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# Taxonomy of South African ericas (*Erica* L.) and differentiation of their seeds

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**Abstract:** The paper presents an attempt of the systematic analysis of 33 species of the *Erica* genus, orginating from the Republic of South Africa. The analysis was based on morphological and anatomical features of seeds, distinguished in the course of the research. As a result, the studied taxa were divided into two distinct groups. One includes almost exclusively species with smooth seeds, the other one – species with reticular and papillae-covered seeds. The obtained division of the taxa is completely different from the systematic divisions of the genus accepted so far.

**Key words:** *Erica*, seeds, morphology, anatomy, African range



## 1. Introduction

*Erica* L. is the second largest genus in the Ericaceae family. The number of species differs depending on the author, and oscillates between 500 and almost 800 species (Guthrie & Bolus 1905; Mabberley 1997; Oliver 2000). The term *Erica* itself derives from the old Greek term „ereica" used by Theophrast to describe some plants occurring in the Mediterranean region. In the contemporary times, this term was used by many authors, but officially as a name of the genus, it was introduced into botany by C. Linnaeus in *Species Plantarum*, published in 1753.

Heaths are perennial plants with lignified stems, mostly dwarf-shrubs or small shrubs, more rarely larger shrubs, and sporadically – small trees. The stems are covered with small, narrow leaves with revolute margins. Flowers are supported with 3 bracts (in two whorls 2 + 1), and have 4 free sepals and a sympetalous corolla of various shapes (ampullaceous, globose, urceolate, campanulate, tubular or cyathiform). They have 8 stamens with anthers opened by round or oval pores. The anthers usually have characteristic appendages. The ovary of the pistil is divided into 4 locules with numerous ovules. The ovary is inserted on the nectaripherous disc. The fruit is a capsule dehiscent in the center of locules (loculicidal capsule) (Drude 1897; Baker & Oliver 1967).

Originally, on the basis of the number of stamens, Linnaeus described in his *Species Plantarum* (1753) 23 species belonging to the *Erica* genus. A large importance in the research of heaths had the genus revision, performed by Salisbury (1802). He presented a clear, explicit revision of the genus. It resulted in the merge of genera *Erica* and *Blaeria*. At the same time, he excluded *Calluna* and *Salaxis* as independent genera. The subsequent studies, and particularly the exploration of South Africa, brought about the intensive increase in the number of described species. Nevertheless, since many researchers had their own visions of the genus, a number of newly described genera also increased. Two classifications created at the same time, partly on the same material, will be used as an example.

Klotzsch (1838), in quite complex and not quite coherent units, grouped the genera distinguished mostly by himself.

Genera and species Ericearum:

Tribe 1: Symphysandrae – anthers connate
- a. stamens 8 – *Salaxis, Philippia**, *Lagenocarpus**
- b. stamens 6 – *Coccosperma**
- c. stamens 4 – *Blepharophyllum**

Tribe 2: Adelophostemones – free anthers, filaments monadelphous

*Bruckenthalia*

Tribe 3: Eleutherostemones – free anthers, filaments distinct
- a. stamens 8 – *Erica*, *Calluna*, *Nabea**, *Eremia, Eleutherostemon**

b. stamens 6 – *Hexastemon**
c. stamens 4 – *Blaeria, Ericinella*, Thamnium*, Comacephalus*, Grisebachia*, Acrostemon*, Thoracosperma*, Sympieza, Pachycalyx*, Plagiostemon*, Octogonia*, Coilostigma*, Thamnus*, Simocheilus*, Finckea*, Anomalanthus*, Codonanthemum, Syndesmanthus*, Macrolinum*, Omphalocaryon*,*
d. stamens 3 – *Tristemon**

The different classification order was presented by Bentham (1839), who referring to Salisbury's work (1802) distinguished one tribe and two subtribes:

