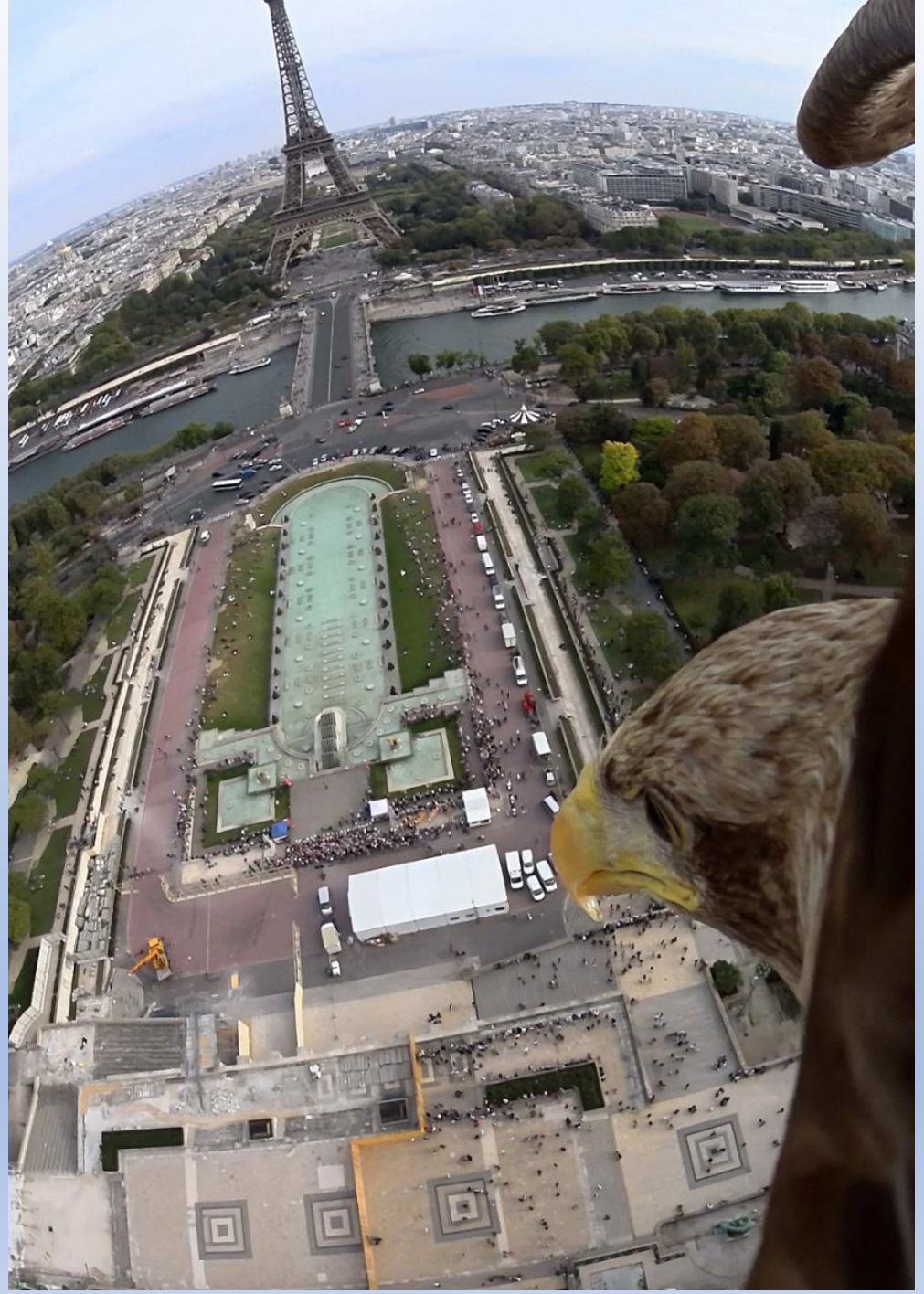


Birds' eye views

Graham R. Martin

University of Birmingham, UK

"The 100% authentic eagle eye view"

Every bill tells a story

Every eye tells a story

Vision is *complex* and *multifaceted*

Species differ in:

Spatial resolution (acuity)

Fields of view

Contrast sensitivity

Speed of vision

Little variation in Colour Vision across species.

However, there is a division between species which do or do not have vision in the Ultra Violet. Only half of all species have true UV vision.

