Photograph of a Close Lightning Flash

Abstract. *A lightning flash has been photographed striking a European ash tree at a distance of 60 meters. The tree sustained no external physical damage. The probability of obtaining this photograph is estimated to be 10^{-3}, or once in 1000 years.*

In the course of experiments on lightning near Lugano, Switzerland, I photographed an unusually close lightning flash that struck a 7-m European ash tree (*Fraxinus excelsier* L.) only 60 m from my observation point (Figs. 1 and 2). The fact that the discharge did not cause ignition of or any external damage to the tree makes this observation and fortuitous photograph worthy of further comment.

The black and white reproduction of the lightning flash was originally obtained with a Kodak Retina IIIC camera loaded with Kodachrome II Daylight film. The 50-mm lens was set at *f*/5.6, and the shutter was on time exposure. Both Figs. 1 and 2 were taken from the same position, although the orientation of Fig. 2 is slightly different in order to show the entire European ash.

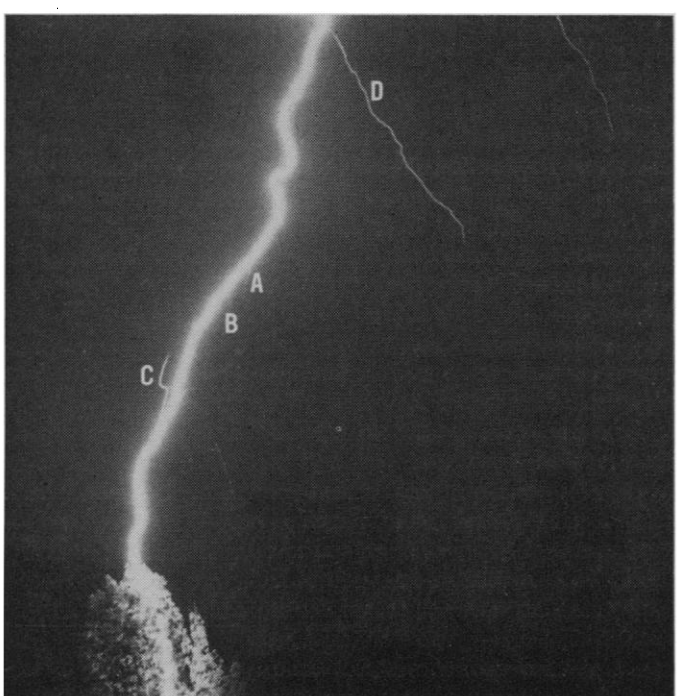
There is no doubt that the lightning flash was striking the tree. The left side of the tree was "back lighted," and the right side of the tree was "front lighted" by the flash (Fig. 1). A close examination of the print reveals that the downward propagating stepped leader, indicated by the direction of branching at *A* and *B* in Fig. 1 (*1*), is met by an upward connecting discharge whose direction of propagation is indicated by the branch at *C*. The junction point occurs between *B* and *C*, approximately 12 m above the tree top.

Since the branches do not appear to be overexposed, measurements of the luminous diameters may be significant. The diameter of the upward branch at *C* is approximately 5 cm, and the diameter of the downward branch at *D* ranges from 3 to 4 cm. As pointed out by Evans and Walker (*2*), measurements of this type will tend to overestimate the correct luminous diameter. For completeness the heavy exposure of the main channel produces an apparent luminous diameter of 0.3 m, but no significance is attached to this number.

The luminous channel followed the main trunk of the tree. Yet an inspection of the tree and the surrounding area revealed no evidence of its having been struck by lightning. Apparently there was no external physical damage to the tree. The splitting of the bark on trees by lightning strikes is well known (*3*), and in a recent study Fuguay *et al.* (*4*) associated the continuing currents of lightning with forest fires. Figure 1 appears to be the first direct proof that lightning can strike trees without causing external damage. It is not known whether the tree was internally damaged. A core sample was not taken. Subsequent observation of the European ash or a core sample should reveal whether the tree sustained internal damage. Unfortunately, the condition of the bark at the time of the strike is unknown. Intense thunderstorms had been in progress for approximately ½ hour, and undoubtedly the bark was wet.

