Comparison of Two Artificial Ultraviolet Light Sources used for Chuckwalla, *Sauromalus obesus*, Husbandry

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ABSTRACT - Two studies were conducted to determine the suitability of the Westron Corp. self-ballasted mercury vapor lamps in the captive maintenance of the chuckwalla lizard, *Sauromalus obesus*. Initially, preference for basking under either a Westron lamp or an incandescent flood lamp was measured in a separate enclosure involving five individuals selected from a group of eight juveniles. Following this, the eight chuckwallas were divided into two groups and maintained for fifteen months in indoor enclosures illuminated with either an incandescent flood lamp and fluorescent Sylvania 350 BL combination or a single Westron self-ballasted mercury vapor lamp. Snout-to-vent length (SVL), body mass, and cloacal body temperatures were measured every two weeks. After nine months, the lizards were radiographed to assess bone density and blood was collected for assay of 25-hydroxyvitamin D. No significant differences in SVL and body mass growth rates, cloacal body temperatures or bone densities were observed between the two groups. The serum 25-hydroxyvitamin D concentrations for lizards exposed to the incandescent lamp/Sylvania 350BL combination were significantly less than those measured in lizards exposed to the Westron lamp and wild-caught lizards. Furthermore, the Westron lamp maintained 25-hydroxyvitamin D at levels comparable to those observed from a wild-caught sample. Observations support a preference for basking under a Westron lamp. These data suggest that the Westron lamp is at least as effective as an incandescent/blacklight combination in maintaining desert dwelling chuckwallas and that either setup may result in adequate vitamin D production sufficient to sustain healthy bone density.

Key words: chuckwalla, *Sauromalus obesus*, blacklights, lighting, ultraviolet radiation, self-ballasted mercury lamps, vitamin D.

INTRODUCTION

Over the last two decades, ultraviolet radiation (UVR), especially the ultraviolet B (UVB) component, has come to be recognized as an important factor in the captive husbandry of some reptiles, particularly various lizard species. UVB is required for the conversion of provitamin D_3 (7-dehydrocholesterol) to previtamin D_3, which is subsequently thermally isomerized to vitamin D_3 in the skin (Chen, 1999). Once formed, vitamin D enters the circulation and is metabolized in the liver to 25-hydroxyvitamin D (25 (OH) D). This is the major circulating form of vitamin D that is measured to determine vitamin D status. 25 (OH) D is then metabolized in the kidney to 1,25-dihydroxyvitamin D (1,25 $(OH)_2$ D). The active form, (1,25 $(OH)_2$ D), is important for its role in calcium and phosphate metabolism especially in relation to bone growth and maintenance (Lian, *et al*, 1999).

For over a decade, the Dallas Zoo Department of Herpetology has used visible-light and heat-emitting incandescent flood lamps in conjunction with fluorescent Sylvania 350 blacklights to illuminate many of the enclosures. This combination has proven to be effective for a variety of species over many genera, resulting in successful reproduction, hatching, and growth over the years. However, its implementation

requires at least two fixtures and their placement within or above an enclosure can be challenging. Furthermore, the irradiance of UVR, especially UVB, is rapidly reduced with distance and may be inadequate at the substrate level in large enclosures such as those that house large varanids and iguanids.

For years, the Westron Corporation (Oceanside, NY) has manufactured a self-ballasted mercury vapor plant lamp marketed as "Wonderlite." The ability of this early lamp to convert 7-dehydrocholesterol to previtamin D_3 *in vitro* was verified by Holick, *et al* (2002). In 1995, Westron Corp. modified the lamp to emit even more UVR, which was considered essential if it was to be used for reptile husbandry. This lamp was briefly marketed as "Dragonlite" but was then changed to "ActiveUVHeat." This was therefore a single lamp that could potentially provide not only heat and visible light but also ultraviolet A (UVA) and UVB. Various anecdotal accounts and endorsements of the putative efficacy of the Westron lamp in reptilian husbandry began to appear, especially from zoos (www.uvheat.com/zandv.htm). Their efficacy was explored in greater detail with the carnivorous Komodo dragon, *Varanus komodoensis* (Gillespie, *et al,* 2000, Gyimesi and Burns, 2002) but dietary vitamin D_3 was an important confounding factor in these studies. Despite small sample sizes, an experimental approach was designed to determine if the Westron lamp was at least comparable to the traditionally used incandescent/ blacklight combination for raising juvenile chuckwallas in the absence of dietary vitamin D_3. It was assumed that this herbivorous and diurnal desert species would be a sensitive indicator of the adequacy of the heat and UVR conditions.

