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Nutlet ornamentation in selected *Salvia* L. species *(Lamiaceae)*

Abstract

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Micromorphological characters of the nutlet surface has been analysed in 13 species of *Salvia* belonging to the subgenera *Salvia*, *Sclarea* (Moench.) Benth., *Calosphace* Benth., *Leonia* (Llav. & Lex.) Benth. and *Covola* (Medik.) Briq. by scanning electron microscopy. The results suggest that nutlet sculpturing is useful as a taxonomic character for subgeneric delimitation.

Introduction

Salvia is a large and polymorphic genus of the Lamiaceae comprising about 900 species with an almost cosmopolitan distribution (Standley & Williams 1973, Hedge 1992, Rodrigues-Hahn & al. 1992). It has been extensively studied from the taxonomic angle (Bentham 1876, Briquet 1897, Pobedimova 1954, Hedge 1968, 1972, 1978).

Some *Salvia* species are used as medicinal plants in folk medicine, as well as garden ornamentals. Many of these species are aromatic, rich in essential oils, and of future potential economic interest.

Patudin & al. (1976) analysed the fatty acid composition of nutlet lipids and Barberán (1986) the flavonoid compounds for taxonomic purposes. The systematic value of nutlet characters has been studied in selected *Lamiaceae* genera (Wojciechowska 1961, 1966, 1972, Doroszenko 1986). It has been demonstrated that the nutlet sculpturing has value for the delimitation of the closely related genera *Micromeria, Satureja, Calamintha, Clinopodium, Acinos* in the tribe Saturejeae (Marin 1989, Husain & al. 1990). Besides, a recent investigation of *Teucrium* showed that nutlet microcharacters such as ornamentation and the presence/absence of oil glands could be of taxonomic significance at the sectional level (Marin & al. 1994). Hedge (1970) has found a wide and interesting range of nutlet form of the genus *Salvia* from S.W. and C. Asia. He also reported on the mucilage production and apparently differences between species.

In the present study, micromorphological characters of nutlet ornamentation in species of *Salvia* selected from the different subgenera and sections are examined and described hoping that they might provide useful additional characters for infrageneric delimitation of this complex genus.

The given classification of *Salvia* is according to Briquet (1897), updated by Pobedimova (1954) and Hedge (1972, 1974).

Material and methods

The nutlet surface of 13 *Salvia* species from the different subgenera and sections was analysed. The sources and classification of the plant material are given in Table 1. Nutlets were grown at the Botanical Institute and Garden "Jevremovac" in Belgrade. Species were determined and compared with authentic herbarium material. Voucher specimens are deposited in Herbarium at the "Jevremovac" Botanical Garden in Belgrade.

