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The stinging hair of *Urtica membranacea* Poiret *(Urticaceae)* III. Nuclear structure and DNA content

By

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With 9 Figures

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Summary

Corsi G. 1994. - The stinging hair of *Urtica membranacea* Poiret *(Urticaceae).* III. Nuclear structure and DNA content. – Phyton (Horn, Austria) 33 (2): 221–229, 9 figures. – English with German summary. We have studied, with cytological and cytophotometric methods, the nuclear metabolism of the stinging structure of *Urtica membranacea* Poiret, which appears rather complex owing to the presence of glandular trichomes on the pedestal.

This paper reports data on the nuclear structure and on the DNA content of the stinging hair as well as of the cells of the pedestal and those of the glandular trichomes found on it.

The results suggest that the stinging hair is not a simple container but that it partecipates to the elaboration of the stinging fluid. In addition, we can hypothesize a similar role for the pedestal cells and perhaps even for those of the glandular trichomes.

Zusammenfassung

Corsi G. 1994. Das Brennhaar von *Urtica membranacea* Poiret *(Urticaceae)* III – Kernstruktur und DNA-Gehalt. – Phyton (Horn, Austria) 33 (2): 221–229, 9 Abbildungen. – Englisch mit deutscher Zusammenfassung.

Es wurde der Kernstoffwechsel des Brennhaares von *Urtica membranacea* Poiret cytologisch und cytophotometrisch untersucht. Dieser erscheint wegen des Vorkommens von Drüsenhaaren auf dem Sockel ziemlich kompliziert. Es wird über die Kernstruktur und den DNA-Gehalt des Brennhaares, der Sockelzellen und der

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darauf liegenden Drüsenhaare berichtet. Die Ergebnisse weisen darauf hin, daß das Brennhaar nicht nur einen einfachen Behälter darstellt, sondern auch an der Produktion der Brennflüssigkeit beteiligt ist. Darüberhinaus wird eine ähnliche Rolle für die Sockelzellen und möglicherweise sorgar für die Drüsenhaare angenommen.

1. Introduction

The stinging structures of the *Urticaceae* have been already investigated a good deal, as regards their morphology and toxicology, but rather little regarding their nuclear metabolism and this in spite of the fact that this is of great interest, also for its close relationships with the secretory process.

A fairly recent study on *Urtica dioica* (MATHWIESER & GUTTENBERGER, 1987) is the only one reporting data on the DNA content measured by means of cytophotometry. Nothing is known, in this respect, about *Urtica membranacea*.

This species, under study for many years (CORSI & GARBARI 1990, CORSI & al. 1991, CORSI 1992, CORSI & MAFFEI 1992) appears particularly

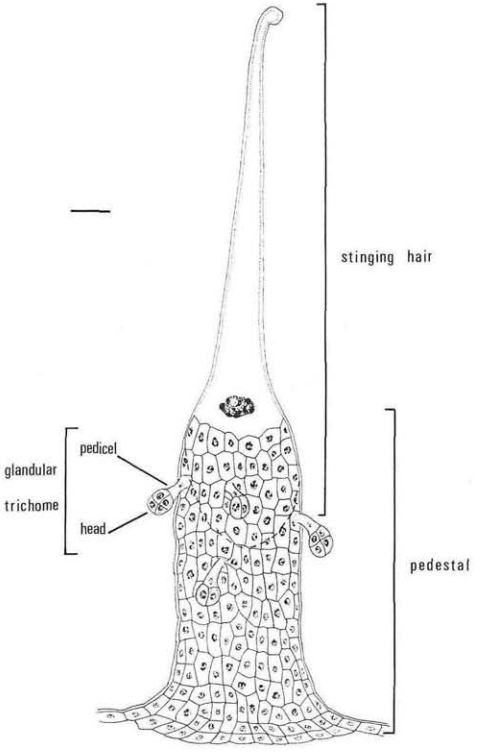


Fig. 1 The stinging structure of *Urtica membranacea*. (bar = 80 μm)

interesting because its stinging structure presents the unique characteristic of having, on the pedestal, some small glandular trichomes with a monocellular pedicel and a secreting head usually composed of four cells (CORSI & GARBARI 1990) (Fig. 1).

The present study regards the nuclear structure and the DNA content (measured by microdensitometry) of the stinging hair, of the cells of the pedestal and of the glandular trichomes found on the pedestal itself. The aim is to make a contribution to the knowledge of the differentiation of the stinging hair, in relation to the type and mode of the secretion, but also to elucidate the functional role of the glandular trichomes [which, on the basis of specific histochemical tests, have been found to be closely involved with secretion and/or the storing of numerous compounds also with a precise biological activity (CORSI 1992)] and of the pedestal cells [for which we have a hypothesis as regards their participation in the synthesis of the irritating fluid (RAUTER 1872, HABERLANDT 1886, EMMELIN & FELDBERG 1947) and in which substances of great interest have beeen already detected histochemically (CORSI 1992)].

