J. Phytogeogr. & Taxon.
38 : 69-77, 1990

Keshab R. RAJBHANDARI* : Epidermal Microstructures of the Lemma and Palea of *Poa* (Gramineae)

ケシャブ・R・ラジバンダリ*：イチゴツナギ属（イネ科）の内えいと外えいの表皮の微細構造

Abstract

The epidermal microstructures of the lemma and palea of sixty-two species of *Poa* were studied under a scanning electron microscope in order to examine their taxonomical significance. Long cells, hooks, prickles, macrohairs and stomata were found on the lemma and palea surfaces of *Poa*. In addition, silica cells were found in two species only, *Poa bulbosa* and *P. douglasii*. The surface structures of lemma and palea show that the species of *Poa* are closely linked and that the characteristics are similar to those of the other genera belonging to subfamily Pooideae, especilly in the absence of microhairs and papillae. However, the surface structures are not found to be helpful for distinguishing sections of *Poa*.

Key Words: Epidermal microstructure-Lemma-Palea-*Poa*-SEM

Poa L., belonging to Poeae tribe of subfamily Pooideae, is a grass genus of about 500 species (CLAYTON and RENVOIZE, 1986). It is distributed in the regions of high latitude and high altitude (HARTLEY, 1961). The taxonomy of *Poa* is said to be difficult (HITCHCOCK *et al.*, 1969 ; TATEOKA, 1985 ; CLAYTON and RENVOIZE, 1986). Previous taxonomic studies of this genus were primarily based on gross morphology. The surface structures of lemma and palea have been helpful to elucidate the taxonomic relationships of various genera, such as *Agrostis* and its related genera (BJÖRKMAN, 1960 ; RAJBHANDARI, 1985), *Panicum* and other genera of Paniceae (HSU, 1965 ; CLARK and GOULD, 1975 ; SHAW and GOULD,1979), *Eriochloa* (SHAW and SMEINS, 1981), *Ichnanthus* (SHAW and WEBSTER, 1983), *Ptilagrostis* (BARKWORTH, 1983), *Melica* and other genera (THOMASSON, 1986) and annual species of *Muhlenbergia* (PETERSON, 1989). During the taxonomic study of the species of *Poa* belonging to section *Ochlopoa*, CHRTEK and JIRÁSEK (1962) checked the surface structures of the palea of nine species under a light microscope. But no comparative studies of the epidermis of the lemma and palea of the genus *Poa* have been carried out so far.

The purpose of this study is to examine the taxonomical significance of the epidermal structures of the lemma and palea of *Poa*.

Materials and Methods

The materials used in this study (Table 1) were obtained from herbarium specimens of University of Tokyo (TI), National Science Museum, Tokyo (TNS), and the Department of Forestry and Plant Research, H. M. G. of Nepal (KATH). Sixty-two species of *Poa* were examined. In some cases one specimen and in the others two to ten specimens for each species were examined.

Three to ten mature spikelets from each specimen were taken for examination. Middle portion of the abaxial surface between the keel and lateral veins of lemmas and between the keels of paleae of the lowest florets of spikelets was observed. The materials were cleaned in acetone in an ultrasonic cleaner for two to three minutes, dried in air and mounted on aluminium stubs with double coated cellophane tape. They were coated with platinum in an Eiko IB-5 ion coater for 3

* Department of Botany, University Museum, University of Tokyo, Hongo 7-3-1, Bunkyo-ku, Tokyo 113, Japan. 〒113 文京区本郷 7-3-1 東京大学総合研究資料館 Present address: National Herbarium and Plant Laboratories, Department of Forestry and Plant Research, Godawari, Lalitpur, Nepal.

Table 1. List of the specimens of *Poa* examined.