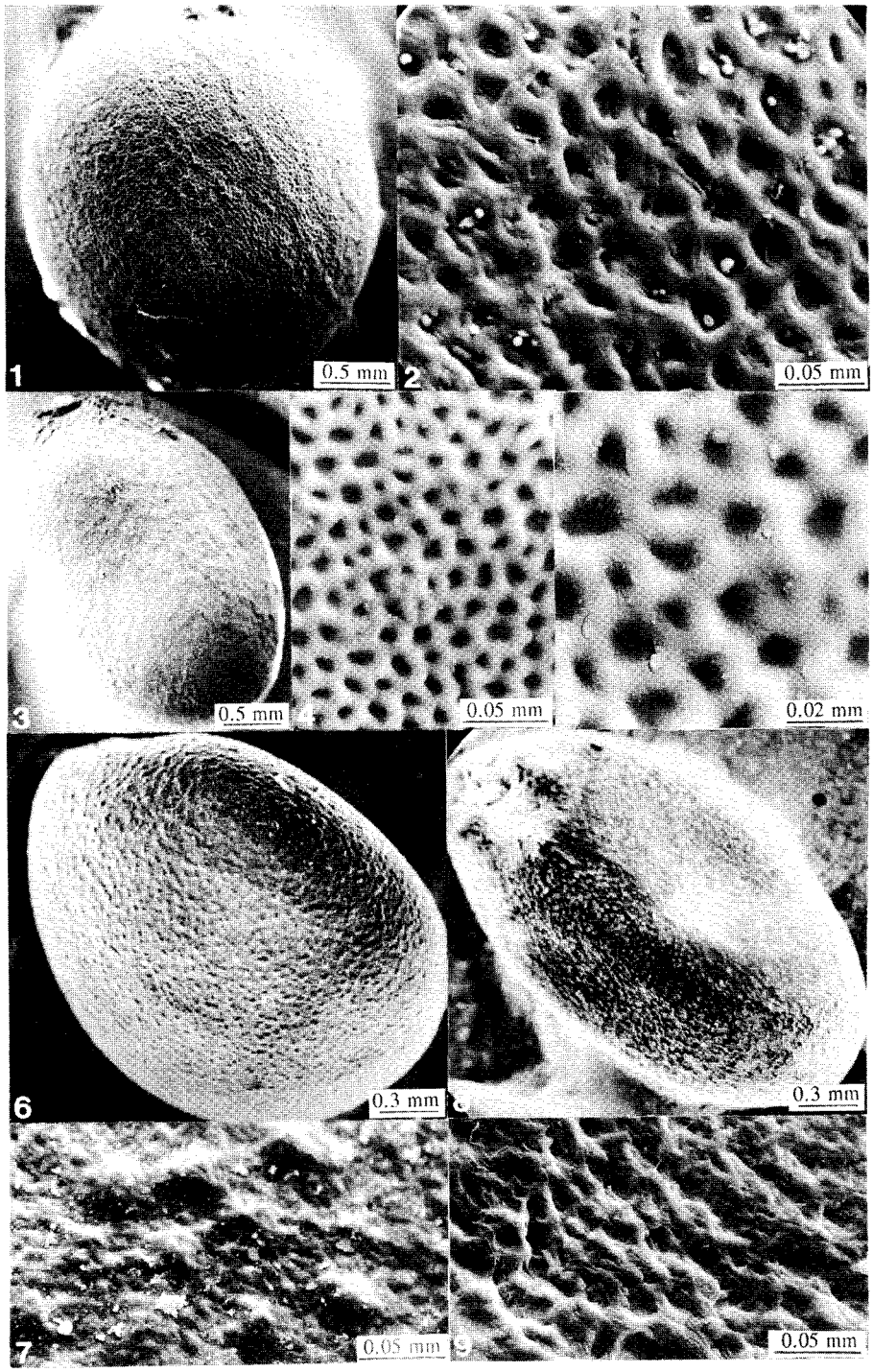
At least three samples of mature nutlets were collected for SEM analysis. The samples were mounted on stubs and coated with *c.* 30 nm of gold-paladium (85:15) in a JEOL JEE 4B vacuum evaporator and examined with a JEOL JSM T.35 scanning electron microscope.

Table 1. Classification of *Salvia* species studied and their sources.

