Corners Limited

is the proud sponsor of the

2014 ASAG Workshops

SHINING A LIGHT ON AVIAN VISUAL PERCEPTION

ASAG Avian Welfare Workshop
AZA 2014 Mid-Year Meeting

Linda Henry, SeaWorld San Diego
Linda.henry@seaworld.com

Photo by Frank Todd

- Welfare
  - AZA ACM guidelines for light provision
  - Defined
- Overview of vision in birds
  - Perception and function
- Review of the literature
  - What we *think* we know
- Factors influencing light provision
  - What constitutes the *right* light?
- Future research
  - We don't know what we don't know
- Conservation and light
  - Increasing awareness

1.2 Light

Careful consideration should be given to the spectral, intensity, and duration of light needs for all animals in the care of AZA-accredited zoos and aquariums.

Identify spectral, intensity, and duration requirements for your species. Specify daily, seasonal, age related (young), or gender related, etc. changes in light intensity/duration delineations if appropriate.

Define areas that are unknown and need further research.

"Animal Care Manual template" Association of Zoos & Aquariums. Association of Zoos & Aquariums. Web. March 2014.

Welfare:

AZA refers to welfare:
"…collective physical, mental, and emotional states over a period of time…"

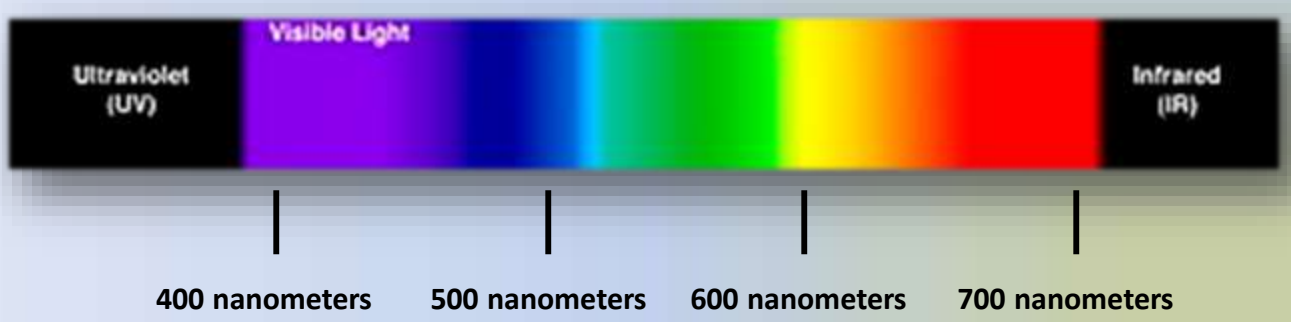
Explained as "…healthy, comfortable, well-nourished, safe,
able to develop and express species-typical relationships, behavior, and cognitive abilities…"

Association of Zoos and Aquariums Animal Welfare Committee's Definition of Animal Welfare, www.aza.org

Light Provision Challenge

Human and avian vision differs; humans are "blind" to the avian perspective

- Human visual range 400-700nm
- Avian visual range ~320-~700nm



Smith E. 2003. "**Effect of UV light on bird welfare."** PowerPoint presentation at *Ultraviolet Vision in Birds: Implications for Care and Conservation*, 7-8 November 2003, Brookfield Zoo, Chicago, IL.

Light Provision Options

"Identify spectral, intensity, and duration requirements for your species."

- Outdoor
  - Local photoperiod
  - Supplement with artificial light
- Outdoor + indoor
- Indoor
  - Daylighting (e.g., skylights, light tubes)
    - Glass/plastic do not transmit <334nm
  - Artificial lights
    - Designed for human visual needs

Photo by Frank Todd

What is the birds' eye view?

- Highly visually dependent
- Large eyes
- Size and shape variable
  - flat, globular and tubular

Photo by Frank Todd

Avian light detection

- Eyes (retina to optic nerve)
- Extraretinal photoreceptors

Foster RG and Soni BG. 1998. **Extraretinal photoreceptors and their regulation of temporal physiology.** *Reviews of Reproduction* 3:145-150.

