

CUTANEOUS SENSITIZATION TO BLUE-GREEN ALGAE

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ALLERGIC dermatitis produced on contact to vegetation in susceptible individuals is a common occurrence and a large variety of plants, pollens, flowers, plant oils, leaves, and woods have been incriminated as proved etiologic agents. However, we have been unable to find any reference in the literature to cutaneous sensitization to aquatic vegetation, although there is no reason to suspect that organic compounds of this source are exempt from the capacity to sensitize the human skin under suitable conditions of exposure and contact. Therefore, our recent experience with a patient who manifested an allergic dermatitis apparently due to contact type sensitivity to a blue-green alga was felt to be worthy of reporting. To our knowledge there have been no previous case reports of epidermal sensitization to a member of the Myxophyceae.

CASE REPORT

A 6-year-old white girl was first seen on June 25, 1952, for evaluation of a dermatitis. The history, given by her mother, was that the present skin eruption simply represented another exacerbation of a recurrent pruritic seasonal dermatitis of 3 years' duration. The eruption, since the initial onset at 3 years of age, had always been limited in its occurrence to the months of June, July, and August. Its appearance always followed swimming in a lake in Pennsylvania where she spent the summer, and on one occasion it occurred after bathing in a Canadian lake during her only visit to that region. It had never been observed after swimming in an artificial pool or ocean water, or following a bath or a shower, and never appeared in other bathers swimming in the same water either at the same or at other times of the day. Apparently it was unrelated to temperature, exposure to sunlight, or playing at the water's edge in a bathing suit without actual body contact with the lake water. The onset of the dermatitis usually occurred within one to two hours following swimming and was limited to the face, neck, shoulders, upper chest, and extremities and had never been observed on areas covered by the bathing suit. The referring physician, who had previously observed the typical course of the dermatitis, had described its appearance as erythematous-papulo-vesicular which on occasions had progressed to oozing and crusting. Provided there was no further contact with the lake water the eruption would usually subside spontaneously within two weeks and the skin would remain clear until the next episode of lake bathing. The present episode of dermatitis, the second to occur that summer, began rather typically two days previously and was first observed about two hours after bathing in the lake.

Physical examination revealed a well-developed, well-nourished 6-year-old white girl, not appearing acutely or chronically ill. There was a skin eruption limited to the thighs, lower legs, arms, upper anterior chest, neck, ears, and abdomen. The dermatitis was characterized by large irregular patches of erythema of the involved skin with pinhead-sized red papules and slightly larger vesicles. The remainder of the findings on physical examination were all within normal limits.

A survey was made of the lake (Lake Carey, Pa.) and specimens were taken of the lake water, the aquatic vegetation, and vegetation from the shore and along the path to the lake front. Appropriate patch tests of these were applied according to standard procedure to normal and previously uninvolved skin of the back. The following results were noted after removing the patches forty-eight hours after their application: (1) all aquatic

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vegetation (except algae) indigenous to the lake in question, negative; (2) filtered lake water, negative; (3) tap water, negative; (4) lake water sediment, 4+. This patch test resulted in an area of erythematous-papulo-vesicular dermatitis which was an exact duplication of the originally observed dermatitis. The application of ice to the skin for fifteen minutes did not result in any immediate or delayed skin reaction.

A biologic microscopic survey of the sample of lake water revealed the plankton forms found to be few, but one form, a species of *Anabena*, was present in tremendous numbers. The general color of the lake was green from the population of *Anabena*. Associated with it in the sample were small numbers of other blue-greens in the genera *Coelosphaerium*, *Microcystis*, and *Aphanocapsa*. A few individuals of a desmid, *Staurostrum*, and a ubiquitous dinoflagellate, *Ceratium hirundinella*, were present. Of the animal forms present none was in great numbers. The most common was a rotifer, *Notholca longispina*. *Keratella cochlearis* and *Polyarthra trigla* were also present. Of the plankton crustaceans there were a few in the genera *Bosmina*, *Daphnia*, and *Cyclops*.

Results of further patch testing with materials applied for forty-eight hours were as follows: (1) *Anabena* filtered from lake water, 4+; (2) chloroform solution of *Anabena*, 3+; (3) phycocyanin pigment (extracted in crystalline form by ammonium sulfate from a solution of *Anabena* in chloroform water¹), 3+; (4) filtrate from (3), negative; (5) hydroxylamine (liberated by decomposing blue-green algae^{3, 4}) 0.1 per cent aqueous solution, 4+.

Twenty-five normal subjects served as controls in evaluating the results of patch tests. All were tested to identical samples and quantities of the materials that produced positive tests in the patient. All subjects showed negative reactions to *Anabena*, a chloroform water solution of *Anabena*, and phycocyanin. More than one-half of control subjects showed 1+ to 2+ reactions to hydroxylamine 0.1 per cent aqueous solution.

It was later verified that the dermatitis could be produced at will in the child by swimming in the lake water that contained a "bloom" of the blue-green algae whereas other individuals were unaffected under identical conditions.