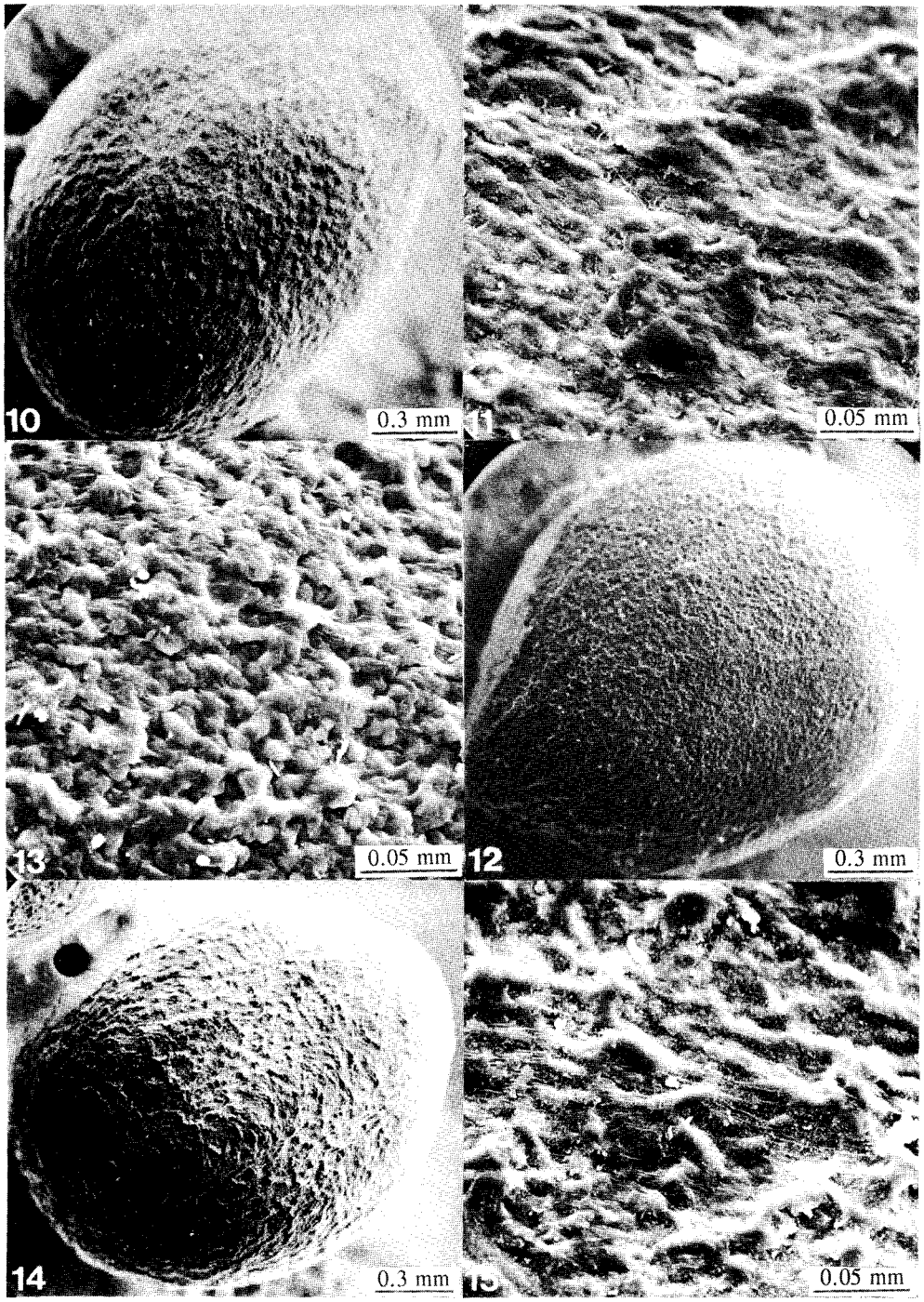
Taxon	Origin
Subgenus *Salvia*	
Sect. *Salvia*	
S. officinalis L.	Beograd (Yugoslavia)
Sect. *Drymosphace* Benth.	
S. glutinosa L.	Brno (Czech Republic)
Subgenus *Sclarea* (Moench) Benth.	
Sect. *Sclarea*	
S. sclarea L.	Pisa (Italy)
Sect. *Horminum* Benth.	
S. viridis (L.) Batt.	Sićevačka klisura (Yugoslavia)
Sect. *Plethiosphace* Benth.	
S. austriaca Jacq.	Kikinda (Yugoslavia)
S. jurisicii Kosanin	Beograd (Yugoslavia)
S. nemorosa L.	Bern (Switzerland)
S. nutans L.	Gazibaba (Yugoslavia)
S. pratensis L.	Berlin (Germany)
Subgenus *Leonia* (Llav. & Lex.) Benth.	
Sect. *Heterosphace* Benth.	
S. lyrata L.	Cluj-Napoca (Romania)
Subgenus *Covola* (Medik.) Briq.	
Sect. *Hemisphace* Benth.	
S. verticillata L.	Kukavica (Yugoslavia)
Subgenus *Calosphace* Benth.	
S. coccinea Juss.	Berlin (Germany)
S. splendens Ker-Gawl.	Berlin (Germany)

