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Urtica membranacea Pearl Glands. II. – Some Aspects of Nuclear Metabolism

By

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with 5 Figures

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Summary

Corsi G. 1994. *Urtica membranacea* pearl glands. II. – Some aspects of nuclear metabolism. – Phyton (Horn, Austria) 34 (1): 95–102, with 5 figures. – English with German Summary.

By cytological and microdensitometric methods some aspects of the nuclear metabolism of the pearl glands of *U. membranacea* Poir. and of the glandular trichomes associated with them have been studied. The results seem to agree with the previously made hypothesis that the pearl glands are in some way connected with water metabolism and that the associated glandular trichomes are implicated in the regulation of the interrelation between the plant and some particular animals.

The functional meaning of the association between pearl gland and glandular trichome is not yet clear. Studies regarding this problem are in progress.

Zusammenfassung

Corsi G. 1994. *Urtica membranacea* Perldrüsen. II. – Aspekte des Kernstoffwechsels. – Phyton (Horn, Austria) 34 (1): 95–102, 5 Abbildungen. – Englisch mit deutscher Zusammenfassung.

Einige Aspekte des Kernstoffwechsels der Perldrüsen von *U. membranacea* Poir. und mit ihnen in Verbindung stehenden Drüsenhaaren wurden mit cytologischen und mikrodensidometrischen Methoden untersucht. Die Ergebnisse unterstützen die früher aufgestellte Hypothese, daß die Perldrüsen in gewisser Weise mit dem Wasserhaushalt in Beziehung stehen und daß die Drüsenhaare in die Regulation von Wechselbeziehungen zwischen der Pflanze und einigen Tieren eingebunden sind.

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Die funktionelle Bedeutung der Assoziation von Perldrüsen und Drüsenhaaren ist noch nicht klar. Diesbezügliche Untersuchungen sind im Gange.

Introduction

The pearl glands of *Urtica membranacea* Poir. are unicellular and have the peculiar characteristic of forming themselves always in correspondence with a pre-existing pluricellular glandular trichome by an enlargement of the basal cell (CORSI & al. 1991, CORSI & MAFFEI 1992). The result is a composed secreting structure brought about by the association of the glandular trichome with the pearl gland (fig. 1) both with a rich and rather complex secretive model (CORSI & al. 1991, CORSI & MAFFEI 1992). Even if some hypotheses have been made (CORSI & MAFFEI 1992), the functional role of the pearl glands and of the glandular trichomes is not at all clear and so is as concerns their association.

We have started the present research in order to contribute to the knowledge of these problems. The research itself concerns the nuclear structure and the DNA content (measured by microdensitometry) of the pearl glands and of the glandular trichomes. This should yield data of great importance, so far unknown, to elucidate the model of differentiation, always correlated to the type and role of secretion, of these structures.

In the relevant literature there exists only one fairly recent information on the amount of DNA in the pearl glands of *Urtica dioica* (MATHWIESER & GUTTENBERGER 1987).

Material and Methods

The material for the present study (vouchers in PI) originates from a spontaneous population of *U. membranacea* growing in the ground of the Botanic Garden of the University of Pisa (Italy). This population has been used previously for various other works on the subject (CORSI & GARBARI 1990, CORSI & al. 1991, CORSI & MAFFEI 1992, CORSI 1992). For the present research we have used epidermal strips of leaves and of leaf stalks and isolated pearl glands together with their associated glandular trichomes. The material has been fixed in 1 : 3 acetic acid-alcohol at 20° for 40 min.,