Materials and Methods

Eight juvenile chuckwallas that had hatched in an outdoor display were moved indoors at about three weeks of age. For the growth assessment portion of the study, they were size matched as pairs and one member of each pair was randomly assigned to one of two compartments by coin toss. They were marked with dots of yellow or red enamel paint for identification. Three times weekly they were fed a diet consisting of chopped kale, Romaine lettuce, apples, cabbage, carrots, cantaloupe, and bananas. None of these plants have been reported to contain vitamin D compounds. Once a week, the salad was sprinkled with calcium carbonate powder (Carolina Biological Supply, Burlington, NC). Based on eight measurements, the mass of $CaCO_3$ per serving was 0.5 ± 0.2g (mean ± standard deviation) while the mass per salad serving was 91.8 ± 11.5g.

When the chuckwallas were about eleven weeks of age and had been indoors for about eight weeks, five of the eight were individually tested for a preference for basking either under an incandescent lamp or a Westron lamp. A wooden enclosure measuring 117 cm W. X 36 cm D. X 76 cm H. was outfitted with two 10 cm wide inclined boards angled upward from the floor center toward opposite ends of the enclosure. Each terminated on a horizontal basking board about 13 cm long and which was secured to the side wall 25 cm from the top. Boards were covered in 100-grit sandpaper for traction. A 160 watt Westron Wonderlite flood lamp directly over one basking platform was height adjusted to produce a temperature of 53 – 56°C (127 – 133°F). The UVR irradiances were measured with a UVP, Inc. (Upland, CA) model UVX radiometer while illuminances were measured with a General Electric (Cleveland, OH) model 217 light meter. All measurements were made at the hotspot basking site. The UVA irradiance was 518 μW/cm² and UVB irradiance was 138 μW/cm²; illuminance was 16,140 lux. The other basking site was illuminated with a 150-watt incandescent ABCo. reflector flood lamp (Philadelphia, PA) adjusted to produce a basking temperature of 53 – 56°C (127 – 133°F). The UVA irradiance was measured as 13 μW/cm² while UVB irradiance was 2 μW/cm²; illuminance was 8,608 lux. Individuals were placed in the enclosure for a total of 54 d. Data on location preference were collected from 4 to 19 d depending on the individual. The food and water were placed at the point at which the angled boards met in the center of the enclosure. They were observed at various times during the day and scored as basking under one of the two lamps when they were either on the basking spot or on the incline adjacent to the basking area where the temperature was lower. Between five and twelve observations were made each day.

For the growth-assessment study, a plastic container was divided in half using a plywood partition resulting in two compartments each measuring 62.5 cm W. X 74 cm D. X 63 cm H. A pile of large rocks measuring about 40 cm high and with ample hiding crevices was constructed in each compartment. Each enclosure contained a 14 cm diameter water dish. The "control", or reference, compartment was illuminated with a 300 watt/R40 reflector incandescent flood lamp (Philips, Somerset, NJ, 08873) directed to the top of the rock pile and with the distance adjusted to produce a basking spot with a maximum temperature of 41.1°C (105.9°F) In addition, two 20 watt Sylvania 350BL fluorescent tubes (Osram Sylvania Inc., Danvers, MA) were positioned directly above the basking spot. The "experimental" or "test" compartment was illuminated with a 300 watt Westron self-ballasted mercury vapor lamp positioned toward the rock pile to produce a maximum basking temperature of 41.1°C (105.9°F). The lamps were on a 12L:12D photoperiod with lights turned on at 0800 hr. In the control compartment, the UVA irradiance was 538 μW/cm² while UVB was 168 μW/cm²; illuminance was 5380 lux. In the Westron test compartment, UVA was measured at 1154 μW/cm² and UVB at 383 μW/cm²; illuminance was 18292 lux.

Body mass, SVL, and cloacal body temperatures were measured every two weeks between 1100 – 1300 hours during the 15 months of study. All temperatures were recorded with a Miller & Weber cloacal thermometer within 30 sec of removal from the chambers to avoid change in body temperature due to restraint. Bone density was clinically examined seven months into the study by radiography of the whole body using a Toshiba, MGU-01 mammography unit (Tochigi 329-26, Japan). Blood was collected at this time by caudal vein or cardio puncture. The serum was separated from the blood, immediately frozen, and sent to the Vitamin D, Skin, and Bone Laboratory, Boston University School of Medicine for analysis of 25 (OH) D concentrations using a competitive-binding assay (Chen, *et al*, 1990).

Serum samples from nine wild-caught specimens (Arizona Scientific Collecting Permit # SP701967 to B. Aucone) collected in the Tempe, AZ area in June 2002 were analysed for

25 (OH) D concentration using the same techniques as the captive lizards. Blood was obtained within 24 hr of capture and specimens were released at their capture point within 72 hr. All lizards collected were adults and determined to be eight males and one female. These values served as a field control for comparison with the 25 (OH) D concentrations observed in the captive lizards.

Results were analysed using Systat 6.0 and Sigma Plot 4.0. A paired t-test was used to assess potential differences in basking frequency under the two types of lamps. A repeated measures ANOVA was used for analysis of body mass and SVL growth and for the cloacal temperature data. A one-way ANOVA was used for serum 25 (OH) D data.