Gwinner E and Brandstatter R. 2001. **Complex bird clocks.** *Phil Trans R Soc Lond* B356: 1801-1810. DOI:1098/rstb.2001.0959.

Avian Retina

- Single cones
  - Daylight vision
  - Chromatic
- Double cones
  - Most numerous
  - Function unclear; possible achromatic vision and motion detection
- Rods
  - Dim light vision
  - Achromatic

Photo by Frank Todd

Cuthill IC, Partridge JC and Bennett ATD. 1999. **UV vision and its function in birds.** In Adams NJ & Slotow RH (eds) *Proc 22 Int Ornithol Congr*, 2743-2758. Johannesburg: BirdLife South Africa.

Single Cones

- 4 classes with 4 distinct visual pigments
  - Long wave-sensitive (LWS)
  - Medium wave-sensitive (MWS)
  - Short wave-sensitive 2 (SWS2)
  - Short wave-sensitive 1 (UVS/VS)
- Oil droplets
  - Filter to fine tune wavelength reaching the retina

Hart, NS and Vorobyev M. 2005. **Modeling oil droplet absorption spectra and spectral sensitivities of bird cone photoreceptors.** *J Comp Physiol A* 191:381-392. DOI:10.1007/s00359-004-0595-3.
Vorobyev M, Osorio D, Bennett ATD, Marshall NJ, Cuthill IC. 1998. **Tetrachromacy, oil droplets and bird plumage colors.** *J Comp Physiol A* 183:621-623.

- Avian visual range ~320-~700nm
  - LWS (peak 565-570nm)
  - MWS (peak 500-510nm)
  - SWS2 (peak 430-460nm)
  - SWS1
    - VS (peak 409-418nm)
    - UVS (peak 360-380nm)

Light Perception

- #Photons striking photoreceptors
- Cones together = brightness signal
- Cones contrasted = color signal

Rubene, D. 2009. **Functional differences in avian colour vision: a behavioural test of critical flicker fusion frequency for different wavelengths and light intensities.** MSc thesis. Biology Education Centre and Department of Animal Ecology, Uppsala University.

Possible role(s) of UV Perception

- Signaling/mate choice
- Foraging
- Orientation/migration
- Predator avoidance
- Egg/nestling care

Photo by Frank Todd

Do we know species specific spectral needs?

Smith E. **"Effect of UV light on bird welfare."** Brookfield Zoo, Chicago, IL. *Ultraviolet Vision in Birds: Implications for Care and Conservation*, 7-8 November 2003.

Blackwell BF. 2002. **Understanding Avian Vision: The Key to Using Light in Bird Management** in *Proc 20th Vertebr Pest Conf* (RM Timm and RH Schmidt, Eds). Pp 146-152.

UVS	VS
Characteristic of diurnal, terrestrial birds from open habitats	Pigeon
	Chicken
	Ostrich
	Nightjar
	Owls?
Passerines	Humboldt penguin
Psittacines	Other penguins?
Rheas	
Gulls	
Some terns	

? ←

Nocturnal and deep diving birds?

Mullen P and Pohland G. 2008. **Studies on UV reflection in feathers of some 1000 bird species: are UV peaks in feathers correlated with violet-sensitive and ultraviolet sensitive cones?** *Ibis* 150:59-68.

Ross, et al:

- Tested preference for UV+ light environments
- Majority of birds preferred UV+
- Greater sociability in UV+
- Black light (Sylvania F40 T12/350L)

Carvalho, et al:

- Psittacines
- Analyzed SWS1 opsin gene
- UVS pigments ubiquitous in Psittaciformes

Photo by Frank Todd

Ross MR, Gillespie KL, Hoppera LM, Bloomsmith MA, Maple TL. 2013. **Differential preference for ultraviolet light among captive birds from three ecological habitats.** *Appl An Beh Sci* 147:278– 285.

Carvalho LS, Knott B, Berg ML, Bennett ATD and Hunt DM. 2010. **Ultraviolet-sensitive vision in long-lived birds.** *Proc R Soc* B. DOI:10.1098/rspb.2010.1100.

Capuska, et al:

- Analyzed SWS1 opsin gene
- Contend that UVS is rare in seabirds
- Confirmed UVS Laridae

Jouventin, et al:

- King penguin
- Signal function beak spot
- Found UV reflectance
- Higher in adults—role in pairing?