Vision is *highly dependent* upon light level

Acuity

colour vision

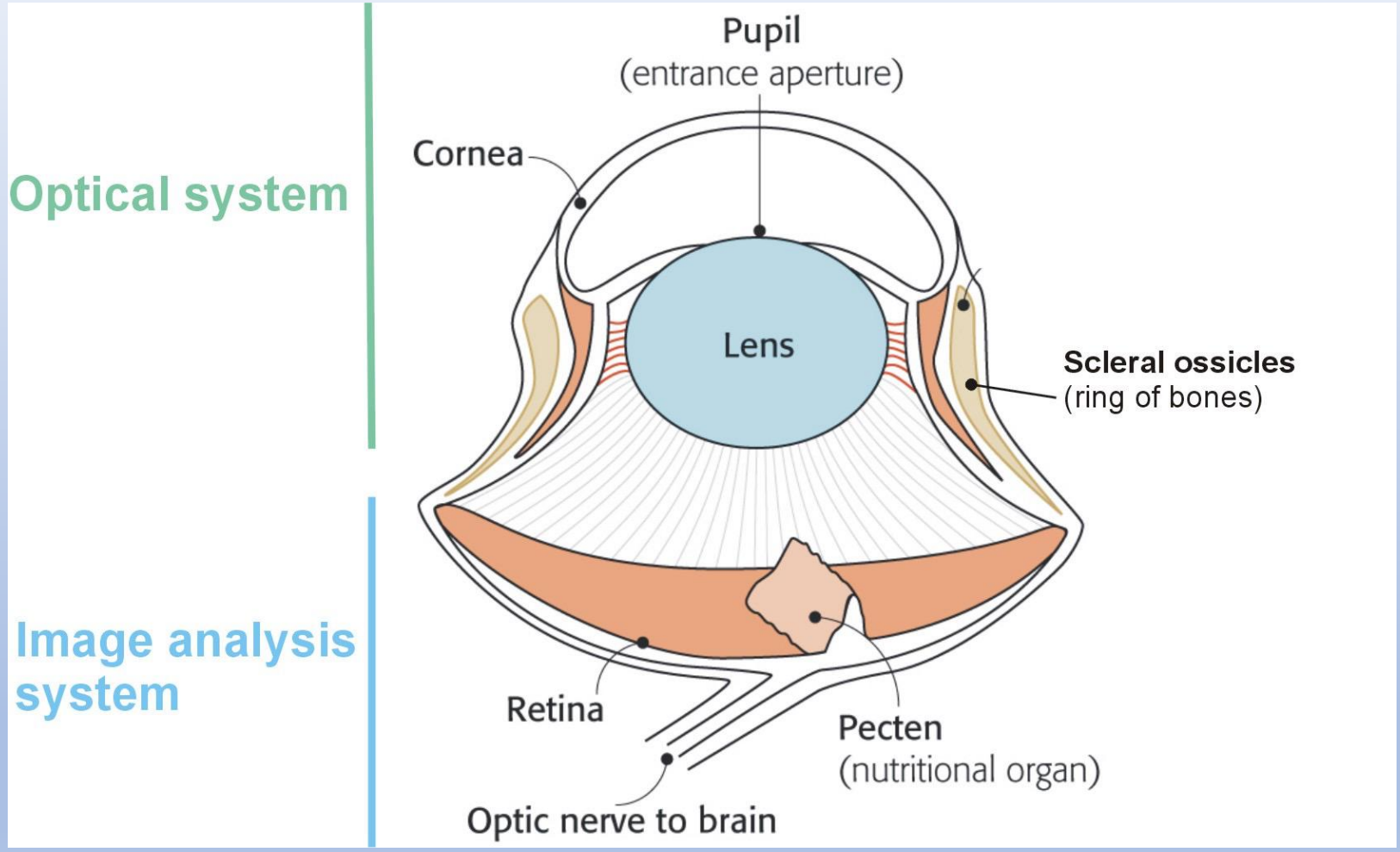
contrast sensitivity

speed of vision

Therefore, when thinking about vision in the natural world time of day is important

Where does variation in vision between species come from?

The two main functional components of an eye are independent

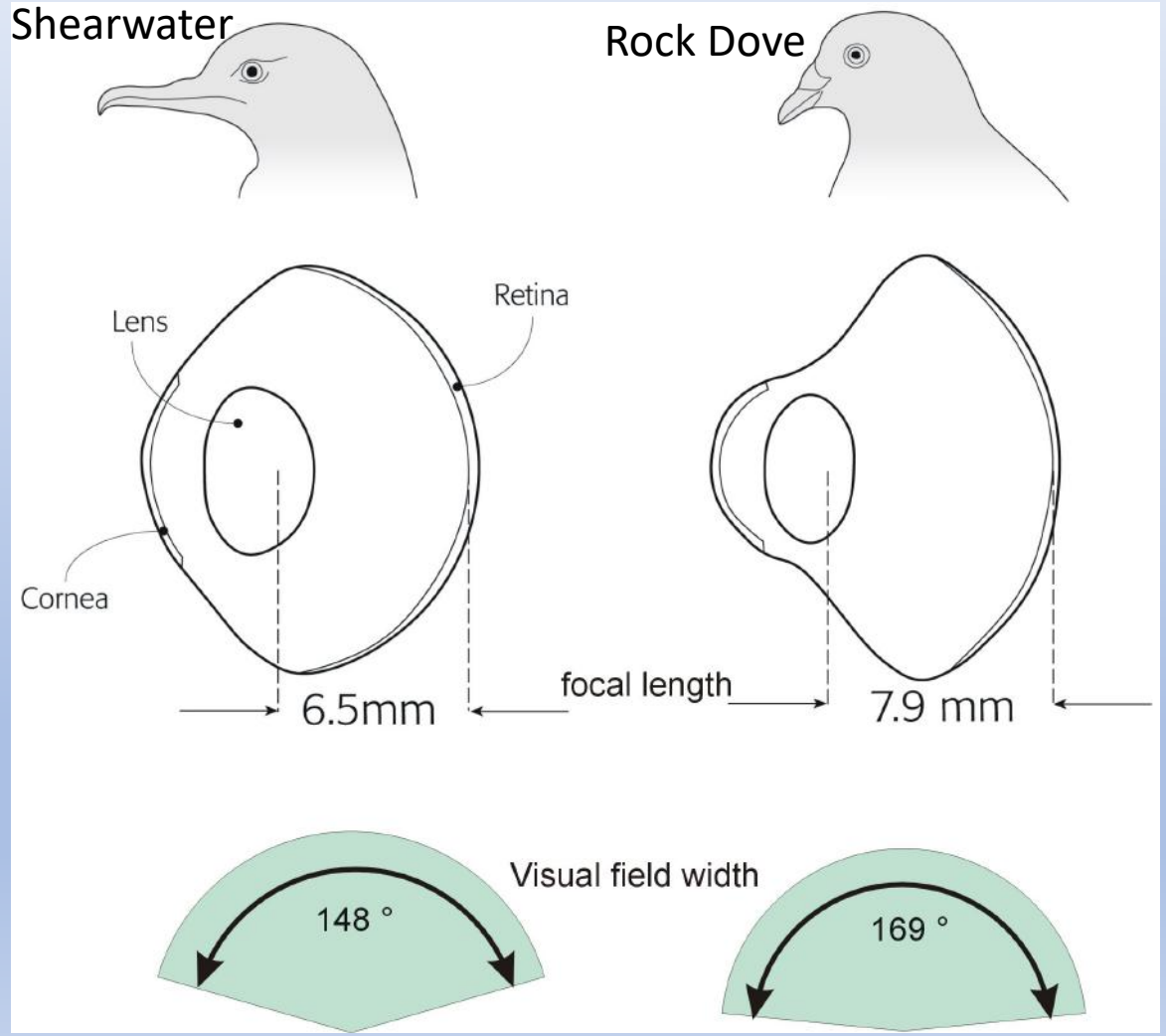


Variation in optical systems:

focal length (image size and brightness)

field of view (how much of the world is seen at any instant)

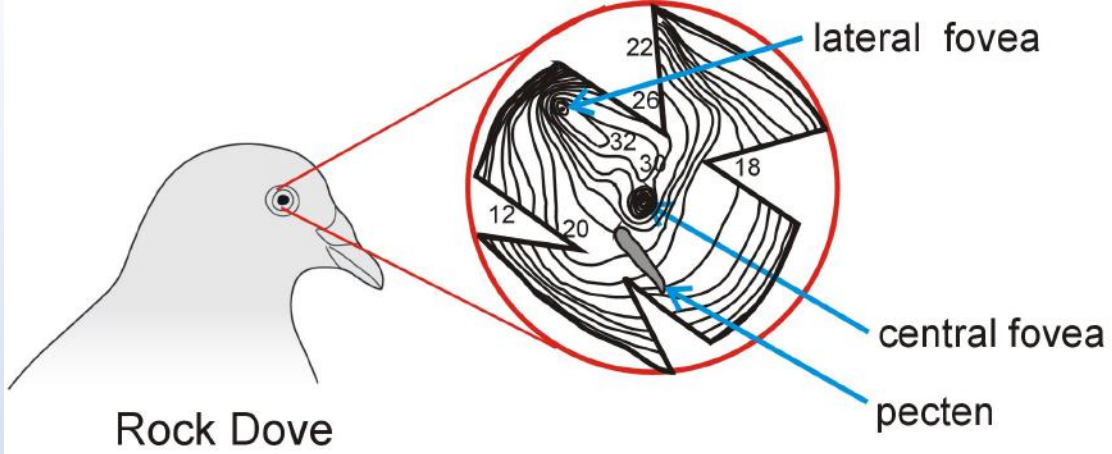
Smaller and brighter image: nocturnal activity