Tribe: Ericeae
Subtribe: Euericeae – ovary with 4, more rarely 5 or 8 loculus, multiovular loculus
*Erica, Pentapera, Calluna, Macnabia* [=*Nabea*], *Philippia, Ericinella, Blaeria, Bruckenthalia*
Subtribe: Salaxideae – ovary with 1 to 4 loculus, single-ovular loculus
*Salaxis, Eremia, Acrostemon, Sympieza, Grisebachia, Simocheilus, Syndesmanthus, Coilostigma, Codonostigma, Scyphogyne, Lagenocarpus.*

Both classifications present a different attitude, a different way of classifying the taxa, and a various organization. Bentham's classification was accepted by many researchers. With later changes and complements, he presented both the place of *Erica* in the family, and the division within the genus with distinguished four sub-genera and numerous sections (he distinguished 49 sections, a few chosen ones are presented).

Drude proposed a similar layout in his study (1897), which was the next great work covering the whole range of *Erica* and Ericeae. As opposed to Bentham, he included into *Erica* as a subgenus the taxon Pentapera which Bentham considered to be a separate genus. Both Bentham's and Drude's studies are until today the basis of systematic considerations of the *Erica* genus, presenting this genus as a whole.

Heaths, as well as the related taxa included in the Ericeae tribe, show a specific longitudinal pattern of distribution. Their range extends from the northern Europe to southern Africa, reaching up to the Middle East. However, the distribution of taxa within the area is very uneven. Some regions are completely devoid of heaths, while others are species-rich and constitute the centers of biodiversity (Fig. 1).

Almost the entire Europe with the northern part of Africa may be considered one of such taxa-rich regions. It is home to 23 species. On the opposite side of the genus range, in the South Africa, there are about 760 species concentrated in a relatively small area. Other

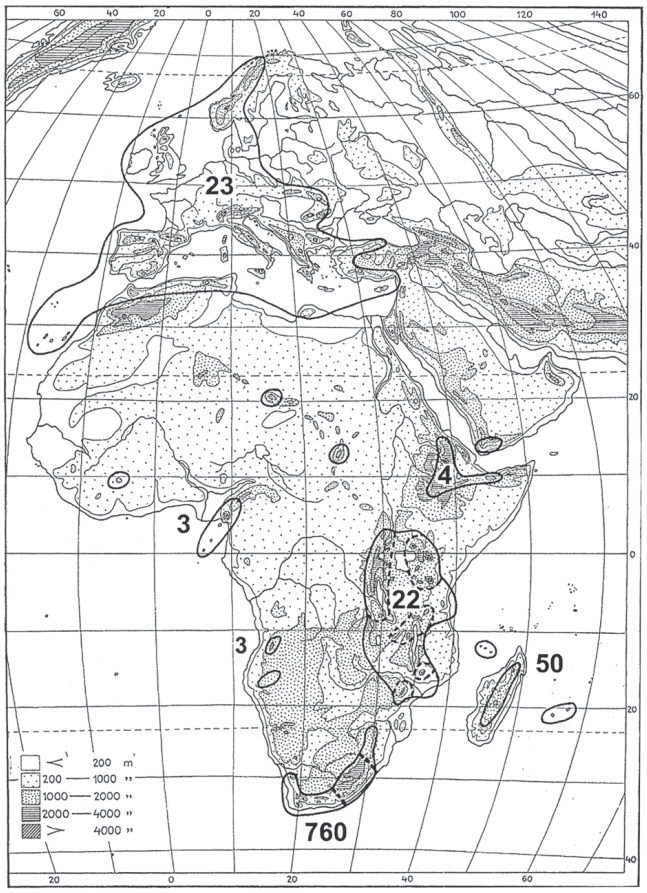



**Fig. 1.** Distribution of the species of Ericeae excluding *Calluna* and *Daboecia* (after Oliver 2000)

centers of biodiversity include the central-eastern Africa with 22 species and Madagascar with 50 species (Oliver 2000).