Capuska GEM, Huynen L, Lambert D, Rauenheimer D. 2011. **UVS is rare in seabirds**. *Vision Research* 51:1333-1337.
Jouventin P, Nolan PM, Ornborg J, and Dobson S. 2005. **Ultraviolet Beak Spots in King and Emperor Penguins.** *The Condor* 107:144-150.

Mullen and Pohland:

- Emphasized non-passerine birds
- Looked at UV reflectance of feathers
- Contend UV plays an important role in mate choice
- Structural colors = honest signal (e.g., age, fitness)
- Likely UV perception in more groups

Photo by Frank Todd

Mullen P and Pohland G. 2008. **Studies on UV reflection in feathers of some 1000 bird species: are UV peaks in feathers correlated with violet-sensitive and ultraviolet sensitive cones?** *Ibis* 150:59-68.

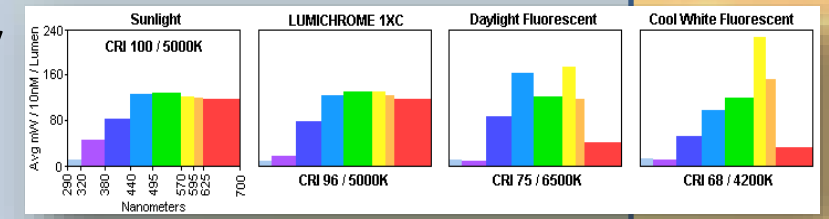
Light Provision

Challenges

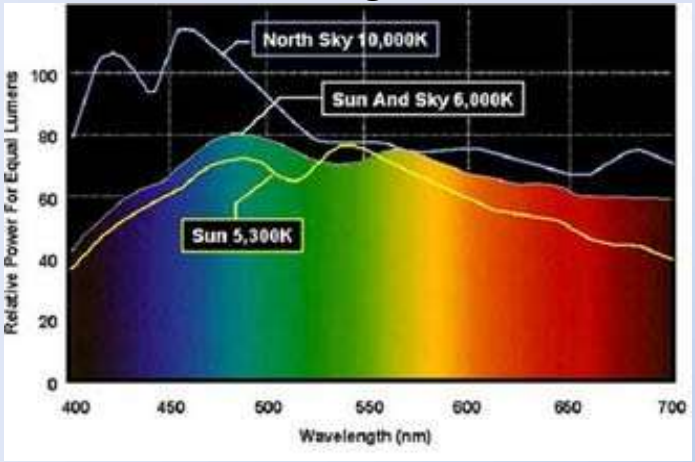
- Light intensity is lost exponentially with distance from source
- Surface area increases with distance from source
- Foot candle/lux measure inadequate
- "Full spectrum" lights vary

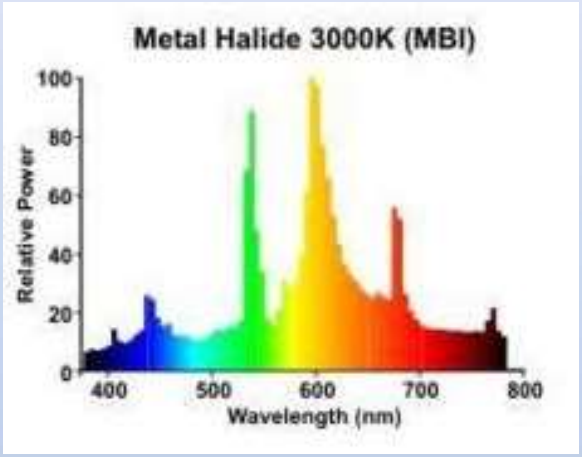
Solutions

- Ask a lot of questions
- Spectral Power Distribution Curves (SPD)
- Combine light sources