DISCUSSION

The greenish discoloration of lakes, ponds, and stagnant bodies of water is a familiar sight during the warm summer months even though the cause may not be generally recognized as a "water bloom" due to accumulations of tremendous populations of blue-green algae near the surface. The results of the decay of these algae have been recognized as being of economic importance. Disagreeable tastes and odors are imparted to the drinking water.² Increased bacterial flora result from the decay and this together with the living plants depletes the oxygen requirement for fish and other aquatic animals.³ Poisonous substances such as hydroxylamine produced from the decay of proteins with which blue-green algae are supplied may kill fish³ and may result in the poisoning of cattle and other domestic animals that drink this water.^{3, 4}

Aquatic vegetation may under certain conditions be of etiologic importance in allergic reactions. Heise has reported on the allergenicity of certain blue-green algae, *Oscillatoriaceae*⁵ and *Microcystis*,⁶ in the production of hay fever-like symptoms in swimmers. Though some members of the group *Phycomycetes* are the only predominantly aquatic fungi, other fungi of proved allergenicity, such as *Penicillium*, can be found in flocculent tufts in tanks and swimming pools and *Fusarium* capable of development when submerged is thus occasionally encountered in nature.⁷

Though this is believed to be the first case reported of contact type dermatitis due to cutaneous sensitization to a blue-green alga, *Anabena*, there had

never been any reason to suspect that organic chemical compounds found in aquatic vegetation possessed any special characteristics to exempt them from this potential capacity. A possible reason for this infrequency is probably related to conditions concerned with exposure and contact. The opportunity for body contact with the offending form of aquatic vegetation would not necessarily be the only prerequisite, for contact would have to be of sufficient duration to permit cutaneous absorption and compensate for the dilution factor and the skin washing effect of the water on the allergen. In this regard it is noteworthy that of the sites of involvement of the dermatitis where there had been contact with the *Anabena*, the most marked lesions were found on the upper thighs and behind the ears where it had been observed that the algae had been caught under the edge of the bathing suit and by the hair and held there in prolonged contact with the skin.

The events related in the history, the appearance and distribution of the lesion, the ability to reproduce the dermatitis on exposure to the suspected etiologic agent, and the proof offered by positive patch tests in the patient, with negative reactions obtained on testing 25 normal controls, implicate *Anabena* as the etiologic agent in this instance of contact dermatitis. *Anabena*,² a blue-green alga, is botanically classified in Phylum, Myxophyceae; Suborder, Heterocystineae; Family, Nostocaceae; Genus, *Anabena*, and is found in the form of short, curved or straight chains of cells. Microcystis and Oscillatoriaceae, algae described by Heise^{5, 6} as etiologic allergens in the production of hay fever-like symptoms, are also Myxophyceae but belong to different families from *Anabena*. Our plankton samples were practically pure cultures of *Anabena* containing very few of the algae referred to by Heise,^{5, 6} who makes no mention of finding *Anabena* in his samples.

On further analysis it was found that at least one of the constituents of this alga responsible for this contact dermatitis was phycocyanin. This organic compound of the chemical formula $C_{48}H_{120}O_{18}N_{12}$ is the predominant blue pigment of the blue-green alga² which distinguishes it from other forms of plant life that contain predominantly chlorophyll. The fact that on application to the skin, phycocyanin reproduced the lesion in the patient whereas control patch tests with phycocyanin on normal individuals were negative suggests that its mechanism of action was a contact allergen rather than a primary irritant.

Since hydroxylamine (NH_2OH) is liberated from the decaying proteins of large "water blooms" of blue-green algae in amounts sufficient to be injurious to fish and domestic animals,^{3, 4} the possibility was considered that this too might be important in the production of dermatitis. Accordingly, a patch test of a solution of this material was applied to the skin of the patient and resulted in a positive reaction. However, similar patch tests with a 0.1 per cent aqueous solution of this base resulted in positive reactions on more than one-half of tested normal individuals, thereby indicating its primary irritant action on the skin. Thus, if this chemical compound found in solution in the lake water was a causative factor in the production of dermatitis any mechanism of action as an allergen is not apparent. In this regard it is noteworthy that we are aware of conjunctivitis occurring in swimmers in lakes exhibiting a "water

bloom'' of blue-green algae. Among etiologic possibilities this could arise as an allergic conjunctivitis in atopic individuals sensitive to the forms of algae as reported by Heise⁵,⁶ or sensitivity to other aquatic fungi of proved allergenicity such as *Penicillium* and *Fusarium*, or perhaps to a contact type of ocular sensitivity to *Anabena* similar to the contact skin sensitivity of the patient reported here. However, the possibility of a primary irritant action on the conjunctiva of a significant concentration of hydroxylamine in solution in the lake water must be considered and evaluated.