Results

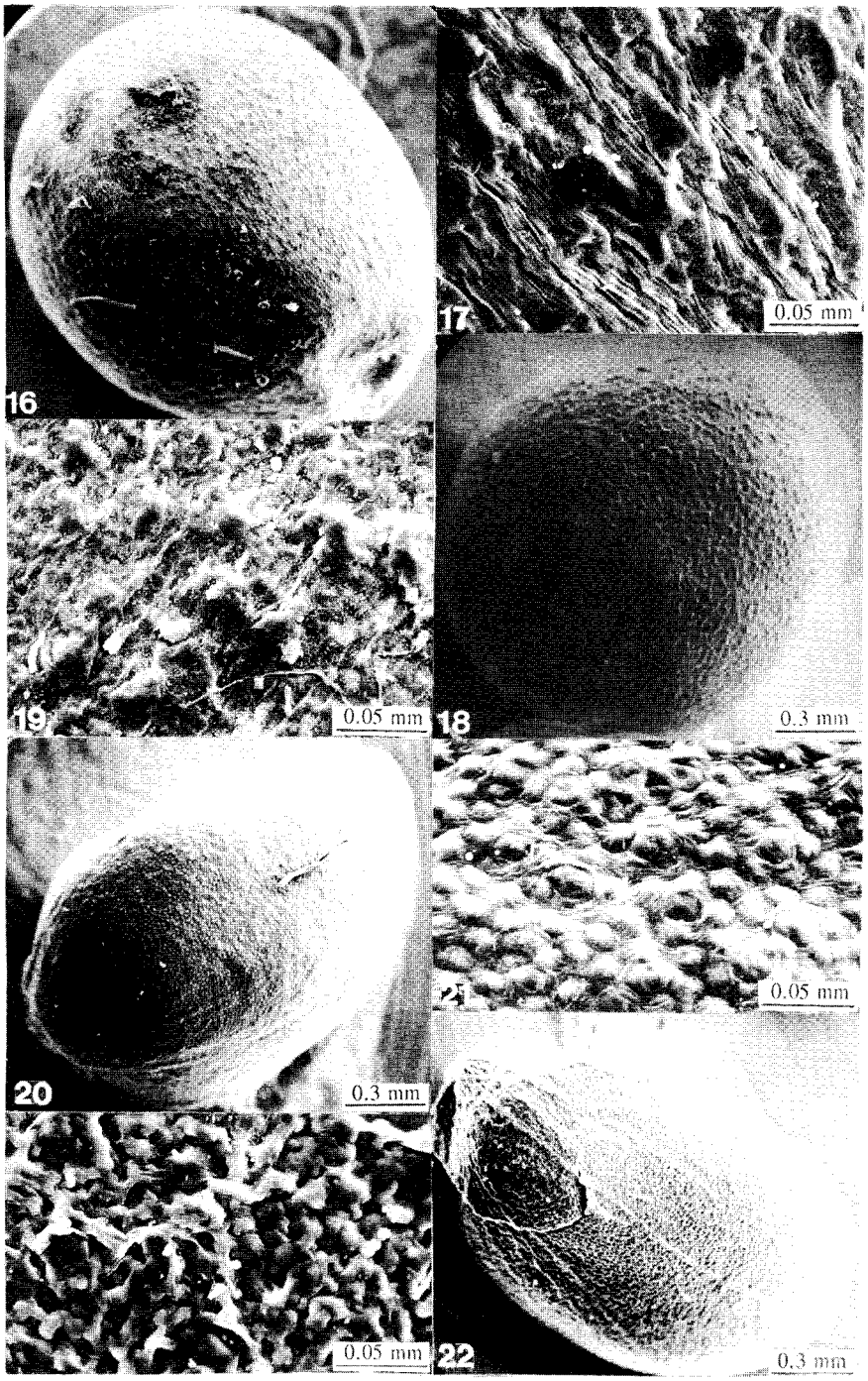
From the subgenus *Salvia*, *S. officinalis* (Figs. 1, 2) and *S. glutinosa* (Figs. 3-5) were analysed. These two species were very similar, though the pattern in *S. glutinosa* was smaller and smoother. The nutlet testa of *S. officinalis* consisted of isodiametric hexagonal or pentagonal cells, the centre of which was sunken.



