Sex-Specific UV and Fluorescence Signals in Jumping Spiders

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There is widespread evidence for animal photoreceptors that are sensitive to ultraviolet (UV) wavelengths, and numerous functions for UV reflectance have also been shown (*1*). In addition, visible light fluorescence induced by UV wavelengths has been implicated in animal signaling in certain marine invertebrates and in the plumage of parrots (*2*, *3*). We report a case of courtship signaling in which both UV reflectance and UV-induced fluorescence are used on a sex-specific basis. In the ornate jumping spider *Cosmophasis umbratica*, the males have UV-reflective patches of scales on the face and body that are displayed during conspecific posturing (*4*). These are lacking in females (*4*), but females have palps with a UV-excited bright green fluorescence that is absent in males (Fig. 1, A to C).

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We examined the consistency of courtship behavior in environments that were either rich or lacking in UV wavelengths. By using a transparent filter that specifically blocked UV wavelengths (fig. S1), we removed UV reflectance cues in males (♂UV−) and prevented the fluorescence of females (♀F−). We also restricted nonvisual communication by using individual glass arenas. By manipulating UV-blocking filters over both, either, or none of the glass arenas, we obtained four scenarios: ♂UV+ and ♀F+; ♂UV–, ♀F–; ♂UV+, ♀F–; and ♂UV–, ♀F–.

Under full-spectrum light, males readily courted females by adopting a courtship posture comprising a flexed-up abdomen, arched legs, and extended vibrating palps; females responded either with displays comprising hunched legs and bent abdomen or by briefly running away (*4*). Without UV, females either made no response or simply turned away (without running). Similarly, males either ignored nonfluorescing females by turning away or responded with a reduced display lacking some behavioral elements. We found that a large proportion of the same pairs that successfully interacted in the presence of UV (♂UV+, ♀F+) failed to show intersexual behavior in its absence (♂UV–, ♀F–) (Fig. 1D).

To ensure that the courtship responses of the spiders were an effect of sexual colors and not behavioral changes in the opposite sex, we compared the behavioral responses of individuals of one sex under full-spectral light when the partner of the opposite sex was illuminated by UV-deficient light. Among the 20 UV+ males that actively courted F+ females, most (16) failed to court the female when she lacked fluorescence [♂UV+, ♀F− (Fig. 1E)], even though her behavioral reactions remained statistically the same as under normal light. And among 12 F+ females that responded to courting UV+ males (♀F+, ♂UV+), most (10) ignored the same male that now lacked UV cues (♀F+, ♂UV−) (Fig. 1F), even though these males also continued to show consistency in courtship. We conclude that sexual coloration is a crucial prerequisite for courtship.

Jumping spiders have excellent eyesight (*5*), and the retinas of the principal eyes are known to have photoreceptors with maximal sensitivities to UV and to green light (*6*, *7*). The UV receptors have already been shown to have a role in male-male interactions (*8*). Our study strongly suggests a role for green wavelengths as well. The reflectance spectra of *C. umbratica* males have prominent peaks in both UV and green wavelengths, and the UV-induced green fluorescence is restricted entirely to the palps of females (fig. S2).

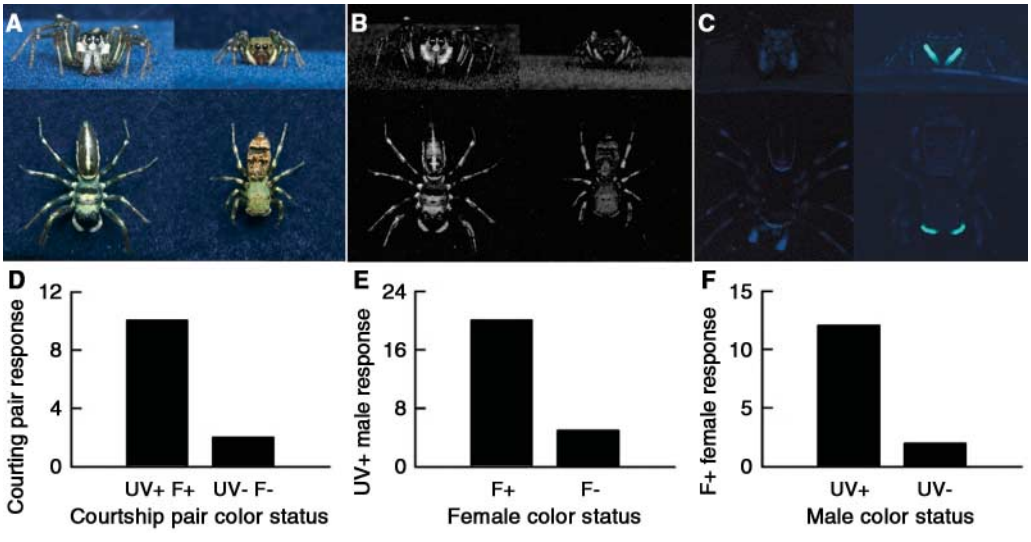

Fig. 1. (**A** to **C**) *C. umbratica* showing UV and fluorescent markings. Males (left) and females (right) from frontal (top) and dorsal (bottom) in (A) human-visible color images, (B) UV images with whiter regions showing strong UV-reflective parts, and (C) color images of UV-induced fluorescence in females (Materials and Methods). (**D** to **F**) Decrease in the number of courtship responses when UV wavebands were removed. (D) Reduction in courtship interactions ($P = 0.004$; one-tailed sign test) when UV was absent from both sexes. (E) Males were uninterested when females lacked fluorescence ($P = 0.0003$; one-tailed sign test), and (F) females were uninterested in males that lacked UV colors ($P = 0.001$; one-tailed sign test).

References and Notes

1. M. J. Tovée, *Trends Ecol. Evol.* **10**, 455 (1995).
2. C. H. Mazel, T. W. Cronin, R. L. Caldwell, N. J. Marshall, *Science* **303**, 51 (2004); published online 13 November 2003 (10.1126/science.1089803).
3. K. E. Arnold, I. P. F. Owens, N. J. Marshall, *Science* **295**, 92 (2002).
4. M. L. M. Lim, D. Li, *Biol. J. Linn. Soc.* **89**, 397 (2006).
5. M. F. Land, in *Neurobiology of Arachnids*, F. G. Barth, Ed. (Springer-Verlag, Berlin, 1985), pp. 53–78.
6. A. D. Blest, R. C. Hardie, P. McIntyre, D. S. Williams, *J. Comp. Physiol. A* **145**, 227 (1981).
7. A. G. Peaslee, G. Wilson, *J. Comp. Physiol. A* **164**, 359 (1989).
8. M. L. M. Lim, D. Li, *J. Comp. Physiol. A* **192**, 871 (2006).
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Supporting Online Material

www.sciencemag.org/cgi/content/full/315/5811/481/DC1
Materials and Methods
Figs. S1 and S2
References

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