nature

INTERNATIONAL WEEKLY JOURNAL OF SCIENCE

Volume 383 No. 6602 24 October 1996 £4.00 FFr44 DM17.5 Lire13000 A$12

Suntanned hammerheads

Where is the Tunguska debris?

BSE and humans

Jobs in genetics

Suntanning in hammerhead sharks

SIR — For many organisms, exposure to high-intensity solar ultraviolet radiation is detrimental[1,2]. Integumental pigments such as melanin, however, may afford protection from these wavelengths[3]. We found that the integumental melanin content in juvenile hammerhead sharks increases in direct response to increases in solar radiation. Although humans and some terrestrial mammals 'tan' in response to increases in ultraviolet radiation[4], this has never been documented for aquatic vertebrates.

Many marine organisms possess integumental melanin, but this pigment is thought to be maintained at constitutive levels and used primarily for purposes other than solar ultraviolet radiation protection. Many marine fishes can rapidly mobilize pigment to facilitate crypsis or to display behavioural cues, but little is known about the photoprotective role of this pigment in aquatic vertebrates[5,6]. Several studies have shown that some fishes are sensitive to ultraviolet and can experience severe epidermal tissue damage from the sun[7].

Kaneohe Bay, Hawaii, is a nursery ground for the scalloped hammerhead shark (*Sphyrna lewini*) where pups spend most of their time near the bottom, in the deeper, murky portions of the bay[8]. The pups are light tan in colour but change to dark brown/black over several weeks when held in a shallow (1-m deep) seawater pond with a whitish coral sand/rubble floor. Sharks in the pond experience levels of ultraviolet 600 times greater than at the bay floor, at a depth of 15 m.

To determine if shark pups were 'suntanning' in response to increases in solar ultraviolet, we exposed sharks in the pond to three spectral irradiance treatments using filters attached to their pectoral fins: (1) ultraviolet-blocking filter, which blocks wavelengths up to 390 nm but allows transmission of visible light; (2) opaque filter, which blocks all wavelengths of light; (3) no filter, which allows full solar exposure (Fig. 1*a*). We determined changes in melanin densities spectrophotometrically from solutions of skin melanin extract[9], and found that skin exposed to direct sunlight in the pond significantly increases in melanin concentration by $14 \pm 6\%$ ($n=10$) over 21 days, and by $28 \pm 6\%$ ($n=3$) over 215 days (Fig. 1*b*). Skin shielded from both visible and ultraviolet light shows no significant change in melanin concentration; distinct pigmentation delineation occurs where the filters cover the skin. Significant melanization occurs only where sunlight makes direct contact with the skin; ventral surfaces of the sharks' skin remain white.

Histological sections of skin from pretreatment sharks show a low degree of melanization, whereas sharks that were fully exposed to sunlight in the pond showed a marked increase of integumental melanin (Fig. 2). Spectral transmittance through melanin extraction solutions taken from skin of tanned sharks shows the greatest reduction in the ultraviolet-B region (Fig. 1*b*).

Extensive 'tanning' in response to increased solar radiation may have an adaptive role in protecting against the formation of thymine dimers caused by ultraviolet-B radiation (280–320 nm)[10]. It is possible that suntanning is used when the shark pups leave the bay and enter the clear pelagic waters they occupy as adults.

