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BULLETIN
OF THE
TORREY BOTANICAL CLUB

OCTOBER, 1904

The chimney-shaped stomata of *Holacantha Emoryi**

CHARLES E. BESSEY

(WITH PLATE 24)

Last December two fine twigs and a cluster of the ripe fruits of the "burro thorn" (*Holacantha Emoryi* Gray) were brought to the Botanical Department of the University of Nebraska by Mrs. Dorothy Bacon, who had collected them in the Salt River valley, near Phoenix, Arizona. They at once attracted attention because of their complete leaflessness, and the thorny nature of their branches. The shrub is said to grow about three meters high, and to form an impenetrable thicket from the ground up. It grows in the desert, where it was first found about fifty years ago by Major W. H. Emory of the United States Army in one of his expeditions. In the "Notes of a Military Reconnaissance from Fort Leavenworth in Missouri, to San Diego in California" (Washington, 1848), a poor drawing of a branch is given on the second plate of Appendix No. 2 (page 157). From an imperfect drawing, probably the original of the one given in the plate, Dr. George Engelmann surmised that it might be some species of *Koeberlinia*, a most excellent guess, as was afterwards shown. In

* Seven years ago (1897) I read a paper on the peculiar stomata of the "burro thorn" (*Holacantha Emoryi* Gray) before the British Association for the Advancement of Science (at Toronto), accompanying it with a number of drawings. I did not print the paper at that time, hoping to add to it in certain details before doing so. I wished to get young twigs and the small leaves which appear only on the young plants (or the young shoots) in order to study the development of these peculiar stomata. As my repeatedly promised material has not yet appeared, it seems best to publish the paper in its original form with the figures which accompanied it.

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1854 Dr. Gray described and named it,* referring it provisionally to the family *Rutaceae*, however suggesting its relationship with *Castala*, a genus of *Simarubaceae*. Good figures of the flowers (which are dioecious) are given by Torrey in *plate 8* of the "Report on the United States and Mexican Boundary Survey, made under the directions of the Secretary of the Interior, by William H. Emory" (Washington, 1858), and the genus is referred to the *Quassia* family, *Simarubaceae*, a disposition which has been confirmed by Bentham & Hooker, Baillon and Engler & Prantl. The best description of the genus is still that originally drawn up by Dr. Gray, only slight additions having since been found necessary. The description written some years ago by Dr. Gray for the "Synoptical Flora," and which has but recently been published (June 10, 1897), while concise, is very clear and entirely satisfactory.

The plant is locally known as "burro thorn," "sacred thorn" "crucifixion thorn" and, according to a note in *Erythea* (March, 1897) by the Mexicans "*Crucifixo*," and "*Corono de Cristo*." It seems, also, that in some way the pseudo-scientific name "*Crucifera spinosa*" has currency among a certain class of people in Arizona, and it is used under the impression that it is a good botanical name.

Although described as a shrub, Professor J. W. Toumey, of the University of Arizona, assures me in a private letter under date of April 25, 1897, that "it reaches the size, and has the habit, of a tree on the plains four or five miles south of Maricopa." A photograph, in my possession, of a plant near Phoenix, shows it to be a much-branched, spreading shrub, with nothing of a tree-like habit. Seedling plants bear small leaves which are described by Dr. Gray as "lanceolate or linear, half an inch (12 mm.) long, thickish, entire or repand, or with a pair of small basal lobes." The mature plant is leafless, nothing more than the smallest scales remaining as vestiges. The branches have become modified into spreading thorns, which are themselves freely branched again.

* *Plantae novae Thurberianae*: The characters of some new genera and species of plants in a collection made by George Thurber, Esq., of the late Mexican Boundary Commission, chiefly in New Mexico and Sonora. *Memoirs American Academy of Arts and Sciences*. II. 5: 297-328. 1854.