2. Material and Methods

The material for the present study comes from a population of *Urtica membranacea* which grows wild in the Botanic Garden of the University of Pisa and which has been used in previous studies (CORSI & GARBARI 1990, CORSI & al. 1991, CORSI & MAFFEI 1992, CORSI 1992). Exsiccata in PI.

Epidermic strips of leaf and leaf stalk and isolated stinging hairs have been fixed in 1:3 acetic acid-ethanol for 40 min. and then hydrolyzed in 1N HCl for 8 min. at 60° C, stained in Feulgen reagent for 90 min., dehydrated and mounted either in Canada Balsam or in DPX mountant for histology (Fluka Chemika).

As regards microdensitometry, we have measured the stinging hair nuclei as well as the nuclei of the glandular trichomes (keeping separated those of the pedicel from those of the secreting head) present on the pedestal and the nuclei of the pedestal itself. We have measured also the ordinary epidermis cells nuclei.

The amount of DNA per nucleus was measured with a Leitz MPV3 Integrating Microdensitometer, at 565 μm. The DNA contents, in arbitrary units, were transformed to C values by taking the mean DNA content of *U. membranacea* root apex prophases (= 4C) as a standard. Fifty prophases were measured.

3. Results

Nuclear structure

The nucleus of the stinging hair is of a considerable size and contains vacuoles. It is also very variable morphologically: rarely it contains little condensed chromatin, of a no particularly active look (Fig. 2). More often though, the nucleus appears lobed, with deep invaginations containing portions of cytoplasm (Fig. 3) or, more often still, presents chromatin showing structures similar to DNA "puffs" (Fig. 4) which may indicate the

occurrence of extra DNA synthesis. There is no sign of polyteny. Sometimes masses of chromatin looking degenerated are found at a distance from the nucleus towards the apex of the hair (Fig. 5).

The nuclei of the cells of the pedestal look as though they have an active metabolism: their chromatin is readily stained and rather enlarged chromocentres are present (Fig. 6).

In the glandular trichomes, the nucleus of the cell of the pedicel appears practically as it were an ordinary epidermal nucleus. The nuclei of the secretory head, even if they appear to be a little larger and possess apparently enough active chromatin do not seem to have a particularly intense metabolic activity (Fig. 7).

Overall it is possible to make some correlations between the nuclear activity of the stinging hair and that of the glandular trichomes: often, when the nucleus of the stinging hair looks particularly active, the glandular trichomes nuclei appear practically degenerated (Fig. 8) or even not visible any more.

Microdensitometric Analysis

The results are indicated in Fig. 9. The epidermal cells, have 4C DNA-content.

It appears evident that the stinging hair is highly polyploid: in fact it can reach DNA value up to 340C, with an average of 140C. Fig. 9 shows that the DNA distribution is almost continuous and that the values are very variable.

The nuclei of the cells of the pedestal present DNA values between 8C and 12C and they are very uniform as it is clear from the histogram of Fig. 9.

Regarding the glandular trichomes on the pedestal, the cell of the pedicel has values around 4C, the same as the epidermal cells. Those of the secreting head have a little higher DNA values which are up to 16C in some rare case, but, above all, these cells have rather variable but continuous values as can be seen in Fig. 9. Different cells in the same secreting head can have different DNA content.

Fig. 2 A nucleus of the stinging hair showing chromatin with very little activity. (bar = 10 μm)

Fig. 3 A lobed nucleus of the stinging hair showing deep invaginations surrounding bits of cytoplasm. (bar = 10 μm)

