

Micromorphological Characters of Fruits of Some *Anchusa* L. (Boraginaceae) Species from Turkey

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Abstract

Six taxa of *Anchusa* L. collected from Northern Turkey were investigated to evaluate the taxonomic importance of fruit morphology using scanning electron microscopy (SEM). This study shows that the mericarps commonly called “nutlets” are obliquely ovoid to oblong ovoid with an acute lateral beak and a thick basal areole. In *Anchusa azurea* Miller var. *azurea* erect a mericarp with rounded apex is typical. This species can be discriminated by the size of mericarp (2.0-4.5×5.0-9.0 mm). In all the taxa, the coat surface showed a mixture of small, flattened papillae and tubercles with variable density depending on the taxa. In *A. azurea* var. *azurea* and *A. arvensis* (L.) Bieb. subsp. *orientalis* (L.) Nordh., the papillae was simple, while in the other taxa have a lobed, rosette-like shape. This can be used as a good taxonomic character. Because it shows significant differences between species.

Key words: *Anchusa*, fruit morphology, taxonomy, Turkey, SEM.

INTRODUCTION

Anchusa L. is one of the major genera of the Boraginaceae family which is distributed at the Mediterranean and extends through Europe, Western Asia and Tropical Africa [1]. It was reported that a total of 15 species of *Anchusa* belonging to six subgenus are present in Turkey; one species and two subspecies of them were known to be endemic [2]. *Anchusa* L. species are morphologically characterized by bracteate cymes, hypocrateriform corollas with a long tube, spreading limb and faucal scales at the throat and by mericarp with ventral attachment to a gynobase [3-5]

The great form diversity present in this heterogeneous genus and the variation of several characters with potentially taxonomic value leads to variable interpretations [1, 6-9]. Guşuleac's morphological studies resulted in the well-supported separation at the genus level [10-12]. He further subdivided *Anchusa* L. into six subgenera: *Cynoglottis*, *Lycopsis*, *Buglossum*, *Buglossellum*, *Buglossoides* and *Anchusa*. However, this system was not followed by later authors regarding flora investigations [4, 13]. Recent studies related with micromorphology, palynology and karyology of *Anchusa* have widely supported Guşuleac's generic treatment [14-16]. Furthermore it was determined that *Cynoglottis* (Guşul.) Vural&Kit Tan and *Anchusella* Bigazzi, Nardi&Selvi, the latter originally described as *Anchusa* subgenus *Rivinia* Greuter, appeared as separate genera in view of their features [17-18]. The presence of only two fertile stamens and reduction of the basal mericarp rim as well as other characters in flower structure supported the institution of the new genus *Anchusella*, consisting of *A. variegata* and *A. cretica* [18].

The fruits of Boraginaceae have been used by most of the authors to describe and classify tribes, genera and also

subgeneric taxa [10-12, 14-16, 18-20]. It was reported that peculiar fruit shapes are especially found in *Anchusa* and of the related genera *Anchusella*, *Hormuzakia*, *Cynoglottis* and *Pentaglottis*, providing a fundamental character for their separation in the genus rank [1]. Greuter [8] used macroscopic characters of the mericarps such as size, shape and colour in distinguishing different taxa of *Anchusa* L. The ornamentation of the mericarp surface is usually considered as a reliable systematic character within the tribe Boragineae [18]. Selvi & Bigazzi [5] reported that the sculpturing pattern of the coat surface is slightly variable between the subgenera. In a recent paper, Bigazzi & Selvi [15] determined that the mericarp of *A. samothracica* showed a prominent reticulation and a coat surface with lobed papillae, which displayed more conspicuous, spinescent tubercles. So far, there have been a few attempts to study the mericarp morphology in *Anchusa* using scanning electron microscopy. No studies have been conducted to assess taxonomic differences in most of *Anchusa* taxa, including those encountered in the Northeast Anatolian region of Turkey. The aim of this study was to provide a description of mericarp morphological diversity through a comparative analysis of material collected in Northern Turkey in order to establish their usefulness for future taxonomic works.

