



## **Studies in the Compositae of the Arabian Peninsula and Socotra — 1. *Pulicaria gamal-eldinae* sp. nova (Inuleae) bridges the gap between *Pulicaria* and former *Sclerostephane* (now *P.* sect. *Sclerostephane*) 1**

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NORBERT KILIAN

## **Studies in the *Compositae* of the Arabian Peninsula and Socotra – 1. *Pulicaria gamal-eldinae* sp. nova (*Inuleae*) bridges the gap between *Pulicaria* and former *Sclerostephane* (now *P. sect. Sclerostephane*)<sup>1</sup>**

### **Abstract**

Kilian, N.: Studies in the *Compositae* of the Arabian Peninsula and Socotra – 1. *Pulicaria gamal-eldinae* sp. nova (*Inuleae*) bridges the gap between *Pulicaria* and former *Sclerostephane* (now *P. sect. Sclerostephane*). – Willdenowia 29: 167-185. 1999. – ISSN 0511-9618.

A species discovered in the province of Al Mahra, SE Yemen, holding an intermediate position between *Pulicaria* and the small NE Somalian genus *Sclerostephane* is described as new to science. A comparative study of the morphology and anatomy of achenes and pappus of this species, of *Sclerostephane* and of species of the Omani-Makranian *Pulicaria glaucescens* group, which is identified as the closest ally of the new species, shows that the peculiar achenes of *Sclerostephane*, which were the decisive reason for its separation from *Pulicaria*, are morphologically much closer to those of the latter genus than thought previously. Reconsideration of the phylogenetic position of *Sclerostephane* based on these results leads to the conclusion that *Sclerostephane* is more appropriately treated as a section of *Pulicaria*, in which also the new Yemeni species is to be included. The new species is described as *Pulicaria gamal-eldinae*, and belongs to the informal *P. glaucescens* group, comprising *P. boissieri*, *P. carnosae*, *P. edmondsonii* and *P. glaucescens*. *P. sect. Sclerostephane* is formally established, the necessary new combinations *P. collenettei*, *P. discoidea* and *P. longifolia* are made, and a key to the species of the new section is provided.

### **Introduction**

The small genus *Sclerostephane* was established as a segregate of *Pulicaria* by Chiovenda (1929). Its monographers (Wagenitz & Gamal-Eldin 1983) assumed that its closest relatives are most likely to be found in *Pulicaria* sect. *Platychaete*. They considered reducing the genus to a section of *Pulicaria*, but decided to keep it separate because of its peculiar achenes, which are presumably strongly derived. This taxonomic solution has recently been supported by Anderberg (1991).

<sup>1</sup> This and the following instalments of this series in the present volume are dedicated to Prof. H. W. Lack on the occasion of his 50th anniversary.

The achenes of *Sclerostephane* have two peculiarities: (1) an apical tubular outgrowth of the achene wall, which encloses the base of the corolla and carries the pappus, (2) one or two transverse constrictions, which subdivide the more or less cylindrical achenes into two or three sections. These constrictions are caused by an often asymmetrical thickening of the achene wall above and below them. Due to these peculiarities, *Sclerostephane* achenes look fairly odd and one might regard them at first glance as diseased.

During a field trip in 1998, specimens of a new species with surprising affinities to *Sclerostephane* have been collected in SE Yemen. Since hitherto *Sclerostephane* has been considered endemic to N Somalia, where five closely related but in achene morphology remarkably diverse species are known to occur (Wagenitz & Gamal-Eldin 1983), the discovery is remarkable by itself. In addition, the new Yemeni species shows such close affinities to the *Pulicaria glaucescens* group, which is distributed from N Oman and SE Iran to S Pakistan and has been treated hitherto as belonging to either *P.* sect. *Platychaete* (e.g. Hooker 1880-82) or to a separate genus *Platychaete* (e.g. Rechinger 1980), that a re-evaluation of the status of *Sclerostephane* and its delimitation from *Pulicaria* becomes inevitable.

### Material and methods

The investigation is based on material collected during an excursion by S. Ghazanfar, P. Hein & N. Kilian in the province of Al Mahra, SE Yemen, in September 1998 and on material housed in the herbaria of B (Botanischer Garten und Botanisches Museum Berlin-Dahlem), E (Royal Botanic Garden Edinburgh) and K (Royal Botanic Gardens Kew).

Morphology of the achenes and their pappi was investigated using a stereo microscope with a maximum magnification of  $\times 50$  and a scanning electron microscope. Achene and pappus anatomy were studied on toluidin blue stained permanent preparations of transverse and longitudinal microtome sections (3  $\mu\text{m}$ ) prepared according to the following method: the achenes were soaked in a mixture (6:1) of 10 % aqueous solution of sulfosuccinate and 96 % ethanol at 4 °C for 24 h, then dehydrated in an 1:1, 3:7, 1:9 incremental series of sulfosuccinate/ethanol for 24 h each, finally twice dehydrated in pure 96 % ethanol for 45 min, subsequently soaked for 6 weeks in commercial hydroxyethylmethacrylate (Kulzer Technovit 7100 and Kulzer Solidifier No. 1, 100 ml : 1 g) at 4 °C before final embedding in a 1:15 mixture of these reagents.

### Achenes and pappus of *Sclerostephane*, of the new Yemeni species and the *Pulicaria glaucescens* group

The achenes of *Sclerostephane* were studied in detail by Wagenitz & Gamal-Eldin (1983). Two representative members of the genus have been re-examined.

*S. adenophora* (Fig. 2-3) represents the achene type with two constrictions and a double pappus. The bristles of the inner pappus break off easily with the fracture line (f) clearly recognisable in Fig. 2c-d. Closer examination reveals that the outer pappus is a prolongation of the apical tube and that the bristles of the inner pappus divide from about the edge of the tube (Fig. 2d, Fig. 3a-d). It can, however, also be seen in Fig. 2d that the pappus does not originate from the tube edge but instead forms below the fracture zone of the individual bristles a tissue lining the inside of the tube (pl) down to its base. As shown in Fig. 3b-c, this tissue (pl) is composed of c. 1-2 layers of longish to filiform cells, starting on the base of the tube immediately beneath the place where the corolla arises. The very base of the bristles consists of short, isodiametric cells, apparently preforming the fracture zone (f) of the bristles (Fig. 3c-d).

The achenes of *S. longifolia* have one or two inconspicuous constriction(s) (Fig. 4a) and are strongly asymmetrical in transverse section (Fig. 4c), whereas they are symmetrical in *S. adenophora* (Fig. 4d). In contrast to the latter species *S. longifolia* does not possess an outer pappus prolonging the tube (Fig. 4a-b). As in *S. adenophora*, the pappus of *S. longifolia* forms

the top layer (pl) of the inside of the tube, and the pappus bristles (pi) arise at the apical edge of the tube (Fig. 4b).

Hence, the interpretation by Wagenitz & Gamal-Eldin (1983: 98, fig. 16b & 18) that the pappus originates from the upper edge of the tube and has quasi been lifted by the tube is not fully confirmed. The pappus of *Sclerostephane* actually originates from the base of the tube but is connate to its inside up to the upper tube edge, where it then differentiates into the inner and outer pappus or the bristles of the inner pappus respectively. This point is of importance when we now consider the achenes of the new Yemeni species.

The achenes of the new Yemeni species (Fig. 5, 6a-b) perfectly agree in their basic structure with the *Sclerostephane* achenes. Their asymmetrical thickening and constriction is even more pronounced than in *S. longifolia* and *S. adenophora* and similar to the situation in *S. collenettei* (Wagenitz & Gamal-Eldin 1983: fig. 32a). There is, however, one essential difference. The pappus in the new Yemeni species differentiates into the inner and outer pappus immediately at the base of the tube. The pappus bristles divide from the base and the outer pappus remains connate to the tube until overtopping it (Fig. 5d, 6a, c-d), whereas the pappus remains undifferentiated up to about the tube edge in the species of *Sclerostephane* (Fig. 3c, 4b).

Transverse sections of the tube near its apical edge (Fig. 7a-b) and near its base (Fig. 7c-d) show at first that the asymmetry of the achene as well as the ribs of the wall are continued into the tube. In Fig. 7c-d, we can identify three tissues (from the margin to the centre of the tube): (1) the achene epidermis (e) easily recognisable by the oxalate crystals in its cells, (2) parenchymatous tissue (tp), and (3) pappus tissue (pl) in a thin layer (of partly flattened cells) on the inside of the tube, which are less gracile than those of the inner pappus bristles (Fig. 7b). In Fig. 7c-d the epidermis is partly replaced by 1-2 layers of cells similar to those on the inside of the tube. Towards the tube edge tissue of these cells (p) fully replaces the epidermis (Fig. 7a-b). These cells finally form the outer pappus, which thus seems to originate from both sides of the tube (compare also Fig. 6c); this is, though less distinct, also true in *S. adenophora* (Fig. 3d) and, still less distinct, in *S. longifolia* (Fig. 4b).

If we compare the longitudinal sections of mature achenes of both *Sclerostephane* (Fig. 8a) and the new Yemeni species with such of young achenes (Fig. 8b-d), we see that the pappus, as usual, is fully differentiated and that, moreover, the tube is developed in its basic structure already before anthesis. In the new Yemeni species, it is particularly evident that the tube in its early stages is built of longish cells much similar to those of the outer pappus. With maturation, the tissue in the centre of the tube wall differentiates into parenchymatous tissue, whereby the parenchymatous cells adjacent to the pappus tissue on the inside of the tube frequently get an intermediate shape. At the same time, epidermis tissue grows on the outside of the tube wall.

