ETNOLOGISKA STUDIER

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GÖTEBORGS ETNOGRAFISKA MUSEUM

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GÖTEBORG

1972

TOBACCO FROM A TIAHUANACOID CULTURE PERIOD

WOLMAR E. BONDESON

Apoteket Älgen, Stockholm

Among the recent finds in the tomb of a medicine-man from a Tiahuanacoid culture in the highlands of Bolivia there was a skin pouch (Gothenburg Ethnographic Museum, Coll. No. 70.19.9a), containing powder and small splinters of apparently vegetable origin. The great interest linked to the nature of this tomb material made it important to try a botanical identification of the fragments (Coll. 70.19.9b).

MACROMORPHOLOGY

A detailed examination shows that the material consists mainly of herbaceous stem fragments. There are some relatively well preserved, transversely cut stem pieces, flattened, up to 18 mm long and 2 to 5 mm wide, longitudinally furrowed and often showing leaf- and branch-scars. The bulk, however, is composed of more or less broken, smaller stem pieces and powder. Particles microscopically identified as leaf-, seed- and capsule-fragments (see below) are few in number and mostly not recognizable as such with the naked eye.

Sparse particles, microscopically not identified, or identified as fragments of grass culms and glumes and of moss gametophytes, are probably unintended admixtures of the kind regularly met with in gathered herbs. Insects and products of their activity constitute a small portion of the material. Damage caused by insects and probably by other animals as well may partly explain the scantiness of soft tissues (leaf mesophyll, endosperm, embryo etc.) in the material.

MICROMORPHOLOGY

Methods

The material was soaked in hot water and kept ready for sectioning in a 4 per cent solution of formaldehyde in water. Hand sections were prepared and boiled in chloral hydrate solution (100 g chloral hydrate dissolved in 40 ml of water) and finally mounted in glycerol.

Stem fragments

The stem fragments have an epidermis, bearing numerous remnants of trichomes and occasionally one or more complete specimens of trichomes. The vascular cylinder shows a secondary structure, characterized by bicollateral arrangement of a continuous xylem cylinder between an external and an internal leptome, each accompanied by strands of fibers.

The epidermis shows a distinct longitudinal cuticular striation, proceeding a short way up the basal part of the trichomes, which otherwise have a smooth cuticle. Stomata appear to be of the anisocytic type and are mostly longitudinally oriented. Two kinds of trichomes were found, both simple and thinwalled: *1.* Conical covering trichomes (Fig. 1 a), about 100 to 500 μ long and up to 80 μ wide at the base, uniseriate, three- to six-celled, bluntly pointed. *2.* Glandular trichomes (Fig. 1 b), about 500 to 600 μ long with a uniseriate, three- to six-celled stalk, up to 90 μ wide at the base, and with an enlarged, multicellular, uni- to biseriate glandular head. In some of the trichomes very minute crystalline bodies were observed; these were interpreted as calcium oxalate crystals, though no characteristic forms were seen.

In slender stem parts the cortex consists of a collenchyma of the angular type with intercellular spaces, while in thicker parts there is a modified, more thinwalled collenchymateous parenchyma. Crystal-sand idioblasts occasionally occur in the cortex, measuring about 50 μ in width and 100 μ in the longitudinal direction of the axis.

In the external leptome crystal-sand idioblasts occur more regularly and in a bigger number; they are usually relatively thin and very extended longitudinally, i.e. about 20 μ wide and 400 μ long. In the internal leptome they are similar but few in number.

In the secondary xylem bordered pitted vessels, measuring about 35 μ radially and 40 μ tangentially, form radial multiples of up to six vessels. The axial wood parenchyma is diffuse. The rays are uniseriate or occasionally biseriate, the individual cells are upright, their height being 60 to 300 μ, their average width radially 30 μ, tangentially 20 μ.