MATERIALS AND METHODS

Mature fruits from five *Anchusa* species were freshly collected at flowering stage during 2004-2005 from different locations around Samsun, located in Northern Anatolia, Turkey.

Sample specimens are stored at the Herbarium of the Department of Biology (OMUB) at the University of Ondokuz Mayıs, Turkey. Measurements and optical observations of

Table 1. Main characters found for taxa of six *Anchusa* on the basis of mericarp morphology.

Species/ Character	<i>A. leptophylla</i> subsp. <i>leptophylla</i>	<i>A. leptophylla</i> subsp. <i>incana</i>	<i>A. undulata</i> subsp. <i>hybrida</i>	<i>A. azurea</i> var. <i>azurea</i>	<i>A. pusilla</i>	<i>A. arvensis</i> sub sp. <i>orientalis</i>
Shape of the mericarp	Obliquely-ovoid	Obliquely-ovoid	Obliquely-ovoid	Oblong-ovoid	Obliquely-ovoid	Obliquely-ovoid
Length of the mericarp (mm)	2.0-3.5	2.0-3.5	1.5-3.0	5.0-9.0	3.0-4.0	1.5-2.0
Width of the mericarp (mm)	2.5-5.5	2.0-4.0	2.0-3.5	2.0-4.5	2.5-4.0	2.0-2.5
Colour of the mericarp surface	Greyish-brown	Greyish-brown	Pale-brown	Greyish-brown	Greyish-brown	Pale-brown
Presence of lateral beak	Distinct	Distinct	Distinct	Absent	Distinct	Distinct
Presence of basal areole	Thickened Not prominent	Thickened Not prominent	Thickened Not prominent	Thickened Prominent	Thickened Prominent	Thickened Prominent
The reticulation of costae	With conspicuous protrusions	With conspicuous protrusions	With more conspicuous protrusions	Thinner ridges parallel to main axis	With flattened ridges	With conspicuous protrusions
Shape of papillae and tubercles in the coat surface	Rosette-like	Rosette-like	Rosette-like	Flattened and simple	Rosette-like	Mostly unicellular and multicellular

mericarp colours were carried by using stereomicroscope trademark Leica. For scanning electron microscopy, dry mature mericarps were directly mounted on stubles using single-side adhesive tape and sputter-coated with gold. The prepared specimens were examined and photographed on a JEOL-JSM 6400 model SEM. Seed structure terminology were adapted from Barthlott [21-22].

Examined Specimens

A5 Amasya: Köle Mazar, 350 m, 04.vii.2004, Ulu 147; A5 Samsun: Karadağ, Doruk village, 900 m, 29. vii. 2005, Ulu 304 ; A6 Samsun: Gelemen, 10 m, 17.v. 2004, Ulu 010; A6 Samsun: Tekkeköy, 25 m, 12.vii.2005, Ulu 261; A5 Samsun: near Karadağ, Ahmetsaray village, 800 m, 02.vi. 2004, Ulu 272; A5 Samsun; Tekkeköy, 7 m, 09.v. 2005, Ulu 204.

RESULTS AND DISCUSSION

Among the examined taxa, two basic morphological mericarp types could be distinguished: Obliquely-ovoid with lateral beak and oblong- ovoid with rounded apex. Both showed a wide range of seed coat surface sculpturing patterns (simple, tuberculate, lobed rosette- like). The main differences regarding studied characters are shown in Table 1. In all here considered taxa the mericarps are obliquely-ovoid and bears a lateral beak and thick basal ring (Figure 1 a-f). Unlike the other investigated *Anchusa* species, SEM observations showed that *A. azurea* var. *azurea* had a oblong-ovoid mericarp (Figure 1d). Erect mericarp (longer than wide) (2.0-4.5x5.0-9.0mm) with almost parallel sides and rounded apex are typical for *A. azurea* (Figure 1d and Table 1). These results supported the assumption of Selvi & Bigazzi [5] that the mericarp of *A. azurea* is rather typical longer than wide.