The late ontogeny of the apical achene tube thus teaches that 'achene wall tissue' and 'pappus tissue' cannot morphologically be told apart in earlier states of development. The separation in pappus and tube wall is a result of a final specialization and differentiation of formerly undifferentiated tissue. Identifying tissues of the apical tube as either representing 'pappus' or belonging to the achene or tube wall (as, e.g., parenchyma or epidermis) consequently refers only to the ultimate morpho-functional differentiation of the apical tubular outgrowth.

To understand the difference between *Sclerostephane* and the new Yemeni species regarding the differentiation of the double pappus (compare Fig. 3c and 6d), it is of some significance that in both cases the pappus roots at the base of the tube and that pappus tissue lines the inside of the tube. The most convenient explanation for the difference is that the apical, tube-forming outgrowth of the achene wall in *Sclerostephane* includes also the 'initials' of the inner pappus and lifts them to the edge of the tube (Fig. 3c), whereas other pappus 'initials' remain at the basal position and differentiate into or produce the pappus tissue that lines the inside of the tube and supports the inner pappus. In the new Yemeni species the 'initials' of the inner pappus are, in contrast, not lifted by the apical outgrowth, with the result that the bristles of the inner pappus divide basally (Fig. 6d).

So far, the conclusion appears justified that the apical tubular outgrowth in *Sclerostephane* and the new Yemeni species are homologous but represent two different variants of the same basic structure.

Studying the *Pulicaria* species from the Asian mainland east of the Arabian Peninsula, which were beyond the scope of the revision of Gamal-Eldin (1981), I realised that the species of the *Pulicaria glaucescens* group, commonly placed in *P.* sect. *Platychaete*, show surprising affinities to the new Yemeni species, with respect to general appearance as well as achene and pappus characters. This group comprises four closely related species. Three, viz. *P. glaucescens* (Boiss.) Jaub. & Spach, *P. boissieri* Hook. f. and *P. carnosa* (Boiss.) A. Anderb., have a mainly Makranian distribution (Kürschner 1986), the fourth, *P. edmondsonii* Gamal-Eldin, is endemic to the north of Oman and U.A.E., has been described only recently and has so far not been associated with *P. glaucescens* and its allies (Gamal-Eldin 1984). They all are dwarf or low shrubs, have small, narrow and partly succulent leaves, rather small capitula, a  $\pm$  campanulate involucrem of  $\pm$  imbricate,  $\pm$  rigid, coriaceous involucreal bracts, and no marginal ray flowers. The achenes are sclerenchymatous and differ from the typical stout and similarly sclerenchymatous achenes of *P.* sect. *Platychaete* (see, e.g., Gamal-Eldin 1981: fig. 217c, 219c, 220), which are clearly constricted below the pappus and thus exhibit a shoulder-like structure in lateral view, in that the outer pappus is not set off from the achene but the achene wall is passing over into it. Apparently overlooked so far, the same kind of tubular apical outgrowth of the achene wall as is present in both the Yemeni species and *Sclerostephane* also occurs in this group. It is, however, less pronounced (in *P. glaucescens*, Fig. 9a-b) or rudimentary (in *P. carnosa*, Fig. 9b-c) and seems even completely absent in *P. edmondsonii*. The achenes of the *P. glaucescens* group, on the other hand, lack the transversal constrictions and asymmetrical thickening. With the new Yemeni species they share the basal division the pappus bristles from the outer pappus, which is likewise connate to the tube (Fig. 9b,d).

With respect to the morphology of the pappus bristles (Fig. 10), *Sclerostephane*, the new Yemeni species and the *P. glaucescens* group show both similarities with and differences between each other. In all species, the pappus bristles are conspicuously flat and broad, distichously toothed in the basal portion and  $\pm$  tristichously toothed higher up. Clear differences can be seen, on the other hand, when comparing the teeth of the bristles: they are spreading and almost free from each other in *S. adenophora* (Fig. 10d) but almost parallel and largely connate in the new Yemeni species (Fig. 10a), whereas connate to different degrees in *P. glaucescens* and *P. carnosa* (Fig. 10b-c), which thus hold intermediate positions. This is, however, the same range of variation as observed within *P.* sect. *Platychaete*.

### Phylogenetic considerations

A progression from achenes with a thin parenchymatous wall and sclerenchymatous elements situated only in the ribs of the achene wall leading to achenes with a thick, entirely sclerenchymatous wall has been suggested for *Pulicaria* by Gamal-Eldin (1981: 61). Such sclerenchymatous achenes occur in single species of *P.* sect. *Pulicaria*, in *P.* sect. *Vieraeopsis*, and generally in *P.* sect. *Platychaete*, in which the *P. glaucescens* group is commonly placed. *P.* sect. *Platychaete* is furthermore characterised by flattened and rather broad, di- to tristichously  $\pm$  connate-barbellate pappus bristles, which are considered as derived when compared with those of *P.* sect. *Pulicaria*. All species of *Sclerostephane* have similar sclerenchymatous achenes, their achene wall anatomy is basically of the same type as the sclerenchymatous achenes of *Pulicaria*, and their pappus bristles are morphologically close to those in *P.* sect. *Platychaete*. Considering the variation of the pappus bristle morphology in *P.* sect. *Platychaete*, it must even be stated that *Sclerostephane* falls fully within this range (compare, e.g., Fig. 9d and Gamal-Eldin 1981: fig. 220 showing the pappus of *P. stephanocarpa*). For these reasons a closer relationship between *Sclerostephane* and *P.* sect. *Platychaete* has been assumed earlier (Wagenitz & Gamal-Eldin

1983: 104). In fact the peculiar apical tube of the *Sclerostephane* achenes is according to Wagenitz & Gamal-Eldin (1983: 104), the only character consistently distinguishing both genera. However, from a phylogenetic point of view, maintaining of *Pulicaria* and *Sclerostephane* as two genera, implies that differentiation of both from a common ancestor must have preceded the evolution of the different sections of *Pulicaria*. Consequently, the derived achene and pappus characters shared by *Sclerostephane* and *P. sect. Platychaete* would have to be the result of parallel development.

The new Yemeni species and the achene features found in the *Pulicaria glaucescens* group cast new light on the relationship between both genera. Comparing the typical sclerenchymatous achenes of *P. sect. Platychaete* on the one hand with those of the *P. glaucescens* group, the new Yemeni species and *Sclerostephane* on the other hand, we can recognise two different types of sclerenchymatous wall thickening with respect to the transition of the achene wall into the pappus, and may assume that they represent two different evolutionary lines of derivation from slender thin-walled achenes of the *P. sect. Pulicaria* type.

Regarding the relationships of the new Yemeni species, of *Sclerostephane* and of the *Pulicaria glaucescens* group, it can be stated with certainty that the new Yemeni species is more closely related to the *Pulicaria glaucescens* group than to *Sclerostephane*. This appears evident not only from the overall resemblance between the Yemeni species and the *Pulicaria glaucescens* group (habit, leaf and involucre characters, the size of their capitula being distinctly smaller than in *Sclerostephane*) but in particular from their sharing the basal division of the double pappus. With respect to the asymmetrical thickening as well as the constriction of the achenes of the new Yemeni species, features not shared by any of the species of the *P. glaucescens* group, one has to consider that also in *Sclerostephane* the first feature is not present in three and the second not present in one of its five species.

When considering the *Pulicaria glaucescens* group and the new Yemeni species as one lineage, the only reliable feature delimiting *Sclerostephane* from both this lineage and the rest of *Pulicaria* is the dividing of the double pappus at the apical edge of the tube. If we include the new species in *Pulicaria* while maintaining *Sclerostephane* as a separate genus, we would have to make the assumption that most of the peculiar synapomorphies of the *Sclerostephane* achene and pappus have evolved independently also in *Pulicaria*. This, however, appears rather unlikely, in particular since the absence of comparable achene developments in other genera of the tribe and family speaks against their being a morpho-functional adaptation to environmental conditions.

The alternative, to include both the Yemeni species and the *Pulicaria glaucescens* group in *Sclerostephane*, would shift the boundary between *Sclerostephane* and *Pulicaria* between a species of the *P. glaucescens* group such as *P. carnosa* with an only rudimentary apical tube and *P. sect. Platychaete*. This would not only considerably diminish the discontinuities between both genera but again imply an improbable extensive parallel development of peculiar synapomorphies in both genera.

Although the maintenance of *Sclerostephane* as a separate genus besides *Pulicaria* seemed so far a justified solution, the new findings provide strong support for its inclusion in *Pulicaria* as the sister group of the *P. glaucescens* group with inclusion of the new Yemeni species. The fact that the species of either group, but in particular those of *Sclerostephane*, are conspicuously similar in appearance to each other, could indicate that both groups divided from their common ancestor rather late. In the light of the data available, it seems to me the most likely assumption that the differentiation of the double pappus at the tube edge in the *Sclerostephane* lineage is the result of a more recent mutational step, and that this N Somalian lineage is thus further derived. A taxonomic treatment of both groups as members of a new section of *Pulicaria* therefore appears to me the most appropriate solution.