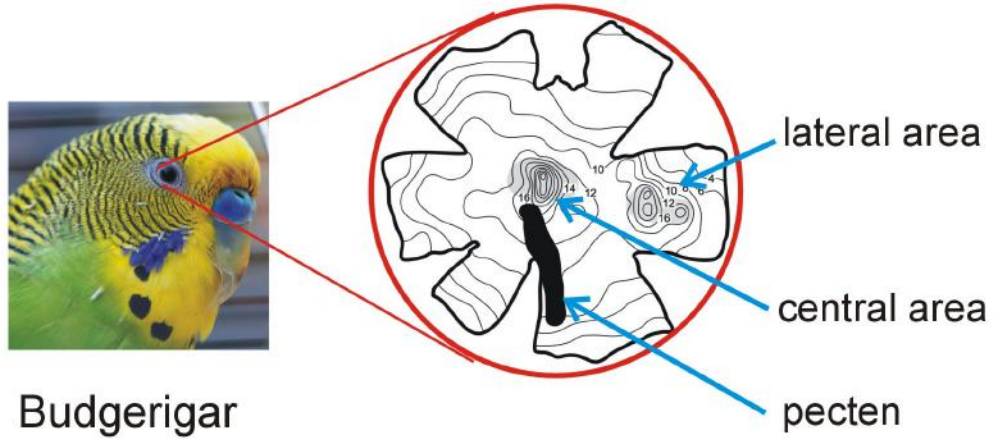


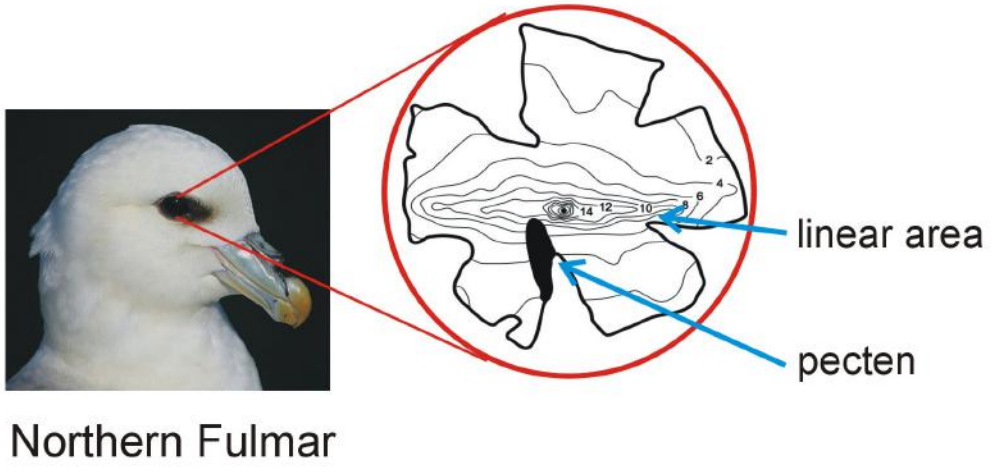
Larger and dimmer image: diurnal activity

Variation in image analysis

Density contours of photoreceptors cells (rods, cones, ganglion cells) across the retina