Poa abbreviata R. Br.: USSR: *Petrovsky & Polozova* 6005 (TNS).
P. acroleuca Steud.: Japan: *Murata* 22180 (TI); *Nakajima* s. n. (TI); *Tateoka* 5002 (TNS).
P. alpina L.: Sweden: *Alm* 48 (TNS).
P. annua L.: USA: *Norberb* s. n. (TNS); *Shimizu et al.* 33529 (TI); Denmark: *Holm-Nielsen* 25 (TI); Nepal: *Rajbhandari* 7963 (KATH); *Rajbhandari* 7587 (KATH); *Rajbhandari & Roy* 3717 (KATH); China: *Tuyama* s. n. (TI); Japan: *Mizushima* s. n. (TI); *Honda* s. n. (TI); *Rajbhandari* J1 (TI).
P. arctica R. Br.: Sweden: *Samuelsson* 202 (TI); Norway: *Nannfeldt* 12991 (TNS); USSR: *Skvortsov et al.* 10746 (TI).
P. bactriana Roshev.: USSR: *Kamelyn* 639 (TNS); *Ienlu* 1763 (TNS).
P. bulbosa L.: Sweden: *Norrman* s. n. (TI); *Sterner* 207 (TI).
P. calliopsis Litw.: Nepal: *Rajbhandari* 8365 (KATH); Bhutan: *Kanai et al.* 7514 (TI).
P. canbyi (Scribn.) Piper: USA: *Swallen* 6031 (TNS).
P. cenisia All.: Romania: *Nyarady* 926 (TI).
P. chaixii Vill.: Sweden: *Smith* 3113 (TNS); USSR: *Skvoltsov* 19 (TI).
P. chapmaniana Scribn.: USA: 'Baltimore Herbarium' 1219 (TNS).
P. cheelii J. Vickery: Australia: *Vickery*, NSW 43187 (TNS).
P. compressa L.: England: *Hubbard* 151 (TNS); Romania: *Nyarady* 1170 (TI); Japan: *Hisauchi* 1331 (TI).
P. confinis Vasey: USA: *Hitchcock* 1213 (TNS).
P. costiniana J. Vickery: Australia: *Helms*, NSW 45793 (TNS).
P. crassinervis Honda: Japan: *Kimura* 74 (TNS); *Mayebara* 180 (TI); *Yahara et al.* 9004 (TI).
P. cusickii Vasey: USA: *Cronquist* 7062 (TNS).
P. douglasii Nees: USA: *Hoffman* 1983 (TNS). ssp. **macrantha** (Vasey) Keck.: USA: *Hitchcock* 1238 (TNS); *Tracy* 12224 (TNS).
P. eminens Presl: USA: *Hitchcock* 1244 (TNS); Canada: *Marie-Victorin et al.* 43989 (TI).
P. ensiformis J. Vickery: Australia: *Maiden & Forsyth* s. n. (TI).
P. epilis Scribn.: USA: *Hitchcock* 1216 (TNS); Canada: *Taylor et al.* 3237 (TNS).
P. fauriei Hack.: Japan: *Okuyama* 10581 (TNS); *Amano & Maki* 35 (TI).
P. fernaldiana Nannf.: USA: *Hitchcock* 1178 (TNS); Canada: *Lavigne* 1401 (TI).
P. glauca Vahl: USA: *Hitchcock* 1217 (TNS); Norway: *Nannfeldt* 13869 (TNS).
P. hakusanensis Hack.: Japan: *Furuse* s. n. (TNS); *Ogawa* 8 (TI).
P. hayachinensis Koidz.: Japan: *Hattori* s. n. (TI); *Honda* s. n. (TI); *Kawano* s. n. (TNS).
P. himalayana Nees ex Steud.: Nepkal: *Rajbhandari & Roy* 1681 (KATH).
P. hisauchii Honda: Japan: *Hisauchi* 38467 (TNS); *Kurosaki* 14199 (TI); *Murata* 11556 (TI); *Tuyama* s. n. (TI).
P. howellii Vasey & Scribn.: USA: *Tracy* 7490 (TNS).
P. infirma H. B. K.: Mexico: *Pringle* 4671 (TI).
P. juncifolia Scribn.: USA: *Hitchcock* 1196 (TNS).
P. labillardieri Steud.: Australia: *Ingram* 51212 (TNS).
P. laxa Haenke: Norway: *Ahlberg* s. n. (TI); *Johnsen* s. n. (TNS).
P. macrocalyx Trautv. & Mey.: USSR: *Tatewaki* 11276 (TI); *Tobita* s. n. (TI).
P. malacantha Kom. var. **shinanoana** Ohwi: Japan: *Furusawa* s. n. (TI); *Sakurai* s. n. (TNS); *Teramoto* s. n. (TI).
P. maroccana Nannf.: Morocco: *Nannfeldt* s. n. (TNS).
P. matsumurae Hack.˜ Japan: *Date* s. n. (TNS).
P. minor Gaudin: Romania: *Nyarady* 928 (TI).
P. nemoralis L.: Canada: *Dore* 8444 (TI); *Rouleau* 83 (TNS); Sweden: *Asplund* 209 (TI); Yugoslavia: *Orendi* s. n. (TNS).
P. nepalensis Wall.: Nepal: *Rajbhandari* 7315 (KATH); *Rajbhandari et al.* 10543 (KATH); *Stainton et al.* 2686 (TNS).
P. nervosa (Hook.) Vasey: USA: *Cronquist* 7392 (TNS).
P. nevadensis Vasey ex Scribn.: USA: *Hitchcock* 1224 (TNS).
P. nipponica Koidż.: Japan: *Murata et al.* 149 (TNS); *Okubo* s. n. (TI); *Siota* 15 (TI).
P. pagophila Bor: Nepal: *Kanai et al.* 726646 (TI); *Rajbhandari* 61875 (KATH).
P. palustris L.: USA: *Metcalfe* 5737 (TI); Sweden: *Asplund* 210 (TI).
P. polycobea Stapf: Nepal: *Rajbhandari* 8296 (KATH).
P. poophagorum Bor: Nepal: *Polunin et al.* 2533 (TNS); *Rajbhandari* 8706 (KATH).
P. pratensis L.: Canada: *Rouleau* 2051 (TNS); Sweden: *Ryden* s. n. (TI); Nepal: *Rajbhandari* 8345 (KATH); Bhutan: *Kanai et al.* 1493 (TI); N. Korea: *Imai* s. n. (TI).
ssp. **angustifolia** (L.) Gaud.: Sweden: *Londbom* s. n. (TNS); Finland: *Linkola* 1057 (TI); Nepal: *Rajbhandari & Roy* 3386 (KATH).
P. radula Fr. et Sav.: Japan: *Mizushima* 1207 (TI); *Momiyama* 80 (TI); *Okuyama* 12511 (TNS); *Sunawara* s. n. (TI); *Takahashi* 15032 (TI).

P. rehmannii (Aschers. et Graebn.) Woloszcz.: Romania: *Gusuleac and Topa* 1177 (TI).
P. remota Forselles: Sweden: *Moller* s. n. (TNS); USSR: *Makarov* 20 (TI).
P. sachalinensis (Koidz.) Honda: USSR: *Probatova* 5454 (TI); *Sase* s. n. (TNS); Japan: *Murata et al.* 37956 (TI).
P. secunda J. Presl.: USA: *Pohl* 7206 (TNS).
P. sibirica Roshev.: USSR: *Kozhevnikova* s. n. (TI); *Reverdatto* s. n. (TNS).
P. sikkimensis (Stapf) Bor.: Nepal: *Rajbhandari* 61687 (KATH).
P. supina Schrad.: Sweden: *Nennfeldt* 12992 (TNS); *Samuelsson* 213 (TI); *Smith* 4008 (TI).
P. trivialis L.: USA: *Chase* 1222 (TNS); *Utech* 79-313 (TI); UK: *Howell* R. 18 (TNS); W. Germany: *Emura* 1394 (TI); Sweden: *Aberb* s. n. (TI); *Nannfeldt* 22974 (TI); India: *Kanai et al.* 2784 (TI); Japan: *Toba* 635 (TI).
P. tuberifera Faurie ex Hack.: Japan: *Murata* 20608 (TI); *Okuyama* 22318 (TNS); *Satow* 7577 (TNS).
P. versicolor Trin. ssp. **ochotensis** (Trin.) Tzvel.: Taiwan: *Sasaki* s. n. (TNS); Japan: *Hatsuma* 31250 (TI); *Momose* s. n. (TI).
P. viridula L.: Japan: *Itaru* s. n. (TNS); N. Korea: *Nakai* 12467 (TI).
P. vrangelica Tzvel.: USSR: *Petrevsky & Andranova* 6006 (TNS).