Results

All five lizards used in the lamp-preference study basked more frequently under the Westron lamp. Of a total of 238 observations, 139 were under the Westron lamp while 99 were under the incandescent lamp, that is, the lizards were observed 40% more frequently under the Westron lamp. This difference is significant using a paired t-test ($p<0.01$).

The initial body mass of the four lizards in the control (incandescent/BL) group was 34.1 ± 8.5 g (mean ± standard deviation) while that of the four specimens in the Westron (test) group was 30.5 ± 7.9 g. The body mass of the control group at the end of the study was 100.5 ± 9.1 g and the mean mass for the Westron group was 98.3 ± 36.4 g. No significant difference in body mass between the two groups was detected by repeated-measures ANOVA. Body mass increase for the combined groups and based on 27 measurements for each of the eight lizards is Mass = 2.51t (weeks) + 31.1 ($r^2 = 0.98$).

The initial SVL for the four control lizards was 96.3 ± 3.0 mm while that for the Westron group was 93.8 ± 7.2 mm. The mean SVL of the control group at the end of the study was 134.0 ± 5.1 mm while that of the Westron group was 135.8 ± 13.0 mm. There was no significant difference in SVL between the two groups by repeated-measures ANOVA. Body length increase for all eight lizards each measured 27 times is SVL = 1.42t (weeks) +101.5 ($r^2 = 0.92$).

The mean cloacal body temperature for the four control lizards on the first measurement was 37.0 ± 1.2°C while that of the four in the Westron group was 36.7 ± 1.1°C. The mean cloacal temperature at the end of the study for the controls was 33.6 ± 1.8°C and that for the Westron group was 31.8 ± 3.1°C. There were no significant differences in cloacal temperatures between the two groups detected by repeated-measures ANOVA. There was a significant decline in mean cloacal temperatures over the course of the study for both groups and can be modeled as Temp. = 36.32t (weeks) – 0.09. ($r^2 = 0.21$).

The mean value of the serum 25 (OH) D concentration for the three samples obtained from the control (incandescent/BL) lizards was 41 ± 6 ng/ml (103 ± 16 nmol/L; range: 34 – 45 ng/ml) while that for the four samples from the Westron group were 94 ± 32 ng/ml (234 ± 78 nmol/L; range: 70 – 140 ng/ml). The mean value for the nine samples acquired from the field controls were 85 ± 30 ng/ml (211 ± 75 nmol/L; range: 55 – 130 ng/ml). The value for the indoor controls is significantly lower than that of the other two groups when data were log transformed (ANOVA: $F_{2,13} = 6.7$, $p = 0.01$; Tukey test, control vs. Westron treatment and control vs. wild-caught $p < 0.05$)

Radiographs demonstrated similar density of long bones, specifically humerus, femur, tibia, radius and ulna, for both control and experimental lizards (Gamble, 2002. pers comm)

Discussion

The reasons for the preference to bask under a Westron lamp compared to an incandescent lamp at equivalent basking-site temperatures remains a matter of conjecture. Possible explanations may include the differences in the illuminances and UVR irradiances between the two lamps. Ferguson, *et al* (2002) and Ferguson, *et al* (2003) have shown that voluntary exposure to UVR is increased when dietary concentrations of vitamin D_3 are restricted.

The lack of differences in body mass and SVL growth rates between the two groups supports the view that the two lighting regimens are comparable in their ability to facilitate physiological processes associated with growth.

The small but significant decline in cloacal body temperatures can be explained as a reflection of spatial and temporal partitioning associated with maturation and territoriality. At the beginning of the study, juveniles would simultaneously share basking sites and hence have similar body temperatures. With maturity, apparently dominant individuals claimed the optimal basking spot while others would wait for an opportunity to utilize this area or settle for a cooler basking area.

The Westron lamp was associated with higher 25 (OH) D levels compared to the incandescent/BL controls. However, since bone density in both groups was similar, it may be inferred that even concentrations as low as 34 ng/ml (85 nmol/L), the lowest value measured, are capable of facilitating adequate bone mineralization. In wild caught *Varanus komodoensis*, Gillespie, *et al* (2000) report blood levels ranging from 47 ng/ml (117 nmol/L) up to 130 ng/ml (323 nmol/L). In the present study, the lowest value for a wild caught chuckwalla was 55 ng/ml (137 nmol/L) while two specimens had values as high as 130 ng/ml (323 nmol/L). The large variation in 25 (OH) D concentrations among apparently healthy animals is compatible with the view that it serves as a blood storage form of vitamin D_3 rather than as a regulated, biologically active metabolite (Laing and Fraser, 1999).

The Westron self-ballasted mercury lamp appears to provide sufficient UVR for chuckwalla husbandry and possibly a variety of other species as well. Its range of output from infrared (heat) through visible to UVB make it a convenient lamp to use. In addition, the high wattages available make it suitable for larger enclosures, though the heat load when used in smaller vivariums must be considered.

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