All parts of the surfaces of the branches and thorns are of a pea-green color, and minutely roughish to the touch. Upon making a transverse section the epidermis is found to be of unusual thickness, being no less than three, four, or five layers deep. The outer wall is of excessive thickness, and those below, while much thinner, are still very thick. The lateral walls, also, are greatly thickened, so that in a superficial view the cell-cavities are widely separated. Microchemical tests show that the outer epidermal cell-walls are strongly cuticularized, while those below are less so, or not all.

Below the epidermis lies a thick mass of palisade cells (*p*), averaging 110 μ in thickness, abundantly supplied with chlorophyl. These cells are closely packed in about three layers, the cells averaging from three to four times as long as their diameter. In this palisade mass there occur at frequent intervals large crystal-cells, each containing one large clustered crystal (*c*). The tissue beneath the palisade cells is thick walled (*h*), but the walls are not cuticularized, the stain reaction being that characteristic of cellulose.

The stomata are thickly scattered over the surface of the stems and thorns, a careful count showing that they number about seventy-three per square millimeter. Each stoma lies at the bottom of a narrow chimney-shaped cavity (*cy*) which passes entirely through the thickness of the epidermis and is prolonged both above and below it. This stomal channel is thus of greater length than the thickness of the epidermis. The measurements are as follows :

Average thickness of the epidermis.	72 μ .
Average depth of chimney-shaped channel.	123 μ .
Average height of chimney above the surface of the epidermis.	43 μ .
Average depression of the stoma proper below the inner boundary of the epidermis.	40 μ .

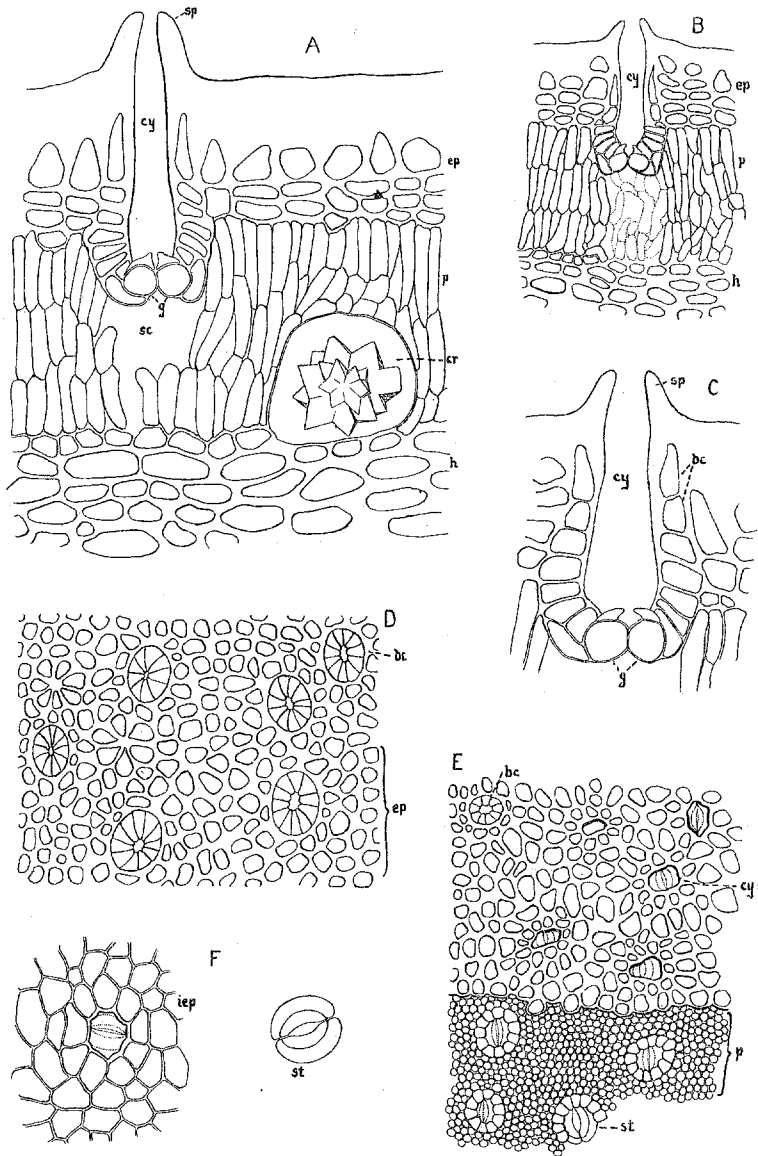
Cross-sections of the stomal cavity (chimney) show that at its outer end it is round or elliptical, and of somewhat smaller diameter than elsewhere. Below the top of the chimney the cavity is round, elliptical, ovate, or irregularly oblong in section, and has an average diameter of about 25 μ (*cy*). The walls of the chimney are composed of about eight vertical rows of cells (*bc*), whose