minutes to give a coating of 0.02 μm. The materials were then observed with a Hitachi S-700 scanning electron microscope and photographed using Kodak Tri-X pan film at accelerating voltages of 15 and 20 kV.

Results

The surface of the lemma and palea of sixty-two species of *Poa* was proved mainly to be made up of rectangular long cells which were 11 to 140 μm long and generally 2-30 times longer than wide. The periclinal walls of the long cells were found to be concave. The anticlinal walls were sinuate. In *P. bulbosa* (Fig. 1a, b) and *P. douglasii* (Fig. 1c, d) the periclinal walls were either convex or flat and the anticlinal walls sinuous and interlocking. In the paleae of some specimens of *P. bulbosa* the periclinal walls of long cells were concave.

Three types of dermal appendages, hooks, prickles and macrohairs, were found on the surface (Table 2), They were found on the basal and middle parts. Hooks (Fig. 1k-H) were smaller structures (4-9 μm long), with an abruptly pointed apex and a prominently swollen base. They occurred alternating with the long cells. Except in *P. crassinervis* (Fig. 1g, h) and *P. maroccana* (Fig. 1i, j), hooks were found on the lemmas and paleae of all the species examined. The ratio of the number of hooks to that of long cells in lemmas was usually one, as in *P. nipponica* (Fig. 2c), *P. palustris* (Fig. 2e), *P. pratensis* subsp. *angustifolia* (Fig. 2a) and *P. trivialis* (Fig. 2g). In the lemmas of the species, such as *P. annua* (Fig. 1e), *P. confinis* (Fig. 2k), *P. laxa* (Fig. 3g), *P. supina* (Fig. 1k) the ratio was less than one. *P. abbreviata, P. acroleuca, P. epilis. P. howellii, P. macrocalyx, P. polycolea, P. sibirica* and *P. tuberifera* showed variation in the occurrence of the hooks (Table 2). Hooks were sometimes absent in the lemmas of *P. bulbosa*. In the paleae also the ratio of the number of hooks to that of long cells was usually one, such as in *P. palustris* (Fig. 2f), *P. pratesis* ssp. *angustifolia* (Fig. 2b) and *P. trivialis* (Fig. 2h). But the occurrence of hooks in the paleae varies in *P. abbreviata, P. alpina, P. howellii* (Fig. 3f), *P. nepalensis, P. nipponica* (Fig. 2d), *P. polycolea, P. poophagorum, P. radula, P. sibirica* and *P. tuberifera*. In the paleae of *P. supina* (Fig. 1l) the surface was devotid of hooks but a few hooks occurred along the keels. Sometimes the hooks were absent in some paleae of *P. annua* (Fig. 1f), *P. bulbosa* (Fig. 1b), *P. douglasii* ssp. *macrantha* and *P. infirma*. In the species, such as *P. arctica* (Fig. 2j), *P. confinis* (Fig. 2l), *P. douglasii* (Fig. 1d), *P. eminens* (Fig. 3b), *P. epilis* (Fig. 3d), *P. laxa* (Fig. 3h), *P. pagophila* (Fig. 3l) and *P. supina*, the ratio of the number of hooks to that of long cells was less than one.

Among the examined species prickles (Fig. 2k-P) were commonly found on lemmas and paleae. The prickles, robust, sharply pointed structures with swollen bases and bent apex, were larger (9-60 μm long, 8-30 μm at base) than the hooks. Prickles varied in size even on the same lemma, as in *P. eminens* (Fig. 3a, prickle 9-50 μm long). In the lemmas of *P. fauriei, P. glauca, P. radula* and *P. tuberifera*, and in the paleae of *P. polycolea, P. radula* and *P. tuberifera*, sometimes, the prickles were absent.