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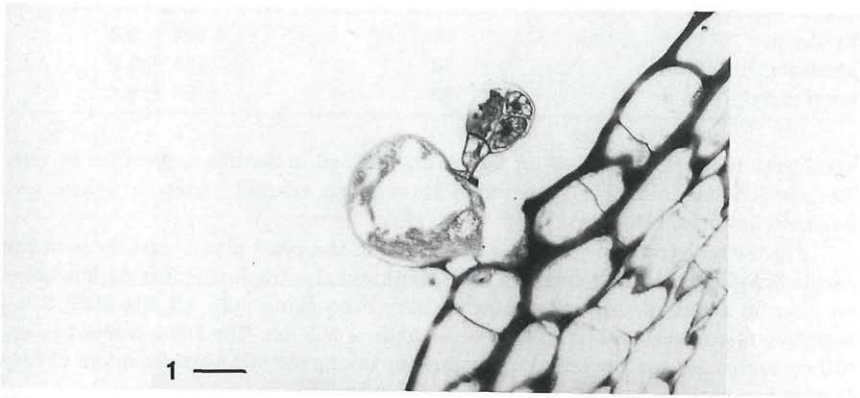
Fig. 1. Pearl gland (unicellular) with the associated glandular trichome (pluricellular). (Toluidine blue) (bar = 33 μm).

Fig. 2. The pearl gland is beginning to be formed from the basal cell of the glandular trichome (arrow). The nucleus of the basal cell (double arrow) is starting to increase in size. (Feulgen) (bar = 18 μm).

Fig. 3. Paired polytene chromosomes in a pearl gland. Close to the pearl gland an epidermic nucleus (arrow) (Feulgen) (bar = 15 μm).

Fig. 4. Unpaired polytene chromosomes in a pearl gland. (Feulgen) (bar = 22 μm).

Fig. 5. Nuclei with dispersed and little stainable chromatin in two neighbouring pearl glands. The associated glandular trichome (arrow) appears degenerated. (Feulgen) (bar = 33 μm).



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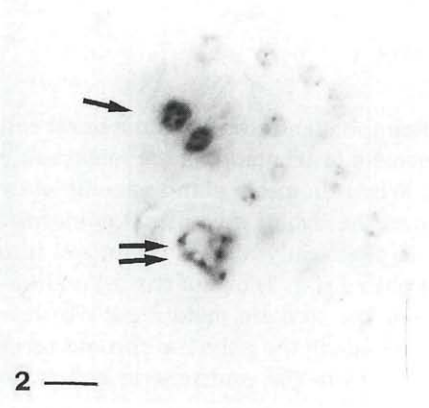

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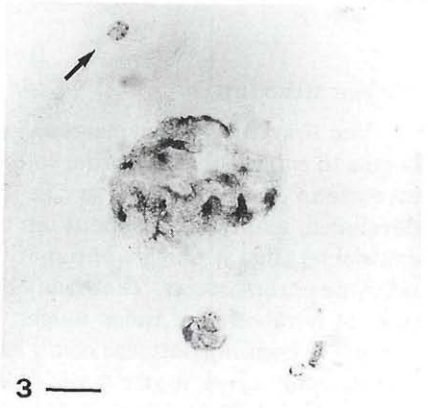

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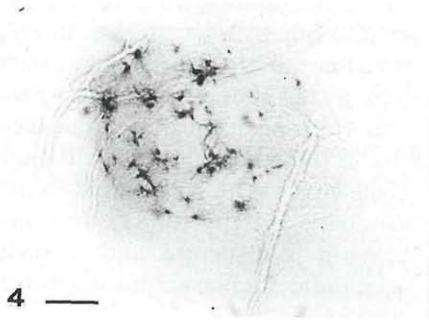

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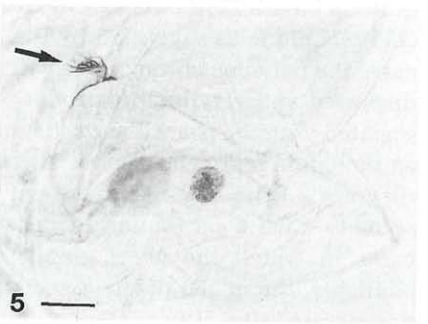

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Table 1

DNA content (arbitrary units; means + standard deviation)

Type of cell	Number of nuclei	DNA content
Epidermis	40	162 ± 5.2
glandular hair head	20	181 ± 1.8
pearl gland	45	8468 ± 8.6

hydrolized in 1N HCl at 60° C for 8 min. and stained in Schiff's reagent for 90 min. The stained material, was dehydrated through an ethanol series to xylene and mounted in Canada Balsam.

