

A SCANNING ELECTRON MICROSCOPE SURVEY OF THE LEMMA IN PHLEUM, PSEUDOPHLEUM AND RHIZOCEPHALUS (GRAMINEAE)

MUSA DOĞAN*

ABSTRACT. Micromorphological characteristics of the lemma in three closely related genera, namely *Phleum*, *Pseudophleum* and *Rhizocephalus*, are shown to be taxonomically significant at generic and infrageneric level. In *Phleum*, the recognition of four sections, *Phleum*, *Chilochloa*, *Maillea* and *Achnodon* is fully justified on the basis of information gathered with the help of the Scanning Electron Microscope (SEM).

INTRODUCTION

The genus *Phleum* L. was first described by Linnaeus in his *Species Plantarum* (1753); in *Flora Rossica*, Grisebach (1853) distinguished three sections, *Achnodon* Griseb., *Chilochloa* (Beauv.) Griseb. and *Euphleum* Griseb. in the genus *Phleum*. Boissier (1884) divided the genus into two groups, *Annua* and *Perennia*, on the basis of habit. Boissier also recognized the monotypic genus *Maillea* Boiss. next to *Phleum*. In the work of Graebner & Acherson (1902), the previously established sections, *Euphleum* and *Chilochloa*, were both recognized, and *Maillea* was accepted as an individual genus. Komarov *et al.* (1963) and Bor (1970) did not make significant changes to the infrageneric grouping of *Phleum*. Later, Tzvelev (1976—English translation 1984) made some changes to the infrageneric grouping by recognizing two sections, *Achnodon* and *Chilochloa* under the subgenus *Chilochloa* (Beauv.) Peterm. as well as subgenus *Phleum*. Recently, in *Flora Europaea* Vol. 5 (1980), four sections were recognized, three of which were those adopted by Tzvelev (*op. cit.* 1984) and a fourth, sect. *Maillea*, based on *Maillea crysoides* (d'Urv.) Bois. Table 1 shows the previous infrageneric groupings used by the above authors.

Boissier, in his *Diagnoses Pl. Orient. Nov. Ser. 1* (5):69 (1844) described another genus, *Rhizocephalus* (based on *R. orientalis* Boiss.) which is very close to *Phleum*, but differs in its protruding and terminally mucronate lemma. Doğan (1982) recently described a monotypic genus, *Pseudophleum* (based on *Phleum gibbum* Boiss.), which had been wrongly placed under *Phleum* group *Annua* by Boissier and since then, due to its very local distribution in Turkey, had not been thoroughly investigated. Recently, Clayton & Renvoize (1986) reduced *Pseudophleum* to a member of *Phleum*, but were unable to place it under any of the previously known sections.

Prat (1932) studied glumes and lemmas in a number of genera and illustrated some of the epidermal cell types. Baum (1971, 1980) investigated surface views of glumes, lemma and caryopsis in *Avena* L. and some other Triticoid genera by means of the SEM. Kaufman *et al.* (1972) investigated silicification patterns of inflorescence bracts (glumes,

*Department of Biology Education, Middle East Technical University, 06531 Ankara, Turkey.

TABLE I
Previous Infrageneric Classifications in *Phleum*.