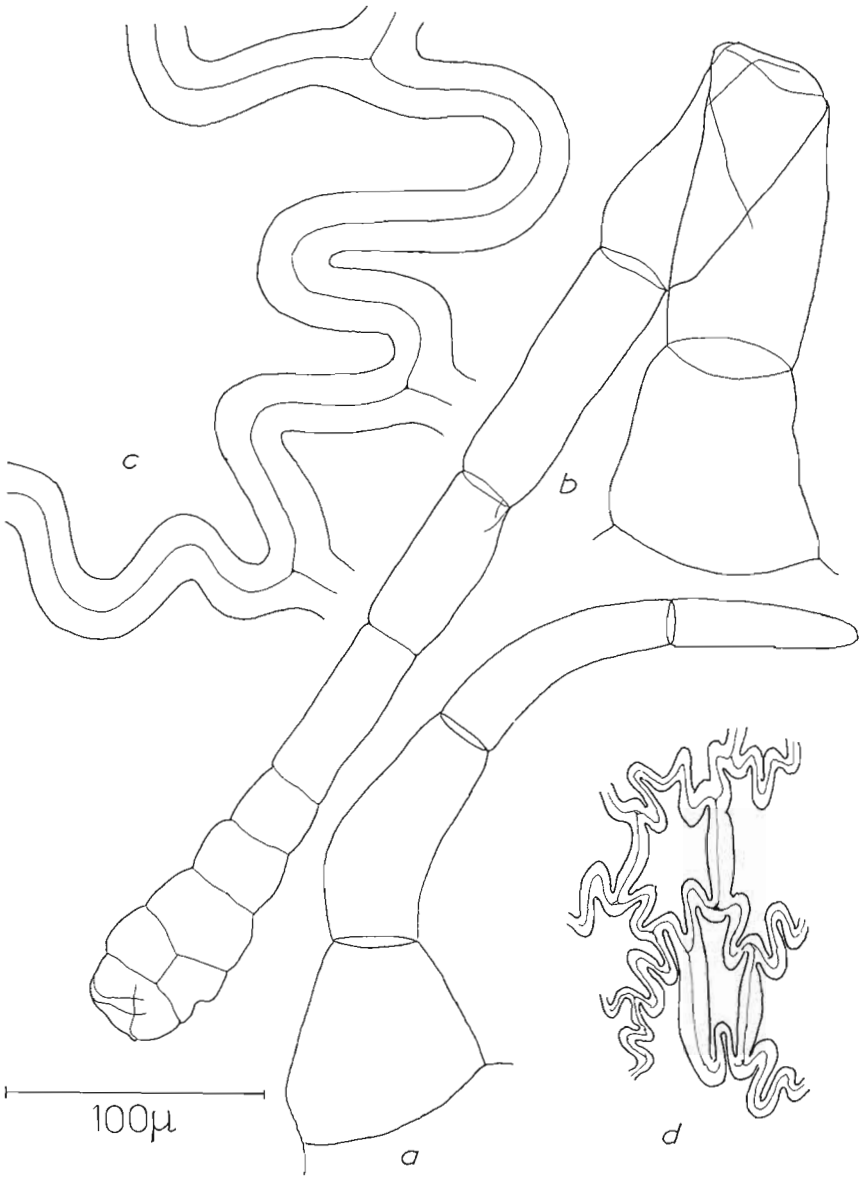

Figure 1: a. Covering trichome; b. Glandular trichome; c. Seed coat epidermis, lateral walls; d. Innermost layer of endocarp.

Leaf fragments

The leaf fragments are few in number, brownish to dark brown, without exception very small.

The epidermis consists of tabular cells having a striated cuticle and slightly sinuous anticlinal walls. The stomata appear to be of the anisocytic type; they are slightly elevated and oriented in different directions; the guard-cell pairs measure about 35 μ in length and 20 μ in width, the circumference being elliptic. On both leaf surfaces there are rounded, up to 70 μ wide scars and some meagre remnants of trichomes, indicating a previous presence of a large number of thin-walled trichomes.

