Marine biology

Ultraviolet-absorbing compounds in antarctic organisms

DENEB KARENTZ

Laboratory of Radiobiology and Environmental Health
University of California
San Francisco, California 94143-0750

WALTER C. DUNLAP

Australian Institute of Marine Science
Queensland 4810, Australia

Springtime ozone depletion over Antarctica during the past decade has resulted in unseasonably elevated levels of ultraviolet-B (UV-B) (280–320 nanometers) reaching the Earth's surface. This has prompted many questions about the ecological impact of the "ozone hole" on antarctic communities. Field research has focused primarily upon the identification of repair and protective mechanisms used by antarctic species to survive ultraviolet exposure in the altered springtime environment. Work completed on DNA damage and repair is presented elsewhere (Mitchell and Karentz, *Antarctic Journal*, this issue). This article describes results from a survey of antarctic organisms for the presence of natural ultraviolet sunscreens.

Mycosporine-like amino acid compounds (MAAs) absorb light from the ultraviolet portion (280–400 nanometers) of the solar spectrum. These compounds have been isolated from marine organisms (invertebrates, algae, and fish) collected in temperate and tropical regions (Nakamura, Kobayashi, and Hirata 1982; Chiocarra et al. 1980; Dunlap et al. 1989). Because of their spectral absorbing characteristics, MAAs have been recognized as possible biochemical protection for harmful ultraviolet radiation exposure of marine species (Dunlap, Chalker, and Bandaranayake 1988). During spring 1988, 57 species (1 fish, 48 invertebrates, and 8 algae) were collected from marine habitats in the vicinity of Palmer Station (Anvers Island, Antarctic Peninsula). Samples were freeze-dried, extracted in methanol, and analyzed by high-performance liquid chromatography for the presence of MAAs (for detailed methods see Karentz et al. in press).

Eighty-six percent of the organisms studied contained at least one MAA (table). Eight MAAs, in total, were identified from these antarctic species. Seven of these (palythine, porphyra-334, shinorine, mycosporine-glycine, palythene, asterina-330, and palythinol) were known previously from tropical and temperate marine organisms. The eighth MAA (mycosporine-glycine:valine), which has not been reported from organisms studied at other latitudes, was found in 60 percent of the antarctic invertebrates analyzed.

This work provides data that emphasize the widespread occurrence of MAAs in marine organisms at all latitudes, suggesting that MAAs may be a universal strategy for ultraviolet protection. The common occurrence of MAAs in antarctic organisms indicates that these organisms may have some degree of natural protection from increased ultraviolet exposure resulting from springtime ozone depletion.

We would like to thank field party members M.C. Land and F.S. McEuen for their assistance in collecting; and the Palmer Station staff from ITT/Antarctic Services, Inc., for their excellent support. This project was sponsored by National Science Foundation grant DPP 87-12533 to D. Karentz and J.E. Cleaver; Office of Health and Environmental Research, U.S. Depart-

Species analyzed, common name and total number of MAAs isolated in each sample

Species	Common name	Number of MAAs
Gromia oviformis	Rhizopod	0
Sponge no. 1	Sponge	7
Sponge no. 3	Sponge	4
Sponge no. 5	Sponge	6
Sponge no. 6	Sponge	5
Anemone no. 1	Sea anemone	5
Bolinopsis n. sp.	Ctenophore	0
Callianira antarctica	Ctenophore	0
Obrimoposthia wandeli	Planarian	5
Planarian no. 2	Planarian	5
Amphiporus michaelseni	Ribbon worm	5
Parborlasia corrugatus	Ribbon worm	5
P. fueguina	Ribbon worm	5
Aglaophamus ornatus	Polychaete	5
Neanthes kerguelensis	Polychaete	6
Terebella ehlersi	Polychaete	7
Tomopteris carpenteri	Polychaete	3
Polychaete no. 2	Polychaete	5
Trachelobdella australis	Leech	6
Limacina helicina	Pteropod	6
Margarella antarctica	Snail	4
Paludestrina antarctica	Snail	7
Trophon cf. *geversianus*	Snail	5
Nudibranch no. 1	Nudibranch	5
Tonicina zschaui	Chiton	3
Cyamium cf. *commune*	Clam	5
Limulata cf. *ovalis*	Clam	5
Achelia spicata	Sea spider	6
Calanus propinquus	Copepod	5
Cymodocella tubicauda	Isopod	6

Species analyzed, common name and total number of MAAs isolated in each sample (*continued*)