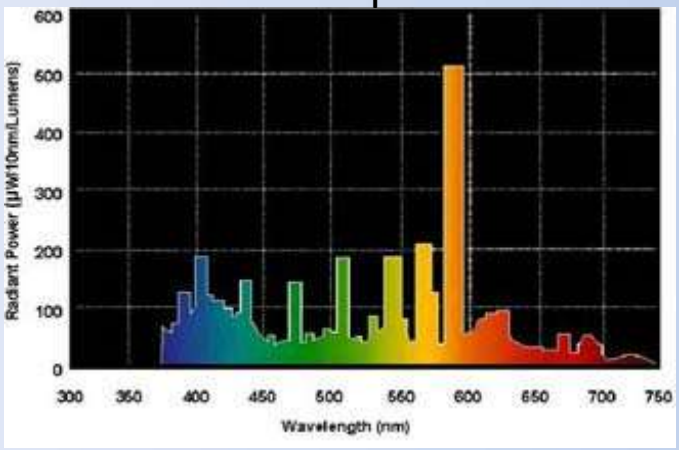


Sunlight

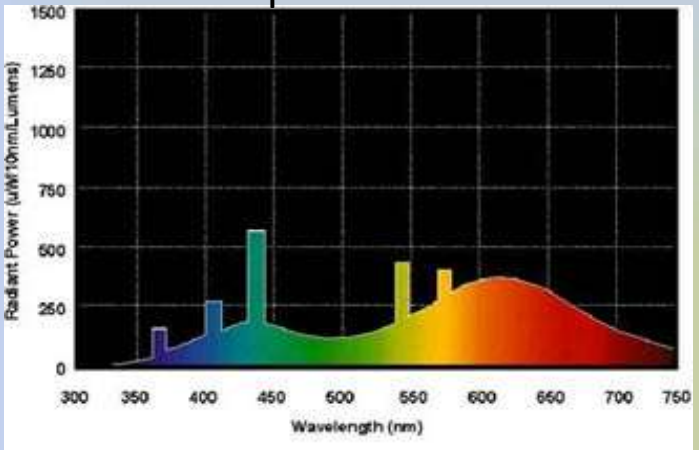




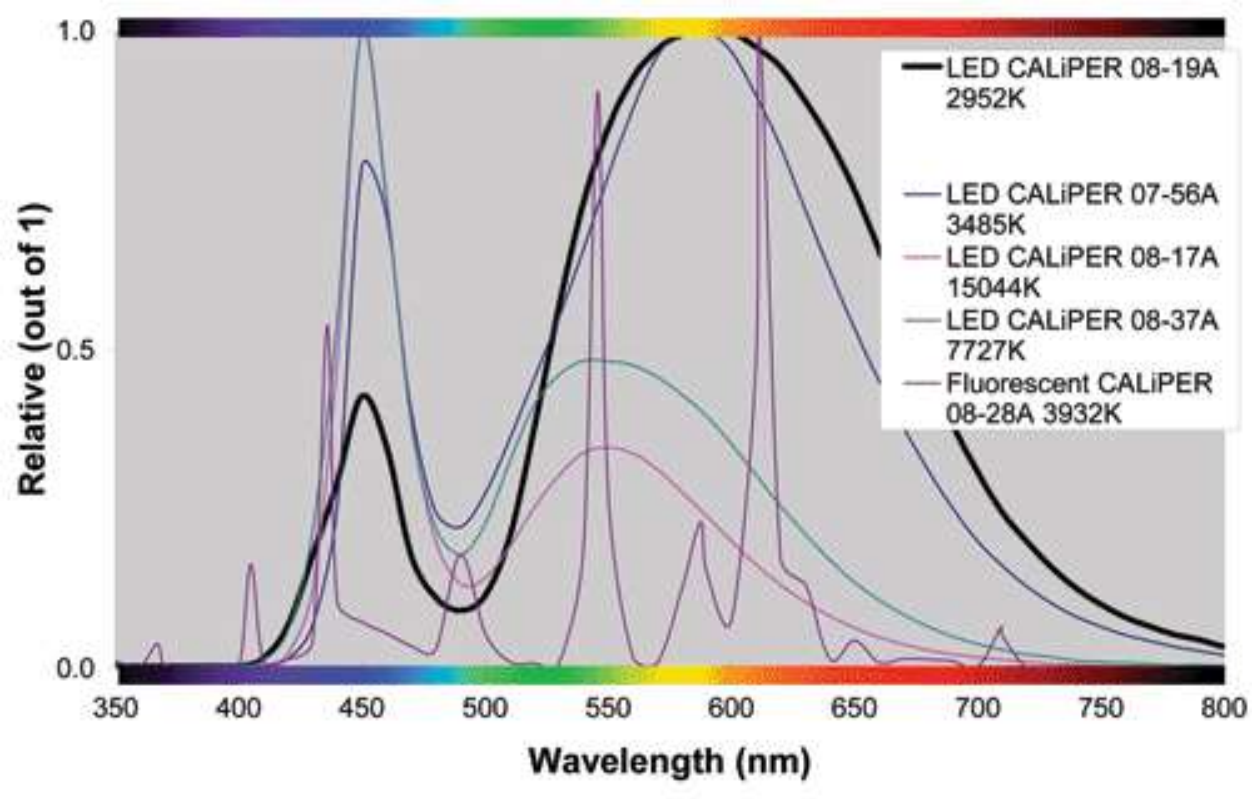
Multi Vapor HID



Plant & Aquarium Fluorescent



Images downloaded from :
http://www.gelighting.com/na/business_lighting/spectral_power_distribution_curves
https://www.ies.org/lighting/science/color.cfm



LED do not produce UV or IR

Image downloaded from http://continuingeducation.construction.com/article.php?L=223&C=947&P=6

Light Provision

Considerations

- Reflectance/absorbance habitat elements
  - Walls, substrates, “Furniture”,
  - Aviary covers--filter out spectrum
  - Sky light covers—filter out spectrum
- All light inputs
  - i.e., exit signs, seasonal décor, emergency lights, pathway lighting, graphics, etc.
- Regular relamping
- Artificial ≠ sun intensity
  - Relative difference between light and dark

Light Provision and Flicker

- Flicker = visible pulsation of a light source
- CFF = Critical Flicker Fusion Frequency
  - Pulsation is perceived as continuous
    - Human CFF ~50-60Hz
    - Avian CFF >100Hz
- Light intensity/wavelength affect flicker perception
- Sensitivity in birds less well-studied
- Fluorescents, LED
  - Use high frequency electronic ballasts
  - LED?

Rubene, D. 2009. **Functional differences in avian colour vision: a behavioural test of critical flicker fusion frequency for different wavelengths and light intensities.** MSc thesis. Biology Education Centre and Department of Animal Ecology, Uppsala University.

Light Provision and welfare

Literature Review

- No evidence that UV deficient artificial lighting adversely affects the welfare of birds