In recent studies, much attention attracts the type of *Erica* fruit and the number of ovules/seeds produced in the ovary. In a widely understood genus, the structure of the ovary and fruit show a high variability. The majority of species have 4-locular ovaries, but there are also ones with 3, 2 or 1 locules. The locules may contain numerous or single ovules. This diversity leads to many divergent assessments. Also seeds attract much attention since they show similar changeability, but their structure, just as in the case of fruit, is not well known (Oliver 1991; Szkudlarz 2001; Fagúndez & Izco 2003a, 2003b, 2004a, 2004b). This was a decisive factor to start the research on the morphological and anatomical structure of the seed coat, carried out on the group of chosen species, with the aim of selecting the features useful for the taxonomical analysis. The obtained results gave the basis for an attempt of taxonomical grouping of the studied taxa.

## 2. Material and methods

The object of the studies were seeds of 33 species of the *Erica* genus. The material was obtained from the

* genera described by Klotzsch (1838)

Compton Herbarium National Botanical Institute in Claremont in the Republic of South Africa (Table 1). All localities are situated in the West Cape Province RSA.

In order to perform anatomical research, dry seeds were soaked in 75% alcohol, and then cross-sections of the central part of the seed were made. From these cross-sections, microscopic preparations were made, for observation under the light microscope. The morphological structure of dry seeds was studied with the use of a stereomicroscope and scanning electron microscope. The material for observations in the scanning microscope was first sputtered with gold. All the measurements, both of anatomical and morphological structures, were performed with the help of the computer software for the analysis of the microscopic image – Lucia Screen Measurement.

The studies allowed to determine a number of features that created the basis for the taxonomic analysis (Table 2). The similarity between seeds of the studied taxa was estimated by the closest neighborhood method.

## 3. Results

Anatomical and morphological studies of the *Erica* seeds allowed to distinguish some features, which became the basis for the taxonomical analysis. The first group of features involves the size and shape of seeds. Despite the fact that all the seeds are small and this is how they are described for the whole family, there is a large variety also in this respect. The size of seeds (determined by their length) oscillates between 0.3 to almost 2 mm (Figs. 2-4). The shape of the seeds is also variable, often even within one species, which poses an additional difficulty in clear, comfortable grouping. The shape of the seeds fluctuates from almost spherical, through elliptic, to egg-shaped. Some species form seeds more or less angular, which differ significantly even within one species.

The other group of features concerns the surface of seeds, i.e. the sculpture. It is the most characteristic, but also considerably varied group of features (Figs. 5-8). The character of the surface is influenced by