Greuter [8] used the mericarp colour to distinguish *A. cretica* from *Lycopsis variegata*. However, in all the investigated taxa the colour of mericarp surface differed greyish-brown or pale-brown (Table 1). Therefore the colour of mericarp was not

used as diagnostic character to distinguish *Anchusa* species in this study.

It was reported that in *Anchusa*, the single mericarp usually bears a lateral beak and a thick basal ring [1]. In all the taxa except for *A. azurea* var. *azurea*, the mericarp have a lateral beak (Figure 1d). In *A. azurea* var. *azurea*, the mericarp was typical straight and rounded apex. The other investigated taxa have nutlets with a lateral beak (Figure 1 a-c, e-f).

The reticulation of costae was used by Selvi & Bigazzi [5] to distinguish *A. azurea* from other *Anchusa* species and was considered by Bigazzi et al. [18] as the important feature of *Anchusa* mericarps. The coat surface in *A. azurea* var. *azurea* was characterized by secondary thinner ridges parallel to the main axis (Figure 1d). In *A. arvensis* subsp. *orientalis*, *A. undulata* subsp. *hybrida*, *A. leptophylla* subsp. *leptophylla* and *A. leptophylla* subsp. *incana*, the areas between adjacent ridges showed more conspicuous protrusions (Figure 1a-c, f). In *A. pusilla*, the mericarp had a reticulation of flattened ridges and prominent basal ring (Figure 1e).

The sculpturing pattern of coat surface was also helpful in the discrimination between investigated *Anchusa* species. The coat surface was covered with a small, flattened papillae and tubercles in most of the investigated taxa, but in *A. azurea* var. *azurea* and *A. arvensis* subsp. *orientalis*, only simple papillae was found (Figure 2 f, h). In *A. arvensis* subsp. *orientalis*, the occurrence of unicellular papillae was restricted to the ridges whereas the areas between adjacent ridges showed multicellular tubercles formed by fusion of several papillae (Figure 2 h). In contrast, in the other taxa they showed a lobed rosette-like shape (Figure 2 a-e, g). It was reported that most *Anchusa* species such as *A. officinalis*, *A. undulata* subsp. *hybrida*, *A. littora*, *A. capellii* and *A. formosa* have papilla with lobed, rosette-like shape [1]. These features can be used to distinguish some species, because *A. azurea* var. *azurea* and *A. arvensis* subsp. *orientalis* have simple and unicellular papillae. On the other hand, the mericarp of *A. azurea* var. *azurea* could be distinguished from any other investigated

species by the presence of simple papillae (Figure 2 f). Selvi & Bigazzi [1] determined that the coat surface of *A. azurea* is characterized by the presence of simple papillae. The coat surface of *A. leptophylla* subsp. *leptophylla* and *A. leptophylla*

subsp. *incana* was covered with lobed papillae, which are more conspicuous (Figure 2 a-d).