## Conclusions

According to the above results on the achene and pappus morphology as well as according to the phylogenetic considerations, the new Yemeni species is described as a member of *Pulicaria*. The

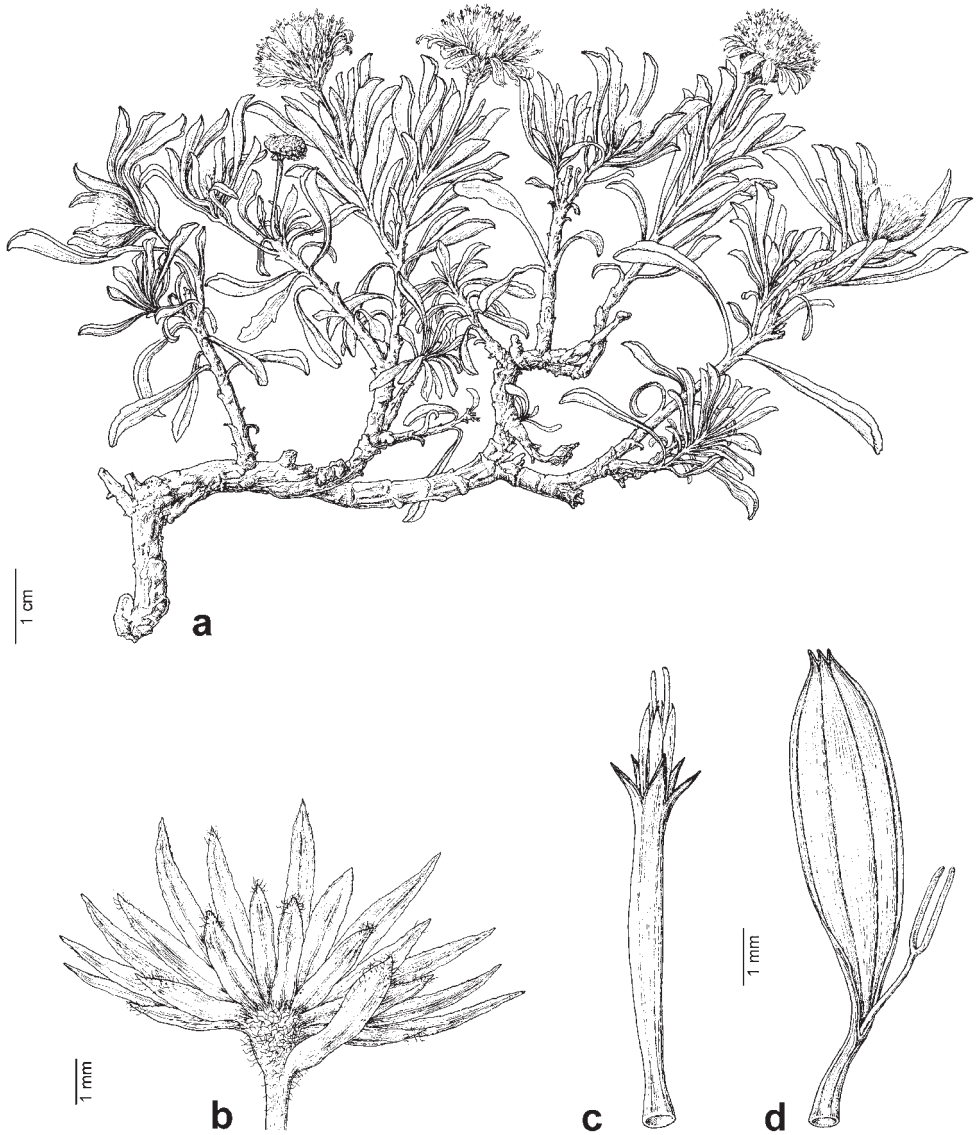


Fig. 1. *Pulicaria gamal-eldinae* – a: habit; b: involucre; c: ray flower; d: disc flower. – Scale: a = 1 cm, b-d = 1 mm; drawings by Ingo Haas after the holotype.

genus *Sclerostephane* is reduced to the rank of a section of *Pulicaria* and both the new species and the *P. glaucescens* group are placed into this section.

*Pulicaria gamal-eldinae* N. Kilian & P. Hein, **sp. nova** – Fig. 1, 5-7, 8b-d, 10a

Holotype: Yemen, Al Mahra, Ras Fartak Mts, track between Haswayn and Ghaydah, pass, 620 m, 15°49'N, 51°57'E, rocky slopes, 24.9.1998, *Ghazanfar, Hein (4909) & Kilian NK 5118* (B; isotypes: E, K, S).

Species *Pulicariae carnosae* affinis, sed capitulis heterogamis radiatis, achaeniis sparse pilosis in parte inferiore, transversaliter valde asymmetricis constrictis et tubo apicali parietis achaenii in pappum exteriorem transiente usque c. 1 mm (cum pappo) longo differt.

We dedicate this interesting species to Mrs Elsayeda Gamal-Eldin who significantly contributed to our knowledge of the *Pulicaria-Sclerostephane* group.

#### Description

*Dwarf shrub*; older branches with a soft, greyish, frequently cracked bark tissue of large cells, leafless but with 1-2 mm long basal remnants of the former leaves having the same texture as the bark tissue; younger branches leafy throughout, each with a single terminal capitulum. Leaves up to c. 25 mm long, 0.2-0.7 mm wide, weakly fleshy, entire, oblanceolate, attenuate into a narrow, semiamplexicaule base, apically rounded or with a small mucro pointing backwards. Leaf margins, leaf axils, peduncles and terminal portion of (outer) involucre bracts rather inconspicuously ulotrichous, glabrescent with age. Peduncles with 0-2 bract-like reduced leaves, sometimes close to the involucre; before anthesis capitula usually surpassed by the uppermost leaves and only overtopping them at anthesis. Capitula at anthesis c. 1-1.5 cm in diameter (in herbarium material, length of ray flower not counted), heterogamous. Involucre bracts green, in about 3 series, linear-lanceolate (the outermost linear-oblanceolate to linear-lanceolate), 0.7-1.1 mm wide, with a distinct midrib and a scarious margin often weakly serrulate; both the few outermost bracts and the middle bracts 3-4 mm long, acute to acuminate and with a narrow scarious margin, the inner bracts 4.5-5.5 mm long, narrower, acute and with a broader scarious margin. Receptacle convex, at fruiting 4-6 mm in diameter, attachment areas of the achenes somewhat conical. Ray flowers pistillate, corolla bright yellow, ray lamina 5-6 × 2-2.5 mm, its three apical teeth 0.4-0.6 mm long, tube 1.6-1.9 mm long. Disc flowers perfect, corolla yellow, tubular, 5.8-6.4 mm long, with 5 narrowly triangular, acute lobes 0.6-0.9 mm long; anther tube and style yellow. Achenes including the outer, weakly delimited coroniform pappus 2.5-3.5 mm long and c. 1.2 mm in diameter, adaxially ± incurved and with a strong transverse constriction (to almost 1/2 the diameter) mainly restricted to the adaxial side in the middle third, above the constriction somewhat thicker than below, then strongly attenuate into the apical tube being prolonged by the outer pappus without clear delimitation; achene wall longitudinally ribbed, brown, weakly pubescent of appressed-antrorse twin hairs (mainly at the base and just above the constriction). Pappus double; outer coroniform pappus apically lacerate, prolonging the apical tube for c. 0.5 mm; inner pappus of c. 12 flat setae arising from the base of the tube, 4.5-6 mm long, 0.15-0.22 mm wide and four layers thick in the major part of their lateral extension, their margin serrulate due to long-connate, spreading-erect teeth.

#### Distribution and ecology

The species has been collected in three localities in the coastal area of Al Mahra, the easternmost province of Yemen. It is probably also present in adjacent Oman, as is indicated by a specimen from E Dhofar (see below), which is, however, too young for definitive identification.

Climatically, the known localities are situated in a region of S Arabia, which is affected by the SE monsoon between June and early October but probably also receives some winter and spring rainfall (Fisher & Membry 1998). Judging from the vegetation, the precipitation seems to decline considerably to the west of the mountains of Dhofar and E Al Mahra. On coastal and monsoon facing escarpments and ridges the lower precipitation supports a vegetation dominated by dwarf shrubs, including *Pulicaria gamal-eldinae*, shrublets and small subshrubs, which cover more or



less sparsely the usually rocky ground. In the eastern part of the Yemeni distribution area of *Pulicaria gamal-eldinae* this type of vegetation is found on escarpments little above sea level, in the western part of the area, as, e.g., on Jabal Sharwayn W of Qishn, it is largely restricted to elevations at above c. 400-500 m.

Additional specimens seen [“etc.” stands for further duplicates to be distributed]

YEMEN: AL MAHRA: Jabal Sharwayn 10 km W of Qishn, rocky plateau and slopes, 550-600 m, 24.9.1998, *Hein, Ghazanfar & Kilian PH 4874b* (B); *ibid.*, 28.9.1998, *id. PH 5098* (B); track from Ghaydah to Hawf, mountain 20 km E of Al Faydami, 16°29'N, 52°34'E, S facing escarpment, 50-230 m, 26.9.1998, *Kilian, Ghazanfar & Hein NK 5166* (B, etc.), *PH 5001* (herb. P. Hein, etc.). OMAN: Dhofar, Jabal Qinqari near Sudh, 17°02'N, 55°01'E, 4.11.1983, *Lawton 2525* (E) – identification uncertain.

### Classification

*Pulicaria gamal-eldinae* is considered here to form a monophyletic group with both the species of the *P. glaucescens* group and the species hitherto placed in the genus *Sclerostephane*. The group is taxonomically treated as a section of *Pulicaria*, based on *Sclerostephane* Chiov.

*Pulicaria* sect. *Sclerostephane* (Chiov.) N. Kilian, **comb. & stat. nov.** ≡ *Sclerostephane* Chiov., Fl. Somala 1: 200. 1929. – Lectotype (designated by Wagenitz & Gamal-Eldin 1983: 104): *Sclerostephane discoidea* Chiov.