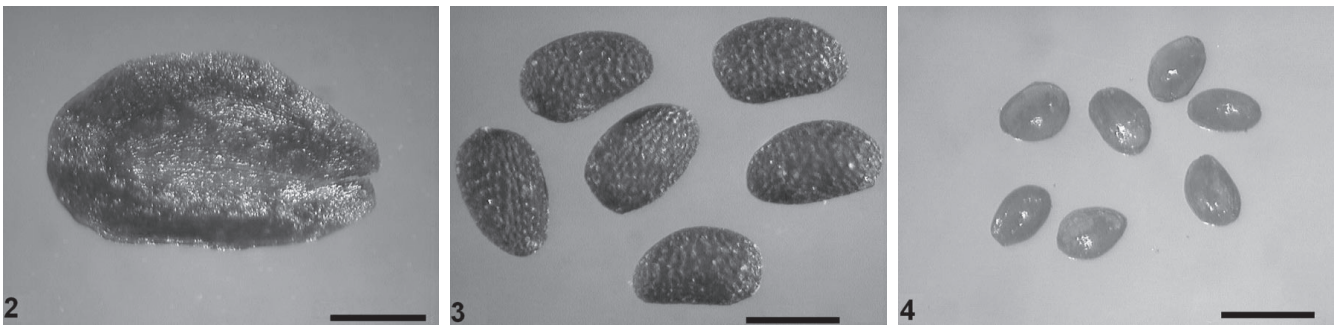
**Table 1.** List of material studied

| No. | Name of *Erica* species | Sampling station | Data | Collector |
|---|---|---|---|---|
| 1 | *E. accommodata* | Jonaskop | 03.10.1999 | Oliver s.n. |
| 2 | *E. albens* | Garcia's Pass | 03.08 1984 | Bohnen 8455 |
| 3 | *E. alfredii* | Pilaarkop | 26.02.1999 | Oliver s.n. |
| 4 | *E. altiphila* | Stettynsberg | - | Oliver 11026 |
| 5 | *E. arcuata* | Montagu | - | Oliver 10476 |
| 6 | *E. argentea* | Porterville | 12.03.1994 | Oliver s.n. |
| 7 | *E. axilliflora* | Rietfontein | 02.09.1994 | Oliver 10557 |
| 8 | *E. baccans* | ex Hort. Hermanus. *Woodvine s.n.* & Hout Bay | - | unknown collector |
| 9 | *E. banksii* | Stanford | - | Oliver 11275 |
| 10 | *E. bicolor* | Paarl Mtn | 30.09.1999 | Raimondo 5566 |
| 11 | *E. borboniifolia* | Pilaarkop | 26.2.1999 | Oliver s.n. |
| 12 | *E. bruniades* | Hartbeeskloof | 13.11.1993 | Oliver 10407 |
| 13 | *E. calycina* | Kouga Mtns | 16.12.1991 | Oliver 9918 |
| 14 | *E. carduifolia* | Greyton | 29.11.1992 | I.Oliver s.n. |
| 15 | *E. cetrata* | Hansiesberg | 21.12.1996 | Oliver s.n. |
| 16 | *E. coccinea* | Constantiaberg | - | Oliver 11357 |
| 17 | *E. conferta* | Langeberg | 02.05.2001 | Helm s.n. |
| 18 | *E. cooperi* | Ugie | April 1994 | Sangster s.n. |
| 19 | *E. cristata* | Paardeberg/Kogelberg | 20.04.1992 | Oliver s.n. |
| 20 | *E. cristiflora* | Cedarberg | - | Taylor 10830 |
| 21 | *E. cruenta* | Korente River | - | Oliver s.n. |
| 22 | *E. fascicularis* | Sunny Seas | - | Oliver s.n. |
| 23 | *E. fuscescens* | Saasveld | 10.10.1985 | Vlok 1181 |
| 24 | *E. jasminiflora* | Shaw's Pass | - | Oliver s.n. |
| 25 | *E. juniperina* | Robinson Pass | April 1994 | Oliver 10433 |
| 26 | *E. karooica* | Klaasvoogds | - | McDonald 1824 |
| 27 | *E. mammosa* | Porterville | 12.03.1994 | Oliver s.n. |
| 28 | *E. monsoniana* | Cedarberg | 16.12.1979 | Forsyth 55 |
| 29 | *E. nabea* | Baviaanskloof | 24.07.1984 | Schumann 230 |
| 30 | *E. odorata* | Groenlandberg | Nov. 1994 | Oliver s.n. |
| 31 | *E. pseudocalycina* | Langeberg | 26.11.1987 | McDonald 1489 |
| 32 | *E. umbelliflora* | Cango Valley | - | Moffett 551 |
| 33 | *E. viridiflora* | Robinson Pass | April 1994 | Oliver s.n. |

Explanation: - lack of data

**Table 2.** List of characters

| No. | Feature |
|---|---|
| 1 | seed length: to 0.5 mm – 0; 0.5 <= 1.0 mm – 0.5; 1mm < 1 |
| 2 | seeds shape: spherical or nearly spherical – 1; seeds elongated - 0 |
| 3 | seeds cylindrical (rounded at cross section) seeds 0; seeds flattened - 1 |
| 4 | seeds winged – 1; seeds unwinged - 0 |
| 5 | testa cells: isodiametric or up to 2x as long as wide – 0; elongated up to 7(10)x as long as wide – 0.5; strongly elongated. over 10x as long as wide - 1 |
| 6 | radial walls (antiklinal): slightly undulate – 0; strongly undulate – 0.5; straight - 1 |
| 7 | outer walls: concave – 0; flat – 0.5; convex - 1 |
| 8 | microsculpture: smooth – 0; tuberculate – 0.5; wrincled - 1 |
| 9 | radial walls (anticlinal): unthickened – 0; thickened - 1 |
| 10 | radial walls (anticlinal): straight. rectangular at cross section – 0; triangular at cross section – 0.5; elliptic at cross section - 1 |
| 11 | outer walls (periclinal): thickened – 0; unthickened - 1 |
| 12 | thickness inner walls (periclinal): up to 2 µm – 0.5; to 10 µm – 0; over 10 µm - 1 |
| 13 | pores in inner walls (periclinal) small and rounded – 0; large - 1 |
| 14 | seed coat thickness: up to 10 µm – 0; 10 – 20 µm – 0.5; 20 – 40 µm – 1; over 40 µm – 1.5 |