In evaluating the etiology of the dermatitis of the patient reported here several other possibilities were of necessity considered in the differential diagnosis. These included (1) the aggravating effects of water on a pre- or co-existing dermatitis; (2) a seasonal atopic type dermatitis with climatic etiologic factors; (3) a seasonal skin sensitivity to ultraviolet rays; (4) contact dermatitis due to sensitivity to the materials or dye in the bathing suit; (5) contact dermatitis due to plants found along the lake shore, e.g., poison ivy, pollens, etc.; (6) a physical (cold-temperature) allergy; (7) chigger or other insect bites; (8) ''swimmers' itch'' due to schistosome cercariae. All of the above possibilities were ruled out. There was no history of any pre-existing dermatitis. Skin lesions were not observed if the patient only wore a bathing suit, exposed herself to sunlight, played along the shore among various types of grasses and weeds, and did not go in swimming in the lake. Furthermore, the distribution of the dermatitis was limited to exposed areas of the body not covered by the bathing suit and skin lesions did not appear following swimming in other types of water, bathing in fresh running cold or warm tap water, and skin contact with ice or exposure of the skin to sudden changes of water of different temperature gradients.

''Swimmers' itch,'' a maculopapular-urticarial eruption, as a reaction to the skin penetration of schistosome cercaria, is a well-known entity in the lakes of Michigan, Minnesota, and Wisconsin where it has been extensively studied.⁸ There have been reports of its occurrence in a few other states and in Europe. No one knows of its possible occurrence in Pennsylvania since there have been no reported studies on the problem in this area. In the lake under question, fish have been found to contain larval forms, and birds, such as blue herons and kingfishers (common primary hosts of the adult fluke), are inhabitants of the lake area. To our knowledge a search has never been made for the appropriate intermediate snail host or the miracidial forms. Though the appearance of the skin lesions in our patient could possibly resemble that of schistosome dermatitis, it is not believed that this was the etiologic agent. Cercariae were not seen in microscopic examination of water samples or on the vegetation mentioned previously. However, even more significant, there have been no other instances of dermatitis reported in other bathers swimming in the same water at the same time. Schistosome cercariae when hatched in crops attack the skin of practically all individuals with whom they come in contact.

Dermatoses have been reported from contact with marine animals; hydroids,⁹ coral,¹⁰ and the tentacles of the Portuguese man-of-war.¹¹ Sams¹² has reported on the occurrence of an acute urticarial-papular eruption found among sea

bathers along the southern coast of Florida. The exact etiology has not been determined but it has been speculated that "Seabather's eruption" may be due to some living, microscopic organism, in the nature of nematocysts from some form of coelenterate which is free-floating, or perhaps from some unicellular organism equipped with similar stinging apparatus.¹² However, it is noteworthy that Ayres¹³ has called attention to a patient with this dermatitis who reported that the initial onset of the pruritus occurred in some bathers on the Gulf Coast at the time of the "red tide." This is of particular interest in that salt water algae were found responsible for this discoloration of the sea water.¹⁴ In further considering dermatitis found in swimmers it is noteworthy to point out the existence of another type of fresh and salt water algae, the diatoms. These are unicellular and produce shells of pure opalescent silica ($\text{SiO}_2 - n\text{H}_2\text{O}$).¹⁵ Theoretically contact with sufficient numbers of these algae encased in siliceous shells might prove to be mechanically irritating to the skin. However, our plankton sample did not reveal any diatoms.

The question then arises as to the possibility of these blue-green algae getting into general water supplies and causing allergic dermatitis from contact with water in bath tubs, showers, wash basins, laundries, etc. The latter part of this question can be only a matter of speculation, but the entrance of such algae into the general water supply is a fact and depends largely upon the particular type of reservoir supply involved. *Anabena* are inhabitants of lakes, ponds, and other types of lentic bodies of water and are absent from rivers, creeks, and fast-moving streams. Even when the initial water supply from a river is temporarily stored in an artificial reservoir, conditions are still not conducive to the growth of algae, but when the river water is diverted to a natural lake prior to purification processes then algae find more favorable environmental conditions for their growth. However, when the algae-containing water flows over the top of the reservoir wall and from there into a fast-moving stream, before the algae have traveled 100 yards downstream they disappear from the water content.¹⁶ Within this short distance of transit they are removed by catching on and clinging to rocks, plants, and branches protruding within the stream bed and are subjected to traumatic fragmentation exerted by mechanical factors involved in swift moving currents. Blue-green algae are largely inhabitants of surface water so that if the water supply is obtained through pipes draining from the deeper portions of the reservoir, this water will generally be free of any growth of algae. The usual water purification procedures such as settling and chlorination do not affect the presence of algae and thus these unicellular plants have on occasion been found filtered from tap water. However, whether or not *Anabena* or other blue-green algae in question actually survive conditions of transport from the reservoir and whether they or their chemical products of disintegration are actually found in our own supply of tap water is a matter under current investigation.

SUMMARY

1. A case history is presented in which a child developed an erythematous-papulo-vesicular dermatitis of the exposed portions of the body on swimming in a lake containing a "water bloom" of blue-green algae.

2. The patient was found to have an allergic contact type dermatitis due to cutaneous sensitivity to phycocyanin, the blue pigment found in *Anabena*.

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