In this circumscription the section can be delimited from the rest of *Pulicaria* by the following combination of characters: The achene wall is distinctly thickened, has a continuous sclerenchymatous tissue several rows thick, passes into the pappus without conspicuous delimitation, and usually forms a rudimentary or distinctive apical tube connate with pappus tissue at its inside and usually prolonged into the outer pappus; the bristles of the inner pappus are similar to those in *P. sect. Platychaete*, being flat and broad with largely connate to free teeth and divide either from the base or apical edge of the tube.

The section comprises two distinctive species groups, which may deserve formal recognition. The species of the former genus *Sclerostephane*, here informally treated as ‘*P. adenophora* group’, are mesophytes and conspicuously similar to each other in appearance. They are medium sized shrubs with well developed leaves, a glandular indumentum, large capitula and herbaceous involucre bracts, and are confined to N Somalia. The species of the *P. glaucescens* group (including *P. gamal-eldinae*), are also rather similar in appearance, they are (sub)xerophytic dwarf shrubs or shrublets with small, narrow and sometimes even somewhat fleshy leaves, a non-glandular indumentum (if any), small capitula and rigid involucre bracts, occurring in S Arabia and from SE Iran to S Pakistan. A key to the species of the section is provided below.

### Key to the species of *Pulicaria* sect. *Sclerostephane*

- 1 Bristles of the inner pappus dividing right at the base of the apical tube; leaves small, narrow, entire. . . . . [*P. glaucescens* group] 6
- Bristles of the inner pappus dividing at the edge of the apical tube; leaves large, ovate to oblanceolate, mostly dentate at least in the apical portion . . . . [*P. adenophora* group] 2
- 2 Achenes with two distinct transversal constrictions dividing it into three sections . . . . 3
- Achenes with one distinct or 1-2 inconspicuous constriction . . . . . 5
- 3 Capitula discoid, homogamous, the middle section between both constrictions being the smallest . . . . . *P. discoidea*
- Capitula radiate, heterogamous, middle section ± as large as or larger than the others . . . 4
- 4 Inner involucre bracts acuminate, the tip violet; leaves often with undulate margin . . . . . *P. adenophora*

- Inner involucre bracts acute, the tip concolourous, not violet; leaves never with undulate margin . . . . . *P. hildebrandtii*
- 5 Outer pappus absent, achenes c. 3 mm long, with 1-2 indistinct constrictions, apical section, if distinguishable, much shorter than basal section . . . . . *P. longifolia*
- Outer pappus present,  $\leq$  0.2 mm long, achenes less than 2 mm long, with one distinct constriction, apical section as long as or longer than basal section . . . . . *P. collenettei*
- 6 Achenes asymmetrical and with a conspicuous transversal constriction; capitula radiate, heterogamous . . . . . *P. gamal-eldinae*
- Achenes symmetrical, without a transversal constriction; capitula discoid, homogamous . . . . . 7
- 7 Leaves and young branches densely white-tomentose; outer pappus c. 0.5 mm long . . . . . *P. edmondsonii*
- Leaves and young branches glabrous, glabrescent or villose with long hairs but never white-tomentose; outer pappus including apical tube at most 0.3 mm long . . . . . 8
- 8 Shrublet with long, slender, erect branches; leaves to 4 cm long, linear to linear-oblan-  
ceolate . . . . . *P. glaucescens*
- Dwarf shrub, intricately branched with short branches; leaves rarely exceeding 2 cm in  
length, oblanceolate . . . . . 9
- 9 Plant villose with long, white hairs . . . . . *P. boissieri*
- Plant glabrous to sparsely hairy . . . . . *P. carnosa*

### ***Pulicaria glaucescens* group**

***Pulicaria boissieri*** Hook. f., Fl. Brit. Ind. 3: 300. 1881  $\equiv$  *Pulicaria villosa* (Boiss.) A. Anderb. in Pl. Syst. Evol. 176: 110. 1991, nom. illeg. [non Link, Enum. Hort. Berol. 2: 336. 1822]  $\equiv$  *Platychaete villosa* Boiss., Diagn. Pl. Orient., ser. 2, 3: 11. 1856. – Holotype: Scinde, *Stocks* 437 (K!).

Note: Very similar to the following species, also distributed in Sind, Pakistan, and probably not specifically distinct.

***Pulicaria carnosa*** (Boiss.) A. Anderb. in Pl. Syst. Evol. 176: 110. 1991  $\equiv$  *Platychaete carnosa* Boiss., Diagn. Pl. Orient., ser. 2, 3: 10. 1856.

$\equiv$  *Pulicaria hookeri* Jafri, Fl. Karachi: 336. 1966  $\equiv$  *Pulicaria stocksii* Hook. f., Fl. Brit. Ind. 3: 300. 1881, nom. illeg. [non Boiss, Diagn. Pl. Orient., ser. 2, 3: 16. 1856]. – Holotype: Scinde, *Stocks* (K!).

Note: According to Jafri (1966) and Stewart (1972) *P. hookeri* is doubtfully distinct from *P. glaucescens*, but I find it actually conspecific with *P. carnosa*.

***Pulicaria edmondsonii*** Gamal-Eldin in Notes Roy. Bot. Gard. Edinburgh 41: 467. 1984.

Note: Hitherto considered as endemic to N Oman (Gamal-Eldin 1984, Ghazanfar 1992, Heller & Heyn 1993) but also present in the U.A.E. and the Musandam Peninsula in Oman: UAE: NE of Al Hair, 27.4.1984, *Western* 664 (E), Dubai, Haffa - Huwailat Rd, 23.6.1983, *Western* 613 (E); Dubai, J. Hafir, 500-800 m, 11.3.1986, *Müller-Hohenstein* 86130 (E). – Oman, Musandam: 25°48'N, 56°12'E, 1200 m, 2.1985, *Hughes Clarke* 39 (E); *ibid.*, 600ft, 12.3.1978, *Munton* 26 (K).

***Pulicaria gamal-eldinae*** N. Kilian & P. Hein

***Pulicaria glaucescens*** (Boiss.) Jaub. & Spach, Ill. Pl. Orient. 4: 79. 1852  $\equiv$  *Platychaete glaucescens* (Boiss.) Boiss., Diagn. Pl. Orient., ser. 1, 11: 5. 1849  $\equiv$  *Pterochaete glaucescens* Boiss., Diagn. Pl. Orient., ser. 1, 6: 78. 1846.

$\equiv$  *Platychaete sublanata* Bormm. in Beih. Bot. Centralbl. 59B: 298. 1939 (fide Rechinger 1980: 124).

### ***Pulicaria adenophora* group**

***Pulicaria adenophora*** Franch. in Revoil, Faune Flore Pays Çomalis: 37. 1882  $\equiv$  *Sclerostephane adenophora* (Franch.) Chiov., Fl. Somala 1: 202. 1929.

*Pulicaria collenettei* (Wagenitz & Gamal-Eldin) N. Kilian, **comb. nova**  $\equiv$  *Sclerostephane collenettei* Wagenitz & Gamal-Eldin in Bot. Jahrb. Syst. 104: 105. 1983.

*Pulicaria discoidea* (Chiov.) N. Kilian, **comb. nova**  $\equiv$  *Sclerostephane discoidea* Chiov., Fl. Somalia 1: 201. 1929.

*Pulicaria hildebrandtii* Vatke in Österr. Bot. Z. 25: 326. 1875  $\equiv$  *Sclerostephane hildebrandtii* (Vatke) Gamal-Eldin, Phanerogam. Monogr. 14: 296. 1981.

Note: Apparently closely related to *P. adenophora* and, perhaps, not specifically distinct.

*Pulicaria longifolia* (Wagenitz & Gamal-Eldin) N. Kilian, **comb. nova**  $\equiv$  *Sclerostephane longifolia* Wagenitz & Gamal-Eldin in Bot. Jahrb. Syst. 104: 106. 1983.