The mesophyll has a single layer of palisade, the anticlinal walls of which are transversely irregularly plicated, obviously due to compression. In the spongy parenchyma are scattered crystal-sand idioblasts, which are round to oblong, 25 to *35* to 65 μ in diameter. There were in one fragment about 60 such idioblasts per mm^2, but their frequency in the leaf is very variable, some fragments actually being devoid of crystal-sand.

Seed fragments

The seed fragments are pieces of the strongly brown coloured outer epidermis of a seed coat.

The cells are low, about 200 to 330 μ wide, the lateral and inner walls being about 15 to 25 μ thick, the outer walls thin and sunken or, usually, tattered. As seen in tangential view most of the cells are nearly equilateral with markedly sinuous walls (Fig. 1c), but in some fragments there are also seen narrower, longish cells, about 30 to 70 μ wide and only faintly sinuous-walled, belonging to the vicinity of the hilum, radiating from there.

Capsule fragments

The capsule fragments are pieces of a pericarp, which is about 100 μ, at the ridges up to 180 μ thick.

The epidermis of the outer side (exocarp) shows longitudinal cuticular striation; the cells are in tangential view tetra- to hexagonal, about 50 μ wide and 90 μ long, arranged longitudinally in rows and elongated in the same direction; they are flattened and have white, 5 to 15 μ thick outer walls and outer parts of the anticlinal walls, which taper inwards; the lumen is filled with a brown mass.

The ground tissue (mesocarp) is composed of a somewhat compressed

parenchyma with moderately thickened walls; an occasional cell is filled with crystal-sand.

An endocarp is formed by the inner epidermis and usually one hypodermal sclereidal layer; in the ridges there are about five such layers. The hypodermal sclereids are about 25 μ high and up to 70 μ wide; they have yellow, 7 to 10 μ thick walls, the periclinal walls being pitted, the anticlinal walls strongly sinuous. Some of these sclereids project outwards in the mesocarp as rounded papillae, about 25 to 30 μ high, 15 to 25 μ wide with about 7 μ thick, unpitted walls, showing very fine stratification. The inner epidermis cells are about 16 μ high and as wide as the hypodermal sclereids; the walls are about 3 to 10 μ thick, the inner periclinal walls being pitted, the anticlinal walls strongly sinuous. In tangential view they exhibit a peculiar tortuous pattern (Fig. 1d), that is very characteristic, especially when seen against the background formed by the hypodermal sclereids with their papillose extensions, appearing in the optical cross-section as pairs of concentric circles.

CONCLUSIONS

The stem fragments, which constitute by far the biggest part of the material, show a number of anatomical characteristics, which taken together indicate a solanaceous origin, e.g. the internal phloem, some features of the secondary wood (radial multiples of small vessels, uniseriate rays of upright cells), the crystal-sand idioblasts and the trichomes, especially the relatively specific glandular trichomes present. The same origin is indicated for the leaf- and seed-fragments. Leaving out of account the scanty foreign matter, that was in the foregoing judged as "unintended admixtures" and considering, that there are no other vegetable constituents proper to the material than the stem-, leaf-, seed- and capsule-fragments described, it seems reasonable to assume the same botanical origin for all these constituents.

Thus, accepting, that the stem fragments come from the same plant as the leaf fragments with their distinctive crystal-sand idioblasts in the spongy parenchyma and without other crystal forms, this combination points to *Nicotiana*. The seed fragments are consistent with the seed coat epidermis of *Nicotiana rustica L.* and some other *Nicotiana* species examined in this respect.

The structures so far discussed correspond to descriptions by others concerning *Nicotiana* (Esau, 1938; Goodspeed 1954; Metcalfe & Chalk 1950;

Netolitzky, 1911, 1926), but I have seen no publication on the anatomical structure of the pericarp in *Nicotiana*. However, a comparative examination undertaken on recent material proved, that the pericarp anatomy of *Nicotiana rustica* and some other *Nicotiana* species is essentially in accord with the characteristics of the capsule fragments, found in the tomb material.

