Limits of colour vision in dim light

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Humans and most vertebrates loose colour vision when night falls and rely on colour-blind rod vision in dim light. We have shown that nocturnal animals with three different eye designs can use colour vision in very dim light: nocturnal hawkmoths that possess superposition compound eyes learn to associate flower colours with a food reward at starlight levels (Kelber et al 2002, Nature 419:922). Nocturnal carpenter bees with apposition compound eyes learn the colour of landmarks at the nest entrance (Somanathan et al 2008, Curr Biol 18:R996). This is surprising because apposition eyes are not very light-sensitive, and spatial and/or temporal summation are needed to achieve colour vision in starlight. Finally, nocturnal geckos use colour in dim light (Roth & Kelber 2004, Proc R Soc Lond B S6:S485). All of these animals rely on one set of photoreceptors for vision.

We have now tested the limit of colour vision in the horse, a mammal with an arrhythmic life style that possess both rods and cones in the retina. Horses have large eyes and thus potentially highly sensitive vision but it turned out that they loose colour vision at about the same light intensity as humans do (Roth et al 2008, PLoS One 3:e3711). Anatomical and optical studies show that a single cone in the horse retina is just about as sensitive as a human cone. Thus, the similar absolute sensitivities of horse and human colour vision can be explained on the single cone level. Obviously, horse eyes are adapted to highly resolved rod vision in dim light.

The relationship between optical sensitivity and colour vision sensitivity in geckos, hawkmoths, bees and horses will be compared. Which selective pressures set the threshold of colour vision in different animals still remains an open question.