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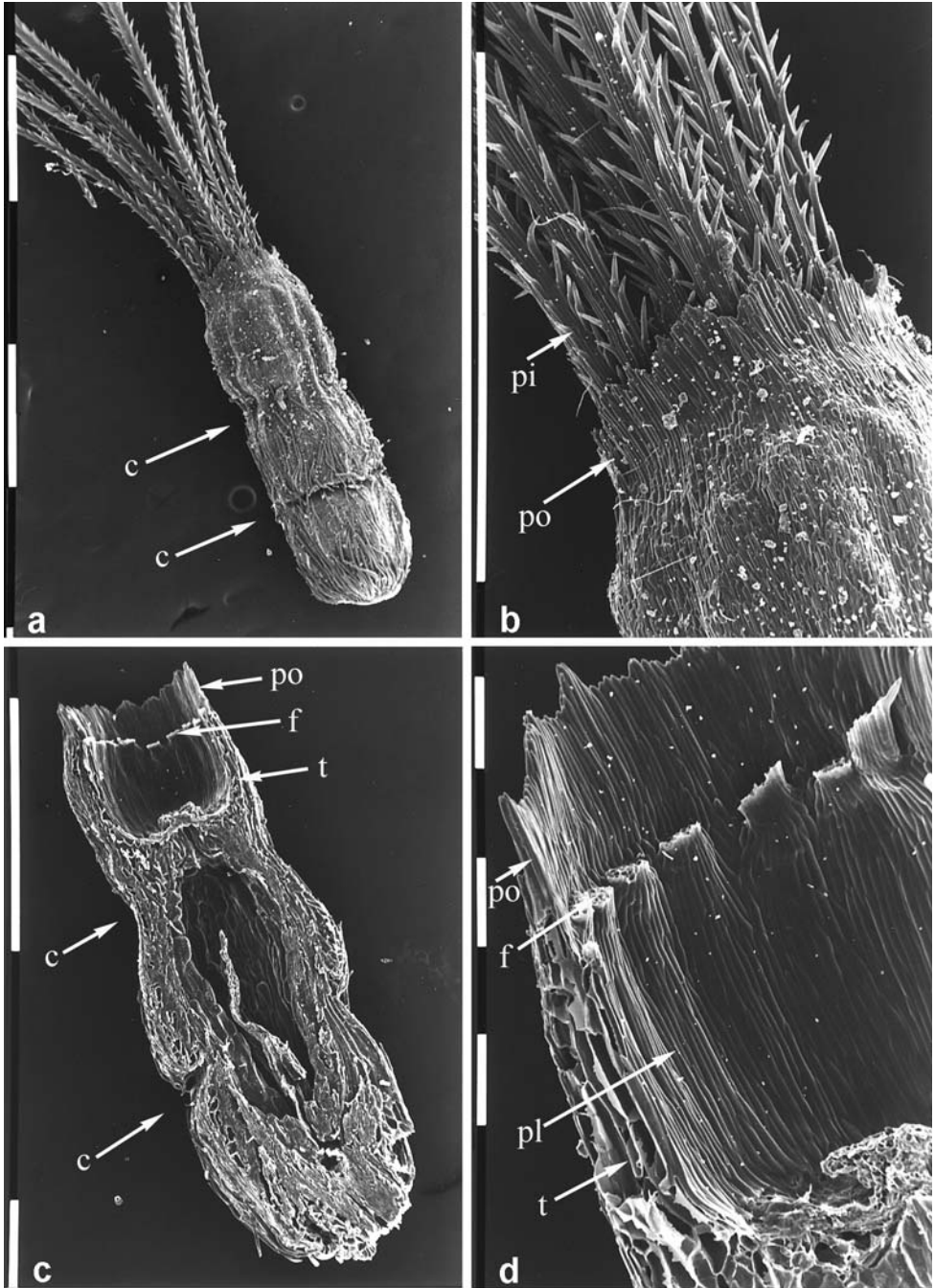


Fig. 2. *Pulicaria adenophora* ( $\equiv$  *Sclerostephane adenophora*), SEM micrographs of achenes – a: overview; b: achene apex; c: longitudinal section; d: detail of the apical tube in longitudinal section. – Scale a-c = 1 mm, d = 0.1 mm; c = constriction, pi = inner pappus, po = outer pappus, f = fracture zone of pappus bristles, t = apical tube wall, pl = pappus tissue lining inside of tube; specimen: Somalia, Quandala, 15.3.1989, Gabriel (B).

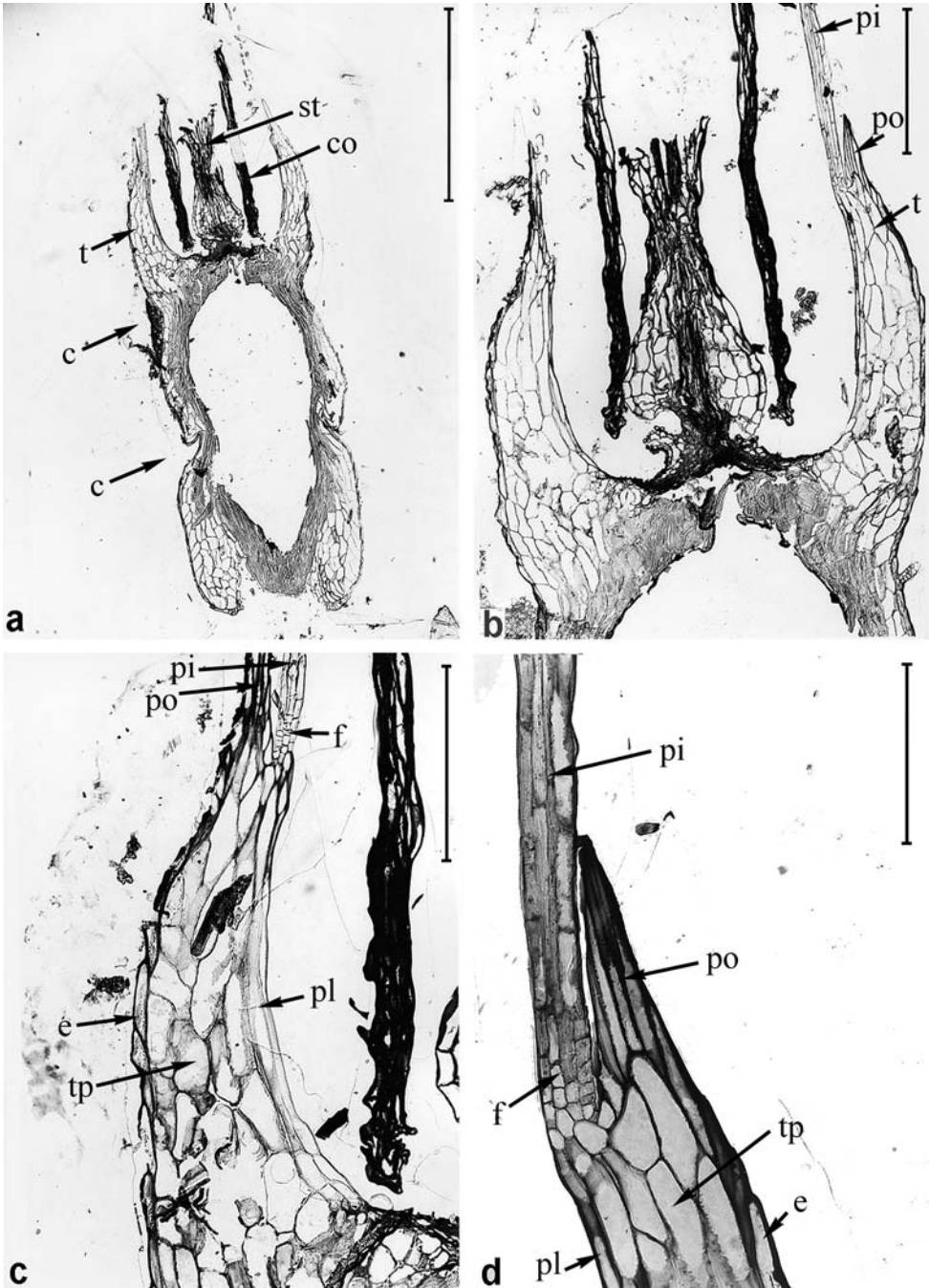


Fig. 3. *Pulicaria adenophora* ( $\equiv$  *Sclerostephane adenophora*), longitudinal microtome sections of achenes – a: overview; b: apical tube in detail; c-d: tube wall (c) and tube wall apex (d) with inner and outer pappus. – Scale: a = 1 mm, b = 0.3 mm, c: 0.2 mm, d: 0.1 mm; c = constriction, t = apical tube, st = style, co = corolla, po = outer pappus, pi = inner pappus, f = fracture zone of pappus bristles, e = epidermis, tp = tube parenchyma, pl = pappus tissue lining inside of tube; specimen: Somalia, Quandala, 15.3.1989, *Gabriel* (B).

