

in Florida before, though it may not be infrequent when the right combination of weather conditions occurs.

That this phenomenon is comparatively rare is suggested by the fact that it has been considered worth writing up by several different people in the past, some of whom seem to have just encountered it for the first time. None of the papers on the subject is accessible to me at this writing, but I believe some are earlier than the reference cited by Mr. Torrey. Some of the best accounts are by MacDougal.<sup>1</sup>

My last previous experience with "frost flowers," as nearly as I can remember, was nearly 25 years before, in Tuscaloosa County, Alabama. There I found the same sort of crystals, though somewhat differently shaped, exuding from the stems of *Verbesina occidentalis*, on December 5, 1905, a day when there was frost in shady places all day.<sup>2</sup>

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<sup>1</sup> MacDougal, D. T., Science 22: 351-352. 1893. Bot. Gaz. 19: 120-121. 1894. Bot. Gaz. 27: 69-71. 1899. References supplied by Editor.

<sup>2</sup> Harper, R. M. Plant World 9: 1906.

### Additional notes

For the benefit of our readers and to give evidence of the ancient lineage of this question we quote in part herewith the short article in the *Botanical Gazette* (19: 120-121) by Dr. MacDougal referred to by Dr. Harper. It appears from this that the observations of this phenomenon go back over 100 years.

"Frost Plants.—Prof. Lester F. Ward's observations on the 'frost freaks of the dittany,' in the GAZETTE for April, 1893, occasioned much interest, since the phenomena illustrate one form of the movement of water in the plant stem. I have elsewhere<sup>3</sup> made a lengthy review of the literature of the frost plants and take occasion to call attention to the following references which may be accessible to the readers of the GAZETTE. Prof. Ward called my attention to the fact that the frost crystals of *Cunila* and *Helianthemum* were noted by Dr. Darling-ton.<sup>4</sup> The first observation of frost phenomena recorded is that of Stephen Elliot on the stem of *Conyza bifrons* (now *Pluchea bifrons*).<sup>5</sup> Sir John Herschel noticed a similar formation on the

<sup>3</sup> Quarterly Bulletin of the University of Minnesota 2: 30. 1894.

<sup>4</sup> Flora Cestricea p. 350. 1837.

<sup>5</sup> Sketch of the botany of South Carolina and Georgia. p. 322. 1824.



stalks of heliotrope and thistle.<sup>6</sup> Prof. John Leconte made an extended study of the frost crystals of *Pluchea camphorata* and *P. bifrons*, in 1848, along the coast of South Carolina and Georgia.<sup>7</sup> Prillieux in his investigations on freezing in intercellular spaces described the formation of radial ice plates by herbaceous plants.<sup>8</sup> These observations were duplicated by Trecul at the same time, and Sachs has given some matter bearing upon this point.<sup>9</sup> In a recent number of this journal Professor Atkinson gave a note recording the fact that these phenomena were seen by him in 1885-86,<sup>10</sup> while Professor Ward has found that the frost freaks of the dittany are a matter of common information in the locality in which his observations were made."

In these accounts there are two points which seem significant. First, the occurrence of the phenomenon was either in the late fall when it is quite possible that the lower or root portions were not entirely dead; or, if later in the winter, they were reported from the southern states, where there is still a chance that the roots might be living. The second point (if we refer to the *broad* plates) is the remarkable restriction of the phenomenon to only a few kinds of plants. *Cunila*, *Pluchea*, and *Verbesina*, in whatever part of the country they may be, are almost the unanimous choice of the "frost flowers." It is certainly significant that with the thousands of herbaceous plants available these should be the ones selected.

In view of these facts one would think that, as Professor Jennison says, the roots are still alive and functioning (a matter that could be easily verified by microscopical examination) and secondly, that these particular genera, in addition to possessing roots tenacious of their vitality, have stems which are peculiarly brittle, splitting easily in a vertical or length-wise direction, perhaps coincident with some corresponding arrangement of the xylem, so that the water forced up the stem, on reaching the outer portions, freezes and splits the bark, the ice thus formed being pushed out by newer ice layers formed within, essentially as Prof. Jennison explains it. Anatomical and microscopic studies could doubtless clear up the whole question, if indeed, this has not already been done.

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<sup>6</sup> London and Edinburgh Phil. Mag. —: 110. 1833.

<sup>7</sup> Proc. A. A. A. S. 1850.

<sup>8</sup> Compt. Rend. 70: 405. 1870.

<sup>9</sup> Lehrbuch. 2 Aufl. p. 614.

<sup>10</sup> Bot. Gaz. 19: 40. 1894.



Graves, Arthur Harmount. 1931. "Additional notes." *Torrey* 31(4), 113–114.

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