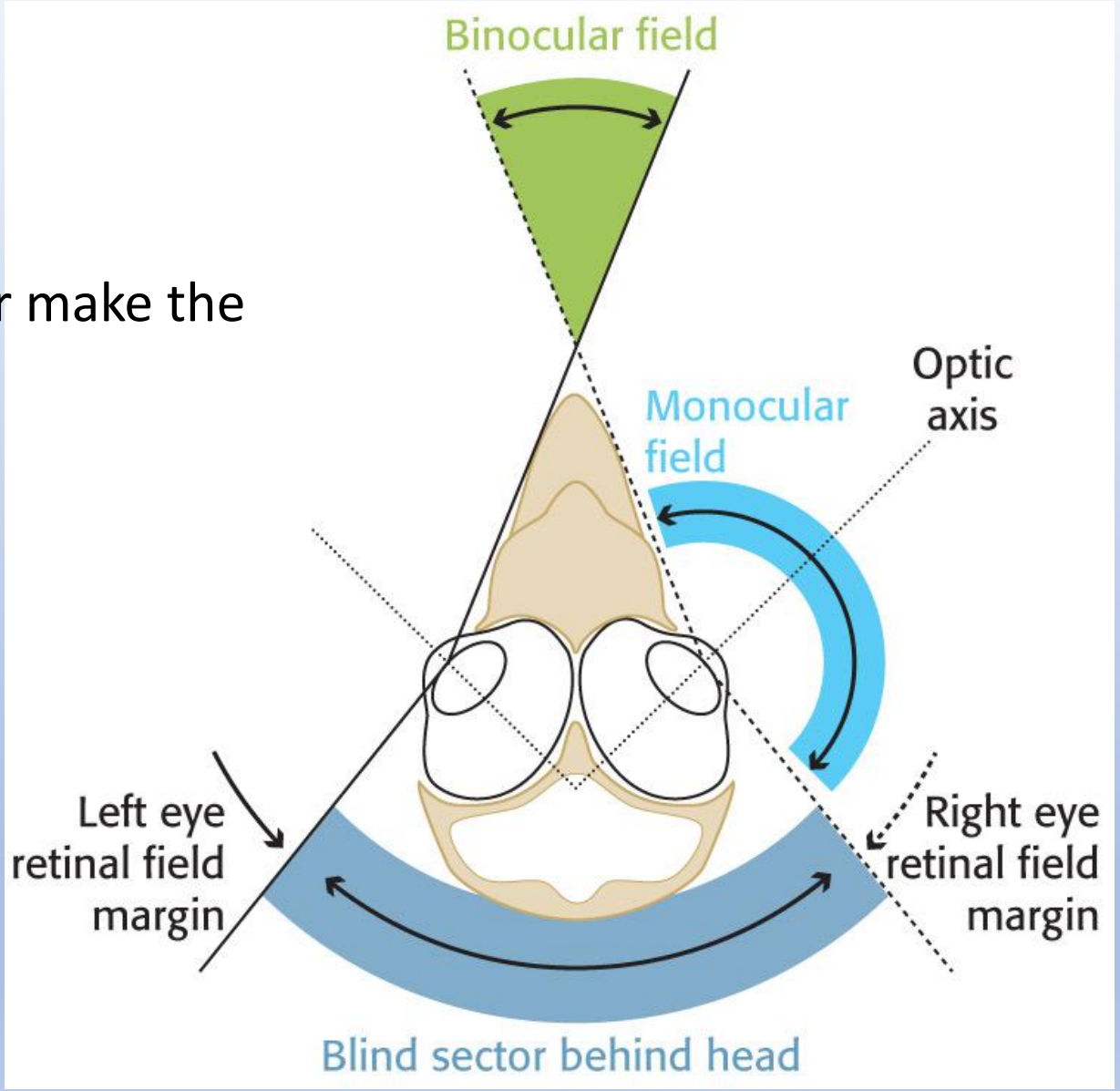






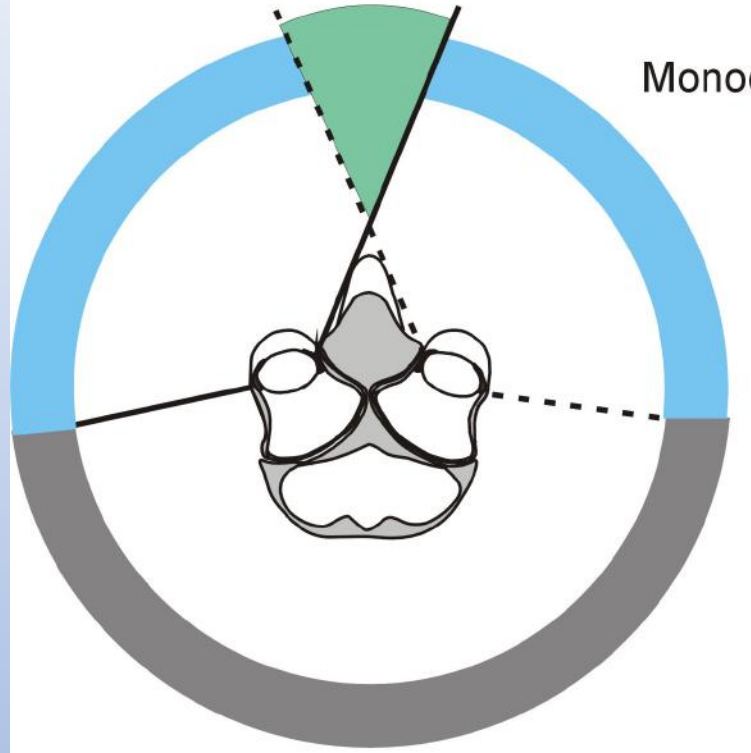
Variation in visual fields

Two eyes together make the visual field



Section through the head in a horizontal plane

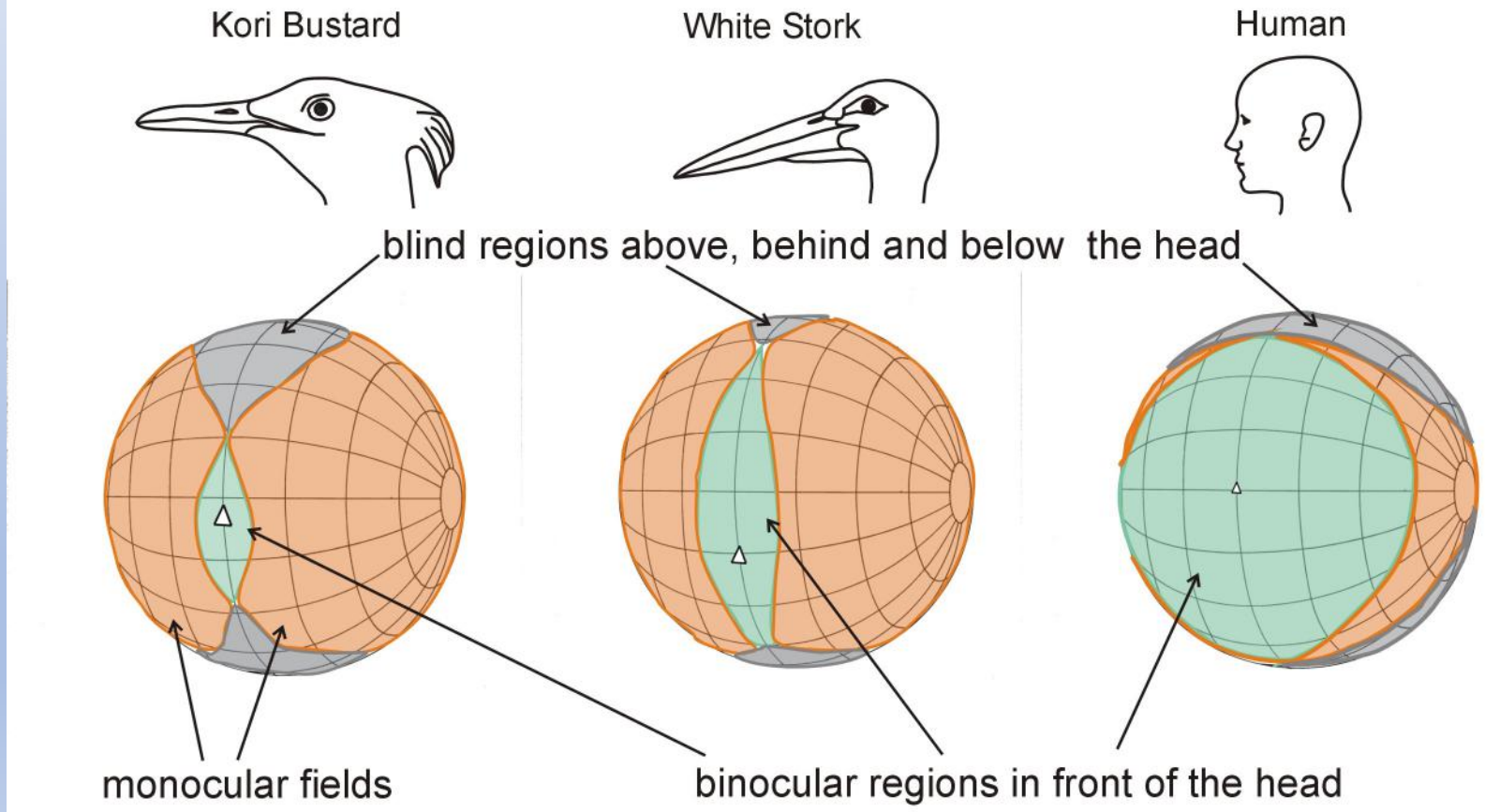
Optic axis = direction of highest acuity