For microdensitometry, besides the nuclei of the pearl glands and those of the associated glandular trichomes, we have measured also the leaf epidermal nuclei as an internal standard. All measurements have been made with a Leitz MPV 3 Integrating Microdensitometer at the wavelength of 565 nm. The DNA content in arbitrary units has been converted to C values by taking the mean DNA content of fifty *U. membranacea* root-tips prophases (= 4C) as standard.

Results

Nuclear structure

The first thing to be observed, when the glandular trichome basal cell begins to enlarge itself in order to become a pearl gland, is the remarkable increase in size of its nucleus (fig. 2). When the pearl gland is completely developed, its nucleus is about ten times the size of the normal epidermal cell nuclei (fig. 3) and its chromatin is practically always organized into polytene chromosomes. These may be paired (fig. 3) or not (fig. 4) and appear to be about ten times longer than the somatic metaphase chromosomes. No banding patterns could be seen along the polytene chromosomes and in many cases it is not possible to locate the centromeric region. In order to have a better view of the polytene chromosomes, we have used the cold technique as suggested by BARLOW 1975 but with no success. In rare cases the polytene chromosomes are not visible and the chromatin appears dispersed and very little stainable (fig. 5). In the glandular trichomes associated with the pearl glands, the nucleus of the pedicel has the same look as the epidermal cells nuclei. The nuclei of the secreting head, although they are a little larger and present a somewhat active chromatin, do not seem to have a particularly intense metabolic activity (fig. 2). In those cases in which the pearl glands chromatin is dispersed and scarcely stainable, the nuclei of the associated glandular trichome appear already degenerated (fig. 5).

Microdensitometric analysis

The results are illustrated in fig. 6 and table I. The nuclei of the epidermal cells, used as an internal standard, have been found to have usually

a DNA value of 4C. The pearl glands have highly polyploid nuclei with DNA values approaching 900C. In fig. 6 we can see also that the distribution of their DNA is almost continuous and that its values are very variable. The low values are not necessarily those of the small developing pearl glands.