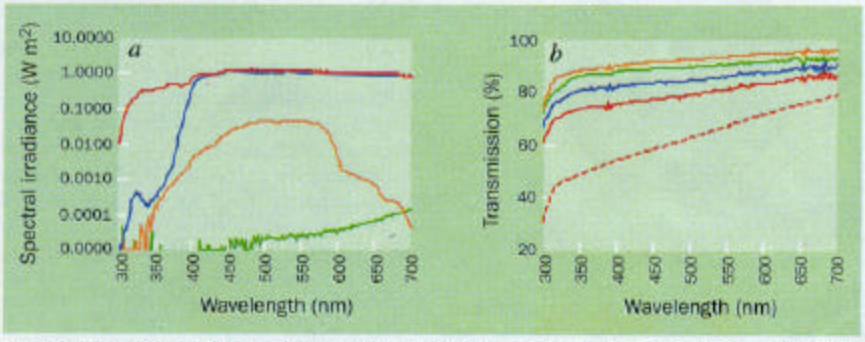

FIG. 1 *a*, We used a LICOR LI-1800 underwater spectroradiometer to measure spectral irradiance (300–700 nm) at the bay floor (15 m depth; orange line); 1 m deep in the shark pond (red line); and through opaque (green line) and ultraviolet-blocking filters (blue line). To determine maximum dosage levels, measurements were made only at midday, on clear days at the beginning of the experiments. *b*, Mean percentage of transmission of light through melanin extraction solutions from sharks' skin before and after receiving varying spectral irradiance treatments. All solutions were extracted from a 5-mm-diameter plug of skin taken from the dorsal trailing edge of the pectoral fin. Orange line, skin taken from recently captured shark pup from the bay floor; green line, skin shielded by the opaque filter; blue line, skin under the ultraviolet-blocking filter; red line, skin fully exposed to ambient sunlight for 21 days; dashed red line, a shark fully exposed for 215 days. Line colours in *b* correspond to treatments in *a*.

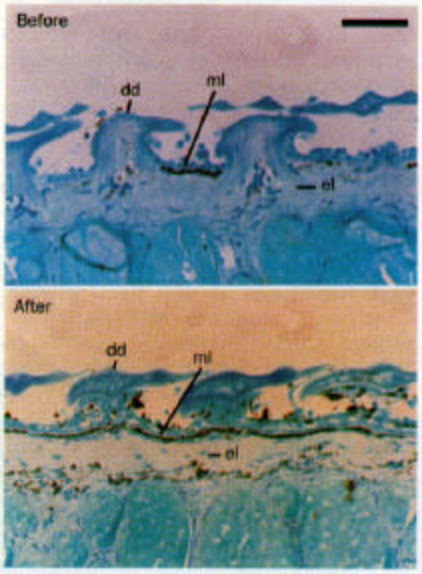

FIG. 2 Cross-sections of hammerhead shark skin from pectoral fin samples stained with methylene blue (sections by J. Wyffels), before (day 0) and after being in the pond for 21 days and exposed to increased solar radiation. dd, Dermal denticle; ml, melanin layer; el, epidermal layer. Scale bar, 50 μm.

These findings offer support for the photoprotective role of melanin in aquatic vertebrates. This shark model may have future biomedical applications, because melanomas and dermal carcinomas are unknown in sharks[11]. Finally, these observations are important for the assessment of biological responses to global increases in ultraviolet.

Christopher Lowe
Gwen Goodman-Lowe
Hawaii Institute of Marine Biology,
University of Hawaii,
PO Box 1346,
Kaneohe,
Hawaii 96744, USA
e-mail: clowe@hawaii.edu

1. Harm, W. *Biological Effects of Ultraviolet Radiation* 181–202 (Cambridge Univ. Press, 1980).
2. van Weelden, H., de Gruijl, F. R. & van der Leun, J. C. in *Biological Effects of UVA Radiation* (eds Urbach, F. & Gange, R. W.) 137–146 (Praeger, New York, 1986).
3. Quevedo, W. C., Fitzpatrick, T. B., Pathak, M. A. & Jimbow, K. in *Sunlight and Man* (eds Fitzpatrick, T. B., Pathak, M. A., Harber, L. C., Seiji, M. & Kukita, A.) 129–137 (Univ. Tokyo Press, 1974).
4. Pathak, M. A. *Ann. NY Acad. Sci.* **453**, 328–339 (1985).
5. Hadley, M. E. *Am. Zool.* **12**, 67–76 (1972).
6. Burtt, E. *Bioscience* **31**, 723–729 (1981).
7. Bullock, A. M. in *Recent Advances in Aquaculture III* (eds Muir, J. F. & Roberts, R. J.) 139–224 (Croom Helm, London, 1988).
8. Holland, K. N., Wetherbee, B. M., Peterson, J. D. & Lowe, C. G. *Copeia* **2**, 495–502 (1993).
9. Wilson, J. F. & Dodd, J. M. *J. Endocrinol.* **58**, 685–686 (1973).
10. Ahmed, F. E. & Setlow, R. B. *Cancer Res.* **53**, 2249–2255 (1993).
11. Stoskopf, M. K. in *Fish Medicine* (ed. Stoskopf, M.) p. 808 (Saunders, Philadelphia, 1993).