ACTA ORNITHOLOGICA
Vol. 27 (1993) No. 2

Jacek RADWAN

Are dull birds still dull in UV?*

Radwan J. 1993. Are dull birds still dull in UV? Acta orn. 27: 125–130.

Skins of 33 passerine birds were examined for ultraviolet (UV) reflectance by means of UV photography. Most of the species studied appear dull to humans, though on the theoretical grounds they might be expected to evolve bright plumage. The qualitative analysis suggested that UV does not increase brightness of most examples of feathers that appear dull in the visible range, though it may add to the conspicuousness of plumage already bright by human standards. Black but shiny or iridescent birds, whose feathers reflect UV, are the possible exception. Though methods used did not allow the quantitative comparison of the strength of this reflectance with that in the visible range, it seems likely that UV may enhance brightness of iridescent feathers of black coloured birds. Moreover, the supplementary examination of some other, randomly selected species, as well as findings by other authors, suggest that in some cases UV may be important in birds' perception of feathers, especially if they are black or white.

Present address: Department of Zoopsychology and Animal Ethology, Institute of Environmental Biology, Jagiellonian University, ul. Ingardena 6, 30-060 Kraków, POLAND.

INTRODUCTION

The significance of coloration for mate choice in birds has recently been much discussed, especially since Hamilton and Zuk (1982) proposed that bright plumage evolved as a trait demonstrating genetic resistance to disease (Read and Harvey 1989a, Zuk 1989, Read and Harvey 1989b). However, human judgements of showiness may not be an adequate approximation of birds' perception of one another, especially because ultraviolet (UV) vision seems to be widespread in birds (Parrish et al. 1984, Chen et al. 1984).

Burkhardt (1982) pointed out that birds' sensitivity to UV light may be important in detection of berries and flowers. He also suggested that birds' plumage may show some additional features in UV, which are invisible to humans. The spectrophotometric investigation of birds' feathers supplied evidence that this sometimes is the case (Burkhardt 1989a, Burkhardt and Finger 1991).

In this study, skins of 33 species of European passerine birds from the Oxford University Museum of Natural History collection were examined for UV reflectance by means of UV photography. Monogamous species which were reported to have extra-pair copulations or showing some degree of polygyny (for review, see Moller 1986) were chosen because Hamilton (1990) suggested that in this type of species bright coloration may be especially important in mate choice. However, most of the

* The work was carried out in the Animal Behaviour Research Group, Dept. of Zoology, Oxford Univ., U. K.

species listed by Moller (1986) possess rather dull plumage. Therefore, it seemed interesting to find out whether any UV reflection patterns could be found in plumage of these species, which could change our view of their showiness. Dark Corvids, which also were reported to mate outside pair-bond (McKinney et al. 1984), are particularly intriguing as they additionally have high parasite loads (Hamilton 1990).

METHODS

The pictures were taken with a Pentacon 50mm lens, which transmits in the near UV to 350 nm. A 125 W black-light mercury-vapour lamp type MB/U (General Electric Company) with range of radiation between 325 and 400 nm served as UV light source. For UV pictures the lens were screened by 18A Kodak-Wratten UV transmittance filter to ensure that any light of more than 400 nm wavelength would not be recorded of the film. The filter also transmits in the infra-red, however the mercury lamp used does not produce such a long wavelength. Therefore the system allowed an investigation of reflectance in the UV wavelength band between 350 and 400 nm. Additionally, control pictures were taken using tungsten light falling on an object at the same angle as the UV light. Both UV and control photographs were recorded on 50 ASA Ektachrome transparency film.

RESULTS AND DISCUSSION

No distinctive patterns in dull coloured feathers were found within the near UV range (Tab. 1). Brown and velvety black feathers do not reflect UV (Tab. 1). Grey and creamy feathers show from slight to strong UV reflectance, probably depending on the degree of melanin presence in these feathers. These results are consistent with Burkhardt's (1989a) findings that melanin pigments absorb UV considerably. More accurate interpretation of grey and creamy feathers' appearance (including UV range) can be obtained by comparing their reflectance in UV with their reflectance in the visible spectrum. This kind of analysis (Burkhardt 1989a, Burkhardt and Finger 1991) suggested that some grey or white feathers reflecting less UV than visible light may appear to birds as having colours complementary to UV. The examples of strong UV reflectance of white, blue and bright-yellow feathers (Table 1) are also in agreement with Burkhardt's (1989a) results. This means that white feathers which reflect UV probably are white for birds as well (Burkhardt 1989a), and addition of UV reflection to already bright feathers (yellow, blue) would probably not add to their showiness.

