Infrared Reflectance in Leaf-Sitting Neotropical Frogs

Abstract. *Two members of the glass-frog family Centrolenidae (*Centrolenella fleischmanni, C. prosoblepon*) and the hylid subfamily Phyllomedusinae (*Agalychnis moreletii, Pachymedusa dacnicolor*) reflect near-infrared light (700 to 900 nanometers) when examined by infrared color photography. Infrared reflectance may confer adaptive advantage to these arboreal frogs both in thermoregulation and infrared cryptic coloration.*

Many arboreal members of the glass-frog family Centrolenidae and tree-frog family Hylidae are green, and thus cryptically colored when viewed in visible light (400 to 700 nm). Infrared color photography (*1*) reveals that two centrolenids (*Centrolenella fleischmanni, C. prosoblepon*) and two phyllomedusine hylids (*Agalychnis moreletii, Pachymedusa dacnicolor*) also reflect light in the near-infrared region (700 to 900 nm). This is, to our knowledge, the first report of infrared reflectance in neotropical frogs. Since photosynthetic leaf surfaces also reflect infrared, these animals are virtually indistinguishable from the leaves on which they sit, both in visible and near-infrared light ranges. All other North American frogs so examined [*Bufo debilis, B. boreas* (2), *B. coniferus; Rana pipiens* (2), *R. palmipes, R. catesbeiana; Hyla cinerea, H. squirella, H. euphorbiacea, H. chaneque*, and *H. cyanomma*] absorb infrared light and stand out sharply against foliage (Fig. 1).

Cott (*3*), using black and white infrared film, found that the Australian tree-frog *Hyla coerulea* (=*Litoria caerulea*) reflects infrared light. *Litoria caerulea, A. moreletii*, and *A.* (=*Pachymedusa*) *dacnicolor* all contain a newly discovered red pigment in unusual melanosomes (*4*). Both *fleischmanni* and *prosoblepon* groups of *Centrolenella* contain a purple pigment in their chromatophores (*5*). Whether these two skin pigments are identical, or play any role in infrared reflectance, has not been determined.

There are two likely functions for infrared reflectance in leaf-sitting frogs. (i) Although the near-infrared is not heat (*6*), photons of these wavelengths will lose energy as heat if they are absorbed by the skin. Thus, the ability to reflect infrared may play a physiological role in thermoregulation by preventing excessive heat gain. (ii) Infrared reflectance may conceal frogs from predators with infrared receptors (*3*). Little research has been done on near-infrared sensitivity, and supportive evidence is sparse. Both the eyes of birds and the pit organs of snakes may act as near-infrared light receptors. In pigeons and chickens, the sensitivity maxima of the eyes are shifted toward longer wavelengths than those of humans (*7*), and the tawny owl responds to infrared light (900 nm) (*8*). Visual sensitivity extending just into the near-infrared would allow birds to see most green frogs on green leaves, although centrolenids and phyllomedusines would remain camouflaged. Boid and crotaline pit organs are usually interpreted as thermal detectors, adaptations for nocturnal predation on warm-blooded prey (*9*). In diurnal snakes, however, these receptors may be used to detect frogs that act as infrared sinks among leaves that are reflecting light of these wavelengths. The facial pits of crotaline snakes are directionally sensitive and may allow infrared depth perception (*10*). Many species of birds and snakes are known to eat frogs and forage in their