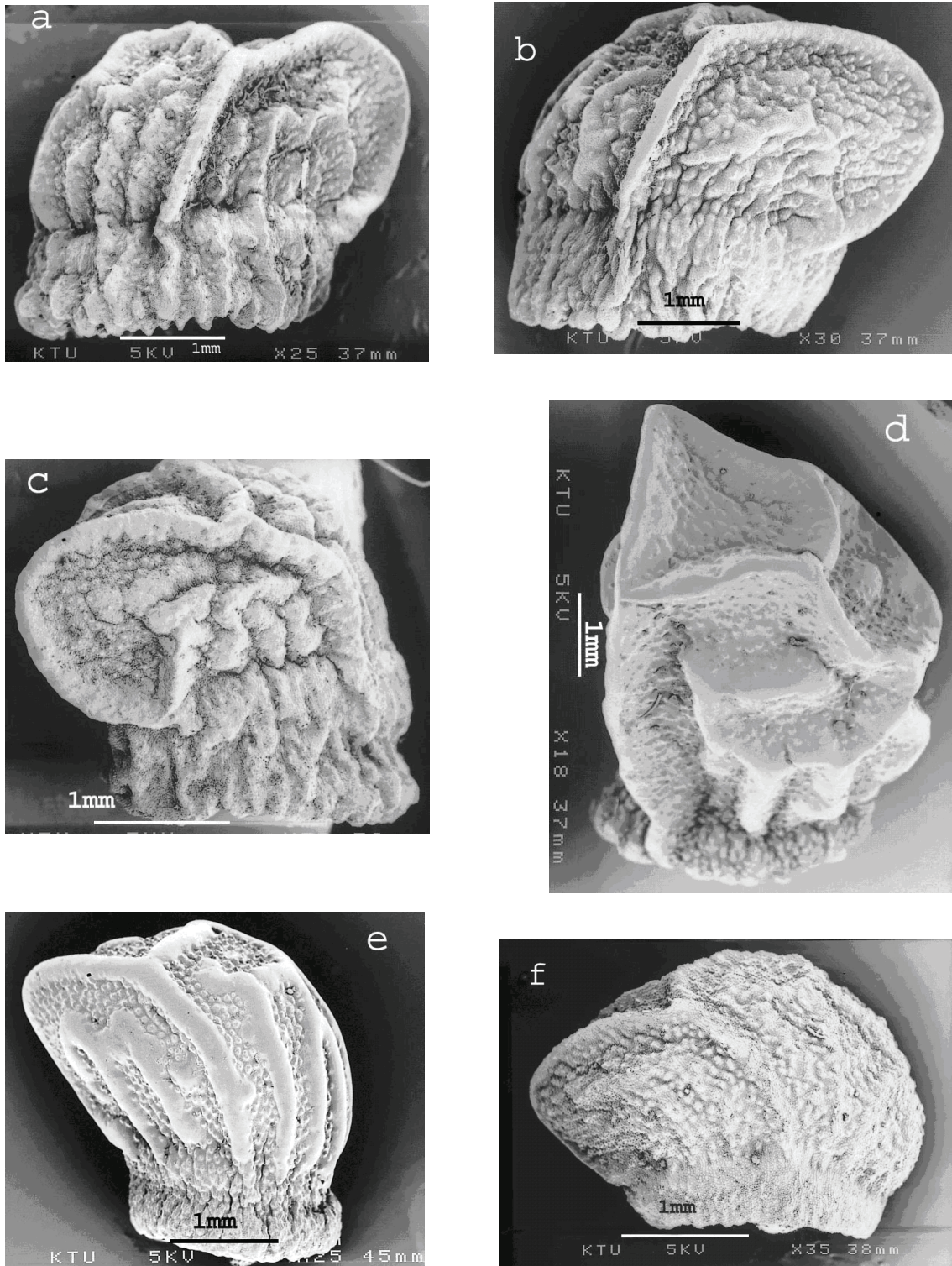


Fig.1. a-f. SEM micrographs of mericarps in lateral view. a) *A. leptophylla* subsp. *leptophylla* b) *A. leptophylla* subsp. *incana* c) *A. undulata* subsp. *hybrida* d) *A. azurea* var. *azurea* e) *A. pusilla* f) *A. arvensis* subsp. *orientalis*.