Macrohairs (Fig. 2i-M), elongated unicellular

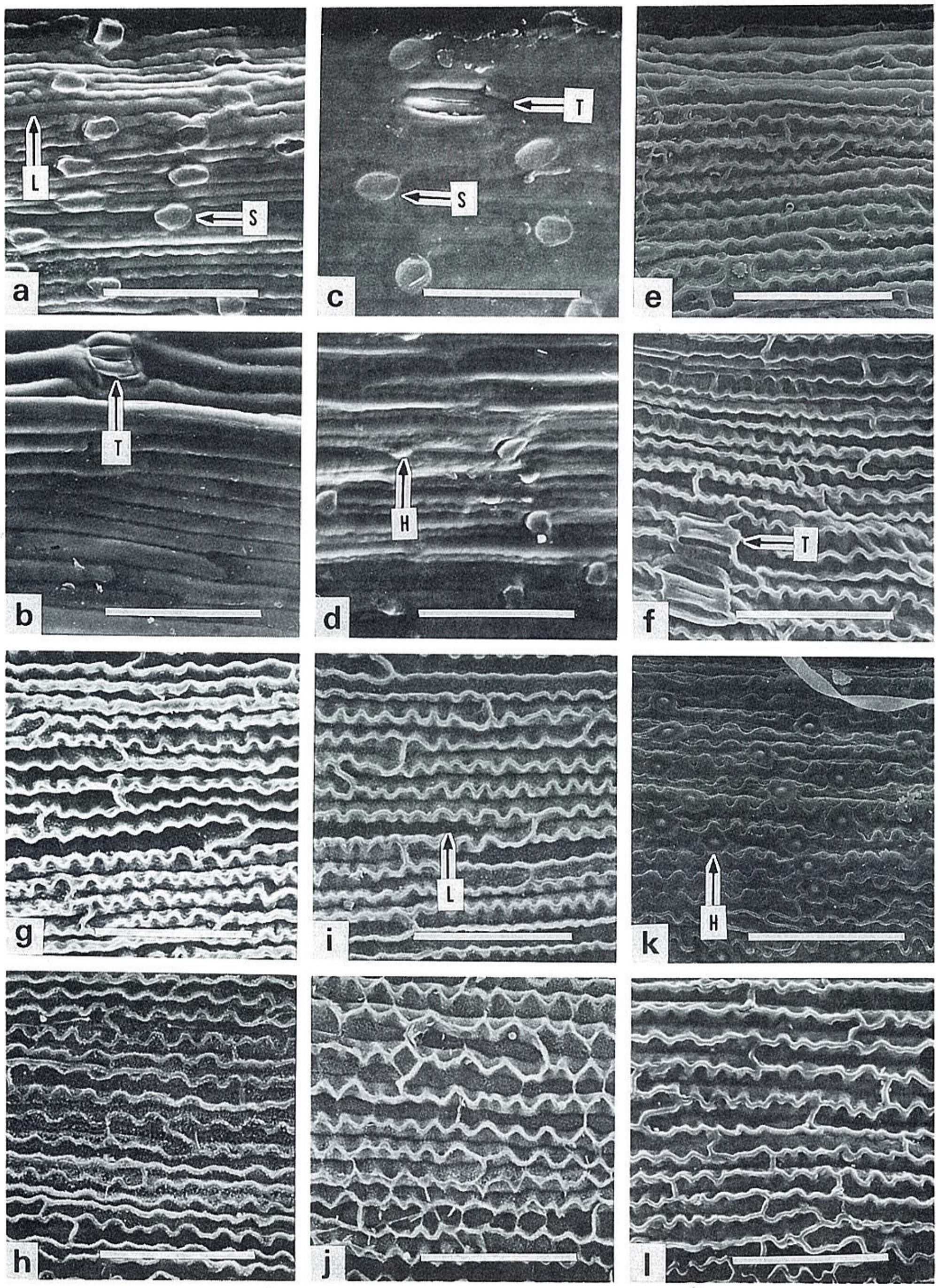

Fig. 1　Scanning electron micrographs of abaxial surface of lemma and palea of selected *Poa* species. H = hook, L = long cell, S = silica body, T = stoma. Scale = 50 μm. a–b : *P. bulbosa* (a, *Norrman* s. n. ; b, *Sterner* 207). c–d : *P. douglasii*. e–f : *P. annua* (e, *Norberg* s. n. ; f, *Rajbhandari* 7963). g–h : *P. crassinervis* (*Kimura* 74). i–j : *P. maroccana*. k–l : *P. supina* (k, *Nannfeldt* 12992 ; l, *Smith* 4008). a, c, e, g, i, k : lemma. b, d, f, h, j, l : palea.

structures, were larger (100-500 μm long or longer than this, and 8-12 μm wide at the base) than the prickles. They could be seen with low magnification (×5-10). Macrohairs were found in the lemma and palea of *P. abbreviata, P. acroleuca, P. arctica* (Fig. 2i, j), *P. hisauchii, P. howellii* (Fig. 3e,

Table 2. Character of the abaxial surface between the midnerve and lateral nerves of the lemma (L) and between the keels of palea (P) of *Poa* observed by SEM.