In shiny-black feathers, UV reflectance depends of the angle of light falling on them and the angle of viewing (Tab. 2). Most of them are simply glossy and show reflectance throughout the visible range. However, Burkhardt and Finger (1991) reported that spectrophotometric analyses of black and shiny feathers of the Raven *Corvus corax* and the Swallow *Hirundo rustica* revealed stronger reflection of these feathers in the UV than in the human visible range.

In some cases (Tab. 2), such as Rook's *Corvus frugilegus* head and neck, Magpie's *Pica pica* wings and tail, Swallow's *Hirundo rustica* back and head, Starling *Sturnus vulgaris* these feathers show iridescent reflectance in short wavelength (violet, blue, green), with colour emphasis changing with viewing angle, and this effect also appears in UV. To interpret these feathers' appearance to birds, the sensitivity diagrams throughout the spectrum need to be known for these species. If these birds are

Table 1. UV reflectance of passerine bird's feathers
Symbols used: V – under-parts, D – upper-parts, B – belly, Br – breast, C – crown, Es – eye-strip, Fh – forehead, H – head, R – rump, W – wing, Wb – wing-bar, T – throat, Ta – tail, (M) – in male only, (F) – in female only.
Tabela 1. Zdolność piór ptaków wróblowatych do odbijania nadfioletu
Symbole: V – strona brzuszna, D – strona grzbietowa, B – brzuch, Br – pierś, C – grzbiet głowy, Es – pręga oczna, Fh – czoło, H – głowa, R – kuper, W – skrzydło, Wb – pasek skrzydłowy, T – gardziel, Ta – ogon, (M) – tylko u samca, (F) – tylko u samicy

Species Gatunek	Reflectance in UV			
	strong	moderate	slight	no reflectance
Acrocephalus arundinaceus		V-creamy		D-olive-brown
Acrocephalus palustris		V-buff		D-brown
Alauda arvensis	B-creamy-white	Br-buff		D,T-brown
Anthus spinoletta	V-creamy-white			D-brown
Anthus trivialis	V-creamy-white	Br-buff		D-brown
Calcarius lapponicus		V-creamy-white		D-brown
Certhia familiaris	Br-greyish-white	B-buff		D-brown
Cettia cetti	T-greyish-white	V-light-brown		D-brown
Cisticola juncidis		V-creamy		D-brown
Emberiza calandra		V-greyish-creamy		D-brown
Emberiza citrinella	V,H(M)-yellow			D-brown
Emberiza shoeniclus	V(M)-white	V(F)-light-brown		B-brown H(M),T(M)-black
Erithacus rubecula		V-light-grey	D-olive-grey	T-orange
Ficedula hypoleuca	V(M),C(M),Wb-white	V(F)-creamy	D(F)-light-brown	D(M)-black
Motacilla flava	V,H(M)-yellow		D-olive-green	
Oeanthe isabellina	R-white	V-buff	D-light-brown	
Oeanthe oenanthe	R-white	D(M)-greyV-buff		Es(M),V(M),Ta(M)-black D(F)-brown
Panurus biarmicus	Br-greyish-white	H(M)-grey	B-light-brown	D-brownEs(M)-black
Parus caeruleus	V-yellowH,V,Ta-blue	D-olive-grey		T-black
Passer domesticus		V-light-grey	C(M)-grey	D-brownT(M)-black
Phoenicurus phoenicurus	Fh(M)-white	D-greyB(M)-creamy	V(F)-greyish-brown	T(M)-blackBr(M)-chestnut
Phylloscopus collybita		V-buff		D-olive-brown
Phylloscopus sibilatrix	T,Br-yellowB-white		D-yellowish-green	
Sylvia communis	T(M)-white	V-buff	H(M)-grey	D-brown
Sylvia nisoria		V-grey	H-brownish-grey	D-brown
Troglodytes troglodytes				brown

more sensitive to UV than to other parts of the spectrum, as is the case with *Leiothrix lutea* (Burkhardt 1989b, Maier 1992), these iridescent colours may be much brighter to birds than they appear to humans.