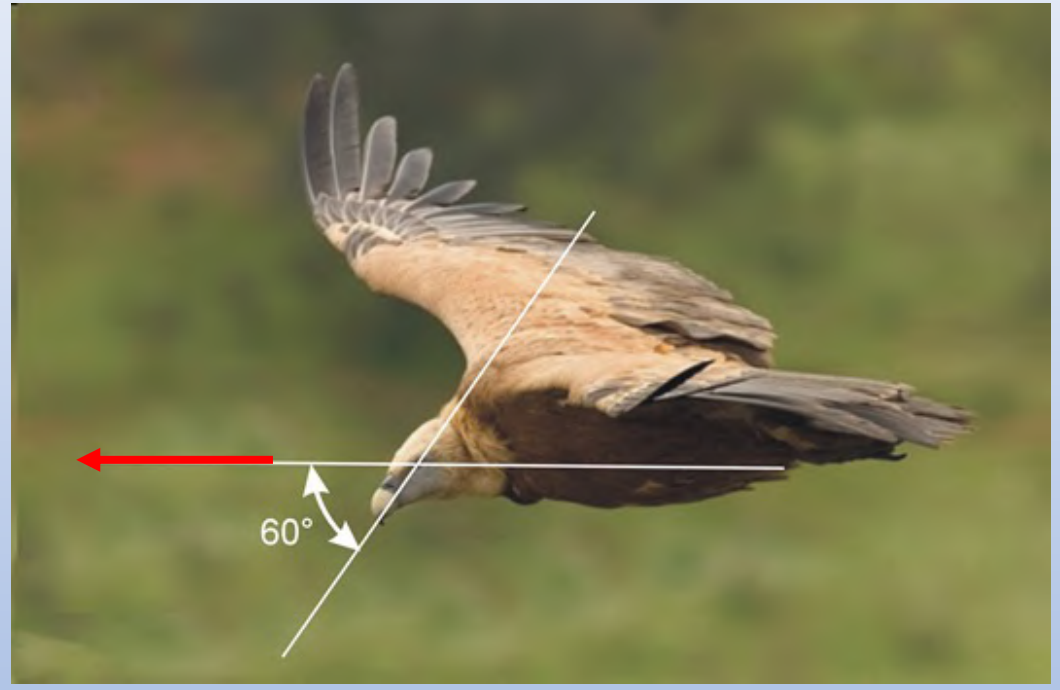
Monocular fields

No blind area 360 degree vision

Three species with very different world views, but the fields of individual eyes are the same



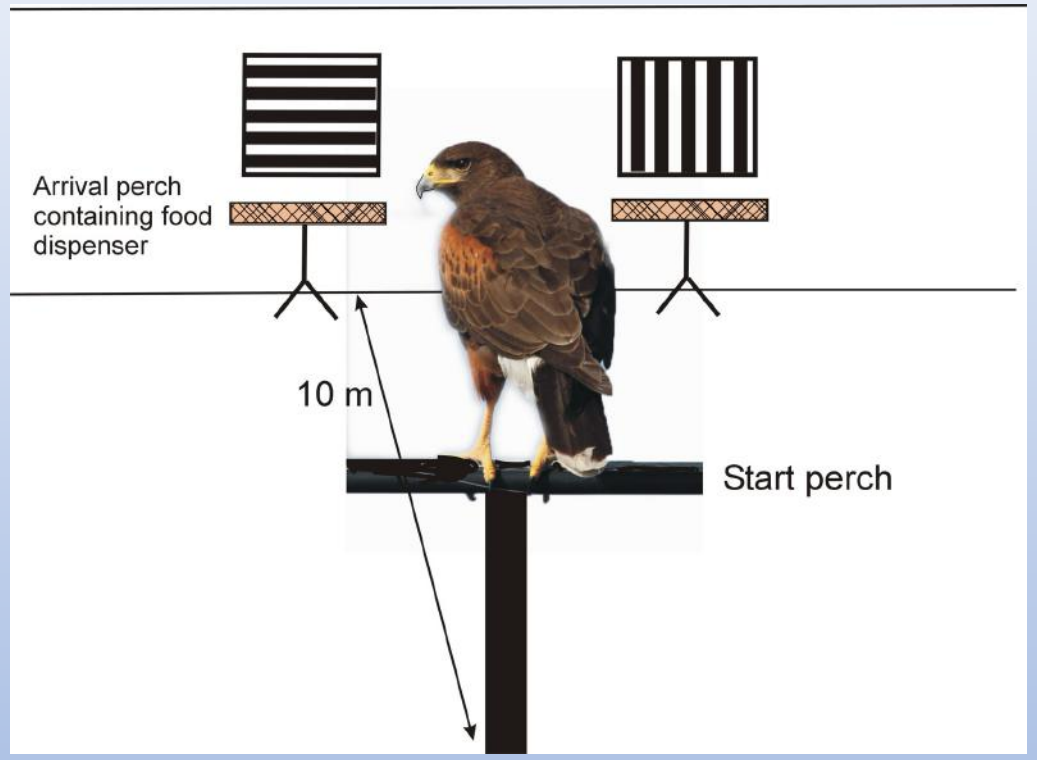
Griffon Vulture *Gyps fulvous*



Consequence of a blind area above the head

Failing to see in the direction of travel

Measuring spatial resolution (acuity)