Taxon	Fig. no.	Ratio of number of hook to that of long cell		Prickles		Macro-hairs		Stomata	
		L	P	L	P	L	P	L	P
Poa abbreviata		1, <1	1, <1	+	+	+	+	−	−
P. acroleuca		1, <1	<1	−	−	+, −	+, −	−	+, −
P. alpina		1	1, <1	−	−	+	−	−	−
P. annua	1 e,f	<1	<1, −	−	−	−	−	−	+, −
P. arctica	2 i,j	1, <1	<1	+	+	+	+	−	+, −
P. bactriana		1	1	−	−	−	−	−	+
*P. bulbosa**	1 a,b	<1, −	<1, −	−	−	−	−	+, −	+
P. calliopsis		1	<1	−	−	−	−	−	−
P. canbyi		1	<1	+	+	−	+	−	+
P. cenisia		1	<1	+	−	−	−	−	+, −
P. chaixii		1	<1	+	+	−	−	−	+, −
P. chapmaniana		1	<1	−	−	−	−	−	−
P. cheelii		1	1	−	+	−	−	−	−
P. compressa		1	1	−	−	−	−	−	+, −
P. confinis	2 k,l	<1	<1	+	+	−	−	−	−
P. costiniana		1	<1	−	−	−	−	−	−
P. crassinervis	1 g,h	−	−	−	−	−	−	−	+, −
P. cusickii		1	1	+	+	−	−	−	+
*P. douglasii**	1 c,d	<1	<1	−	−	−	−	+	−
ssp. *macrantha**		<1	<1, −	−	−	−	−	−	+, −
P. eminens	3 a,b	1, <1	<1	+	+	−	−	−	−
P. ensiformis		1	1	+	+	−	+	−	+
P. epilis	3c,d	1, <1	<1	+	+	−	−	−	+
P. fauriei		<1	<1	+, −	+	−	−	−	+, −
P. fernaldiana		<1	<1	+	+	−	−	−	−
P. glauca		1	<1	+, −	+	+, −	−	−	+, −
P. hakusanensis		1	<1	+	+	−	−	−	−
P. hayachinensis		1	<1	+	+	−	−	−	+
P. himalayana		1	<1	−	−	−	−	−	−
P. hisauchii		1	1	−	−	+, −	+	−	+
P. howellii	3 e,f	1, <1	1, <1	+	+	+	+	−	+
P. infirma		<1	<1, −	−	−	−	−	−	−
P. juncifolia		1	1	−	+	−	−	−	−
P. labillardieri		1	1	+	+	−	−	−	−
P. laxa	3 g,h	<1	<1	+	+	−	−	−	−
P. macrocalyx		1, <1	<1	+	+	−	+, −	−	+
P. malacantha var. *shinoana*		1	<1	+	+	+	−	−	−
P. maroccana	1 i,j	−	−	−	−	−	−	−	−
P. matsumurae		1	1	−	−	−	−	−	+
P. minor		1	<1	−	+	−	−	−	+
P. nemoralis		1	1	−	−	−	−	−	−
P. nepalensis		1	1, <1	−	−	−	−	−	+, −
P. nervosa		1	1	+	+	−	−	−	+
P. nevadensis	3 i,j	1, <1	<1	+	+	−	−	−	−
P. nipponica	2 c,d	1	1, <1	−	−	−	−	−	+, −
P. pagophila	3 k,l	<1	<1	+	+	−	−	−	+, −
P. palustris	2 e,f	1	1	−	+	−	−	−	−
P. polycolea		1, <1	1, <1	+	+, −	−	−	−	+
P. poophagorum		1	1, <1	−	−	−	−	−	−
P. pratensis		1	1	−	−	−	−	−	+
ssp. *angustifolia*	2 a,b	1	1	−	−	−	−	−	+
P. radula		1	1, <1	+, −	+, −	−	+, −	−	+
P. rehmannii		1	1	−	+	−	−	−	−
P. remota		1	1	+	+	−	−	−	−
P. sachalinensis		1	<1	+	+	−	−	−	+
P. secunda		1	1	+	+	−	−	−	−
P. sibirica		1, <1	1, <1	+	+	−	−	−	+, −
P. sikkimensis		1	1	−	−	−	−	−	−
P. supina	1 k,l	<1	<1	−	−	−	−	−	−
P. trivialis	2 g,h	1	1	−	−	−	−	−	+, −
P. tuberifera		1, <1	1, <1	+, −	+, −	+	+	−	−
P. versicolor		1	1	+	−	−	−	−	+
ssp. *ochotensis*									
P. viridula		1	<1	−	+	−	−	−	+
P. vrangelica		<1	<1	+	+	+	−	−	+

+, present; −, not seen.
* silica cells present.

f) and *P. tuberifera*, in the lemma of *P. alpina*, *P. glauca*, *P. malacantha* var. *shinanoana* and *P. vrangelica*, and in the palea of *P. canbyi*, *P. ensiformis*, *P. macrocalyx* and *P. radula*. On some lemmas of *P. acroleuca*, *P. glauca* and *P. hisauchii* and also on paleae of *P. acroleuca*, *P. macrocalyx* and *P. radula* macrohairs were absent.

Silica cells were found in the lemma of *P. bulbosa* (Fig. 1a) and in the lemma and palea of the two subspecies of *P. douglasii* (Fig. 1c, d). They occurred between the long cells. Each silica cell contained a single silica body which was round, dumb-bell sheped or elongated with slightly concave outer surface. The silica bodies were generally 9-20 μm long and 7-14 μm wide. The costal silica bodies on the lemmas of *P. bulbosa* were rectangular and longer (up to 30 μm) with undulate margin.

