spotted Amazon River Turtle	1	2–3	12:12	Cooling	30–35	26–28	24–26	22–24	10–15	F
Pseudemys concina ssp.	Cooters	4	3–4	13:11/14:10	Hibernation	35	25–30	3–10		23–25	GH
Pseudemys nelsoni	Florida Red Bellied Cooter	5	3–4	13:11	Brumation	35	25–30	15		10–15	I
Pseudemys rubriventris	Red Bellied Cooter	5	3–4	13:11	Hibernation	35	25–30	3–10			DF
Pyxis planicauda	Flat–tailed Tortoise	2	2	14:10	Cooling	35–40	28–32	24–26	24–26		EH
Rhinoclemmys pulcherrima	Painted Wood Turtle	1	2	13:11		35	25–30	24–26		5–15	DE
Sternotherus carinatus	Razorback Musk	4	2–3	14:10	Hibernation	35	22–30	3–7		20–22	DE
Sternotherus minor	Loggerhead Musk	4	2–3	14:10	Hibernation	35	22–30	3–7		20–24	BDEFG
Sternotherus odoratus	Common Musk	4	2–3	14:10	Hibernation	35	22–30	3–7			A
Terapene carolina	Eastern Box Turtle	4	2	14:10	Hibernation	35	22–30	3–7		18–22	G
Terapene ornata	Ornate Box Turtle	4	2	14:10	Hibernation	35	22–30	3–7		20	EH

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Testudo graeca ibera/ Testudo ibera	Spur–thighed Tortoise	12	3	14:10	Hibernation	35	20–30	4–7	10–15	18–20	BD
Testudo hermanni	Hermann's Tortoise	12	3	14:10	Hibernation	35	22–26	4–7	10–15		H
Testudo kleinmanni	Egyptian Tortoise	7	3	12:12		30–35	28–30		22–25	2–6	ABCEF
Testudo marginata	Marginated Tortoise	12	4	14:10	Brumation	35	28–32	2–6	20–24		EH
Trachemys decorata	Hispaniolan Elegant Slider	1	3–4	13:11		35–45	25–30		24–26		EH
Trachemys scripta elegans	Red–eared Slider	04/05/08	3–4	13:11	Hibernation	35	25–30	3–10	22	22–25	H
Trachemys scripta scripta	Yellow Bellied Slider	4	3–4	13:11/14:10	Hibernation	35	25–30	3–10		10–15	EF
Anura											
Agalychnis callidryas	Red-eyed Tree Frog	01/02/ 03/14	1–2	14:10	Cooling	30	22–30	15–22 (winter); 22–25 (spring)	17–20	14–16 (winter); 16–18 (spring)	H
Agalychnis lemur	Lemur Leaf Frog	1	1	13:11	Cooling		23–24	22–23	18–19	17–18	H
Agalychnis moreletii	Black-eyed Tree Frog	1	3	14:10	Cooling	25	18–20	15–17	13–15	10–12	H
Alytes muletensis	Mallorcan Midwife Toad	12	1	14:10	Cooling		24–28	8–20	18–14	8–12	DI
Alytes obstetricans	Common Midwife Toad	04/08	1–2	14:10	Cooling		22	17	17	11	BDI
Atelopus spumarius hoogmoedi	Harlequin Toad	1	1	12:12			24–26	22–25	20–23	18–20	CI
Bombina orientalis	Oriental or Chinese Fire-bellied Toad	04/05/09	1–2	14:10	Brumation	25–30	23–25	5–10	16–18	5–10	I
Bombina variegata	Yellow-bellied Toad	04/05/12	1	14:10	Cooling	26	18–26	3–8 (winter); 8–21 (spring)	11–14	2–8 (winter); 6–12 (spring)	DEFIJ
Bufo bufo	Common Toad	04/05/ 06/12	1	14:10	Cooling		18–23	3–8 (winter); 8–21 (spring)	11–14	2–8 (winter); 6–12 (spring)	DEFIJ
Bufo galeatus	Bony-headed Toad	1	2	13:11			26–30	24–26	22–26	22–24	BDEGI
Bufo marinus	Cane Toad	1	2	13:11		30–35	28–32	24–28	24–26	22–24	BDFI
Cruziohyla calcarifer	Splendid Leaf Frog	1	1–2	12:12	Cooling		24–26	23–25	21–23	20–22	H
Dendrobates auratus	Green and Black Dart Frog	01/02/14	1–2	12:12		30–32	24–28	22–25	20–24	20–22	BCEG
Dendrobates leucomelas	Bumblebee Dart Frog	1	1–2	12:12			24–28	22–25	20–24	20–22	BCEG
Dendrobates tinctorius	Dyeing Dart Frog	1	1–2	12:12			24–28	22–25	20–24	20–22	BCG
Dendrobates tinctorius / azureus	Blue Dart Frog	01/07	1	12:12			24–28	22–25	20–24	20–22	BCD
Dendrobates ventrimaculatus	Amazonian Dart Frog	1	1	12:12			24–26	22–25	20–23	20–22	G
Dyscophus guineti	Sambava Tomato Frog	01/02	1	13:11	Dry spell		24–28	22–24	22–24		BCI