Acuity = the highest resolution achieved at high (daytime) light levels

Achromatic (black and white) gratings, acuity with coloured gratings is lower

Comparing acuity

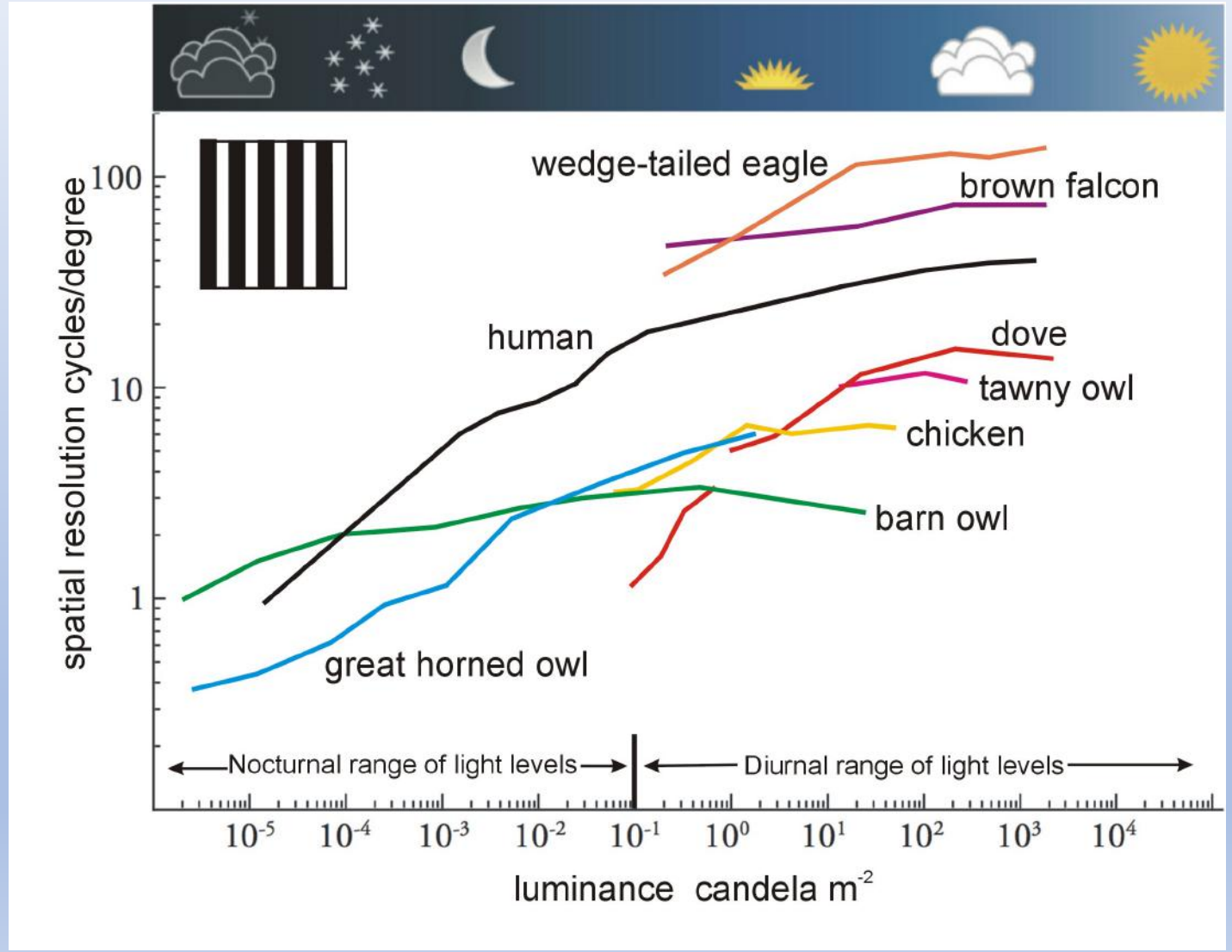
Species	Spatial resolution Cycles/degree	Acuity Minutes of arc
Wedge-tailed Eagle *Aquila audax*	142	0.2
Indian Vulture *Gyps indicus*	135	0.2
Brown Falcon *Falco berigora*	73	0.4
Rock Dove *Columba livia*	18	1.7
Canada Goose *Branta canadensis*	9.6	3.1
Great Horned Owl *Bubo virginianus*	7.5	4
House Sparrow *Passer domesticus*	4.8	6.3
House Finch *Haemorhous mexicanus*	4.7	6.4
Great Cormorant *Phalacrocorax carbo* (underwater)	3.3	9.1
Human	72	0.4

Detecting finer detail or detecting the same detail from further away?

Falcon vs. Dove: 4 - fold difference in acuity.

Goose vs. Human: 8 - fold difference in acuity.