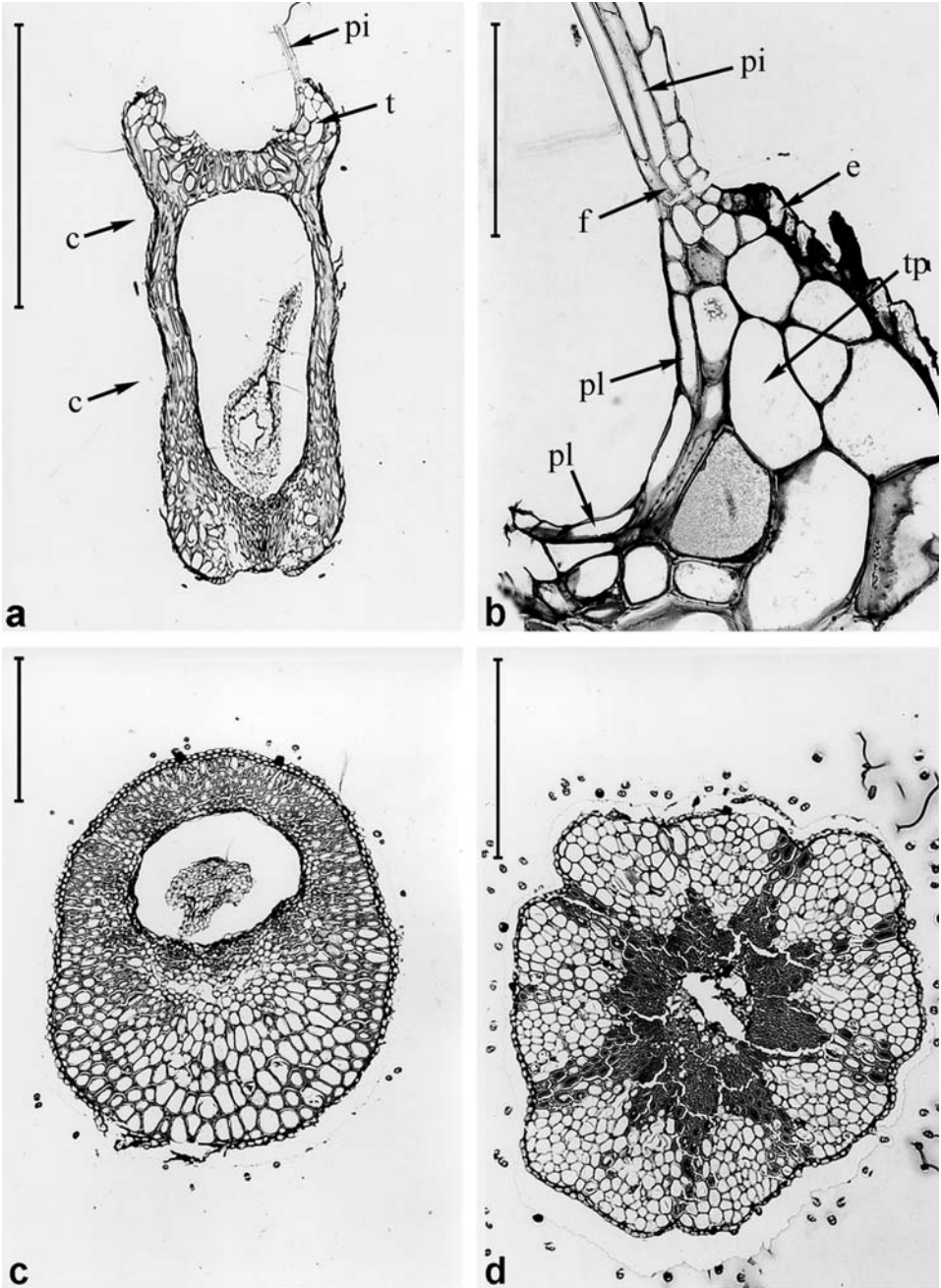


Fig. 4. Microtome sections of achenes of *Pulicaria longifolia* ( $\equiv$  *Sclerostephane longifolia*) (a-c) and *P. adenophora* ( $\equiv$  *S. adenophora*) (d) – a-b: longitudinal sections, overview (a), apical tube with inner pappus (b); c-d: cross section in basal third. – Scale: a= 1 mm, b= 0.1 mm, c-d= 0.3 mm; c = constriction, pi = inner pappus, t = apical tube, f = fracture zone of pappus bristles, pl = pappus tissue lining inside of tube, e = epidermis, tp = tube parenchyma; specimens: a-c: Somalia, Kalabeit, 4.12.1987, *Gabriel* (B); d: Somalia, Quandala, 15.3.1989, *Gabriel* (B).

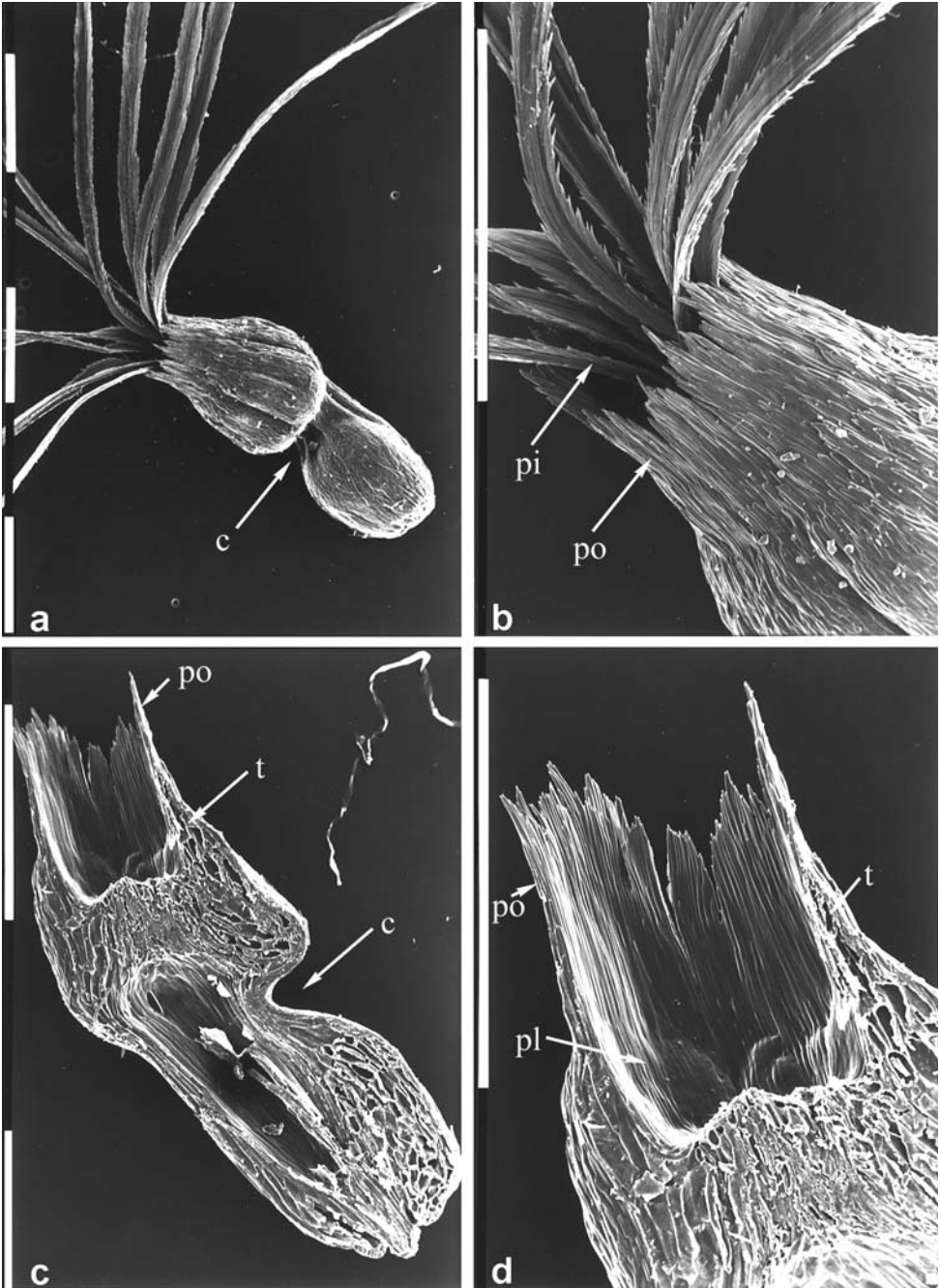


Fig. 5. *Pulicaria gamal-eldinae*, SEM micrographs of achenes – a: overview; b: achene apex with inner and outer pappus; c: achene in longitudinal section; d: detail of apical tube in longitudinal section. – Scale: 1 mm; c = constriction, po = outer pappus, pi = inner pappus, t = apical tube, pl = pappus lining inside of tube; specimen: Kilian, Ghazanfar & Hein NK 5166 (B).

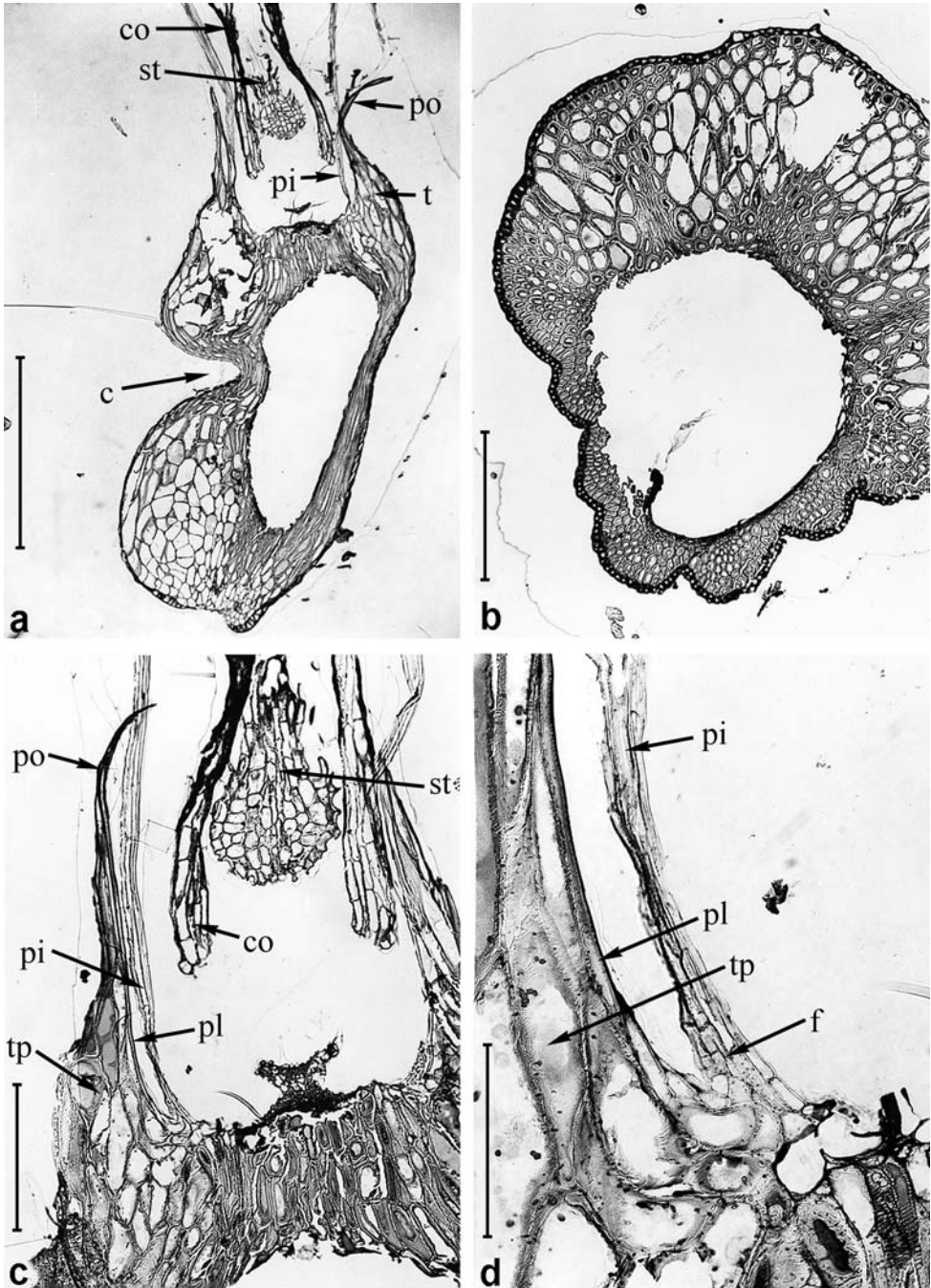


Fig. 6. *Pulicaria gamal-eldinae*, longitudinal (a, c-d) and transverse (b) microtome sections of achenes – a: overview; b: section above the constriction; c: apical tube; d: tube wall with inner pappus. – Scale: a = 1 mm, b-c = 0.3 mm, d = 0.1 mm; co = corolla, st = style, po = outer pappus, pi = inner pappus, t = apical tube, c = constriction, tp = tube parenchyma, pl = pappus lining inside of tube, f = fracture zone of pappus bristles; specimen: Kilian, Ghazanfar & Hein NK 5166 (B).