Stomata were seen in the lemma of two species

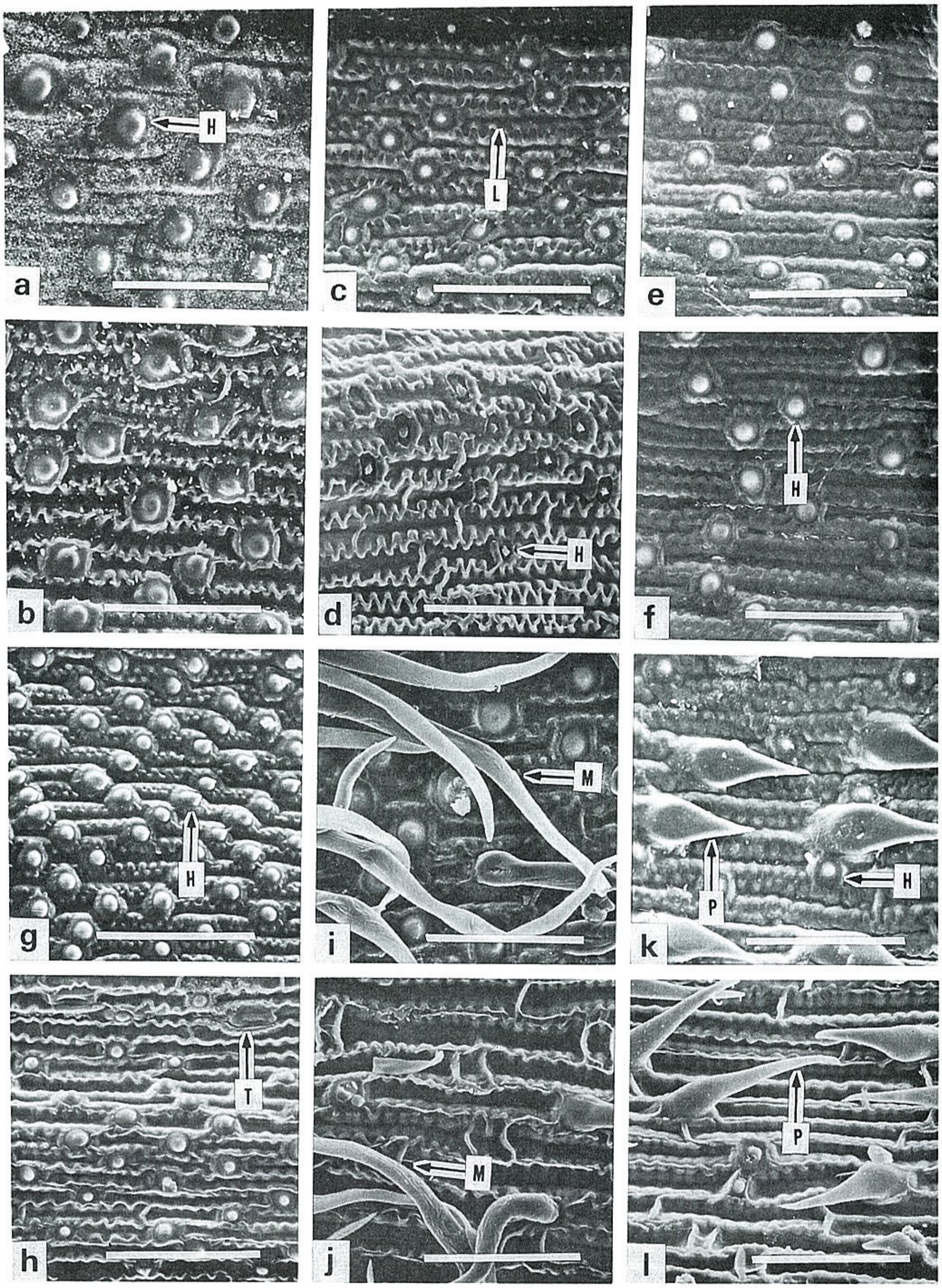

Fig. 2　Scanning electron micrographs of abaxial surface of lemma and palea of selected *Poa* species. H = hook, L = long cell, M = macrohair, P = prickle, T = stoma. Scale = 50μm. a–b : *P. pretensis* ssp. *angustifolia* (*Lindbom* s. n.). c–d : *P. nipponica* (*Murata et al.* 149). e–f : *P. palustris* (*Metcalfe* 5737). g–h : *P. trivialis* (g, *Emura* 1394 ; h, *Utech* 79-313). i–j : *P. arctica* (*Samuelsson* 202). k–l : *P. confinis*. a, c, e, g, i, k : lemma. b, d, f, h, j, l : palea.

only, *P. bulbosa* and *P. douglasii* (Fig. 1c), but were commonly found on the palea which also showed variation in their occurrence (Table 2).

Discussion

The present study of the epidermal structures of lemma and palea of *Poa* shows that the surface