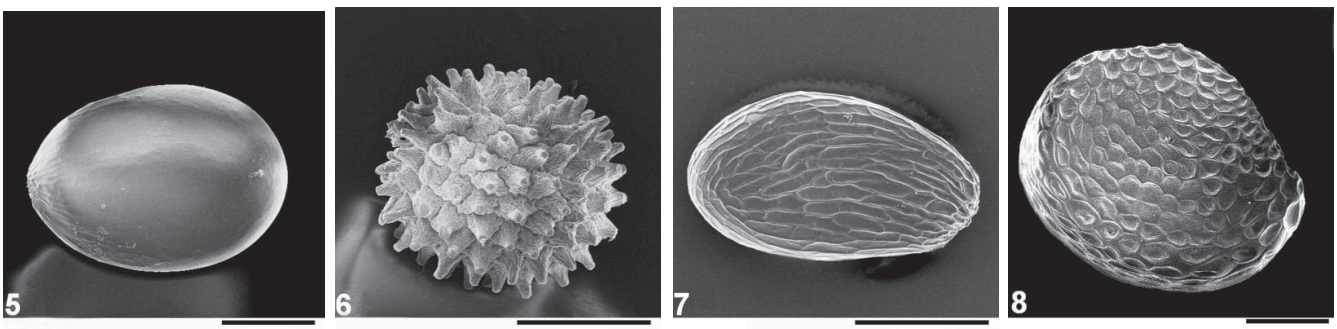

**Figs. 2-4.** Seeds (LM) of *Erica albens* (2), *E. baccans* (3) and *E. bicolor* (4). Scale bar 0.5 mm

several basic elements, which include: the shape i.e. the outline of the epidermis cells of the testa, the contour of radial walls, and the curvature of the external wall, or the lack of it. A quite essential feature is the sculpture of the external wall of the epidermal cells of the testa. For a large number of species, it is smooth, but it also may be covered with tiny tubercles. Sometimes, the surface of those cells is strongly creased. The shope of surface within one cell is called microsculpture (Figs. 9-12).

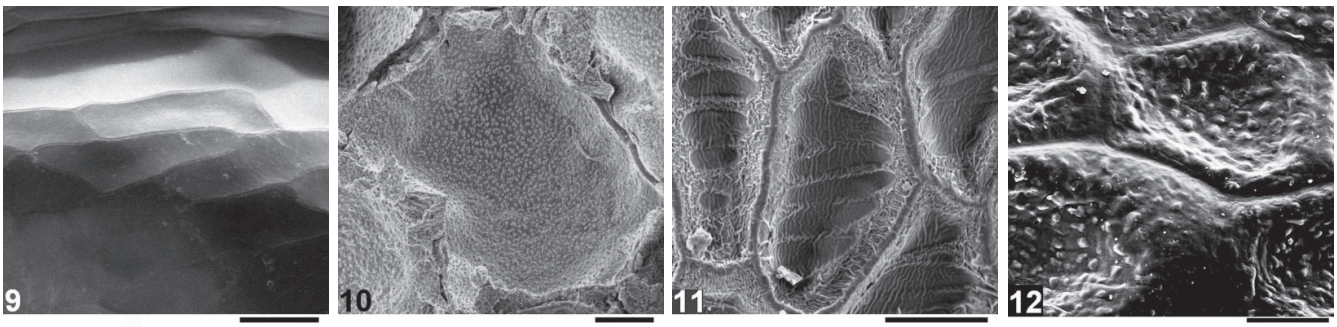
The third group of features concerns the structure of the testa's cells that form the seed coat. The thickening of cellular walls is particularly interesting here. The most typical for the whole Ericeae are cells in which inner and radial walls are thickened, and the external wall remain thin (Figs. 13-16). Another important feature is the thickness of the seed coat. Since it is usually built of one layer of cells, of the testa's epidermis, it is the thickness of this layer that may be identified with the thickness of the coat. The thickness of the seed coat, that is the height of the epidermal cells of the testa, oscillates between several and 120 µm.