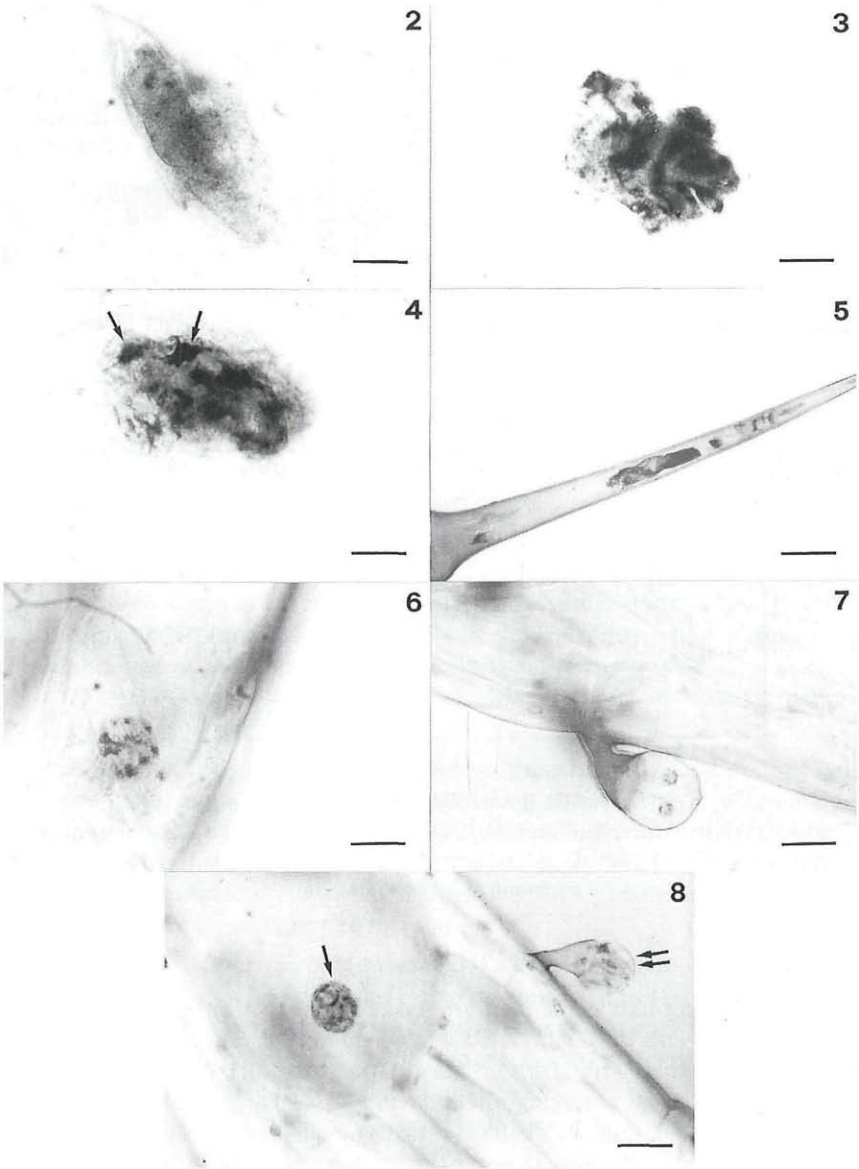
Fig. 4 A nucleus of the stinging hair with highly active chromatin. Some structures looking like DNA "puffs" are visible (arrows). (bar = 10 μm)

Fig. 5 Degenerated chromatin towards the apex of the stinging hair. (bar = 100 μm)

Fig. 6 A nucleus of a cell of the pedestal with enlarged chromocentres. (bar = 10 μm)

Fig. 7 A glandular trichome on the pedestal. (bar=20 μm)

Fig. 8 A nucleus of the stinging hair with active chromatin (single arrow) and glandular trichome with degenerated nuclei (double arrow). (bar=30 μm)