Apparently only one other lightning flash to a close natural object has been photographed and reported in the scientific literature. In 1934, Edwards photographed a lightning flash striking the beach at a distance which he estimated to be 33 m (*5*). Since he apparently did not, or could not, determine the impact point by locating the fulgurite probably formed by the discharge, his estimated distance is only a rough value. The rarity of these photographs is emphasized by the calculation for the probability of obtaining the close photograph reported in this paper.

Berger (*1*) estimated that within 2.5 km of Mount San Salvatore, the frequency of cloud-to-ground lightning flashes at night is 1.1 flashes per year per square kilometer. If we use this



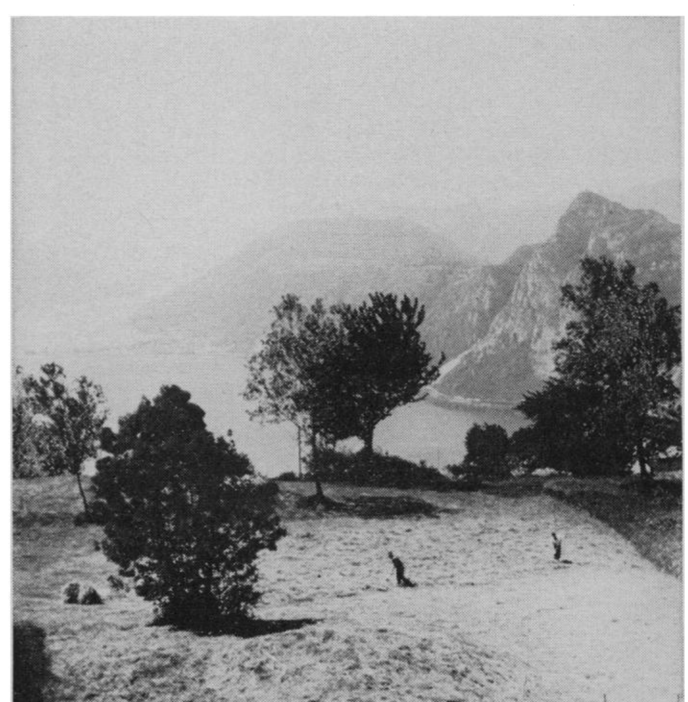


Fig. 1 (left). A lightning flash striking a European ash tree 60 m from the camera. The tree suffered no external damage. Taken 23 August 1967. Fig. 2 (right). The 7-m European ash is left of center in this daytime photograph taken from the same position as the photograph reproduced in Fig. 1.

value for the area in Fig. 2, just 5 km from Mount San Salvatore, we obtain the following probability for a strike 60 m from the observation point within the 35° camera field of view.

$$(1.1 \text{ flashes/yr } 10^6 \text{ m}^2)(\pi\ 60^2 \text{ m}^2/10) = 1.2 \times 10^{-3} \text{ flashes per year}$$

Thus, the probability of obtaining the close lightning photograph in Fig. 1 is about 10^{-3}, or once in 1000 years, at this site.

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References and Notes

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6. I thank Prof. Dr. K. Berger of the Swiss Federal Institute of Technology and High Voltage Research Commission, Zurich, for permission to study lightning near his Mount San Salvatore Laboratory, H. Binz for his interest and assistance, and Drs. J. R. Hastings and C. T. Mason for helpful comments. The photograph of the close lightning flash was obtained while performing lightning research supported by the Westinghouse Research Laboratories, ONR, and FAA.

1 August 1968

Antibodies to Pneumococcal Polysaccharides: Relation between Binding and Electrophoretic Heterogeneity

Abstract. *Antibodies to type III and type VIII pneumococcal polysaccharides were examined with respect to ligand binding and electrophoretic heterogeneity. Both antibodies showed apparent binding homogeneity, although multiple light chain and heavy chain electrophoretic species were demonstrated.*

Antibody heterogeneity is evidenced by the diversity of functional and structural properties in a given antibody population. The former is exemplified by the spectrum of binding energies observed in antibodies to haptens (*1*), and the latter in the electrophoretic heterogeneity of antibody heavy and light chains (*2, 3*).

Although several antibodies bind a hapten homogeneously (*4, 5*), criteria of structural homogeneity have not been applied to these. While it is reasonable to assume that structurally homogeneous antibodies should exhibit binding homogeneity, the reverse need not be true. Thus, a comparison of a criterion of structural homogeneity, the electrophoretic pattern of antibody heavy and light chains with the dispersion of hapten-binding constants, was made.

