Amphibians in a Very Bad Light

In "Shedding Light on Ultraviolet Radiation and Amphibian Embryos" in the June 2003 issue of *BioScience,* Lawrence E. Licht argues that there is no convincing evidence linking ambient ultraviolet-B (UVB) radiation and amphibian population declines. In the same issue, a Viewpoint by W. Ronald Heyer and an editorial support Licht's contention. However, evidence from more than 50 peer-reviewed publications, written by more than two dozen scientists from around the world, illustrates that dozens of amphibian species are harmed by UVB. Moreover, Licht's paper focused narrowly on embryos and ignored the growing literature showing that UVB damages larvae and adults.

Showing little understanding of experimental protocol, Licht criticizes both laboratory and field experiments designed to examine the effects of UVB on amphibians. Referring to laboratory experiments on larvae, he states that "UVB exposure times and doses are usually consistent...and do not account for natural changes and diminishing UVB levels resulting from clouds and overcast skies." This is true, but in field experiments just the opposite is done. Everything (including cloud cover) varies naturally *except* UVB radiation, which is controlled. Specifically, we use a replicated, randomized block design. Experimental and control treatments are conducted side by side, after randomly assigning enclosures to positions at natural breeding sites at the precise depth at which eggs are laid. Blocks usually consist of three treatments: enclosures are open to natural sunlight, covered with a UVB blocking filter, or covered with a control filter that transmits UVB.

Licht specifically criticizes the experimental design of Blaustein and colleagues by referring to another study (see references in Licht 2003) in which some of the plastic filters placed over control enclosures may have been noxious to larvae. Since Blaustein and colleagues used a similar control filter, he suggests that their results are suspect. However, in Blaustein's studies (1) embryos were tested—and Licht (2003) himself states that embryos are not affected by the plastic; (2) the plastic was above the water, so it never touched amphibians or water; and (3) unusual mortality did not occur in control enclosures.

Licht suggests that our techniques do not reflect how the amphibians we have studied for over 20 years lay their eggs. We know the habits of our experimental species. Contrary to Licht's statements, numerous species worldwide, including the ones we study, regularly lay their eggs in shallow water (see *AmphibiaWeb.org).* Often the eggs extend above the surface and are exposed to air and high levels of UVB, especially as ponds dry.

Licht states that amphibians have evolved a "high resistance" to UVB and that "amphibian embryos are resistant to doses of UVB radiation far higher than those they would normally receive from current ambient levels." This is a gross overstatement.

Only a small fraction of the thousands of amphibian species has been examined after exposure to UVB. Licht's "adaptationist" evolutionary scenario is naïve. A basic tenet of natural selection is that all individuals do not respond identically to the same environmental variable. Variation exists within species, between populations, and among species. Amphibians are faced with conflicting selection pressures. Some must develop quickly before their habitat disappears. Therefore, they seek sunlight, where heat from solar radiation enhances development. Selection pressure for seeking thermal regimes that maximize growth was probably important in shaping amphibian behavior.

Although UVB has been a ubiquitous stressor on amphibians throughout evolutionary time (Cockell and Blaustein 2001), unprecedented and increasing levels of UVB have been occurring for anthropogenic reasons for less than 100 years. Thus, increasing UVB is a relatively recent selection pressure. Behaviors limiting amphibian exposure to sunlight and other defenses (e.g., DNA repair) are therefore unlikely to have overridden strong established selection pressures for seeking warmth. It is more likely that amphibians seek sunlight and that those species without effective defense mechanisms against harmful UVB die or are damaged when exposed to UVB (Blaustein and Belden 2003).

Many frog species bask in sunlight for prolonged periods of time, exposing them to high levels of UVB, which damages their eyes, and larvae frequent the shallowest portions of a pond, where they are also exposed to high levels of UVB that can kill them or induce severe sublethal damage (Blaustein et al. 2003). Nevertheless, some amphibians live in habitats that limit their exposure to UVB. Thus, citing Palen and colleagues (2002), Licht states that dissolved organic carbon in the water protects amphibians from UVB throughout the Pacific Northwest. In reality, UVB levels measured in most ponds by Palen and colleagues (2002) are at or above levels that harm amphibians, supporting numerous studies showing that embryos of many species die when exposed to UVB.

Another misleading aspect of Licht's article is his reporting of the findings of experimental studies. Referring to his table 2, Licht states that "embryo mortality has been reported for 9 species" and "no effects" have been reported for 22 species (he failed to include several species). However, if you read the literature cited in Licht's table 2 carefully, of these 22 species, 17 are affected at later developmental stages after being exposed to UVB as embryos. The five remaining species have not been tested after the egg stage. In other words, every tested species listed in his table displays adverse effects following embryonic exposure to UVB, including deformities of the body and eyes, stunted growth and development, and severe physiological problems in later stages—a most alarming result. Thus, for many species, the most severe problems

caused by UVB exposure may come after hatching.

Licht stated that Blaustein's research was questioned when it was first published, citing a "news" report. Unfortunately, he ignores a letter signed by 25 eminent ecologists and published in *Science* that discredits that report. Heyer (2003) is correct in noting that we have gone beyond the study of direct effects of UVB on embryos (Blaustein and Kiesecker 2002). But Heyer's account of Blaustein's "laboratory experiments" with unrealistically high UVB exposures is erroneous. Blaustein's experiments were conducted in the field, not in the laboratory. All ecological parameters were natural, and UVB was not enhanced. Moreover, Heyer's comments on how personalities affect scientific processes seem inappropriate for a scholarly publication.

ANDREW R. BLAUSTEIN
Department of Zoology
Oregon State University
Corvallis, OR 97331

LEE B. KATS
Frank R. Seaver Chair
in Natural Science
Natural Science Division
Pepperdine University
Malibu, CA 90263

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