## 4. Discussion

As a result of the grouping analysis by means of the closest neighborhood method, the studied taxa clearly formed two groups separated by a considerable distance




**Figs. 5-8.** Seeds (side view) SEM of *Erica monsoniana* (5), *E. odorata* (6), *E. banksii* (7) and *E. umbelliflora* (8). Scale bars: 300 µm




**Figs. 9-12.** Seed coat (side view) SEM of *Erica bruniades* (9), *E. alfredii* (10), *E. baccans* (11) and *E. umbelliflora* (12). Scale bar 30 µm

(Fig. 17). One group includes species with seeds which, under a light microscope, are smooth and glossy. This refers to the group pointed by Oliver & Oliver (2002), described as the complex *E. calycina, E. coccinea*. Moreover, this group includes species with reticular seeds, but only with a thin coat. The thickness of the coat of all the seeds of this group does not exceed 20 µm. The other group is formed by species with seeds having a thick coat, over 20 µm. This group is considerably varied morphologically. Within this group, there is a distinct subgroup with seeds covered with papillae, but there is also a pair of species whose seeds are thin, reticular.

Nevertheless, the morphological and anatomical variety of the seeds of this small sample of species does not coincide with the division of the genus accepted so far. Both species included in the same subgenera, and species from the same sections are strongly dispersed. However, this is just an outcome of introductory research of the relatively small (as compared to the whole genus) group of species, so more binding conclusions may be reached after further research.

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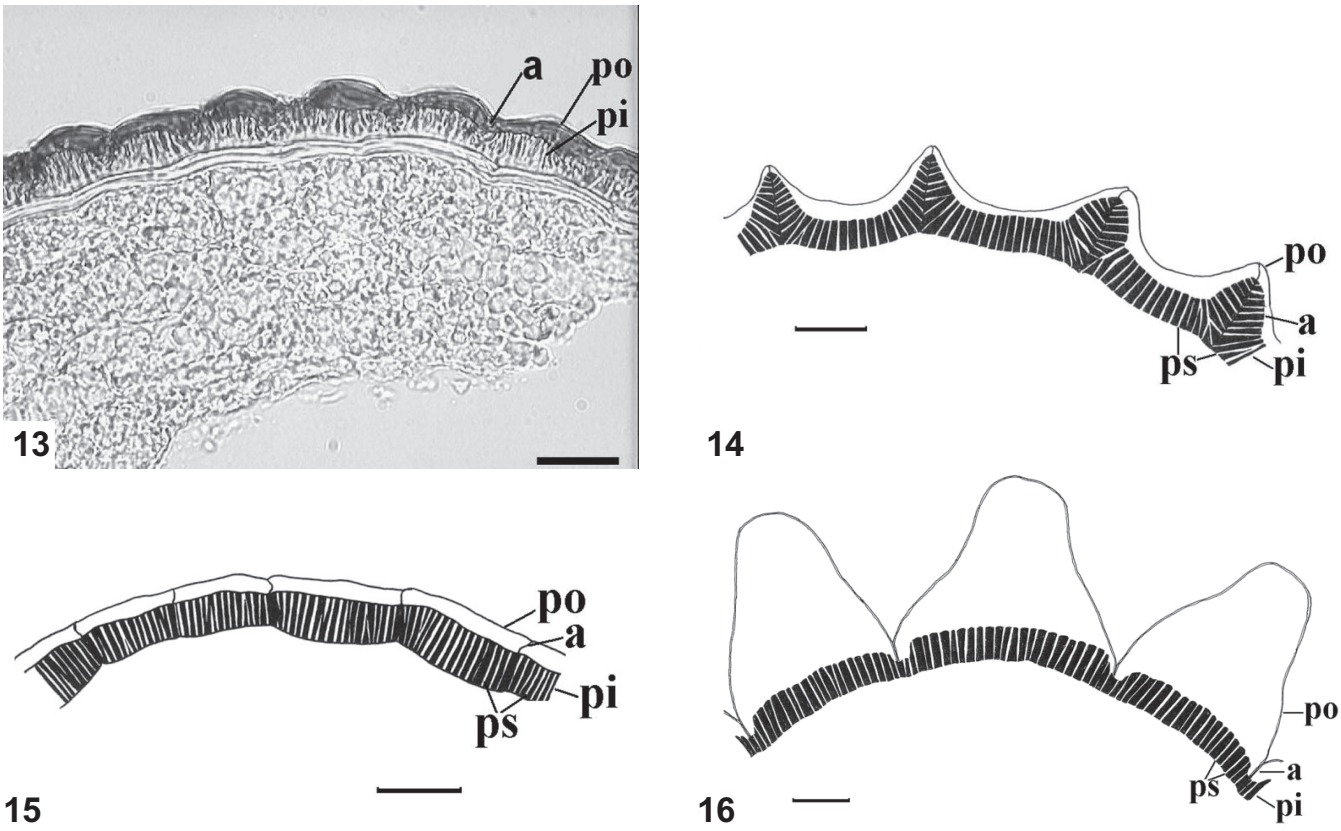