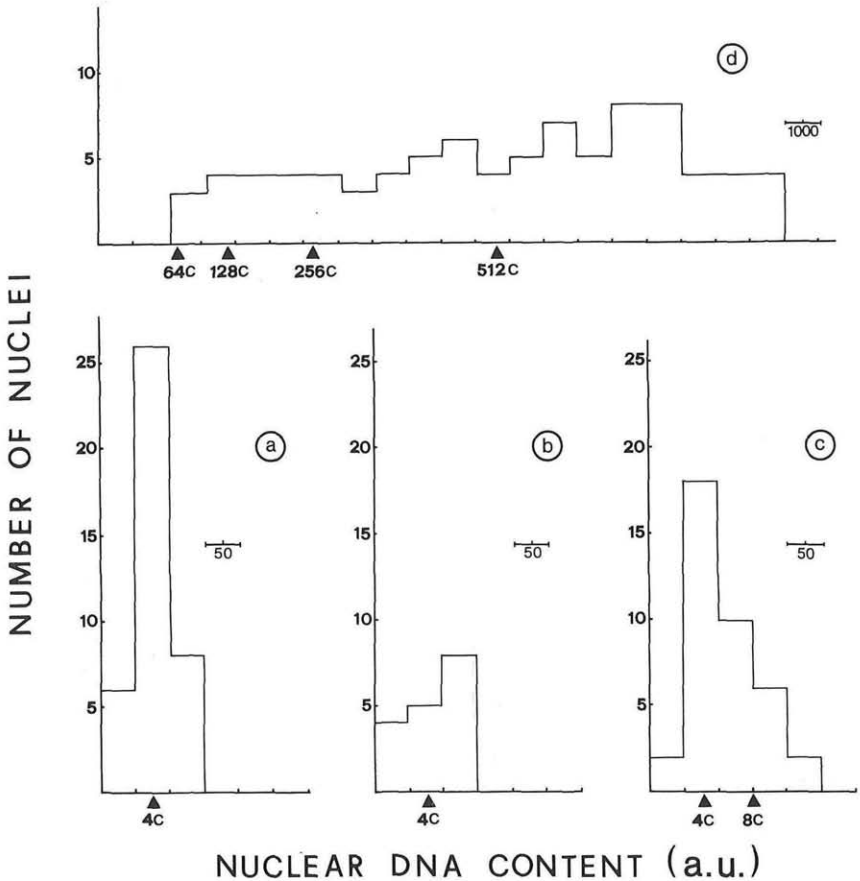

Fig. 6. The relative amount of nuclear DNA (arbitrary units) in:
a) foliar epidermis
b) pedicel of the glandular trichome
c) head of the glandular trichome
d) pearl gland
The 4C value is based on measurements of fifty early root-tip prophases.

In the glandular trichomes associated with the pearl glands, the pedicel nuclei have approximately the same DNA values as those of the epidermal cells, i. e. 4C. The cells of the secreting head have DNA values generally higher, reaching even 16C in some rare cases. In such cells, the DNA

values of the nuclei are in any case very variable and almost continuous in distribution. The various cells forming the same secreting head may have different DNA values.

Discussion

High levels of endo-polyploidy are generally found in such structures as hydathodes, nectaries and salt glands which are active in the elimination of water and ions which is a process requiring a considerable amount of energy (FAHN 1979, UPHOF & HUMMEL 1962). The particularly high levels of polyploidy found in the nuclei of the pearl glands of *U. membranacea* lead us to think that they, as previously hypothesized (CORSI & MAFFEI 1992) may have the same functional role.

Polyteny in plants may be induced by high levels of auxins (NAGL 1981). The presence of polyteny in the pearl glands of *U. membranacea* is perhaps to be considered in relation to the high levels of serotonine found in such structures (CORSI & MAFFEI 1992) since, according to GROSSE 1982, serotonine has an auxin-like activity. The rare cases in which the polytene chromosomes are not present and the chromatin appears dispersed and weakly stainable, may be examples of pearl glands at the end of their vital cycle (they are in fact ephemeral structures). In such cases also the glandular trichome appears to be no more functional.

Polyteny is usually associated with differential DNA replication (D'AMATO 1989). The very variable and almost continuous DNA values we have found, even if they can be partially considered as the expression of a late synthesis of the heterochromatic fraction, allow us to hypothesize a similar situation in the pearl glands of *U. membranacea*. As regards the analysed aspects of nuclear metabolism, we have seen that the glandular trichomes associated with the pearl glands are similar to those of the same morphological type already found in several *Angiospermae* (LANDRÈ 1976, PETERSON & VERMEER 1984, CORSI & CORSI 1988 etc.) and identical to those associated with the stinging hairs and to those present on the epidermis of *U. membranacea* (CORSI 1992 and unpublished observations). Such identity has been established already from the morphological and the histochemical point of view (CORSI & MAFFEI 1992 and unpublished observations).

At this point we are pretty sure that, in *U. membranacea,* the same glandular trichome can be found either isolated on the epidermis or associated with the stinging hair or associated with the pearl gland. It is reasonable to assume that, in these three different situations, the functional role of the glandular trichome may be the same.