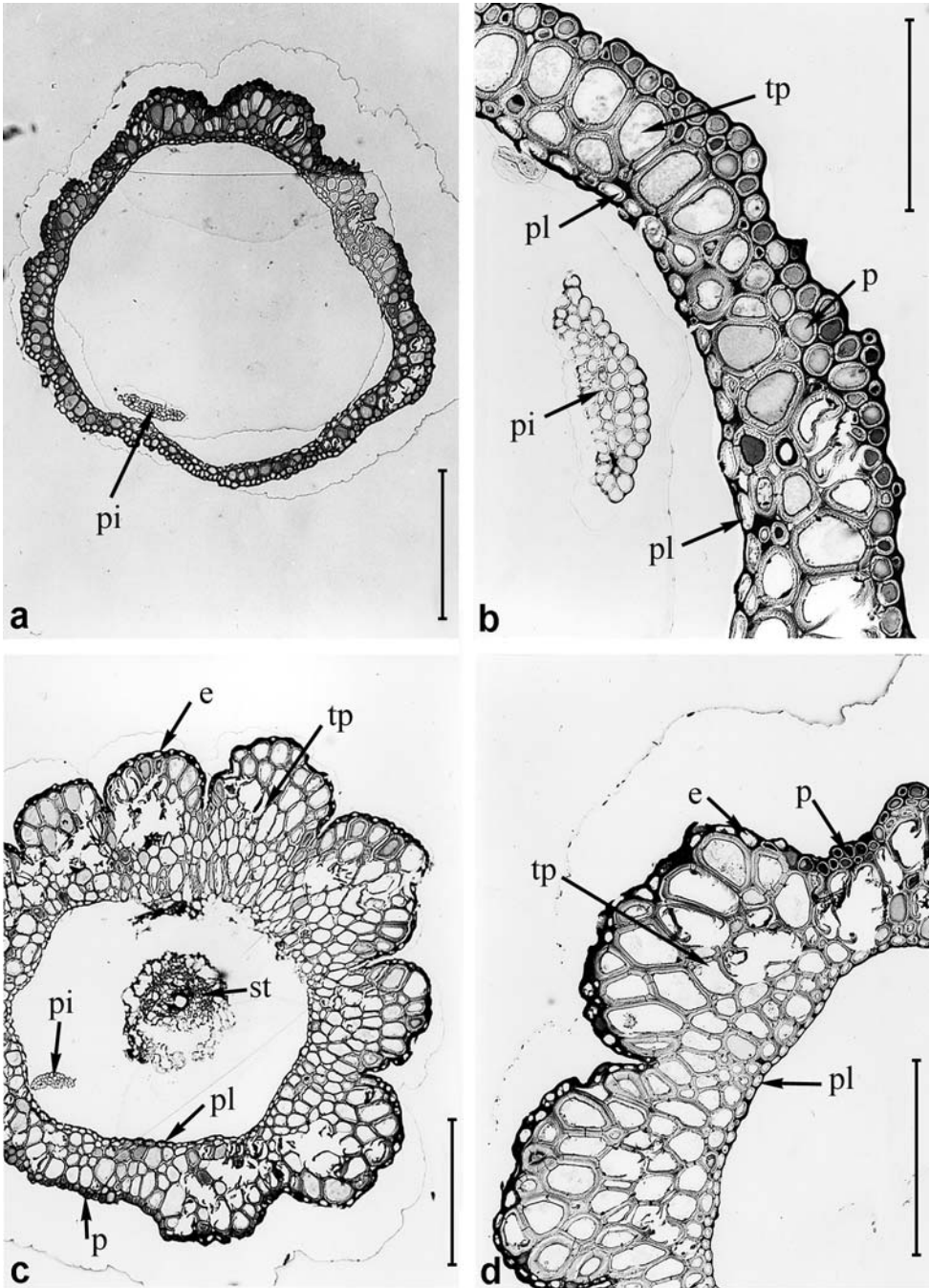


Fig. 7. *Pulicaria gamal-eldinae*, transverse microtome sections of the apical tube of the achene – a-b: near the apical edge; c-d: near the base. – Scale: a,c = 0.3 mm, b = 0.1 mm, d = 0.2 mm; pi = inner pappus, pl = pappus tissue lining inside of tube, p = pappus tissue; tp = tube parenchyma, e = epidermis, st = style; specimen: Kilian, Ghazanfar & Hein NK 5166 (B).

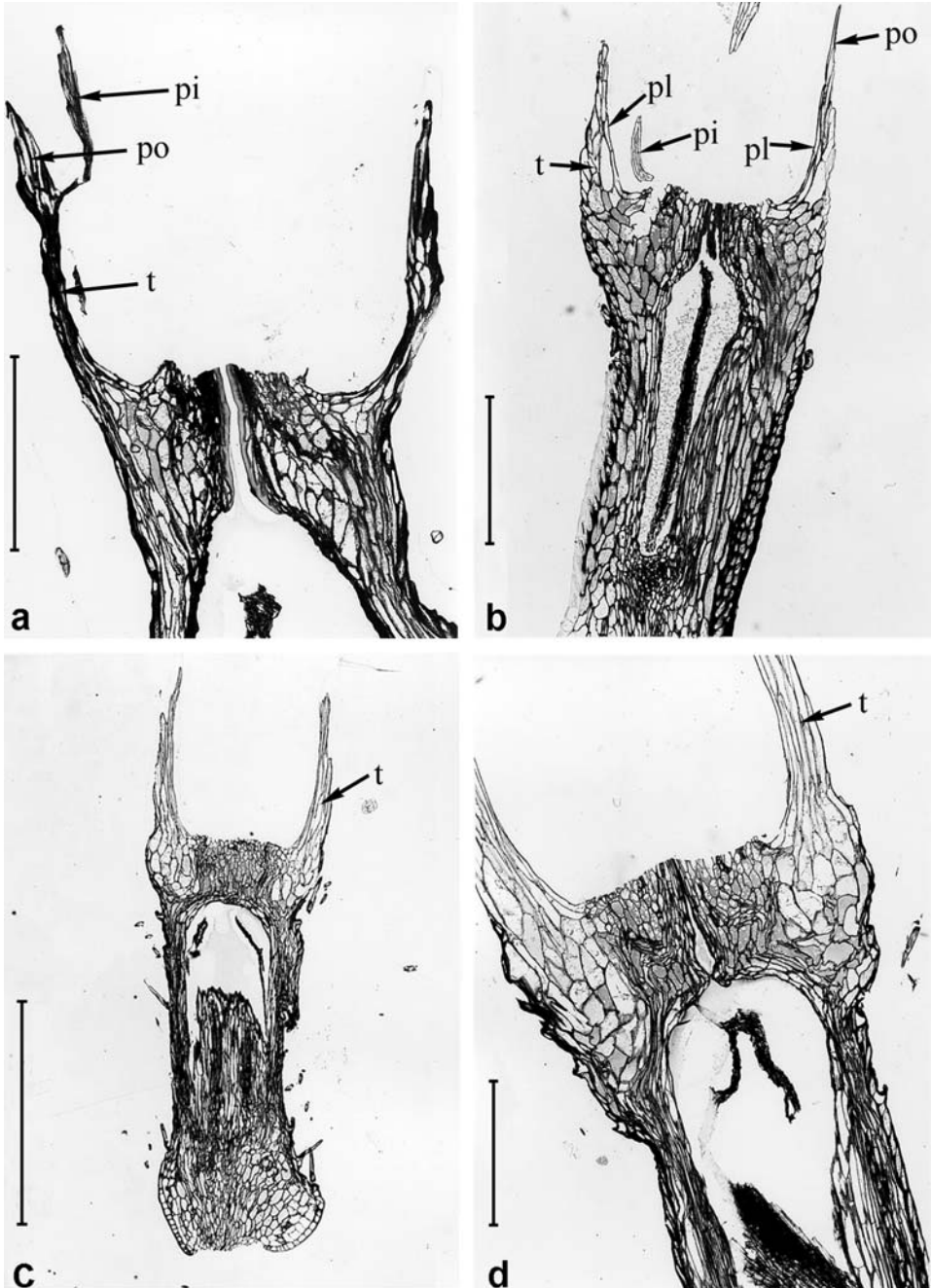


Fig. 8. Longitudinal microtome sections of immature achenes of *Pulicaria adenophora* ( $\equiv$  *Sclerostephane adenophora*) (a) and *P. gamal-eldinae* (b-d) – a-b: achene of flower in bud; c-d: achene of flower at anthesis. – Scale: a = 0.2 mm, b,d = 0.3 mm, c = 1 mm; t = apical tube, po = outer pappus, pi = inner pappus, pl = pappus tissue lining inside of tube; specimens: a: Somalia, Al Mado, Al Madjihan, c. 800 m, 10.3.1988, *Gabriel* (B); b: *Hein, Ghazanfar & Kilian PH 4847b* (B); c-d: *Hein, Ghazanfar & Kilian PH 5098* (B).