Species	Common name	Number of MAAs
Notasellus sarsi	Isopod	6
Euphausia superba	Krill	8
Amphipod no. 2	Amphipod	6
Amphipod no. 3	Amphipod	5
Amphipod no. 4	Amphipod	7
Amphipod no. 6	Amphipod	6
Amphipod no. 8	Amphipod	7
Amphipod no. 10	Amphipod	8
Amphipod no. 13	Amphipod	6
Beania livingstonei	Bryozoan	2
Inversiula nutrix	Bryozoan	6
Granaster nutrix	Sea star	6
Amphioplus affinis	Brittle star	1
Cucumaria cf. *georgiana*	Sea cucumber	0
Ekmocucumis steineni	Sea cucumber	0
Molgula enodis	Sea squirt	7
Salpa thompsoni	Salp	0
Chaetognath no. 1	Chaetognath	0
Icefish no. 1 (larvae)	Icefish	6
Curdiea racovitzae	Red algae	6
Iridea chordata	Red algae	6
Lithothamnion cf. *antarcticum*	Red algae	2
Palmaria decipiens	Red algae	7
Phyllophora appendiculata	Red algae	5
Desmarestia menziesii	Brown algae	3
Algal mat	Filamentous greens	4
Algal mat	Filamentous diatoms	3

ment of Energy, contract DE-AC03-76-SF01012; and a Visiting Investigator Award to D. Karentz from the Australian Institute of Marine Science.

References

Chioccara, F., A. Della Gala, M. de Rosa, E. Novellino, and G. Prota. 1980. Mycosporine aminoacids and related compounds from the eggs of fishes. *Bulletin des Sociétés Chimique Belges*, 89, 1,101–1,106.

Dunlap, W.C., B.E. Chalker, and W.M. Bandaranayake. 1988. *New sunscreening agents derived from tropical marine organisms of the Great Barrier Reef, Australia.* Proceeding 6th International Coral Reef Symposium.

Dunlap, W.C., D.McB. Williams, B.E. Chalker, and A. Banaszak. 1989. Biochemical photoadaptation in vision: UV-absorbing pigments in fish eye tissues. *Comparative Biochemistry and Physiology*, 93B, 601–607.

Karentz, D., F.S. McEuen, M.C. Land, and W.C. Dunlap. In press. A survey of mycosporine-like amino acid compounds in Antarctic marine organisms: Potential protection from ultraviolet exposure. *Marine Biology*.

Mitchell, D.L. and D. Karentz. 1990. Molecular and biological responses of antarctic phytoplankton to ultraviolet radiation. *Antarctic Journal of the U.S.*, 25(5).

Nakamura, H., J. Kobayashi, and Y. Hirata. 1982. Separation of mycosporine-like amino acids in marine organisms using reversed-phased high performance liquid chromatography. *Journal of Chromatography*, 250, 113–118.

Molecular and biological responses of antarctic phytoplankton to ultraviolet radiation

DAVID L. MITCHELL *and* DENEB KARENTZ

Laboratory of Radiobiology and Environmental Health
University of California San Franscisco, California 94143–0750

Air pollution has resulted in global decreases in stratospheric ozone concentrations and an increase in the amount of harmful solar radiation reaching the Earth's surface. The effects of increased ultraviolet-B (UV-B) radiation (290–320 nanometers) on the human population are complex. The obvious and direct consequences include increased incidence of skin cancer and accelerated aging; less obvious and more indirect effects include deterioration of natural systems such as marine plankton, integral to oxygen production and the base of the oceanic food chain. To assess the impact of ozone depletion on marine communities, it is necessary to define the biomolecular response of individual organisms to UV-B.

Ultraviolet light is lethal to living systems. Due to its absorbance spectrum, DNA is considered the major cellular target (i.e., it is the primary chromophore). A portion of the energy absorbed by DNA is converted into stable structural damage, primarily involving interactions between adjacent pyrimidine bases (i.e., thymine and cytosine). The major photoproducts induced are the cyclobutane dimer and (6–4) photoproduct (so named for the chemical linkages between the dimerized bases). These lesions cause significant distortions in the phosphodiester backbone which inhibit transcription of essential genes as well as the onset and progression of DNA replication.

DNA repair mechanisms have evolved in response to this damage:

- photoreaction (PR) specifically splits cyclobutane dimers by the combined action of a simple enzyme and visible light;
- nucleotide excision repair (NER) is a more complex system involving recognition of a broader class of damage, assembly of a DNA repair complex at the site of damage, incision of the DNA backbone upstream from the damage, and the concomittant excision and resynthesis of the damaged strand by the action of DNA polymerase.

We have initiated studies on the induction and repair of UV-B damage in various antarctic phytoplankton species using