Grisebach (1853)	Boissier (1884)	Graebner & Ascherson (1902)	Komarov <i>et al.</i> (1963)	Bor (1970)	Tutin <i>et al.</i> (1980)	Tzvelev (1984)
Sect. <i>Achnodon</i> <i>P. tenuue</i>	Group <i>Annua</i> <i>P. tenuue</i> <i>P. exaratum</i>	Sect. <i>Euphleum</i> <i>P. pratense</i> <i>P. alpinum</i>	Sect. <i>Achnodon</i> <i>P. tenuue</i>	Sect. <i>Achnodon</i> <i>P. subulatum</i>	Sect. <i>Phleum</i> <i>P. pratense</i> <i>P. alpinum</i>	Subgenus <i>Chilochloa</i>
Sect. <i>Chilochloa</i> <i>P. arenarium</i> <i>P. asperum</i> <i>P. boehmeri</i> <i>P. michelii</i>	<i>P. graecum</i> <i>P. arenarium</i> <i>P. asperum</i> <i>P. gibbum</i> <i>P. echinatum</i>	Sect. <i>Chilochloa</i> <i>P. boissieri</i> <i>P. arenarium</i> <i>P. boehmeri</i> <i>P. arenarium</i> <i>P. montanum</i>	Sect. <i>Chilochloa</i> <i>P. boissieri</i> <i>P. arenarium</i> <i>P. paniculatum</i> <i>P. graecum</i> <i>P. phleoides</i>	Sect. <i>Euphleum</i> <i>P. pratense</i> <i>P. alpinum</i> <i>P. montanum</i> <i>P. michelii</i> <i>P. montanum</i>	Sect. <i>Chilochloa</i> <i>P. bertolonii</i> <i>P. pratense</i> <i>P. paniculatum</i> <i>P. michelii</i> <i>P. montanum</i>	Sect. <i>Chilochloa</i> <i>P. hirsutum</i> <i>P. phleoides</i>
Sect. <i>Euphleum</i> <i>P. pratense</i> <i>P. alpinum</i>	Group <i>Perennia</i> <i>P. boehmeri</i> <i>P. michelii</i> <i>P. pratense</i> <i>P. alpinum</i>	<i>P. paniculatum</i> <i>P. subulatum</i>	<i>P. michelii</i> <i>P. paniculatum</i> <i>P. subulatum</i>	<i>P. montanum</i> <i>P. michelii</i> <i>P. phleoides</i>	Sect. <i>Chilochloa</i> <i>P. himalaicum</i> <i>P. paniculatum</i> <i>P. arenarium</i> <i>P. subulatum</i> <i>P. paniculatum</i>	Sect. <i>Achnodon</i> <i>P. himalaicum</i> <i>P. arenarium</i> <i>P. subulatum</i> <i>P. paniculatum</i> Subgenus <i>Phleum</i>
			Sect. <i>Euphleum</i> <i>P. echinatum</i> <i>P. pratense</i> <i>P. alpinum</i>	<i>P. himalaicum</i> <i>P. paniculatum</i> <i>P. exaratum</i> <i>P. boissieri</i>	Sect. <i>Chilochloa</i> <i>P. himalaicum</i> <i>P. paniculatum</i> <i>P. exaratum</i> <i>P. boissieri</i>	Sect. <i>Maillea</i> <i>P. crysoides</i> Sect. <i>Achnodon</i> <i>P. subulatum</i>

lemmas) of *Avena sativa* L. with the SEM. In the works of Hearle *et al.* (1973), Brisson & Peterson (1976) and Portek *et al.* (1980), all previously published major papers dealing with SEM works were brought together to give an overall picture of the subject matter.

The prime goal here is to look into the lemma texture of *Phleum* and its two neighbouring genera, *Pseudophleum* and *Rhizocephalus*, to see whether there are any micromorphological characters which can be used to support the delimitation of the taxa at generic and infrageneric levels.

MATERIALS AND METHODS

To study the micromorphology of the lemma at high magnification an SEM was used. In the preparation of a lemma for study, all lemmas were carefully dissected from authentically named specimens at Edinburgh (E) and mounted on the standard SEM stubs using double-sided sellotape. Specimens were coated with a thin layer of gold (c.10nm). The specimens and upper surface of double-sided sellotape were connected on the aluminium stub by the use of conductive silver paint (Electrodag 9/5 Acneson Colloids).

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EPIDERMAL CELL TYPE. There are two types of cell walls in these three genera: those in *Phleum* and *Rhizocephalus* are sinuate whilst those in *Pseudophleum* are sinuate but are provided with small globose projections at the corner of each fold (Fig. 1B). The presence of the globose projections is a valuable taxonomic character in distinguishing *Pseudophleum* from its neighbouring genera, *Phleum* and *Rhizocephalus*, in the tribe Phleaceae Dum.

EPIDERMAL HAIR TYPES. In *Phleum*, the hair type provides one of the most useful additional characters for the recognition of infrageneric groups and even for distinguishing closely related species. In *Phleum crysoides* (d'Urv.) Hackel ex Franchet (Fig. 2A), the lemma surface is completely glabrous, but in other species there are various types of hairs. In the highland species, *P. alpinum* L. (Fig. 1C, hair length 36–60µm), *Phleum pratense* L. (Fig. 1D, hair length 80–114µm), *Phleum bertolonii* DC. (Fig. 1E, hair length 20–66µm) and *Phleum montanum* C. Koch (Fig. 2C, hair length c.170µm), the hairs are more or less filiform but vary greatly in length from one species to another. *Phleum echinatum* Host (Fig. 1F) and *Phleum paniculatum* Hudson (Fig. 2B) have only slightly different hairs which are oblong-acute in *Phleum paniculatum* (hair length 53–114µm) and retrorsely curved in *Phleum echinatum* (hair length 23–34µm). The presence of these more or less similar hair types in these annual species might suggest that they once had an ancestor from high mountains. *Phleum arenarium* L. (Fig. 2D) grows in lowlands around the Mediterranean and has very dense hairs on its lemma surfaces. Its hair type is similar to that found in *Phleum pratense* (Fig. 1D), but its hairs are longer (hair length 280–533µm). *Phleum arenarium* might have an ancestor from high mountains like the previous two species. The remaining three Turkish species are all annuals and their distribution is confined mainly to

