NOTE *Anatomy*

Light Transmission of the Ocular Media in Birds and Mammals

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ABSTRACT. Differences in the ultraviolet (UV) cutoff of ocular media between birds and mammals have been revealed by spectrophotometric measurements of the transmission of light wavelengths by the cornea, lens and vitreous body in chickens, crows, quails, rats, rabbits and pigs. The light transmission values of the cornea were shown to be above 50% for wavelengths of 330–800 nm in birds, 300–800 nm in rat and 310–800 nm in mammals except for rat. For the lens, the light transmission values were shown to be above 50% for wavelengths of 320–800 nm in birds and rat and 390–800 nm in mammals except for rat. Thus, among the ocular media, the cornea in birds and the lens in mammals except for rat may play a role as a major UV cutoff filter.
KEY WORDS: cornea, lens, light transmission, ultraviolet, UV cutoff filter.

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Some cone cells in the retina have sensitivity to specific light wavelengths [8]. Unlike humans, many birds and rodents have a single cone cell that has sensitivity to ultraviolet (UV) wavelength in their retina [2, 10]. In contrast, the absorption peaks of cone cells in most mammals are outside of the UV range [5]. Furthermore, high sensitivity to UV wavelengths has been established behaviorally in some birds [7] and rodents [6]. Thus, many species of birds and rodents possess UV vision, whereas most mammals do not.

UV-radiation damages ocular tissues. Because UV is harmful, animals that do not have UV vision must have an efficient mechanism to absorb, scatter and detoxify invisible UV wavelength at the level of the cornea, lens or vitreous body. Possibly, because UV can reach the retina of animals that have UV vision, it might be removed anteriorly to the retina of animals that do not have UV vision. Consequently, the light transmission of each ocular medium may vary between animals with UV vision and those without.

The light transmittance of the ocular media in several animals has been reported. For example, the light transmittance of the ocular media of a live rabbit decreases rapidly for shorter wavelengths, being 50% at 400 nm and less than 1% at 380 nm [1]. In contrast, the light transmittance of the ocular media in the pigeon is maintained at or over 50% into the near-UV at 310 nm [3]. However, differences in the light transmission of the cornea between birds and mammals remain inconclusive, because the values that have been measured are inconsistent. For example, the values reported for transmission of the ocular media in pigeon by Govardovskii and Zueva [4] differ from those reported by Emmerton *et al.* [3]. The values for the light transmission of ocular media must be obtained by the same method for an accurate comparison.

In this study, the light transmission of the cornea, lens and vitreous body in chickens (*Gallus gallus*), jungle crows (*Corvus macrorhynchos*), quails (*Coturnix japonica*), rats (*Rattus norvegicus*), rabbits (*Oryctolagus cuniculus*) and pigs (*Sus scrofa*) was measured under the same conditions using a spectrophotometer.

All animals were maintained under the guidelines for Care and Use of Laboratory Animals at Utsunomiya University. Crows were caught by traps set at the experimental farm of Utsunomiya University. Permits to trap crows were obtained from Tochigi prefecture (No. 0010). Quails were obtained from the quail farm of Ebihara Uzura (Moka, Japan). Chickens and pigs were obtained from the Tochigi Prefectural Livestock Experiment Station (Haga, Japan). Rats and rabbits were obtained from Saitama Experimental Animals Supply Co., Ltd, (Sugito, Japan). In the present study, the following animals were used, 4 chickens (male and female adults, weighing 1,500–2,000 g), 7 crows (male and female adults, weighing 550–810 g), 10 quails (male adults, weighing 80–100 g), 9 rats (male and female adults, weighing 200–250 g), 6 rabbits (male and female adults, weighing 1,200–3,000 g) and 4 pigs (male and female, the age of 5–7 months, weighing 70–90 kg).