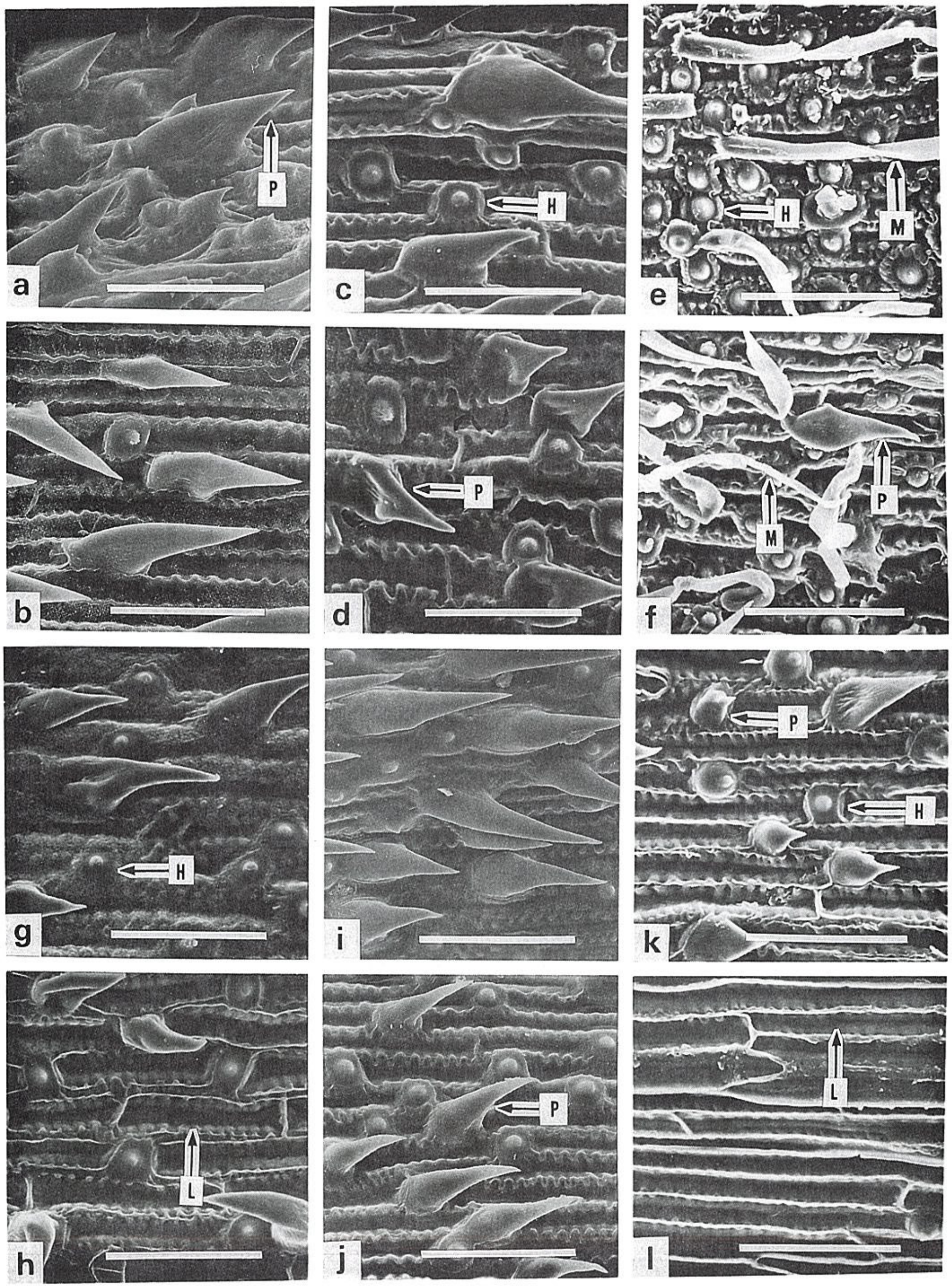

Fig. 3 Scanning electron micrographs of abaxial surface of lemma and palea of selected *Poa* species. H = hook, L = long cell, M = macrohair, P = prickle. Scale = 50 μm. a–b: *P. eminens* (*Hitchcock* 1244). c–d: *P. epilis* (*Taylor et al.* 3237). e–f: *P. howellii*. g–h: *P. laxa* (*Johnsen* s. n.). i–j: *P. nevadensis*. k–l: *P. pagophila* (*Rajbhandari* 61875). a, c, e, g, i, k: lemma. b, d, f, h, j, l: palea.

is made up of long cells and in most species has hooks, prickles, macrohairs and stomata, all of which show variation in occurrence in some of the species. *Poa* is said to be an extremely uniform genus (CLAYTON and RENVOIZE, 1986). The data of the epidermal structures of lemma and palea also show that the surface structures are uniform among the examined species of *Poa*, except *P.*

bulbosa and *P. douglasii*, which are distinct in having silica cells on their lemma and sometimes on palea surfaces.

THOMASSON (1986) examined lemma epidermis of seven genera, four of which (*Glyceria, Melica, Pleuropogon* and *Schizachne*), according to CLAYTON and RENVOIZE (1986), belong to tribe Meliceae of subfamily Pooideae, two (*Briza* and *Catabrosa*) to Poeae and one (*Neostapfia*) to tribe Orcuttieae of subfamily Chloridoideae. He noted that at the generic level, the epidermal characters suggested that *Catabrosa, Glyceria, Melica* and *Pleuropogon* formed a natural group, and that *Briza* and *Schizachne* could be segregated from them by the presence of silica bodies on the surface, and *Neostapfia* did not appear to be closely related to any of the other genera examined in that study. In *Neostapfia*, as described by THOMASSON (1986), the lemma surface showed the presence of irregularly shaped long cells and uncinate and glandular microhairs. No such microhairs are found in the species of *Poa* examined in the present study. *Neostapfia* seems to be distinct from *Poa*.

CHRTEK and JIRÂSEK (1962) examined the surface structures of the palea of the species of *Poa* section *Ochlopoa* by light microscope and found that the surface was characterized by the absence of short cells and was composed exclusively of long cells; the walls were undulated to a certain degree. They used these characters to distinguish section *Diversipoa* CHRTEK and JIŘASEK from section *Ochlopoa* (A. & GR.) V. JIŘAS. The surface of palea in the former has long and short cells in a ratio of more or less 1 : 1, and in the latter the surface has only long cells (CHRTEK and JIRÂSEK, 1962). The present study shows that *P. annua, P. infirma* and *P. supina* of *Ochlopoa* section have hooks on their lemma and palea surfaces (although the ratio of the number of hook to that of long cell is less than one), as found in *P. chapmaniana* and *P. howellii* of their *Diversipoa* section. Thus, no fundamental difference is seen in the palea surface structures in the species put in different sections by CHRTEK and JIRÂSEK.

The present study indicates that the lemma and palea surface structures of *Poa* show the characteristics similar to some other genera belonging to subfamily Pooideae, and differ from the genera belonging to Panicoideae especially in the absence of microhairs and papillae (CLARK and GOULD, 1975; SHAW and GOULD, 1979; SHAW and SMEINS, 1981; SHAW and WEBSTER, 1983). However, the surface structures are not found to be helpful for distinguishing sections of *Poa*.

Acknowledgements

I am indebted to Dr. Hideaki OHBA, Associate Professor of the University of Tokyo, for encouragement and critical reading of this paper. I am thankful to Dr. A. MATSUTANI and Mr. M. AMANO of the University Museum, the University of Tokyo, for discussion. Thanks are due to the Directors of Department of Forestry and Plant Research, H. M. G. of Nepal, and National Science Museum, Tokyo, for facilities, and to Misses Tomoko YAMASHITA and Hiromi TAGAWA for technical help with SEM. I would also like to thank the anonymous reviewer for helpful comments on the manuscript.

References

BARKWORTH, M. E. 1983. *Ptilagrostis* in North America and its relationship to other Stipeae (Gramineae). Syst. Bot. 8: 395-419.

BJÖRKMAN, S. 1960. Studies in *Agrostis* and related genera. Symb. Bot. Ups. **17**: 1-112.

CHRTEK, J. and JIRÂSEK, V. 1962. Contribution to the systematics of species of the *Poa* L. genus, section *Ochlopoa* (A. et Gr) V. Jiřas. Preslia **34**: 40-68.

CLARKE, C. A. and GOULD, F. G. 1975. Some epidermal characteristics of paleas of *Dichanthelium, Panicum*, and *Echinochloa*. Amer. J. Bot. **62**: 743-748.

CLAYTON, W. D. and RENVOIZE, S. A. 1986. Genera Graminum. Kew Bull. Add. Ser. XIII. pp. 389.