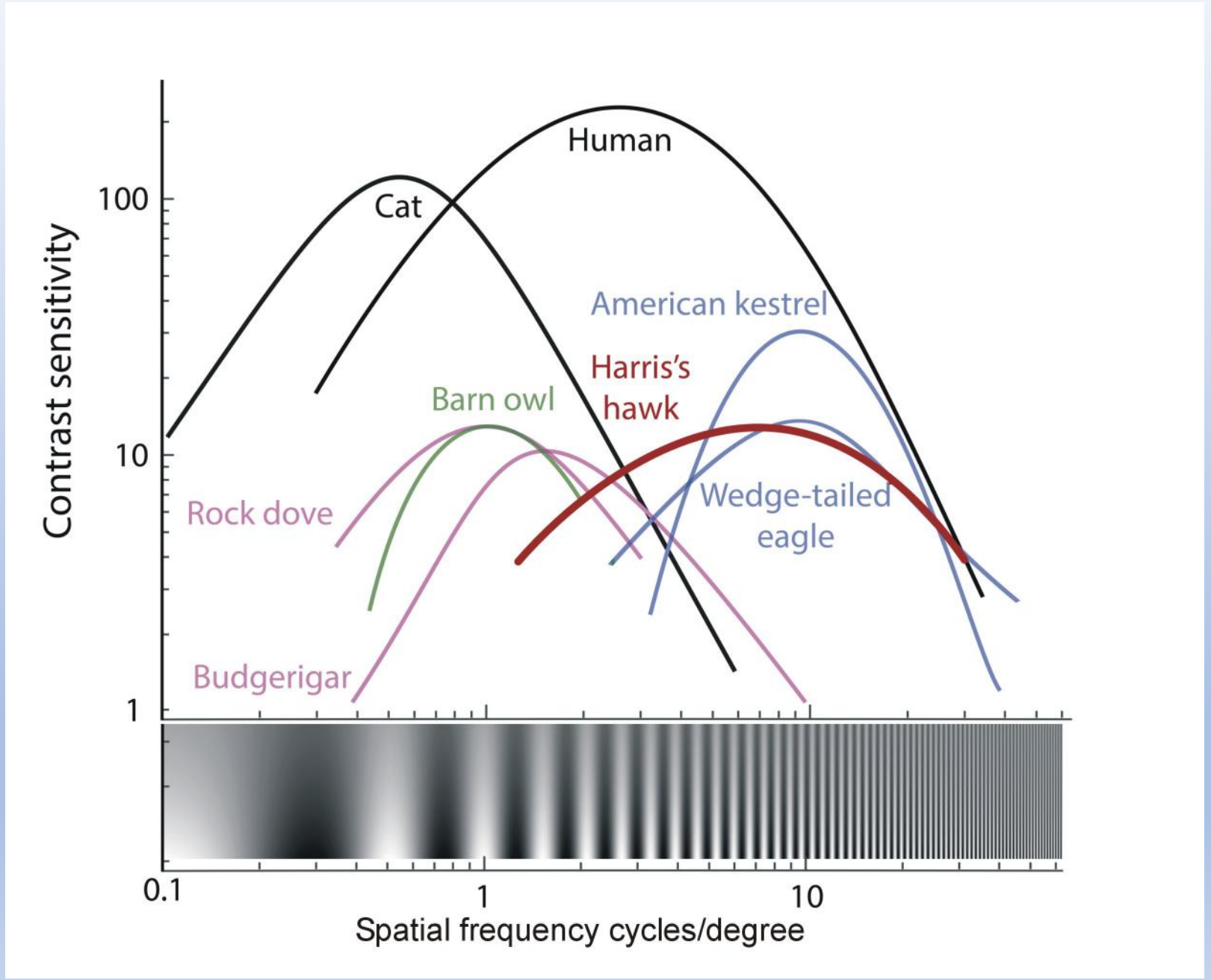
Spatial resolution and light level



Sensitivity to contrast

Contrast sensitivity is lower in birds than in mammals

i.e. birds need greater contrast to see the same detail as humans



Birds and Hazards

Why are these hazards?

Like Vision, flight behaviour is complex and multifaceted

Species differ in:

Speed of travel

Manoeuvrability

Time of activity

Birds frequently, some habitually, carry out key tasks (foraging and flight) using only minimal visual cues/partial information

Some birds may not even be looking ahead in flight

Low light levels = reduced spatial information

Birds use minimal cues in predictable circumstances, just like humans e.g. car driving.

Humans and Car Driving:
what information do you rely on?
Partial information, predicting the way ahead

Five Design criteria for a power line bird diverter

1. The diverter needs to have high internal contrast; achromatic, not coloured.

2. The diverter should embody a degree of movement or flicker.

3. The distance at which a diverter pattern is detectable should be guided by the time at which the diverter can be detected with respect to the approach of the bird towards the target i.e. flight speed is important.

4. Assume the spatial resolution used to detect an obstacle is at least 5 times *lower* than measured acuity (vision at low light levels/poor visibility).

5. Assume that two adjacent diverters should be just visible in the bird's binocular field at the minimum detection distance.

Canada Goose, an ideal worst-case?

Heavy

fast flight (17-19 m/sec)

low manoeuvrability

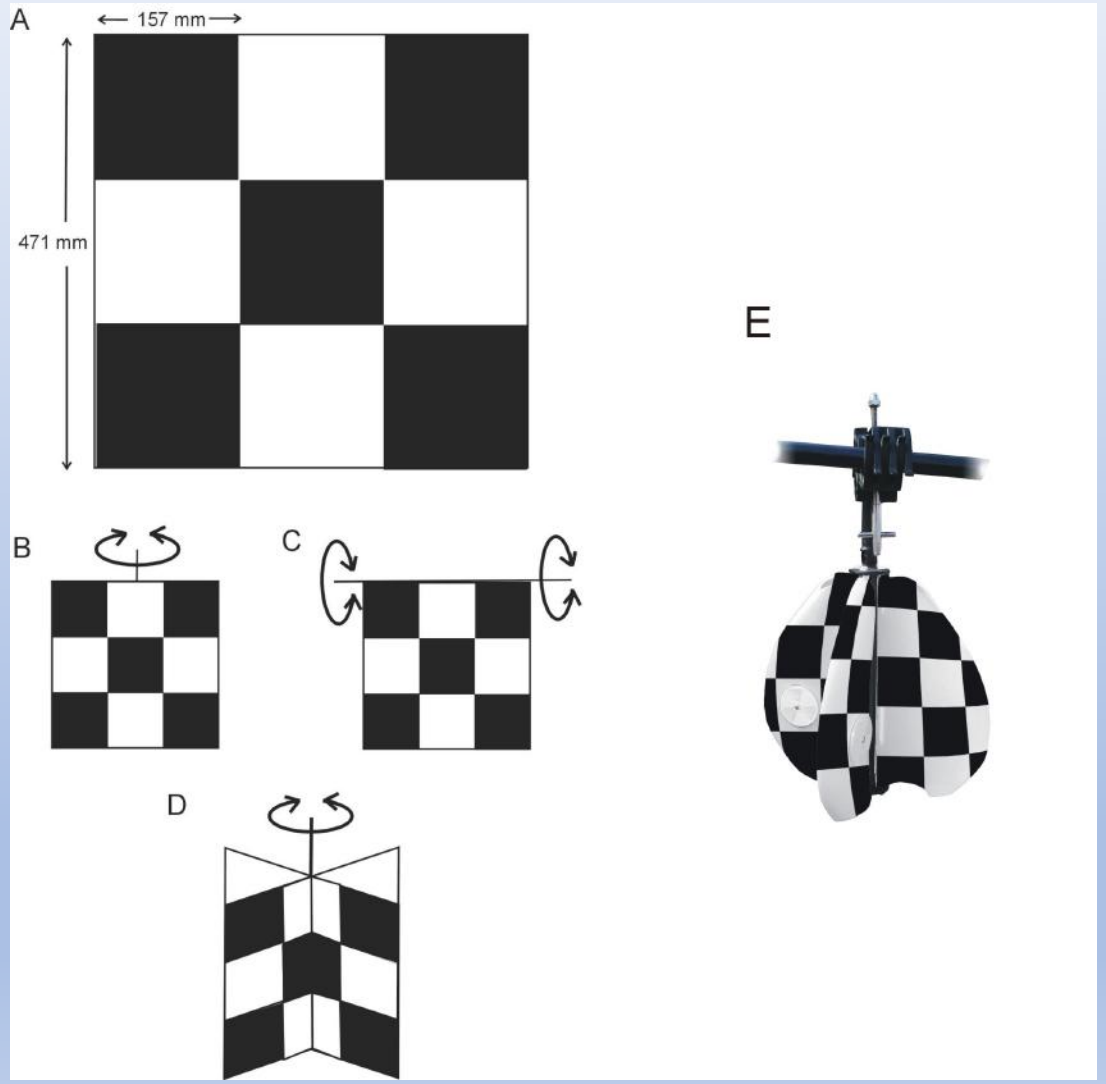
fly at low light levels (dusk and dawn)

fly in poor visibility (misty)