The animals were euthanized by an overdose of pentobarbital sodium (50 mg/kg body weight). The eyeballs were removed from the animals' bodies. The left eyeballs were used for this study, and the right ones were used for other studies. The corneas, lenses and vitreous bodies were separated from the eyeballs as soon as possible and were kept at about 4°C on ice. Although the samples of rat were separated under a stereoscopic microscope (SMZ-2T, Nikon, Tokyo, Japan),

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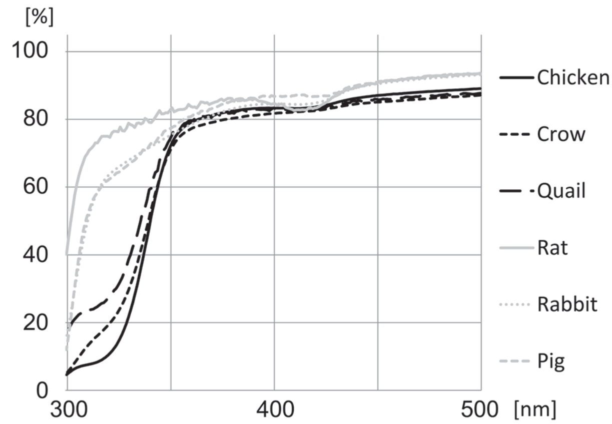

Fig. 1. Mean spectrophotometric transmission curves of the cornea in chicken, crow, quail, rat, rabbit and pig. Vertical axis indicates light transmission, and horizontal axis indicates wavelength.

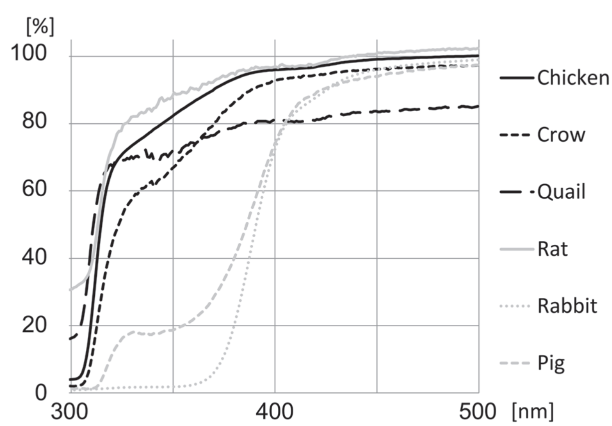

Fig. 2. Mean spectrophotometric transmission curves of the lens in chicken, crow, quail, rat, rabbit and pig. Vertical axis indicates light transmission, and horizontal axis indicates wavelength.

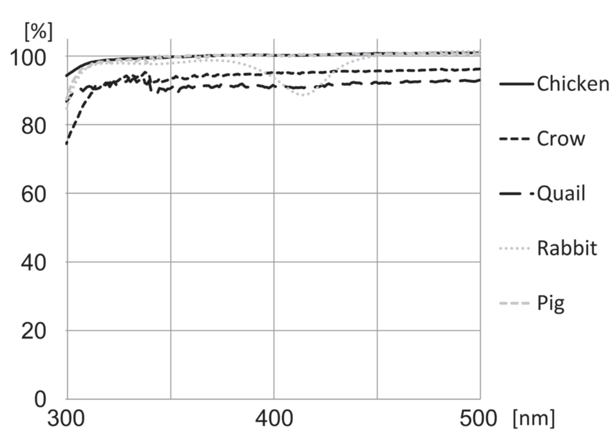

Fig. 3. Mean spectrophotometric transmission curves of the vitreous body in chicken, crow, quail, rabbit and pig. Vertical axis indicates light transmission, and horizontal axis indicates wavelength.

the vitreous bodies of rat could not be collected because the sizes were too small.

The dissected samples were washed with ice-cold Ringer's solution. Each sample on fused quartz was mounted horizontally on a horizontal integrating sphere (PIV-756, Jasco, Tokyo, Japan) in a spectrophotometer (V-650, Jasco), and the transmission of the samples was recorded from 800 nm to 300 nm. For each species, the mean transmission spectra were calculated and plotted at 1 nm intervals.

The transmission curves of the avian corneas overlapped among avian species. In addition, the transmission values of the avian corneas remained above 50% from 800 nm to 340 nm and decreased rapidly from 360 nm to 320 nm (Fig. 1). By contrast, 2 types of transmission curve were observed for mammalian corneas. The transmission value of the rat cornea was the highest among mammals for wavelengths shorter than 400 nm and remained above 50% until about 300 nm (Fig. 1). The transmission curve of the rat cornea declined gradually from about 380 nm to 320 nm and rapidly from 320 nm to 300 nm (Fig. 1). The transmission value of the rabbit cornea was similar to that of pig. For shorter wavelengths than approximately 350 nm, the transmission values of the corneas in rabbit and pig were higher than those in birds and remained above 50% until about 310 nm (Fig. 1). The transmission values of rabbit and pig corneas declined gradually from about 380 nm to 320 nm and then rapidly between 320 nm and 300 nm (Fig. 1).