Additionally, over a hundred randomly chosen species from different families were looked at with the UV viewer, invented and kindly lent to me by Prof. J. D. Pye (University of London), and photographs were subsequently taken of a few more interesting cases such detected. *Tangara cyanicollis*, a very brightly coloured species in human visible range, has some faintly-bluish black feathers on its belly. These feathers reflect UV very strongly. A similar effect of enhanced reflectance in UV was found in faintly blue feathers on the belly of *Pitta baudii* and the wing covers of *Pitta venusta*. The reflectance does not change with the viewing angle which suggests that this effect, much stronger in UV than in the blue range, is caused by Tyndall's light scattering (Dorst 1974). This is consistent with the results obtained by Finger et al. (1992). They found that feathers of the Black Lori *Chalcopsitta atra*, which are black to humans but reflect strongly in UV, have a spongy structure inside their rami, responsible for light scattering. Similar spon-

Table 2. Birds with shiny-black feathers showing UV reflectance changing according to the angle of viewing. *reflectance independent of the angle of viewing; symbols used: V – under-parts, B – belly, Ba – back, R – rump, H – head, N – neck, Br – breast, T – throat, Wb – wing-bar.
Tabela 2. Ptaki o błyszczącym czarnym upierzeniu odbijającym nadfiolet w różnym stopniu, zależnie od kąta padania światła. *odbijalność niezależna od kąta padania światła; symbole: patrz tab. 1.

Species	Reflectance	
	visible	ultraviolet
Corvus corax	shiny-black	high
Corvus corone	shiny-black	high
Corvus frugilegus	H-iridescent (blue-violet) black shiny black	high high
Corvus monedula	N-grey shiny-black, midddle* high	
Pica pica	H,Ba,R-black B,Wb-white W-iridescent (blue) black T-iridescent (green) black	none* very high* high high
Hirundo rustica	Ba-iridescent (blue) black T-chestnut Br-black V-pinkish-whitehigh	high none* none* middle*
Sturnus vulgaris	H,T-iridescent (violet) black Ba,B-iridescent (green) black	high high

gy structures are present also in feathers of *T. caynicollis* (Finger et al. 1992).

A good example of white feathers with slight UV reflectance is the collar of the Magnificent Bird of Paradise *Diophyllodes magnificus chrysopterus*.

Concluding, the study showed that distinctive UV patterns do not enliven the plumage of the dull birds, even though they may add to showiness of already bright birds. However, recent research (Burkhardt and Finger 1991, Finger at all. 1992) showed that there may be exceptions from this rule, especially in the case of black or white feathers. No evidence suggesting the existence of pigments reflecting exclusively in UV was found, although some carotenoids reflect UV together with visible waves (see Burkhardt 1989a). This result is not surprising if we take into account that almost all greens, blues and violets are due either to the Tyndall effect or to iridescence; pigments reflecting short wavelengths, such as turacoverdin and rhodoxantins are uncommon (Dorst 1974, Vevers 1982). This study has shown, however, that the effects of structural colours extend into UV and these may be even stronger in UV than in the visible range. This suggests that UV reflectance may be of some importance in dull but iridescent birds.

ACKNOWLEDGEMENTS

I am very grateful of Professors J. David Pye and William D. Hamilton for their advice, help and comments. I also would like to thank Professor D. Burkhardt whose critical remarks helped to improve this paper, Mike Amphlett for his advice on photography and Dr. Tom Kemp for giving me permission to use the University Museum's collections. Dr. Brian Sumida, Mary Eaves and Andy Bennett commented of the manuscript.

REFERENCES

Burkhardt D. 1982. Birds, berries and UV. A note of some consequences of UV vision in birds. Naturwissenschaften 69: 153–157.

Burkhardt D. 1989a. UV vision: a bird's eye view of feathers. J Comp. Physiol. A 164: 787–796.

Burkhardt D. 1989b. The spectral sensitivity of a passerine bird is highest in the UV. Naturwissenschaften 76: 82–83.