Rabbit antibodies to type III and type VIII pneumococcal polysaccharides were studied for the following reasons. (i) The polysaccharides are composed of linear repeating subunits and are similar in composition to one another; (ii) antibodies specific for one of these polysaccharides will not precipitate with the other; (iii) antibodies are produced in high titers (*6*); and (iv) labeled oligosaccharide ligands are available.

New Zealand white rabbits, homozygous for allotypes a_1 and b_4, were injected three times weekly with formalinized pneumococci (*7*) of either type III or type VIII. The initial dose of 2×10^9 organisms was increased each week, the final dose of 1.6×10^{10} organisms being given the 3rd week. Rabbits were bled on the 24th day. Precipitation analysis, carried out on selected serums from individual rabbits with purified polysaccharides (*8*), yielded 11.2 mg of precipitable antibody per milliliter of type III serum, and 12.3 mg per milliliter of type VIII serum.

Binding analysis was carried out as described (*5*). The ligands were two hexasaccharides that were derived from type III polysaccharide (*9*) and contained either a terminal reducing glucuronic acid or glucose residue that had been labeled by reduction to the alcohol with tritiated sodium borohydride (*10*), and an octasaccharide that was derived from type VIII polysaccharide (*9*) and contained tritiated deoxyglucuronic acid at its nonreducing end (*5*). The octasaccharide has already been used as a ligand to demonstrate homogeneous binding by horse and rabbit antibodies to type VIII pneumococcal polysaccharide (*5*). The results were analyzed according to the Sips equation (*11*)

$$\log \frac{r}{n-r} = a \log c + a \log K$$

where r is the number of moles of hapten bound per mole of antibody, n is the total number of binding sites (two for antibodies), c is the free hapten concentration, K is the average association constant, and a is the heterogeneity index. When a is 1 there is binding homogeneity; when a is less than 1 there is binding heterogeneity. Both preparations exhibit homogeneity of binding within the limits of experimental error (Fig. 1).

For disc-gel electrophoresis, antibodies were specifically precipitated at equivalence from serum with the appropriate polysaccharide. The precipitates were washed twice with a solution containing $0.15M$ sodium chloride and $0.01M$ sodium phosphate, pH 7.4. In

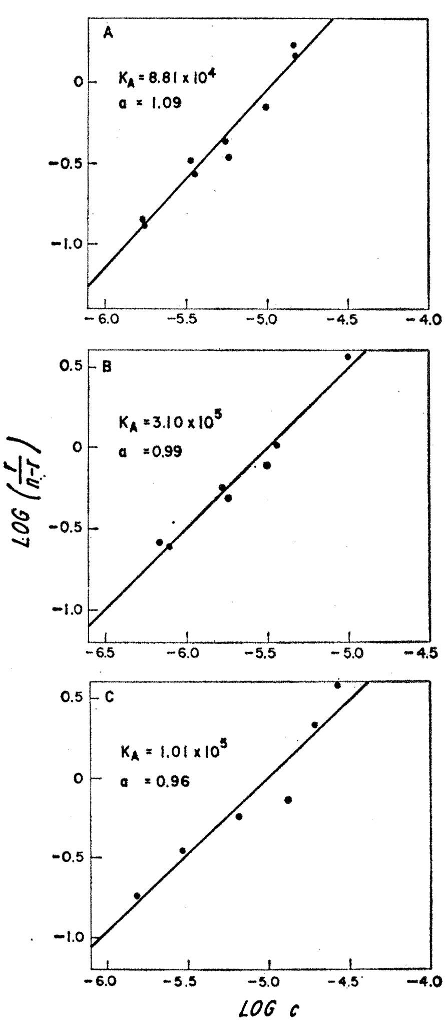

Fig. 1. Sips plots of antibodies to type III and type VIII pneumococcal polysaccharides. The ligands used were tritiated oligosaccharides. (A) Type VIII; (B) type III determined with a ligand containing a nonreducing glucuronic acid end group; (C) type III determined with a ligand containing a nonreducing glucose end group (*9*). The antibody concentration was determined by quantitative precipitation. The data was calculated with the aid of an SDS 940 computer, and the lines were drawn by the method of least squares; K_A is the average association constant in liters per mole.