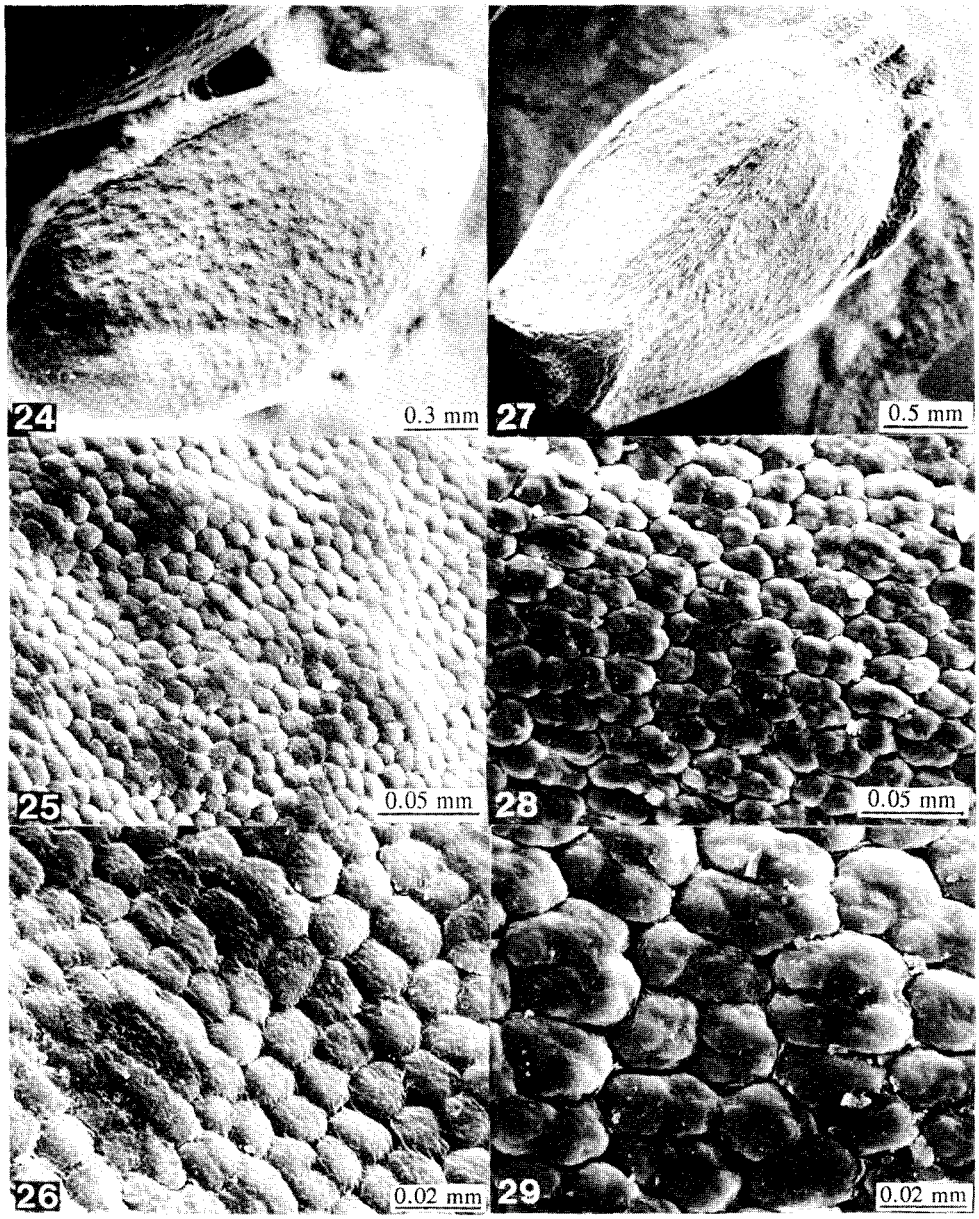
Figs. 1-9. **1, 2,** SEM of nutlet surface in *Salvia officinalis;* **3, 4, 5,** *S. glutinosa*; **6, 7,** *S. sclarea*; **8, 9,** *S. viridis.*



Figs. 10-15. **10, 11,** SEM of nutlet surface in. *S. austriaca;* **12, 13,** *S. jurisicii;* **14, 15,** *S. nemorosa.*



Figs. 16-23. **16, 17,** SEM of nutlet surface in *S. nutans;* **18, 19,** *S. pratensis;* **20, 21,** *S. lyrata;* **22, 23,** *S. verticillata.*



Figs. 24-29. **24, 25, 26,** SEM of nutlet surface in *S. coccinea;* **27, 28, 29,** *S. splendens.*

The lateral walls of these cells were thickened. In *S. glutinosa* pattern was similar, but the cells were smaller and not clearly angular.

Species from three different sections of subgenus *Sclarea* (Moench.) Benth. were analysed: sect. *Horminum* Benth. (*S. viridis*); sect. *Sclarea* (*S. sclarea*) and sect.