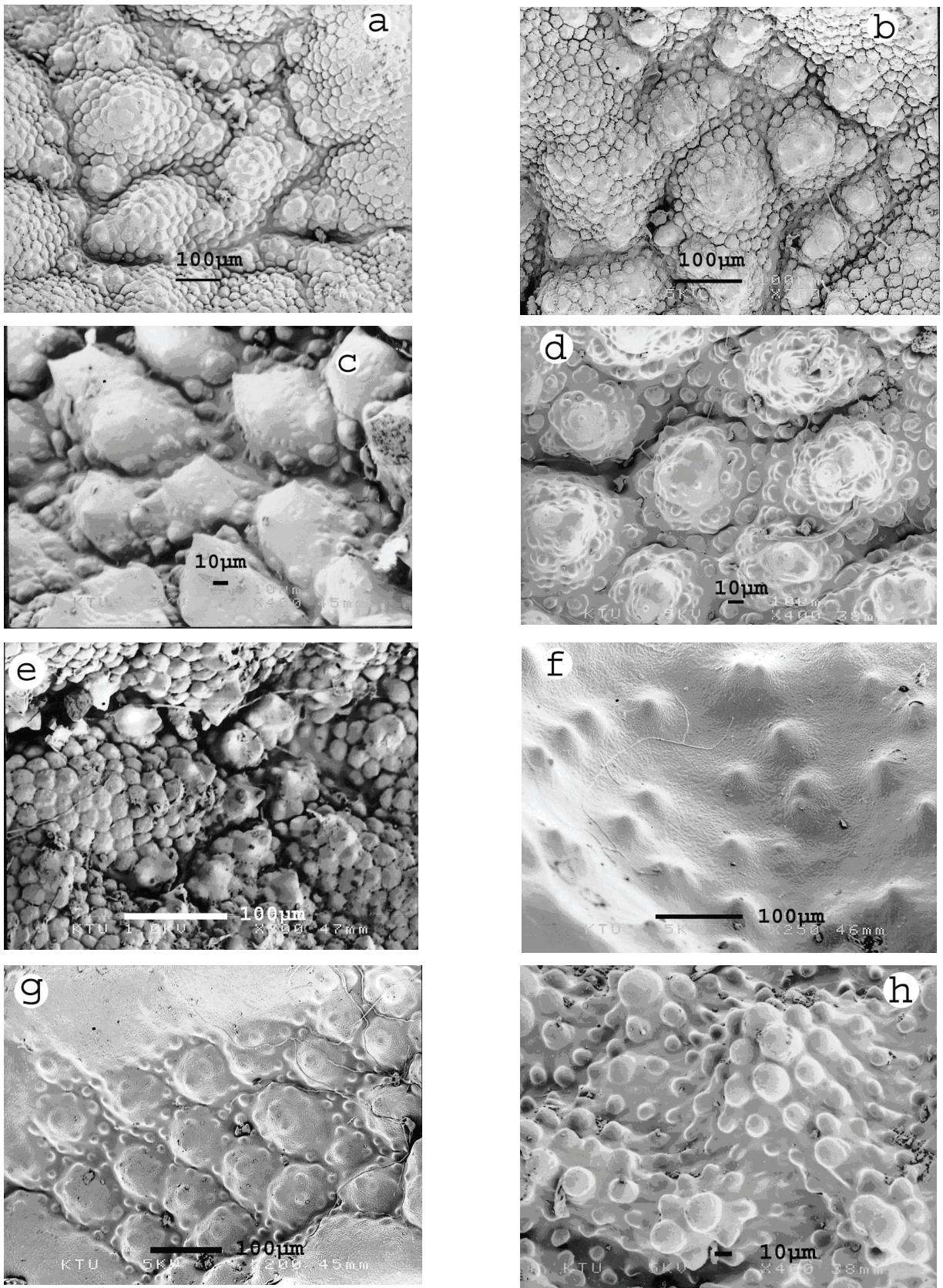


Figure 2 a-h. SEM micrographs of mericarps coat surfaces. a) *A. leptophylla* subsp. *leptophylla* b) *A. leptophylla* subsp. *incana* c) *A. leptophylla* subsp. *leptophylla* d) *A. leptophylla* subsp. *incana* e) *A. undulata* subsp. *hybrida* f) *A. azurea* var. *azurea* g) *A. pusilla* h) *A. arvensis* subsp. *orientalis*.

According to the present obtained data from the study, we conclude that mericarp characters are very useful for the identification of *Anchusa* species. Finally, it was determined that fruit morphology is a good character for taxonomic classification, because it showed significant differences among investigated species. We obtained that fruit morphology could help to clarify the systematics of other species in this genus.

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