From the above statements it is concluded, that the tomb material consists mainly of stem parts of *Nicotiana* and that it contains furthermore very small quantities of leaf-, seed- and capsule-parts of *Nicotiana*.

It remains to determine the species of *Nicotiana*, that can be accepted as the botanical source of the tomb material.

Referring to the information given by Goodspeed (1954) on trichome features in *Nicotiana* species and using his table 8 ("Types and surface distribution of trichomes in the sixty species of *Nicotiana*", op.cit., p. 132–134), 57 species can be excluded, because their stem surfaces do not bear both types of trichomes found in the tomb material.

The three species, which do bear on their stem surfaces both trichome types of the tomb material, are *Nicotiana forgetiana* Hort. ex Hemsley, *N. sylvestris* Spegaz. & Comes and *N. rustica* L.

N. forgetiana is "known only from Flores da Cunha, near Caxias in northeastern Rio Grande do Sul, Brazil," (Goodspeed, 1954, p. 397). Unfortunately I had no material of this species available for micromorphological examination.

N. sylvestris, a native of Argentina, can be excluded, since two herbarium specimens of this species, both grown from seed (1. Adelante. The Garden of A. & A. Blake, Berkeley, California. N. F. Bracelin 1336.—Göteborgs Universitets Botaniska Museum, Göteborg. 2. Uppsala, seed from Daehnfeldt, O. Hedberg 20.9.1943.—Universitetets Botaniska Museum, Uppsala.) show details in their stem trichome structures, which are not in accord with those of the tomb material. The stem trichomes of *N. sylvestris* are, compared with those of the tomb material, somewhat more thickwalled, straighter and stiffer; the covering trichomes are one- to four-celled, prevailingly two-celled, smaller, their individual cells being shorter; the covering trichomes and especially the stalks of the glandular trichomes show a pronounced cuticular striation.

N. rustica is a "highly polymorphic species, long a cultigen and apparently unknown today in the wild state with the possible exception of a single variety below described . . . Of the many more or less distinct races known today . . . two represent horticultural variants while the third, var. *pavonii*,

is more significant in that although largely ruderal in habitat, it gives the impression when seen in the field of being a native element of the vegetation in portions of the Bolivian, Peruvian and Ecuadorian highlands." (Goodspeed, 1954, p. 353).

The micromorphological description given in this paper is in many ways applicable to *N. rustica* (garden specimens studied for comparison). In the herbarium material examined one specimen of *N. rustica* came out as most like the tomb material though there was no complete consistency. Nevertheless I am inclined to assume, that a race of *Nicotiana rustica* L. was the kind of plant, from which the tomb material once was gathered.

It must be questioned, however, if the kind of plant, from which the tomb material was gathered, actually can be found among the now living races of *Nicotiana* species. Goodspeed in his monography on the genus *Nicotiana* gives an ample and penetrative account on origins, relationships and evolution of its species. In illustration of the doubts expressed above I cite from this work (Goodspeed 1954, p. 375) the following words, which also touch problems, now actualized through the finding of plant parts of *Nicotiana* in a Tiahuanacoid tomb: "Presumably *N. tabacum* was in pre-Columbian use, doubtless often in cultivation, in the West Indies, much of Mexico, Central America, Colombia, Venezuela, the Guianas and Brazil. Spinden (l.c.) apparently would extend this range to Peru, Bolivia, Chile and Argentina since tubes "for taking snuff, presumably of tobacco, occur far and wide" in those areas "on the classical level of Tiahuanaco." There is, however, considerable doubt that the material snuffed in the tubes so familiar in remains of certain ancient civilizations in the Americas was "tobacco" obtained either from early races of *N. tabacum* or from progenitors of the species of *Nicotiana* which today are native in the regions concerned. In other words, there is little evidence that *N. tabacum* was in pre-Columbian use in western North America or in lower South America."

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