boundaries may be faintly seen in the stomal papilla in preparations mounted for some time in glycerine. These vertical rows appear to be continuous down to the proper stomal apparatus at the bottom of the chimney. They become much more distinct as they pass inward.

The stomal apparatus at the lower end of the chimney consists of from forty to sixty or more cells which extend down into the mass of palisade tissue about $40\ \mu$, prolonging the chimney about $8\ \mu$. A cross section of this stomal apparatus shows it to be almost perfectly circular, or slightly elliptical, and to consist of from ten to twelve rows of thinner-walled cells than those which form the main portion of the chimney above. At the bottom of this structure is the proper stoma (*st*). It closely resembles the stomata of ordinary plants. The guard-cells are thick and large, and in cross-section are nearly circular. Each is provided with a projecting ridge on its upper surface, and these by approximating form a small "front cavity," the *Vorhof* of the German histologists. The "back cavity" or *Hinterhof* is entirely wanting. The vertical height of the stoma is $27\ \mu$, and its diameter measured in cross-section of the guard-cells is $35\ \mu$. Its diameter measured parallel to the opening very slightly exceeds its transverse diameter.

Beneath the stoma is the usual air-cavity (*sc*) which is lined with irregular and loosely bordered palisade cells. The intercellular spaces in the mass of palisade tissue are very small.

We have in this extraordinary structure a most ingenious device for protecting the plant against loss of water, while at the same time permitting free access of carbon dioxide. The highly translucent epidermis permits photosynthesis while its high degree of cuticularization prevents water-loss. It would be difficult to imagine a structure with a more perfect adaptation to existence under conditions extremely trying to most forms of vegetation.



STOMATA OF HOLACANTHA

Explanation of plate 24

A. Part of a cross-section of a twig: *ep*, epidermis; *p*, palisade tissue; *h*, hypodermal layer with thick, cellulose walls; *cr*, a crystal; *sp*, stomal papilla, in section; *cy*, chimney-like cavity extending from apex of papilla to the stoma at its bottom; *g*, guard-cells of stoma, in cross-section; *sc*, stomal cavity, the so-called air-cavity in the palisade tissue. $\times 240$.

B. Another section similar to A, showing slight variations in the stomal apparatus: the lettering as in A. $\times 165$.

C. Section of a papilla (*sp*), chimney-like cavity (*cy*) and guard-cells (*g*), showing the vertical rows of boundary cells (*bc*). $\times 240$.

D. Section of the epidermis parallel and near to the surface, showing the outer layer of epidermal cells (*ep*), the cavities separated by thick walls; *bc*, the boundary cells of the stomal chimneys in cross-section. $\times 165$.

E. Vertical section of the epidermis parallel to the surface but through or near to its inner layer, showing cross-sections of stomal chimneys (*cy*), and palisade tissue (*p*). At *st* is a stoma, with some of its boundary cells attached. $\times 165$.

F. Transverse section of the epidermis, showing the inner epidermal layer (*iep*) and an isolated stoma (*st*). $\times 165$.