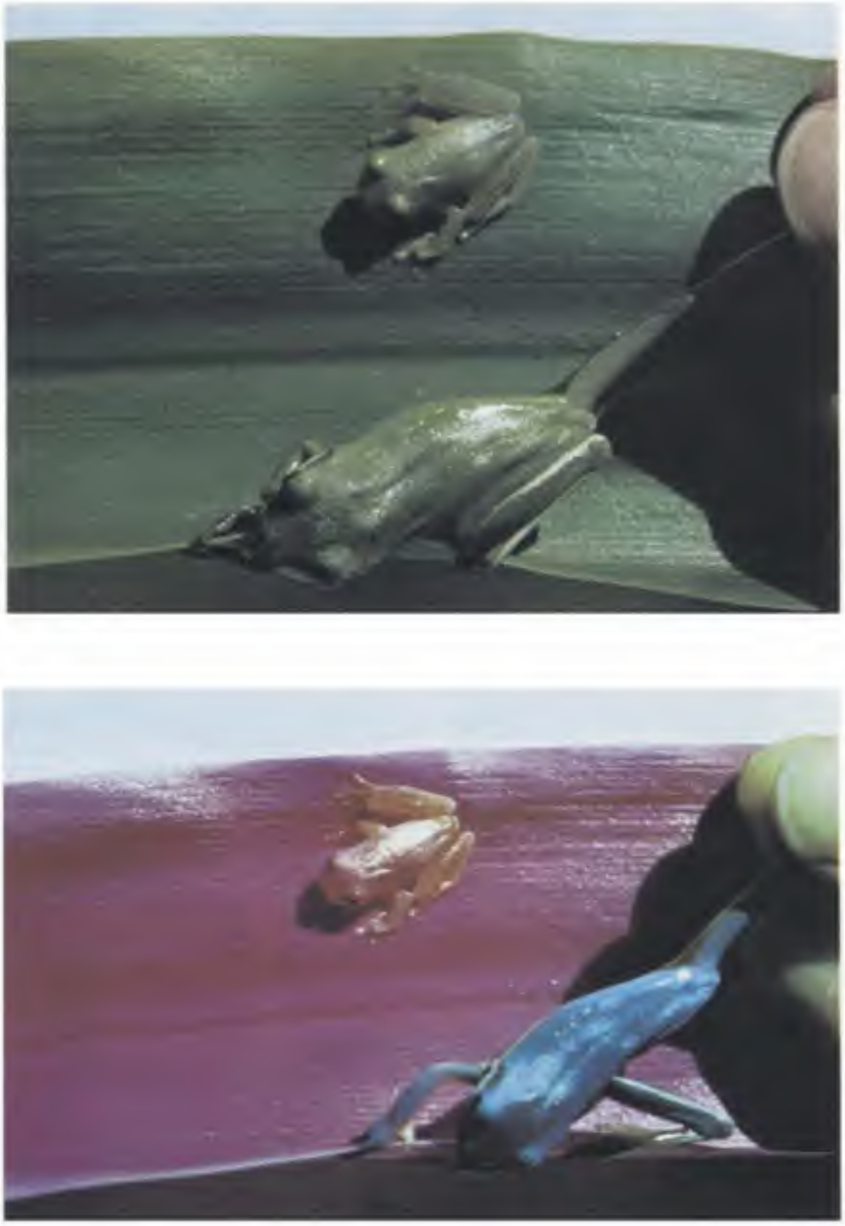

Fig. 1. A comparison of the color characteristics of a hylid and a centrolenid frog in a conventional (top) and an infrared (bottom) color photograph. Although both frogs match the green leaf in light ranges visible to man, only *Centrolenella fleischmanni* (top frog) reflects near-infrared light. This allows it to blend with foliage both in the visible and near-infrared ranges of light, unlike *Hyla cinerea* (bottom frog), which absorbs infrared and is distinguished from the leaf surface in an infrared photograph.

diurnal retreats. Predation by birds and snakes may have selected for infrared cryptic coloration in tropical leaf-sitting frogs.

PATRICIA A. SCHWALM*
PRISCILLA H. STARRETT
Department of Biological Sciences, Allan Hancock Foundation, University of Southern California, Los Angeles 90007
ROY W. MCDIARMID
Department of Biology, University of South Florida, Tampa 33620

References and Notes

1. Kodak Infrared Ektachrome film has a sensitivity extending to about 900 nm [*Kodak Publ. N-17* (1974)]. The three emulsion layers are sensitized to green, red, and infrared light rather than to blue, green, and red. By placing a yellow filter over the camera lens, blue light is excluded, resulting in a shift of colors in the photograph. Green objects appear blue, red objects appear green, and infrared appears red.
2. H. L. Gibson, W. R. Buckley, K. E. Whitmore, *J. Biol. Photogr. Assoc.* **33**, 1 (1965).
3. H. B. Cott, *Adaptive Coloration in Animals* (Methuen, London, 1940), pp. 9–11.
4. J. T. Bagnara and W. Ferris, *Copeia*, 3, 592 (1975).
5. P. H. Starrett and J. M. Savage, *Bull. South. Calif. Acad. Sci.* **72**, 57 (1973).
6. Radiation in these wavelengths (700 to 900 nm) can be emitted by very hot objects, such as the sun or lamp filaments, but it is not heat per se. Similarly, the near-infrared can be reflected or emitted as luminescence by objects that are not hot themselves [*Kodak Publ. M-28* (1972)].
7. R. Granit, *Sensory Mechanisms of the Retina* (Oxford Univ. Press, London, 1947), pp. 294–296.
8. F. L. Vanderplank, *Proc. Zool. Soc. London* **1934**, 505 (1934).
9. P. H. Hartline, in *Handbook of Sensory Physiology*, vol. 3, part 3, *Electroreceptors and Other Specialized Receptors in Lower Vertebrates*, A. Fessard, Ed. (Springer-Verlag, New York, 1974), pp. 297–312.
10. R. C. Goris and S. Terashima, *J. Exp. Biol.* **58**, 59 (1973).
11. We thank N. L. Nicholson and P. M. Shugarman for technical help and suggestions; J. A. McNulty, R. J. Wassersug, and S. Arnold for critical discussions. Permits to collect frogs in Oaxaca. Mexico, were provided to R.W.M. by M. L. Cossio Gabucio and Dr. A. Landazuri Ortiz, Department of Conservation, Mexico. Supported by biomedical sciences support grant RR07012-09 and biomedical research support grant 5 S07 RR07012-10 from the Division of Research Resources, Bureau of Health Professions Education and Manpower Training, National Institutes of Health, to P.A.S. and P.H.S.
* Present address: Committee on Evolutionary Biology, University of Chicago, Chicago, Ill. 60637.

18 November 1976; revised 17 January 1977

REPRINTED FROM
SCIENCE 196: 1225-1227
10 JUNE 1977