- No evidence that low frequency lighting (flicker) adversely affects welfare of birds
- Birds lives may be enriched by the provision of UV light and the use of high frequency sources
- Flicker may be a factor in welfare when combined with repetitive spatial frequency

Smith EL. 2003. **Effect of the visual environment on avian welfare.** PhD dissertation, University of Bristol, Bristol, UK.
Ross MR, Gillespie KL, Hoppera LM, Bloomsmith MA, Maple TL. 2013. **Differential preference for ultraviolet light among captive birds from three ecological habitats.** *Appl An Beh Sci* 147:278– 285.

Research and Future Directions

Photo by Frank Todd

- How important is UV provision?
  - Consequences of provision
  - Is flicker a concern
- 2003 *Ultraviolet Vision in Birds: Implications for Care and Conservation* identified
  - Need for collaboration among Zoos/Aquariums
    - Standardize observation protocols
    - Identify species in need
- Survey current lighting provision and outcomes
  - Collate by species

Conservation Starts With Awareness

- Model intelligent light use
  - Discourage waste, light pollution
    - Shielded fixtures: outdoor
    - Spectrum awareness
      - E.g., sea turtles
- Support bird-friendly exhibits/architecture
- Support relevant initiatives/programs
  - International Dark Sky Association http://www.darksky.org
  - American Bird Conservancy www.abcbirds.org
  - Save a Billion Birds http://www.zoolighting.org

Photo by Frank Todd

Thank you

Tom Schneider
Sara Hallager
Stephanie Costelow
Lauren DuBois
Patty McGill

Photo by Frank Todd


…Conservation continues through us
Photo by Frank Todd

Corners Limited

is the proud sponsor of the

2014 ASAG Workshops