Figs. 2–8

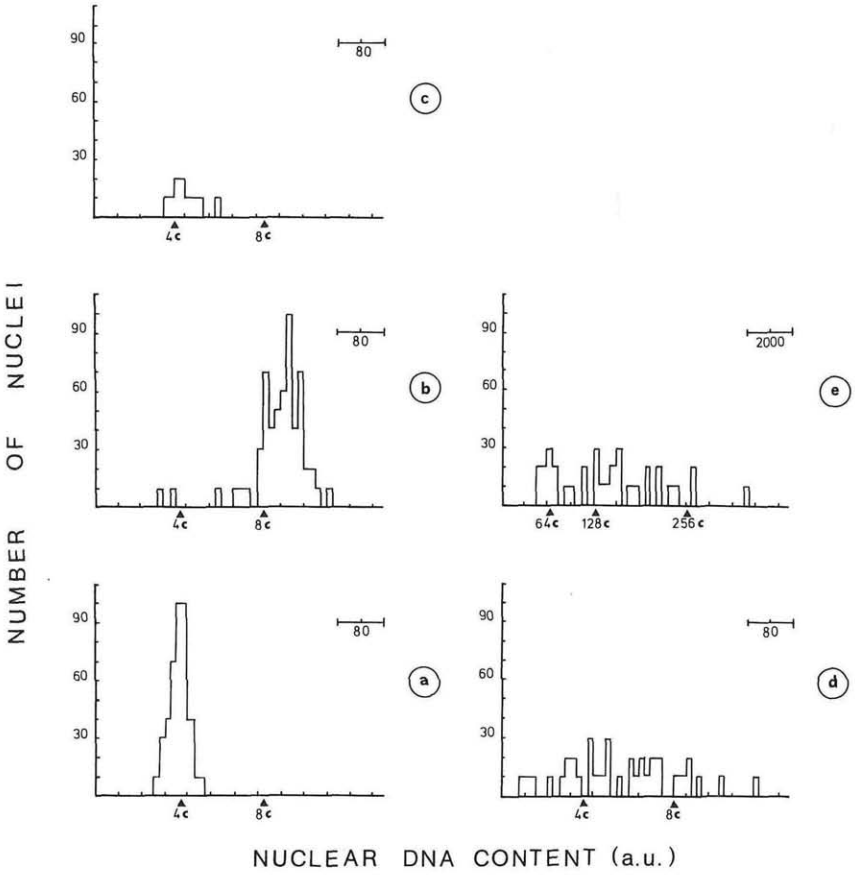


Fig. 9 The relative amount of nuclear DNA (in arbitrary units) in a) foliar epidermis; b) pedestal cells; c) pedicel of the glandular trichome; d) head of the glandular trichome and e) stinging hair.

4. Discussion

The stinging hair of *U. membranacea* appears to be highly polyploid but the level seems to remain a little lower than that reported for the same structure in *U. dioica* by MATHWIESER & GUTTENBERGER 1987. Polyploidy is in any case a very common phenomenon in cells with high metabolic activity whether glandular cells or those of various secreting trichomes (D'AMATO 1952, TSCHERMAK-WOESS & HASITSCHKA 1953, 1954, TURALA 1960, 1962, LANDRÉ 1976 a, b, CORSI & CORSI 1988, CORSI & PAGNI 1991).

The fact that the stinging hair has been found to be highly polyploid indicates that it possesses an extremely high metabolism. But there is more: often the stinging hair nucleus is lobed, the same characteristic has been

reported in *U. dioica* (MATHWIESER & GUTTENBERGER 1987), with deep invaginations that surround parts of the cytoplasm with vacuoles and including, probably, also mitochondria and endoplasmic reticulum.

In certain nectaries and hydathodes, this character has been seen to coincide with the moment of secretion (PERRIN & ZANDONELLA 1971) and is, in any case, a sign of higher cellular activity (GOLDSTEIN 1928, SCHNEPF & NAGL 1970, etc.).

The presence of DNA "puffs"-like structures in the chromatin and the very variable and almost continuous DNA-values, even if this can be partially explained with a late replication of the heterochromatic portion of the genoma, allow us to hypothesize the occurrence of an extra synthesis of DNA co-existing with endopolyploidy. Almost continuous DNA-values have been reported also for the nucleus of the stinging hairs of *U. dioica* (MATHWIESER & GUTTENBERGER 1987). All these data suggest that we can surely exclude that, in *U. membranacea,* the stinging hair is not directly involved with the secretive phenomenon so much so that we are compelled to consider that at least some of the substances, detected with histochemical means, are indeed formed there.

This does not signify that, for example, the cells of the pedestal don't collaborate, in some way that has yet to be discovered, to the secretion itself. The presence in these of endopolyploidy and probably also of extra-synthesis of DNA (on the basis of enlarged chromocentres) which indicate a rather active nuclear metabolism gives us, together with the morphological data (CORSI & GARBARI 1990) and histochemical data (CORSI 1992) a further indication in this sense.

As regards the glandular trichomes on the pedestal, their pedicel cell has a nuclear metabolism of the "epidermal" type. That is behaving in accordance with the various data reported in the literature (cfr. LANDRÉ 1976 a, b, CORSI & CORSI 1988) and indicates that this cell has only a structural purpose and is not involved in secretive processes as sometimes happens (cfr. CORSI & PAGNI 1990).

The cells of the secreting head show a nuclear metabolism which is surely more active in line with their involvement with the secretive activity. The low level of polyploidy proper of these cells is not rare in such type of structure (PETERSON & VERMEER 1984, CORSI & PAGNI 1991).

The continuous distribution of their DNA values appears to be rather common (cfr. LANDRÉ 1976b, CORSI & CORSI 1988, CORSI & PAGNI 1991) and tents to show the co-existence of endopolyploidy with the partial replication of the genoma. This last phenomenon is most probably linked with the moment of secretion (LANDRÉ 1976b).

The fact of having often found that, when the nucleus of the stinging hair presents highly active looking chromatin, the nuclei of the glandular

trichomes are practically degenerated, make us think that the metabolic activity of these precedes in some way that of the stinging hair itself.

Even if it is possible to think of other roles for them (cfr. CORSI & GARBARI 1990, CORSI 1992) the glandular trichomes may well be involved in the production of some precursors and/or some substances which will be part of the stinging fluid. Some histochemical data suggest something of this kind (cfr. CORSI 1992).

The results of the present research on the nuclear metabolism are in line with the preceding studies (cfr. CORSI & GARBARI 1990, CORSI 1992) and indicate once more the complexity of the stinging structure of *U. membranacea*. We hope that further research, under way, will allow us to establish links between this complex nuclear metabolism and the manner and timing of the secretive process.

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