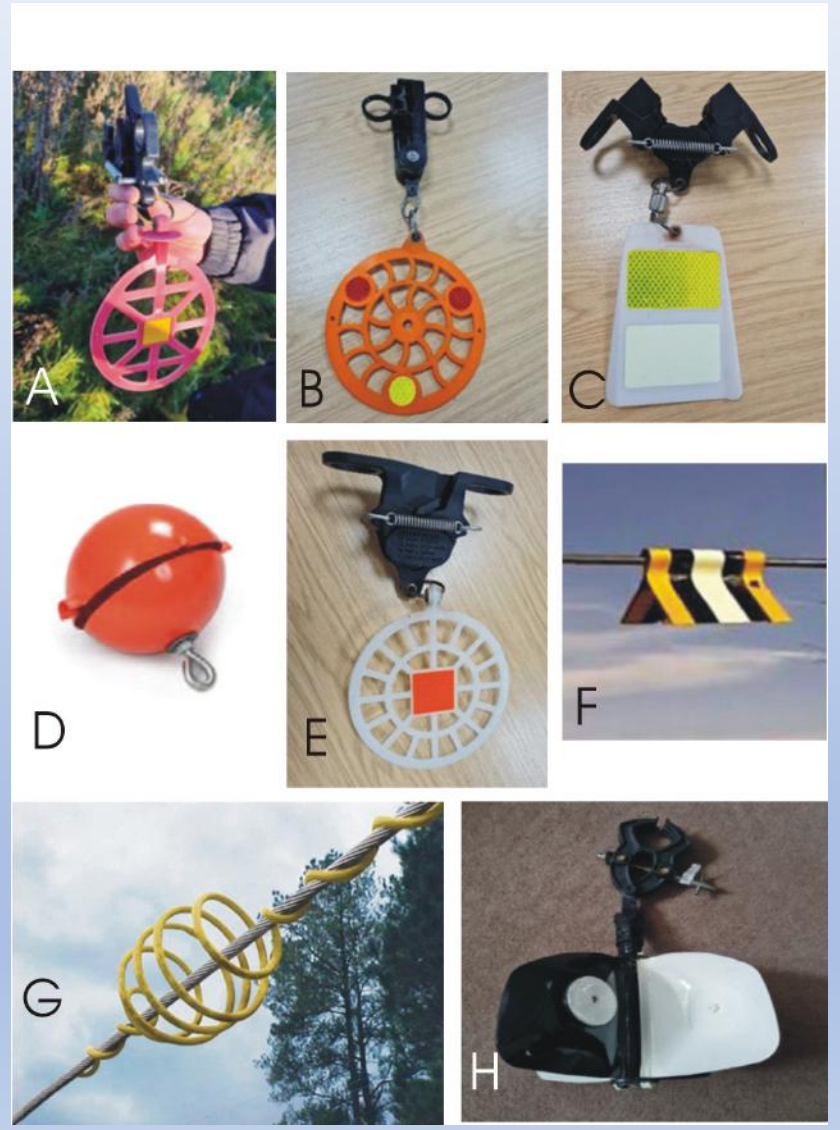
fly in groups

low visual acuity (x 8 lower than human)

An ideal Canada Goose diverter?



Commercially available diverters



In summary

Birds live in very different sensory worlds, birds' worlds are not our world.

(Do not assess diverters by whether we/you can see them.)

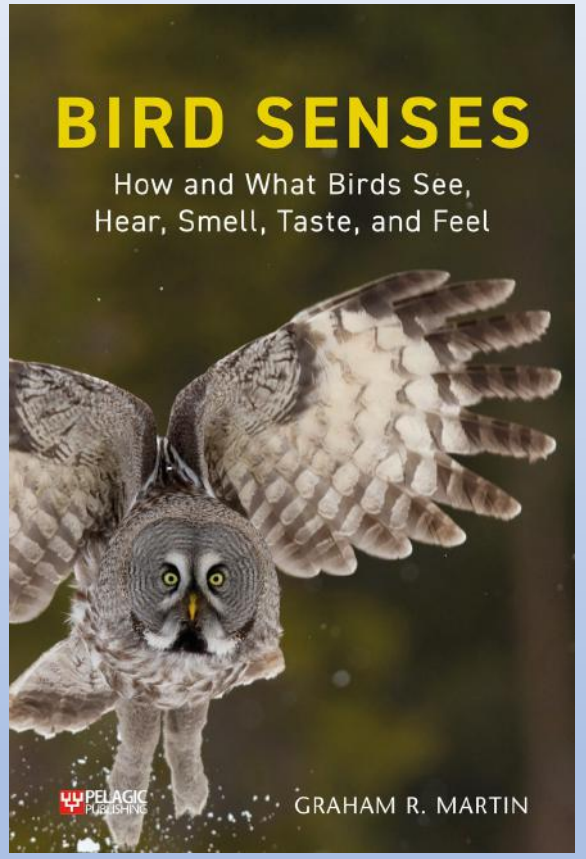
Birds often rely on partial information for the execution of key tasks.

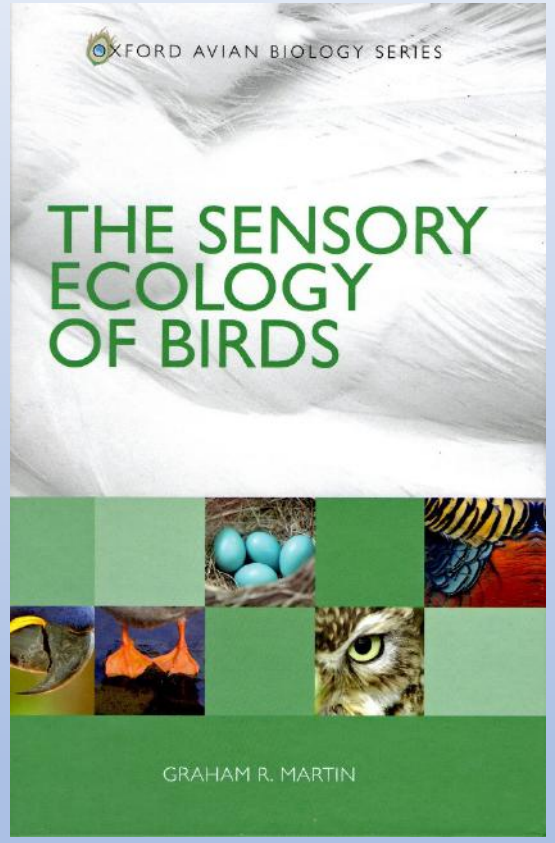
(Birds are not ideal observers, neither are humans.)

Flight hazards must be made explicit.

(Diverters should appear to over emphasize the hazard)

Thank you… and some further reading?





Martin, G.R. 2022. Vision-Based Design and Deployment Criteria for Power Line Bird Diverters. *Birds*, *3*, 410-422.

Martin, G.R. and Banks, A.N. 2023. Marine birds: vision-based wind turbine collision mitigation. *Global Ecology and Conservation*, Volume 42, page e02386.