Whereas the transmission values of birds and rat lens declined from about 390 nm, those of rabbit and pig lens declined from 410 nm (Fig. 2). The transmission curves of the avian lens did not overlap among species, as compared with those of cornea. The transmission values of the chicken lens decreased gradually from 390 nm to 320 nm, then rapidly from 320 nm and remained above 50% until 320 nm (Fig. 2). The transmission value of the crow lens decreased rapidly from 390 nm, gradually near 340 nm, rapidly from 330 nm again and remained above 50% until 330 nm (Fig. 2). The transmission value of the quail lens declined very gradually from 800 nm to 390 nm, gradually from 390 nm to 320 nm, rapidly from 320 nm and remained above 50% until 310 nm (Fig. 2). Whereas the transmission curves of the rabbit and pig lens appeared to be similar, those of the rat lens and chicken lens were similar. The transmission values of the rat lens decreased gradually from 390 nm to 330 nm, rapidly from 330 nm and remained above 50% until 320 nm (Fig. 2). The transmission values of the rabbit and pig lens decreased rapidly from 410 nm and remained above 50% until 390 nm (Fig. 2).

For all animals, the transmission values of the vitreous body remained above 50% until 300 nm (Fig. 3). The transmission values of the rabbit vitreous body fluctuated temporally near 420 nm (Fig. 3), but except for this difference, the transmission curves of all animals overlapped.

Our results agree with some previous researches. For example, the transmission values of avian corneas were reported by Govardovskii and Zueva [4]. They showed transmission decreased rapidly from 360 nm as with our results. Algvere *et al.* [1] reported that the transmission values of whole ocular media (cornea, lens and vitreous body) of living rabbit decreased rapidly from about 410 nm. The results agreed with the transmission carve of rabbit lens in our results.

This study has revealed differences in the UV cutoff of ocular media between birds and mammals. In the cornea and lens, a decrease in transmission from 400 nm to 300 nm, which is in the UV range, was observed as a distinctive difference among the animals. In the avian cornea, the transmission values for wavelengths shorter than 360 nm decreased markedly. This result suggests that light with a UV wavelength shorter than 360 nm can be absorbed or scattered in the avian cornea. The transmission values for UV wavelengths shorter than 360 nm were higher in the avian lens than in the avian cornea. Thus, the avian lens may not serve as a UV cutoff. In the rabbit and pig, by contrast, the transmission values of wavelengths shorter than 400 nm were higher in the cornea than in the lens. Although the transmission values of the cornea in rabbit and pig declined gradually from 380 nm, the values remained above 50% until about 310 nm. Thus, the majority of near-UV wavelengths can pass through the cornea in rabbit and pig. By contrast, the lens of rabbit and pig can absorb and scatter the majority of UV wavelengths, because the transmission values of the lens for wavelengths shorter than 410 nm decreased markedly. The transmission values of the cornea and lens in rat declined similarly, and the values remained above 50% until 320 nm. Thus, the majority of UV wavelengths longer than 320 nm cannot be absorbed in the rat cornea and lens. The majority of wavelengths longer than 300 nm passed through the vitreous body in all animals. Thus, the vitreous bodies in these animals may not have the roll of a UV cutoff for wavelengths longer than 300 nm. In summary, the cornea in birds and the lens in some mammals may play a role as the main UV cutoff filter of the ocular media.

Present study demonstrated the range of reachable light to the retina. In rabbit and pig, they don't have the UV vision, since shorter wavelength than 390 nm could not reach mostly to the retina. On the other hand, UV light must reach to the retina of UV visible animals. Previous study reported that crows have UV vision [9]. However, their visible ranges are unknown. This study cleared that longer wavelength than 340 nm could reach to the retina of crow. Thus, the visible UV range in crows may be ranged 340–400 *n*m.

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