Vision in agricultural animals – What do they see and how do they respond? Poultry, Swine, and Aquaculture

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Visual Retinal Photoreception (through the eyes)



Humans are Trichromatic

Birds are Tetrachromatic



Typical Photopic Spectral Sensitivity



Humans





- 12 times more sensitive to blue spectrum
- 4 times more sensitive to red spectrum
- Ability to see UV A light

Data source: "Spectral sensitivity of the domestic fowl (Gallus g. domesticus)" N. B. PRESCOTT AND C. M. (1999)

Poultry perceive light through the eye as well as through extra-retinal neura pathways

- **1. Visual, Retinal Reception** Photon absorption by photo-pigments rhodopsin (rods), iodopsin (cones) and recently discovered (1998) melanopsin
- **2a. Non-visual / Pineal Reception** Photon absorption by functional photoreceptors located in pineal gland on the top of the brain
- **2b. Non-visual / Hypothalamic Reception** -Photon absorption by deep brain encephalic photoreceptors



Deep red light penetrates best though the skull of birds

Avian skull, skin and brain tissue create natural light filter. Due to presence of blood in the tissue, red light penetrates skull with highest transmission efficiencies.



Source: Hartwig, H.G., Veen, T. van, 1979. "Spectral characteristics of visible radiation penetrating into the brain and stimulating extraretinal photoreceptors." *J. Comp. Physiol*. 130, 277–282.

The color landscape is more complex to poultry

Human Spectral Sensitivity



Poultry Spectral Sensitivity



Red color

- Increases the growth rate of chickens and turkeys at the beginning of the rearing period
- Increases locomotion that helps minimize leg disorders in the late rearing period
- Stimulates secretion of Gonadotropin Releasing Hormone (GnRH), essential for sexual maturation
- Stimulates day-to-day events of ovulation / egg production
- Reduces actual feed consumption per egg laid with no differences in egg size, shell weight, shell thickness, or yolk and albumen weights
- Stimulates / Improves Melatonin production

Green, Blue color

- *Green light significantly enhances growth rate at an early age* by enhancing proliferation of skeletal muscle satellite cells
- Blue light enhance growth at a later age by elevation in plasma androgens
- Blue light spectrum region between 446–477 nm is identified as the most potent wavelength region providing circadian input for regulating melatonin secretion
- Green and Blue light promote myofiber growth due to more effective stimulation of testosterone secretion
- Narrow band blue light reduces locomotion

UVA vision plays an important role in social and feeding behaviors

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Pullets prefer to dwell under UV-A

Research conducted at Iowa State University by Kai Liu and Hongwei Xin:

P<0.01

38.7

LED





*Under non-choice experiment: No apparent differences observed in weight gain, total feed consumed, FCR, activity levels, or eye conditions.

Broiler welfare is improved under UV-A

Research conducted at Texas A&M University by Gregory Archer (unpublished) showed that supplementing with UV-A:

-Reduced stress biomarkers:
3X less corticosterone
2X lower H:L ratio
lower body asymmetry

-Reduced fear responses Lower tonic immobility times Fewer inversion wing flaps



Dynamic lighting

R/G/B/W/UV Spectrum Controllable lighting fixture



• Disease Alerts

Circadian Lighting during egg incubation improves hatchability and chick quality



Fig. 2: Hatch of fertile of broiler and layer eggs incubated under either RED or White LED lights or in the DARK. Bars with different letters (A or B) are significantly different p<0.05. Bars with different letters (C or D) are significantly different p = 0.05 Archer, G., 2015. <u>Effect of Exposing Layer and Broiler Eggs to Red or White Light During Incubation</u>. International Journal of Poultry Science 14, 491–496.

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Green lighting during incubation improves muscle development



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Human vs Swine vision













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Shifting to red color as light dims allows workers to observe pigs without disturbing animal's circadian rhythm

100%





50%











5%

Lighting Schedule - Farrowing Room without feeding stimulus



Lighting can influence productivity enhancements

- Reduction in animal stress levels
- Modification of feeding behavior
- Enhancing fertility and stimulating mating cycle
- Accelerated growth / Average daily gains
- Improved feed conversion
- Heavier average piglet wean weight
- Lower prewean mortality

Animal Welfare

- Lighting systems and programs improves animal welfare by reducing stress and violent behavior among animals under care
- Reduced mortality and damage to the animal prior to harvest
- Enhanced immune system reduces need for antibiotic treatments
- Calm animals are happy and healthy resulting in accelerated growth and well being

The working of light: Fish Differ from People



Benefits of Marine Based LED Lighting

- Philips LED Lighting
 - Optimal fish light spectrum
 - $\,\circ\,$ Visual: better visibility of feed
 - Pineal gland: maturation prevention
 - Increase growth, better feed conversion ratio



- Optimal light distribution
 - Homogenous light distribution in the cage
 - Downward facing light to keep fish below sea lice zone
 - $\,\circ\,$ Makes sure light is optimal at cooler depths



- Optimal light control
 - $\circ\,$ Easy-to-use operator interface
 - $\,\circ\,$ Low dimming to avoid stress
 - $\,\circ\,$ Easy to adjust light recipes
 - Energy saving by daylight harvesting
 - Dimming to control fish depth



Lighting As Control Tool For Salmon Development



- ✓ Shorten spawning time
- ✓ Improve egg quality



- ✓ Increase growth
- ✓ Reduce FCR
- ✓ Reduce mortality
- ✓ Improve welfare
- ✓ Reduce sea lice
- ✓ Reduce sexual maturation



 ✓ Advance smoltification of juvenile salmon during freshwater stage



- ✓ Increase growth
- ✓ Reduce FCR
- ✓ Reduce stress
- ✓ Improve smoltification
- ✓ Reduce mortality after sea transfer

LED Lighting Production Results

Company	Increased growth	Maturation reduction	b-FCR reduction
	4 50/		7.00/
Lerøy	15%	-2,5%	-7,9%
Marine Harvest	10%	-3,1%	-14,2%
Company A**	15,7%	-1,9%	NA
Company B*	5%		NA
Company C	11%		-6%
Company D	16%		-22%
Company E	12.3%	-0.7%	NA
	5.9%	+0.5%	
Company F	3,6%		NA
	14,2%		
Company G**	7%		-11,8%
Company H	8,6%		0%
Company I***	13%		-12%
Company J***	13%		
Company K**/***	22%		
	8%		
	14%		
Company L**	28%		
	12,5%		
Company L**	21,0%		-13,2%
Company N	10,0%		
Average	12,8%	-2,5%	-9,2%

* Used highenergy feed

** all year round lighting regime

*** Other LED as control group

Submerged aquaculture lighting combats sea lice





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