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Epidalea (Bufo) calamita	Natterjack Toad	04/05/12	1	14:10	Cooling		18–23	3–8 (winter); 8–21 (spring)	11–14	2–8 (winter); 6–12 (spring)	DEFIJ
Epipedobates anthonyi	Phantasmal Poison Frog	1	2	13:11			24–28	22–24	22–24		BCDE
Excidobates mysteriosus	Maranon Poison Frog	01/07	2	13:11	Cooling		26–30	20–24	20–24		BDE
Leptodactylus fallax	Mountain Chicken	2	2	13:11		30–35	25–27	24–26	24–26	22–24	BDI
Lithobates vibicarius	Green-eyed Frog	1	2	14:10	Cooling	26	26–28	23–25	20–24	18–20	BC
Mantella aurantiaca	Golden Mantella Frog	1	2	14:10	Cooling		24–26	22–24	20–22	18–20	BDI
Mantella viridis	Green Mantella Frog	1	2	14:10	Cooling		24–27	20–24	17–19	16–17	BCI
Megophrys nasuta	Long-nosed Horned Frog	1	1	13:11			24–26	22–24	20–22	18–20	BDI
Nectophrynoides viviparus	Morogoro Tree Toad	7	2	14:10		30	24–26	18–22	20–22	10–18	BEFG
Oophaga pumilio	Strawberry Poison Frog	01/02	2	13:11			24–28	22–24	22–24		BCEGH
Pedostibes hosii	Borneo Tree Toad	1	3	13:11		30–35	26–30	24–26	22–26	22–24	HI
Pelodryas caerulea	White's Tree Frog	02/07/ 08/09	2	12:12		36	25		20		DEFHI
Phyllobates bicolor	Black-legged Dart Frog	1	1–2	12:12			22–28	20–25	18 –24	16–20	BCH
Phyllobates terribilis	Golden Poison Frog	1	2	13:11			26–28	22–24	22–24		BD
Phyllobates vittatus	Golfodulcean Poison Frog	1	1	13:11			26–28	22–24	22–24		BD
Polypedates leucomystax	Golden Tree Frog	1	2	13:11		30–35	24–28	22–25	20–22	18–20	H
Ranitomeya lamasi	Pasco Poison Frog	1	2	12:12	Cooling		20–22	18–20	18–20	16–18	BC
Ranitomeya reticulata	Reticulated Poison Frog	1	2	13:11			24–28	22–24	22–24		BCEG
Rhacophorus feae	Feae's Flying Frog	1	2	12:12		25	22	22	17	17	EH
Theloderma corticale	Vietnamese Mossy Frog	1	1	13:11			20–26	20–24	18–22	18–21	G
Theloderma stellatum	Bug-eyed Tree Frog	1	1	13:11			20–24	20–24	18–21	18–21	G
Trachycephalus resinifictrix	Amazon Milk Frog	01/02	3	13:11		32–40	28–32	26–30	24–26	22–24	H

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Caudata											
Euproctus platycephalus	Sardinian Brook Salamander	12	1	14:10	Cooling		18–20	Dec-14	18–20	14–16 (winter); 16–18 (spring)	H
Lissotriton (Triturus) vulgaris	Smooth or Common Newt	06/04/ 05/08	1	14:10	Cooling		18–23	3–8 (winter); 8–21 (spring)	11–14	17–18	H
Neurergus kaiseri	Kaisers Newt	10/12	1	13:11	Cooling		24–30	Oct-15	22–25	10–12	H
Salamandra salamandra	Fire Salamander	04/05/ 08/12	1	14:10	Cooling		18–23	3–8 (winter); 8 –21 (spring)	11–14	8–12	DI
Triturus cristatus	Great Crested Newt	06/04/ 05/08	1	14:10	Cooling		18–23	3–8 (winter); 8–21 (spring)	11–14	11	BDI
Tylototriton verrucosus	Himalayan Newt	03/10	1	14:10	Cooling		25–28	15–18	25–28	18–20	CI
Gymophiona: Caeciliidae											
Typhlonectes natans	Rio Cauca Caecilian	1	2	12:12		30–35	28–30	26–28	28–30	26–28	I
Typhlonectes spp.	Aquatic Caecilian, Rubber Eel, Caecilian Worm.	1	1–2	12:12			28–30	27–28	28–30	27–28	IJ