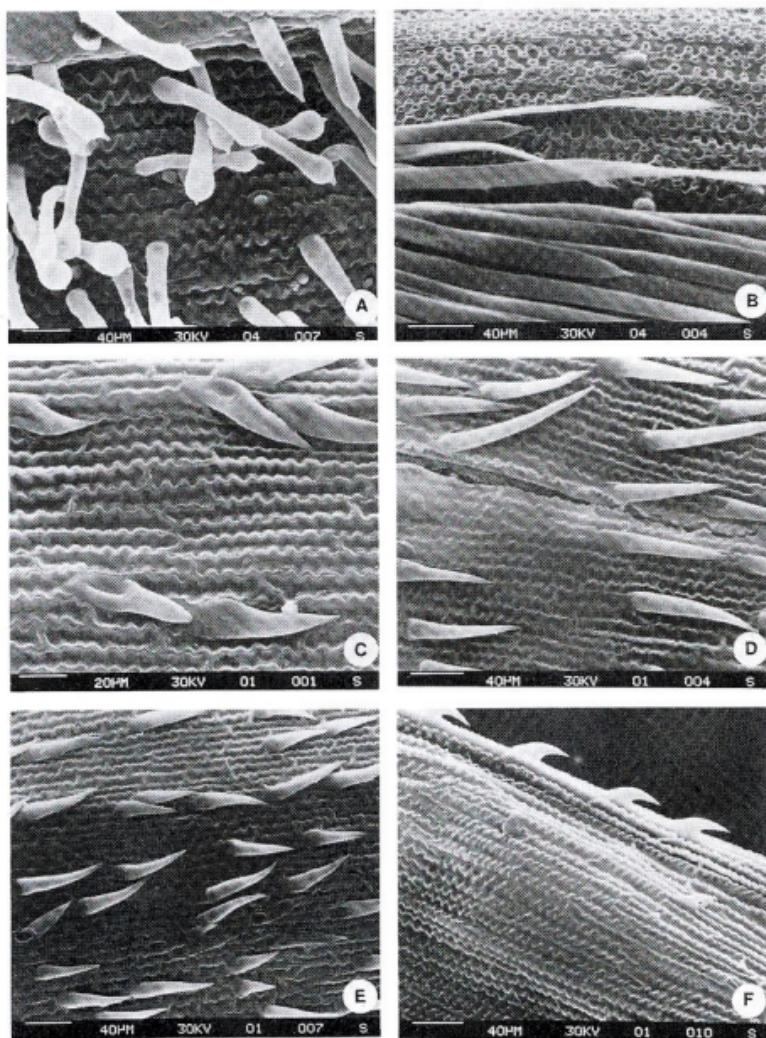


FIG. 1. A, *Rhizocephalus orientalis* (Coode & Jones 136). B, *Pseudophleum gibbum* (22 vi 1854, Balansa). C, *Phleum alpinum* (Duncan & Tait 34). D, *Phleum pratense* (Davis 47587). E, *Phleum bertolinii* (Aytug & Yaltirik 3309). F, *Phleum echinatum* (Noë 1486).