Burkhardt, D., Finger, E. 1991. Black, white and UV: How birds see birds. Naturwissenschaften 78: 279.

Chen D-M., Collins J., Goldsmith T.H. 1984. The ultraviolet receptor of bird retinas. Science 225: 337–340.

Dorst J. 1974. The life of birds, vol. 1: The colours of birds, London. pp 48–59.

Finger, E., Burkhardt, D., Dyck, J. 1992. Avian Plumage Colors. Origin of UV reflection in a Black Parrot. Naturwissenschaften 79: 187–188.

Hamilton W.D. 1990. Mate choice near or far. Amer. Zool. 30: 341–352.

Hamilton W.D., Zuk M. 1982. Heritable true fitness and bright birds: a role of parasites? Science 218: 384–387.

McKinney F., Cheng K.M., Bruggers D.J. 1984. Sperm competition in apparently monogamous birds. In: R. Smith (ed.) Sperm competition and the evolution of animal mating systems, New York. pp 523–545.

Maier, E.J. 1992. Spectral sensitivities including the ultraviolet of the passeriform bird *Leiothrix lutea*. J. Comp. Physiol. A 170: 709–714.

Moller A.P. 1986. Mating systems among European passerines: a review. Ibis 128: 234–250.

Parrish J.W., Ptacek J.A., Will K.L. 1984. The detection of ultraviolet light by nonmigratory and migratory birds. Auk 101: 53–58.

Read A.F., Harvey P.H. 1989a. Reassessment of comparative evidence for Hamilton and Zuk theory on the evolution of secondary sexual characters. Nature 339: 618–620.

Read A.F., Harvey P.H. 1989b. Nature 340: 105.

Vevers G. 1982. The colours of animals. London.

Zuk M. 1989. Validity of sexual selection in birds. Nature 340: 104–105.

STRESZCZENIE

[Czy matowo upierzone ptaki są jaskrawe w świetle nadfioletowym?]

Celem badań było określenie roli promieni nadfioletowych w ubarwieniu upierzenia wybranych gatunków ptaków. Zgodnie z hipotezą Hamiltona i Zuk (1982), jaskrawość upierzenia może być wskazówką używaną w procesie wyboru partnera do rozrodu, dla oszacowanie genetycznej odporności przeciw pasożytom. Hamilton (1990) zasugerował, że ten rodzaj sygnałów powinien odgrywać dużą rolę u monogamicznych gatunków ptaków, u których często występuje kojarzenie poza parą. Jednak u wielu z tych gatunków zarówno samce jak i samice nie posiadają jaskrawego upierzenia.

Do badań użyto eksponaty muzealne 33 gatunków monogamicznych ptaków wróblowatych, u których znane są przypadki kontaktów seksualnych poza parą lub pewien stopień poligamii. Zawartość promieni nadfioletowych w świetle odbitym od piór badano wykonując zdjęcia ptaków w świetle nadfioletowym.

Uzyskane wyniki sugerują, że promienie nadfioletowe nie wpływają na stopień jaskrawości upierzenia większości badanych gatunków (Tab. 1). Pióra o dużej zawartości melanin (czarne, brązowe) odbijały promienie nadfioletowe tylko w niewielkim stopniu lub wcale. Pióra białe odbijały nadfiolet w dużym stopniu, tak że prawdopodobnie odbierane są przez ptaki również jako białe. Nadfiolet występował również w świetle odbitym od jaskrawo upierzonych piór (żółty, niebieski).

Wydaje się natomiast, że promienie nadfioletowe mogą wzmacniać jaskrawość opalizujacego (na niebiesko, fioletowo lub zielono) upierzenia niektórych czarno ubarwionych gatunków (Tab. 2). Efekt ten może być tym silniejszy, że receptory wzroku ptaków mogą być bardziej wrażliwe na nadfiolet niż na zakres fal widzialnych dla ludzi (Burkhardt 1989b, Maier 1992). Ponadto, dodatkowe obserwacje losowo wybranych gatunków ptaków, a także wyniki uzyskane przez innych autorów (Burkhardt i Finger 1991) sugerują, że nadfiolet może odgrywać ważną rolę w postrzeganiu przez ptaki koloru piór u niektórych gatunków, zwłaszcza w przypadku czarnego lub białego upierzenia.