Among the various hypotheses previously made (CORSI & GARBARI 1990, CORSI & MAFFEI 1992), the one which today seems the most probable is that the glandular trichomes, by way of their secretion, may be involved in some kind of interrelation with particular animals such as insects. What

is not at all clear is the functional meaning of the pearl gland/glandular trichome complex as it is that of the stinging hair/glandular trichome. The problem is rather difficult and other studies, including physiological analysis already in progress, may be needed to arrive at a solution.

We conclude also that the pearl glands of *U. membranacea* – which have been found to be rather different, from various points of view, from these of *U. dioica* even if they look very similar morphologically (CORSI & MAFFEI 1992) – are also different as regards the aspects of the nuclear metabolism we have considered. In fact there are polytene chromosomes and very high DNA values in *U. membranacea*; lobate and vacuolated nuclei presenting small regions of condensed heterochromatin (MATHWIESER & GUTTENBERGER 1987 and personal observations) and lower DNA values in *U. dioica* (MATHWIESER & GUTTENBERGER 1987). As already pointed out (CORSI & MAFFEI 1992) it is very probable that, under the term of "pearl glands", could be named structures which are, in part or even entirely, different also in corresponding taxa.

Further studies, it is hoped, will make clear whether the differences between the pearl glands of *U. membranacea* and *U. dioica* can have some correlation with the life form of the two species – annual therophyte the first and perennial chamaephyte the second – or can be linked to quite different types of problems.

Acknowledgements

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Recensio

Ellenberg H., Weber H. E., Düll R., Wirth V., Werner W. & Paulissen D. 1991. Zeigerwerte von Pflanzen in Mitteleuropa. – Scripta geobotanica 18. – Gr. 8°, 248 Seiten, 36 Abbildungen; kart. – Verlag Erich Goltze, D-37073. Göttingen, Postfach 1944. – DM 32,–. – ISBN 3-88452-518-2.

Die 2. Auflage dieser sehr bekannten Zeigerwertliste aus 1979 wurde in Phyton 20:180-181 besprochen. Die nun vorliegende Neubearbeitung ist so stark verändert, daß sie mit Recht nicht als dritte Auflage deklariert, sondern als neues Werk mit leicht verändertem Titel herausgebracht worden ist. Die Tabelle der Zeigerwerte der Gefäßpflanzen ist zwar, abgesehen von kleinen Verbesserungen bei einzelnen Arten und der Aufnahme zusätzlicher Arten, in den Grundzügen gleich geblieben; aber unter dem ökologischen Verhalten kam eine Rubrik für die Salzzahl (neunstufig) dazu, die Angaben über die morphologisch-anatomische Struktur unter Lebensform der 2. Auflage wurden dagegen weggelassen. Eine ganz wesentliche Neuerung ist der Versuch, Häufigkeit in verschiedenen Formen anzugeben [Meßtischblattfrequenz (im Atlas Haeupler & Schönfelder), Dominanz (im Gelände) und Änderungstendenz; alle drei neunstufig], denen noch der Gefährdungsgrad (fünfstufig) hinzugefügt wird. Im übrigen ist das Werk ± ganz neu. Völlig neu hinzugekommen sind die Zeigerwerttabellen für *Rubus*-Kleinarten (diese hätte man trotz des Fehlens der Häufigkeitszahlen auch in die Haupttabelle einschließen können), für Moose und für Flechten, wobei die Tabelle für die Moose im Vergleich zur Gefäßpflanzentabelle am stärksten vereinfacht ist. Aber auch in der allgemeinen Einleitung ist kein Stein auf den anderen geblieben, insbesonders sei auf den umfangreichen Abschnitt „Gültigkeitsbereiche und Problematik der ökologischen Zeigerwerte" und auf die völlig veränderten und erweiterten „Anwendungs- und Darstellungsbeispiele" hingewiesen. Schließlich wird ein neues Programm für PCs zur Manipulation der Zeigerwert-Daten vorgestellt. Langjährige Erfahrung im Arbeiten mit Zeigerwerten ist in diesem Band eingeflossen.

H. Teppner