**Figs. 13-16.** Testa cells (cross-section) of *Erica albens* (LM) (13), *E. baccans* (14), *E. bicolor* (15) and *E. odorata* (16). Scale bar 20 µm; ps – pores, pi – inner periclinal wall, po – outer periclinal wall, a – radial (anticlinal) wall

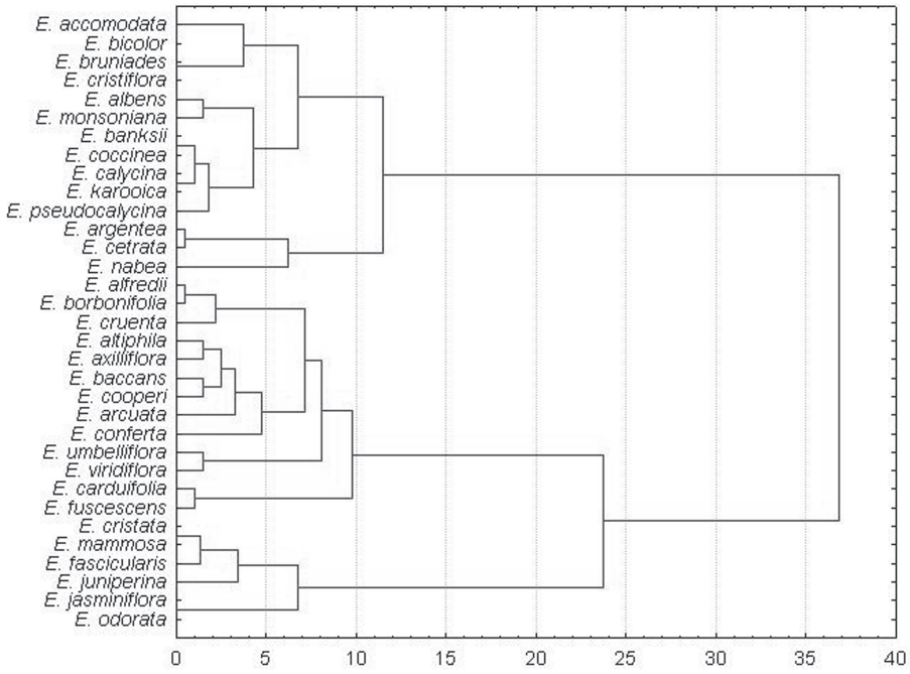


**Fig. 17.** Dendrogram of studied species constructed on the basis of the shortest Manhattan distance

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