Plethiosphace Benth. (*S. austriaca*, *S. jurisicii*, *S. nemorosa*, *S. nutans* and *S. pratensis*). On the nutlet surface of *S. sclarea* numerous characteristic protuberances of multicellular patterns were present (Figs. 6, 7). Nutlets of *S. viridis* were ovate. At higher magnifications they showed shallow discoid or irregular patterns with undulating ridges (Figs. 8, 9).

Nutlets of *S. austriaca* (Figs. 10, 11), *S. jurisicii* (Figs. 12, 13), *S. nemorosa* (Figs. 14, 15), *S. nutants* (Figs. 16, 17) and *S. pratensis* (Figs. 18, 19) were characterised by more or less similar patterns with irregular protuberances and undulating ridges.

Generally, nutlets of the species from subgenus *Sclarea* had quite similar patterns, though they belong to various sections and could be distinguished from the other subgenera by ornamentation.

From the subgenus *Leonia* (Llav. & Lex.) Benth., *Salvia lyrata* was analysed (Figs. 20, 21). Nutlets were papillate. Papillae were mainly very small. Some of them were bigger and probably built from few cells surrounded with striae of different thickness. *Salvia lyrata* has a different pattern compared to the other species analysed.

From the subgenus *Covola* (Medik.) Briq., *S. verticillata* was analysed (Figs. 22, 23). The nutlets were reticulo-papillosae, the surface had a characteristic irregular, reticulate pattern with papillae of varying size.

From the subgenus *Calosphace* Benth. two species were investigated, *S. coccinea* and *S. splendens*. Nutlet surface of *S. coccinea* (Figs. 24-26) consisted of hexangular or pentangular cells (papillae). Nutlets of *S. splendens* (Figs. 27-29) could be described as sphaeropapillose. The papillae were 2-5 celled with clear furrow between them.

There was a significant difference between these two species and those of other subgenera and sections.

Discussion

Even from this limited sample of *Salvia* species, it is clear that nutlet sculpturing could help with the infrageneric classification of this large genus. Each of the five subgenera analysed have the characteristic nutlet ornamentation. There are some more similarities between representatives of subgenus *Sclarea* (especially *Salvia jurisicii*) and subgenus *Covola* (*S. verticillata*). The other three subgenera could be separated very easily. *S. coccinea* and *S. splendens* from the large New World subgenus *Calosphace* are particularly distinguishable from all other species analysed in this work.

The taxonomic significance of nutlet characters within the genus *Salvia* has already been pointed out by Hedge (1970). He found a very wide range of nutlet forms, as well as various types of mucilage which were produced upon wetting of nutlets. In some *Salvia* species from Afganistan, he was able to recognize individual species solely on the form of the mucilage. An overall investigation of mucilage production in the *Salvia* species from the New World has not been undertaken. However, according to preliminary results, it seems to be a less widespread phenomenon (Grubert 1974).

Our morphological results are supported by phytochemistry. A study of diterpenoids in *Salvia* suggests that diterpenoids (abietane, clerodane and pimarane type) are present in most species of the genus. Subgenera *Salvia* and *Sclarea* are characterized by abietane diterpenes, while subgenus *Leonia* from North America has been poorly studied (Rodriguez-Hahn & al. 1992). The Mexican species of subgenus *Calosphace* are generally characterized by the presence of clerodane diterpenoids (Cole & al. 1992). It has been shown that linolenic acid was predominant in nutlet lipids of *Salvia* species from the

subgenera *Sclarea* (sections *Horminum*, *Pletiosphace* and *Sclarea*), *Covola* (sect. *Hemisphace*) and some species from subgenus *Calosphace* (Patudin & al. 1976). Species from other subgenera had low linolenic acid content. The same authors pointed out that species with high content of linolenic acid have hexacolpate trinucleate pollen grains, whereas those with small linolenic acid content have tricolpate binucleate pollen grains.

Results of the earlier *Lamiaceae* nutlet studies have not shown such a diversity of ornamentation pattern as that within *Salvia* (Marin 1989, Husain & al. 1990), but then no other genus is so diverse and with such a wide distribution.

We tend to believe that overall study of nutlet microcharacters of *Salvia* species could be of great importance for infrageneric classification and a better understanding of the phylogeny and evolution of this very interesting genus. These results, along with new ones of further chemical analyses of different secondary and other compounds, should yield data to construct a better classification of the genus *Salvia*.

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