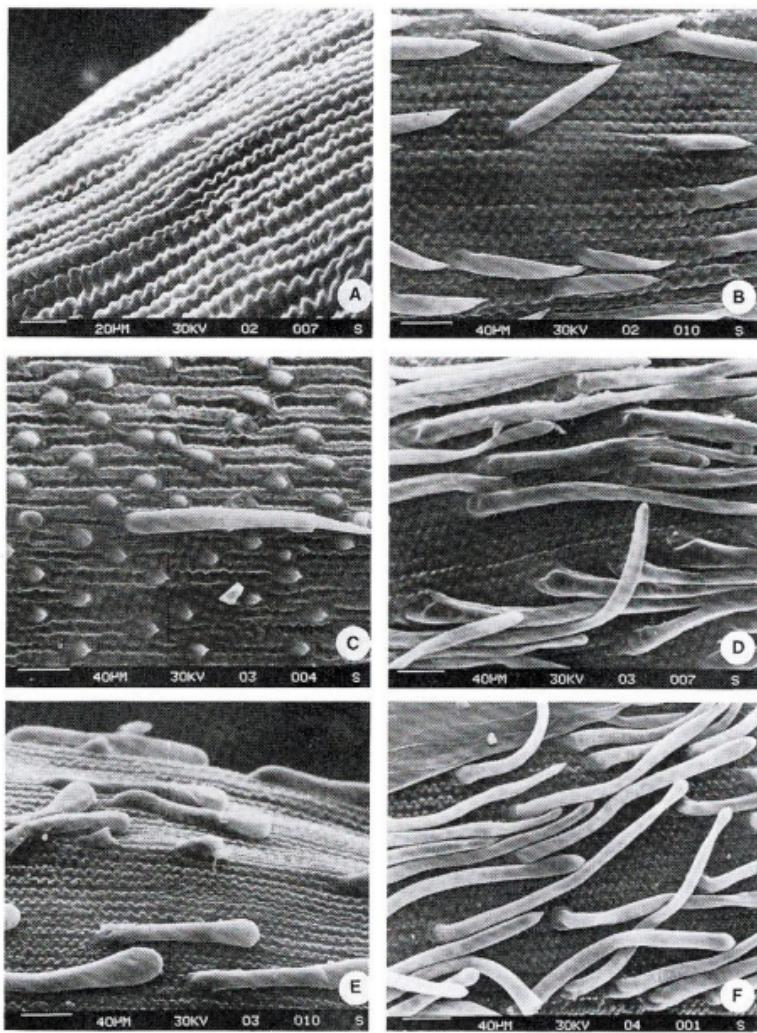


FIG. 2. A, *Phleum crysoides* (12 vii 1870, Bourgeau). B, *Phleum paniculatum* (Davis 33902). C, *Phleum montanum* (Dent 75). D, *Phleum arenarium* (13 v 1905, F. C. Crawford). E, *Phleum exaratum* (Akman 6622). F, *Phleum boissieri* (Davis & Hedge, D.28744).

lowlands around the Mediterranean. These three species have rather different hair types. The hairs are roughly orbicular in *Phleum subulatum* (Savi) Aschers. & Graebner (hair length 13–16 μ m), clavate in *Phleum exaratum* Host ex Griseb. (Fig. 2E, hair length 126–150 μ m), and long cylindrical but obtuse in *Phleum boissieri* Bornm. (Fig. 2F, hair length 213–266 μ m). In *Pseudophleum gibbum* (Boiss.) M. Doğan (Fig. 1B), the hairs resemble those of *Phleum boissieri* but are extremely long and pointed at the apex. In *Rhizocephalus orientalis* Boiss. (Fig. 1A), the hairs are clavate, pointed at the tip and c.106–120 μ m long.

CONCLUSIONS

In the genus *Phleum* micromorphological characters are combined together and used to make taxa as natural as possible. The previously recognized four sections, *Phleum*, *Chilochloa*, *Maillea* and *Achnodon* are accepted here as they were in Davis' *Flora of Turkey* (Doğan, 1985). The habit of the species has in the past caused some confusion in the infrageneric grouping. For example, Bor (1970) placed *Phleum iranicum* Bornm. & Gauba under section *Euphleum* (syn.: sect. *Phleum*), but its micromorphological characters are those of sect. *Chilochloa*. Section *Achnodon*, based on *Phleum tenue* (Host) Schrader (syn.: *Phleum subulatum*), includes in my opinion two more species, *Phleum exaratum* and *Phleum boissieri*, which were previously placed in sect. *Chilochloa* by Bor (op. cit. 1970) and Humphries in *Flora Europaea* Vol. 5 (1980).

However, the main findings of this review are based on the microscopical structure of the lemma surface and particularly its hair type. In sect. *Maillea*, the lemma surface is entirely glabrous, but in the three remaining sections the lemma is covered by hairs. The type of hairs supporting my treatment of the infrageneric grouping in *Phleum* are quite unique within each section, being either clavate as in sect. *Achnodon*, or tapering to a fine point in sect. *Phleum* and *Chilochloa*. Using the information gathered with the SEM and combining it with the characters observed using a hand lens, infrageneric grouping can be summarized as follows:

Sect. 1. *Phleum*

1. *P. pratense* (type of section)
2. *P. echinatum*
3. *P. alpinum*
4. *P. bertolonii*

Sect. 2. *Chilochloa* (Beauv.) Grisebach

1. *P. himaliacum*
2. *P. paniculatum*
3. *P. arenarium*
4. *P. phleoides* (type of section, as *Chilochloa boehmeri* Beauv.)
5. *P. montanum*
6. *P. hirsutum*
7. *P. iranicum*

Sect. 3. *Maillae* (Parl.) Horn af Rantzien
P. crysoides (type of section, as *Maillae crysoides* (d'Urv.)
 Boiss.)

Sect. 4. *Achnodon* Grisebach
 1. *P. exaratum*
 2. *P. boissieri*
 3. *P. subulatum* (type of section, as *Achnodon bellardii* (Will.)
 Link).

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