———, & M. W. HUNT. 1977. Female-female pairing in Western Gulls (*Larus occidentalis*) in southern California. Science 196: 1466.

KLOPFER, P. H., & J. P. HAILMAN. 1965. Habitat selection in birds. Pp. 279–303 *in* Advances in the study of Behaviour, vol. 1 (D. S. Lehrmen, R. A. Hinde, and E. K. Shaw, Eds.). New York, Academic Press.

MCNICHOLL, M. K. 1975. Larid site tenacity and group adherence in relation to habitat. Auk 92: 89–104.

MILLS, J. A., & J. P. RYDER. 1979. A trap for capturing shore and seabirds. Bird-Banding 50: 121–123.

RYDER, J. P. 1976. The occurrence of unused Ring-billed Gull nests. Condor 78: 415–418.

———. 1978. Possible origins and adaptive value of female-female pairings in gulls. Proc. Colonial Waterbird Group 2: 138–145.

———. 1980. The influence of age on the breeding biology of colonial nesting seabirds. Chapt. 5 *in* Behavior of marine animals, vol. 4 (J. Burger, B. L. Olla, and H. E. Winn, Eds.). New York, Plenum Publ. Corp.

———, & P. L. SOMPPI. 1979. Female-female pairing in Ring-billed Gulls. Auk 96: 1–5.

SOUTHERN, W. E. 1977. Colony selection and colony site tenacity in Ring-billed Gulls at a stable colony. Auk 94: 469–478.

———, & L. SOUTHERN. 1979. Philopatry in Ring-billed Gulls. Proc. Colonial Waterbird Group 3: 27–31.

TINBERGEN, N. 1952. On the significance of territory in the Herring Gull. Ibis 94: 158–159.

———. 1961. The Herring Gull's world. New York, Basic Books.

VERMEER, K. 1963. The breeding ecology of the Glaucous-winged Gull (*Larus glaucescens*) on Mandarte Island. British Colombia Occ. Pap. British Columbia Prov. Mus. No. 13.

———. 1970. Breeding biology of California and Ring-billed gulls. Can. Wildl. Serv. Rept. Ser. 12: 1–52.

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## Near-ultraviolet Light Reception in the Mallard

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Humans are incapable of detecting near-ultraviolet light (300–380 nm) and are restricted to wavelengths between about 380 and 780 nm. Several lower vertebrates are known to be sensitive to ultraviolet (UV) light (Kimeldorf and Fontanini 1972, Environ. Physiol. Biochem. 4: 40; Moehn 1974, J. Herpetol. 8: 175; Jenison and Nolte 1980, Brain Res. 194: 506), but few studies have been conducted with higher vertebrates.

The recent demonstrations that homing Rock Doves (*Columba livia*) (Kreithen and Eisner 1978, Nature 272: 347) and three species of hummingbirds (Goldsmith 1980, Science 207: 786) are sensitive to near-UV light prompted the present study of UV light reception in an evolutionarily more primitive migratory species, the Mallard (*Anas platyrhynchos*).

The Mallard ducks were trapped during the Spring of 1979 and 1980 and maintained in an outdoor aviary until used for experimentation. After they were transferred to the laboratory, down feathers were plucked from the body underneath both wings, and standard electrocardiogram (EKG) surface electrodes were attached to the bare skin. Stimulating electrodes, which consisted of soldered syringe needles, were inserted subcutaneously into each leg and securely taped in place. The ducks were restrained by a large elastic band wrapped around the body, and, after the legs were taped together, the birds were taped into a trough-like holding chamber (Hoar and Hickman 1975, A Laboratory Companion for General and

TABLE 1. Cardiac responses of greater than 19 beats/min in Mallards conditioned to a monochromatic UV wavelength of 340 nm in the presence or absence of a UV-absorbing filter.

| Sex | Number | UV light (responses/ trials) | UV light with filter[a] (responses/trials) |
|---|---|---|---|
| Male | 4 | 46/53 | 3/44 |
| Female | 7 | 92/109 | 1/38 |

[a] The filter (Corning CS 3-71), which was occasionally inserted into the light path, had 60% or better light transmission to wavelengths above 480 nm, but less than 0.1% transmission below 460 nm.
[b] Includes data from six birds also tested at 360 nm.

Comparative Animal Physiology, 2nd Ed., Englewood Cliffs, New Jersey, Prentice-Hall, Inc., p. 138). The holding chamber was placed in a cardboard box with a Pyrex glass window through which the birds could laterally view monochromatic light from a tungsten-halogen lamp. The box, which admitted a small amount of dim room light, was provided with a continuous stream of pressurized air as a source of white-noise. The monochromator (Hitachi Perkin-Elmer, Model 139, spectrophotometer) was fitted with a UV-transmitting, visible-absorbing filter (less than 0.1% transmission above 400 nm), which provided a light intensity of about 0.2 uW/cm$^2$ at the exit port at 360 nm (Spectroline, DM 365-N, Ultraviolet Meter). The stimulating electrodes and EKG leads were attached to a recording Physiograph (Model Four). Each duck was presented with a 10-s monochromatic light stimulus, immediately followed by a weak electric shock (3–10 VDC, 200 cps, for about 0.5 s). A conditioned cardiac response was usually observed after the first three trials; an occasional later reinforcement period, however, was sometimes necessary. A positive response was scored if the heart rate recorded during the light stimulus alone was 20 beats/min or higher than the heart rate during the 6 s preceding the light stimulus. Baseline heart rates of the ducks were between about 130–230 beats/min, while heart rates after light stimulation generally ranged between 150–300 beats/min. An ultraviolet-absorbing, visible-transmitting filter (Corning CS 3-71), which had 60% or better light transmission above 480 nm but less than 0.1% transmission below 460 nm, was occasionally inserted into the exit light-path. This was done to insure that positive cardiac responses were due to near-UV light reception and not due to the detection of the small amount of spurious red-harmonic light passed by the UV-transmitting, visible-absorbing filter. (It should be noted that a dark-adapted human observer was unable to discern any red light under these conditions.)

Male and female Mallards were both found to be very sensitive to near-ultraviolet light between 340 and 360 nm (Table 1). That the responses were essentially abolished when the high-pass filter was inserted into the light path confirms that the ducks were responding to near-UV light and not to other cues as well. The present results, which show that the relatively primitive, migratory Mallard can see near UV light, along with the previous studies, which indicate that the more recently evolved species of migratory hummingbirds (Goldsmith 1980) and the homing pigeon (Kreithen and Eisner 1978) have similar capabilities, suggest that UV light may be important in orientation and migration in all migratory and homing birds. This idea is supported by some of our preliminary data, which indicate that three other migratory birds, the Belted Kingfisher (*Megaceryle alcyon*), Brown-headed Cowbird (*Molothrus ater*), and Harris' Sparrow (*Zonotrichia querula*) can detect near-UV light between 330 and 365 nm (Parrish and Ptacek unpubl.). Alternatively, it is possible that these data support the view alluded to by Goldsmith (1980) that UV-light reception is probably present in most, if not all, avian species, because birds retained similar eye structures during their evolution from the UV-sensitive reptiles. Further work, which includes an examination of a variety of both migratory and nonmigratory species, is required in order to give credence to these hypotheses.

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