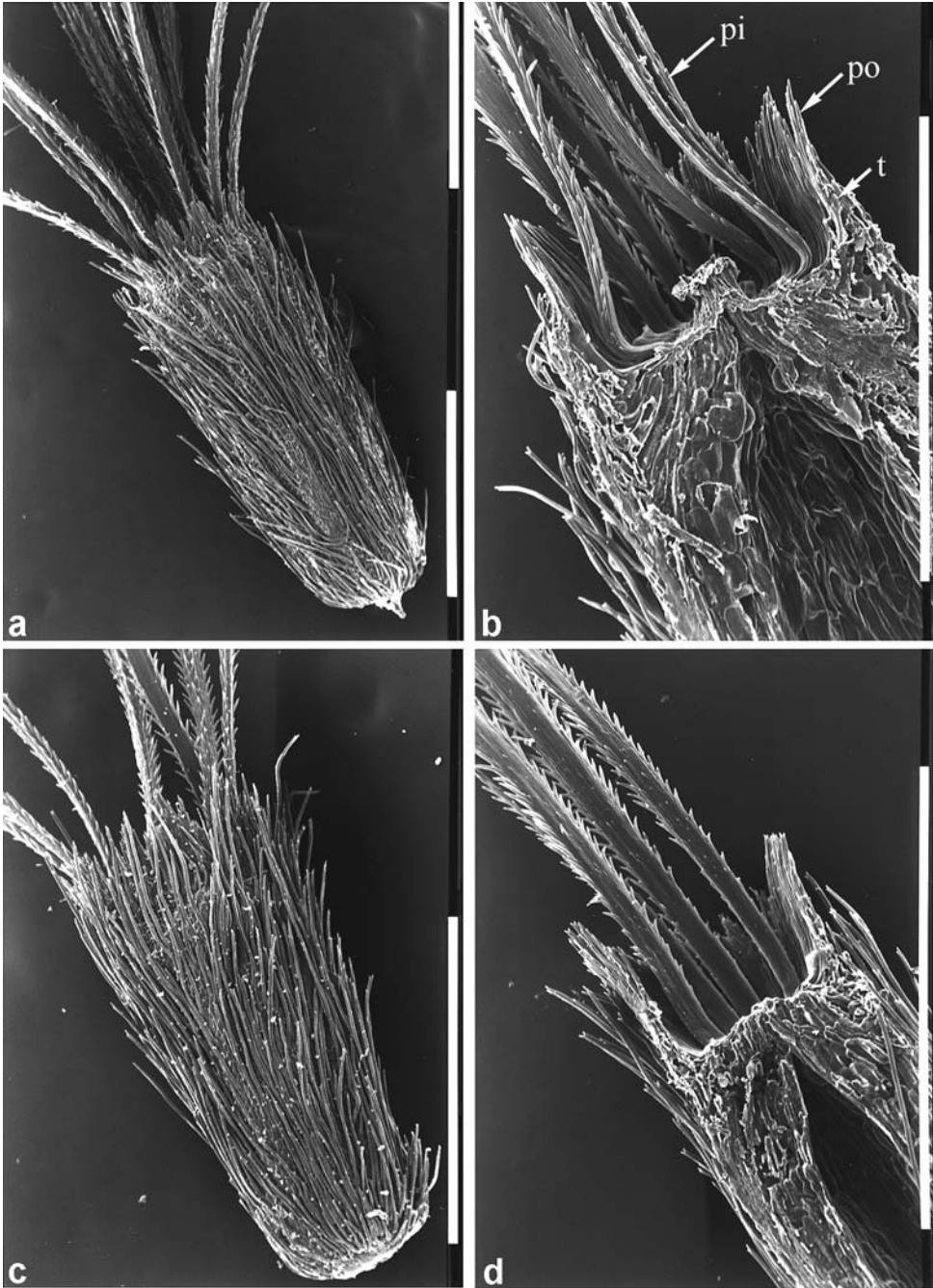


Fig. 9. SEM micrographs of achenes in overview (a,c) and longitudinal section with apex, apical tube and pappus in detail – a-b: *Pulicaria glaucescens*; c-d: *P. carnosus* – Scale: 1 mm; specimens: a-b: Iran, Baluchistan, 74-100 km a bifurcatione viae Khasch-Iranshar versus Bazman, 1600 m, 29.4.1977, *Rechinger 54950* (B); c-d: Pakistan, Cape Monze W of Karachi, 6.4.1965, *Rechinger 27522* (B).

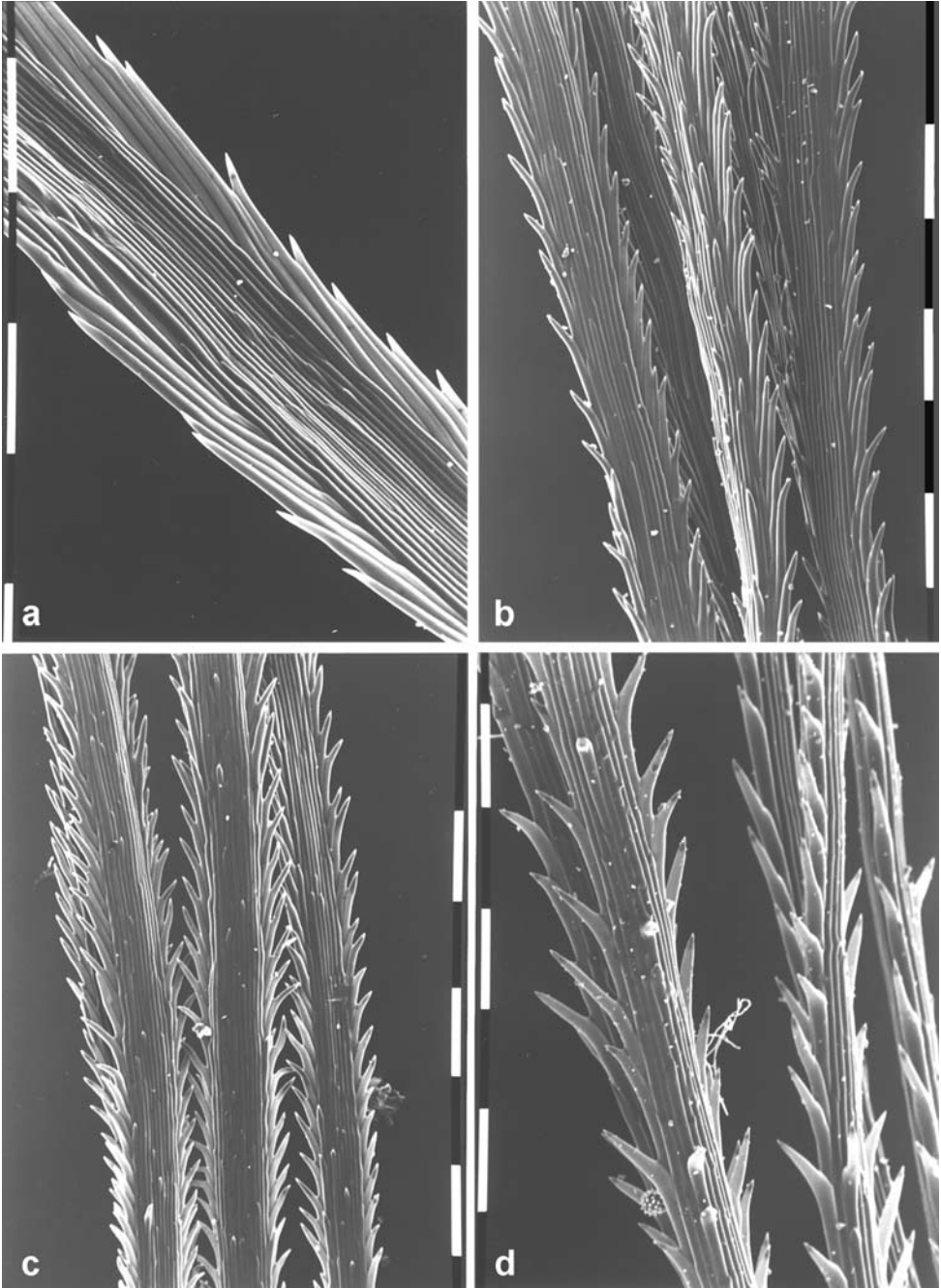


Fig. 10. Pappus bristles (middle third) in detail – a: *Pulicaria gamal-eldinae*; b: *P. glaucescens*; c: *P. carnososa*; d: *P. adenophora* ( $\equiv$  *Sclerostephane adenophora*). – Scale: 0.1 mm; specimens: a: Kilian, Ghazanfar & Hein NK 5166 (B); b: see caption of Fig. 9, Rechinger54950 (B); c: see caption of Fig. 9, Rechinger 27522 (B); d: see caption of Fig. 2, Gabriel (B).