HARTLEY, W. 1961. Studies on the origin, evolution, and distribution of the Gramineae. IV. The genus *Poa* L. Austral. J. Bot. **9**: 152-161.

HITCHCOCK, C. L., CRONQUIST, A. and OWNBEY, M. 1969. Vascular plants of the Pacific Northwest. Part 1: Vascular Cryptogams, Gymnosperms, and Monocotyledons. pp. 914. University of Washington Press, Seattle.

HSU, Chien-Chang. 1965. The classification of *Panicum* (Gramineae) and its allies with special reference to the characters of the lodicule, style-base and lemma. J. Fac. Univ. Tokyo, Sect. III, **9**: 43-150.

PETERSON, P. M. 1989. Lemma micromorphology in the annual *Muhlenbergia* (Poaceae). Southwest. Natural. **34**: 61-71.

RAJBHANDARI, K. R. 1985. The genus *Agrostis* in Nepal (I). J. Jap. Bot. **60**: 65-78.

SHAW, R. B. and GOULD, F. W. 1979. Comparison of palea epidermal characteristics among Paniceae (Gramineae) genera. Bot. Soc. Amer. Misc. Series 158, p. 67.

SHAW, R. B. and SMEINS, F. E. 1981. Some anatomical and morphological characteristics of the North American species of *Eriochlea* (Poaceae: Paniceae). Bot. Gaz. **142**: 534-544.

SHAW, R. B. and WEBSTER, R. D. 1983. Characteristics of the upper anthecia of *Ichnanthus* (Poaceae: Paniceae). Bot. Gaz. **144**: 363-370.

TATEOKA, T. 1985. Chromosome numbers and their taxonomic implications in the genus *Poa* of Japan. Bot. Mag. Tokyo **98**: 413-437.

THOMASSON, J. R. 1986. Lemma epidermal features in the North American species of *Melica* and selected species of *Briza, Catabrosa, Glyceria, Neostapfia, Pleuropogon,* and *Schizachne* (Gramineae). Syst. Bot. **11**: 253-262.

摘　要

62種のイチゴツナギ属(*Poa*)の内えいと外えいの表皮の微細構造を，それらの変異の幅を確かめるために，走査型電子顕微鏡で観察した。この属の内えいと外えいの表面には，長細胞(long cell)，鈎(hook)，刺(prickle)，長毛(macrohair)，気孔が観察された。それに加えて，*Poa bulbosa, P. douglasii* の2種では，珪酸細胞 (silica cell) が観察され，イチゴツナギ属の他の種と区別された。ここで観察された内えいと外えいの表面構造の類似性と変異性はこの属には密接な種間関係があることを示しており，この属の表皮の表面の微細構造の特徴は，特に微小毛 (microhair) と乳頭状突起 (papilla) を欠くという点で，イチゴツナギ亜科 (Pooideae) に属する他の属と類似している。

(Received March 8, 1990)

○ 四国のトウヒレン属（山中二男） Tsugiwo YAMANAKA: *Saussurea* in Shikoku.

トウヒレン属 (*Saussurea*) の植物は，おもにアジアの山地に分布して種が分化している。日本には二十数種あるとされ(大井，1970；北村，1981)，暖温帯の丘陵地から高山帯まで見られる。西南日本では遺存的な植物といわれ（北村，1935)，近畿以西の本州と九州とにはそれぞれ7〜8種が知られている。四国には7種あり，それらのうち最近 IM (1989) が再検討したオオダイトウヒレン (*S. nipponica* MIQ.) の群を除いては，分類学的にあらためて問題にするものはない。ここでは，IM の論文が出た機会に，四国でのこの属の植物の分布と生態をまとめてみた。

分布が最も広いのはヒメヒゴタイ (*S. pulchella* FISCH. ex DC.) で，各県で低地から山地（冷温帯）までの草原に生じ，石灰岩や蛇紋岩地帯にもある。ホクチアザミ (*S. gracilis* MAXIM.) も草原に生えるが，中国山地のように普通には見られず，愛媛・高知県境の四国カルストの大野ヶ原の近くに生ずるほか，愛媛県中・南部の低山地からの報告がある。

ミヤコアザミ (*S. maximowiczii* HERDER) は，一般には山の草原に普通にあるとしているが，四国ではまれである。しかも，徳島県池田町と高知市の生育地はいずれも湿地で，池田町ではサワシロギク，ナガバシラヤマギクなどと混生し，高知市ではおなじところにノハナショウブやカザグルマ（白花）がある。

四国にキクアザミはないと思われるが，キリシマヒゴタイ (*S. scaposa* FR. et SAV.) が分布する。これは九州（熊本，大分，宮崎，鹿児島の各県）の山地でよく見るが，高知県檮原町四万川とそこから越知面へ越すあたりに生じ，後述のトサトウヒレンとともに，四国では蛇紋岩地だけにしか知られていない。

コウシュウヒゴタイ (*S. amabilis* KITAM.) は，関東地方西部と中部地方東部から四国の石灰岩地帯に隔離分布して，おもに冷温帯に生えている。東部では徳島・高知県境の石立山，高知県物部村西谷，西部では鳥形山と黒滝山のほか四国カルストの天狗高原では愛媛県側にもある。

ミヤマトウヒレン (*S. pennata* KOIDZ.) は，四国では中部以西の山地に生じ，愛媛県別子山村の二ツ岳，愛媛・高知県境の寒風山，愛媛県の石鎚山（天狗岳一西ノ冠岳）の岩石地で見られる。

問題のオオダイトウヒレンの群は，IM が四国での3亜種を4亜種とした。そのうち，オオダイトウヒレン (ssp. *nipponica*) は中部以東に生じ，東部では IM などによると讃岐山脈では徳島・香川県境の竜王山とその