

Comparative study of fruit wall structure in *Lapsana*
L. and *Lapsanastrum* J. H. Pak & K. Bremer
(Asteraceae; Lactuceae)

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The mature fruit wall structures were investigated in *Lapsana communis*, its six subspecies and the four species of *Lapsanastrum* (Asteraceae; Lactuceae). *Lapsanastrum* differs from *Lapsana communis* in some features: two or three protrudent costae verse equally developed costae, hairy versus glabrous exocarp, respectively. Moreover, *Lapsana* has no sclerenchymatous fiber cells in mesocarp, while *Lapsanastrum* has sclerenchymatous fiber cells. The differences in fruit wall structure between *Lapsana* and *Lapsanastrum* obviously support the separation of *Lapsanastrum* from *Lapsana s. lat.*

Keywords : Asteraceae, costae, fruit wall anatomy, *Lapsana*, *Lapsanastrum*

Both *Lapsana* L. and *Lapsanastrum* J. H. Pak & K. Bremer are genera of Crepidinae of Lactuceae (Asteraceae). *Lapsana* which comprises *L. communis* L. and its subspecies (Sell, 1981) distributed from North America through Europe to Southwest Asia and four species of *Lapsanastrum*, *L. apogonoides* (Maxim.) J. H. Pak & K. Bremer, *L. humile* (Thunb.) J. H. Pak & K. Bremer, *L. takasei* (Sasaki) J. H. Pak & K. Bremer and *L. uncinatum* (Stebbins) J. H. Pak & K. Bremer, distributed in East Asia. The four species of *Lapsanastrum* were formerly placed in *Lapsana s. lat.* on the basis of shared similar

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Table 1. Taxa of *Lapsana* and *Lapsanastrum* examined and their collection sites.

Taxa	Voucher specimens
<i>Lapsana communis</i> L.	
subsp. <i>communis</i>	Germany. Bayorn, Traunstein. <i>Uotila 20922</i> (KYO) U.S.A. California, Humblot. <i>Ornduff 9800</i> (KYO) Oregon, Corvallis. July 15, 1989, <i>Chambers s.n.</i> (KYO) England. London, Richmond. <i>Hukuhara s.n.</i> (KYO)
subsp. <i>adenophola</i>	Turkey. Anatolia, Lzmir. <i>Balansa 264</i> (K) Erzurum, Pasinler. <i>Davis 46402</i> (K) Kutahya, B2 simar. <i>Coode & Jones 2652</i> (K)
subsp. <i>alpine</i>	Turkey. Anatolia, Kastamune. <i>Batrah 98</i> (KYO) Arkara, Alis. <i>Khan et al. 577</i> (K) Kastamonu, Ilgaz. <i>Darrah 48</i> (K)
subsp. <i>grandiflora</i>	Turkey. Anatolia, <i>Anonymous</i> (K)
subsp. <i>intermedia</i>	Turkey. Adana, Baykan. <i>Davis 19557</i> (K) Bolu, Ala Dagf. <i>Khan & Ratcliff 500</i> (K) Bitlis, Tatran. <i>Tomp 101</i> (K)
subsp. <i>pisidica</i>	Turkey. Amanus, A6 Monts. <i>Haradjiam 4594</i> (K) Tsimboucken, Artalya. <i>Holdoeich s.n.</i> (K)
<i>Lapsanastrum apogonoides</i>	Japan. Hyogo, Mikicshi. <i>Murata & Nishimura 625</i> (KYO) Korea. Kyungsangnamdo, Milyang. <i>Pak & Kim 3022</i> (KNU) Kyungsangnamdo, Kimhae. <i>Pak & Kim 3023</i> (KNU) Kyungsangnamdo, Hadong. <i>Pak et al. 3093</i> (KNU)
<i>Lapsanastrum humile</i>	Japan. Osaka, Mt. Kenbisan. <i>Murata 45470</i> (KYO) Korea. Ulsan. <i>Pak & Kim 3203</i> (KNU) Kyungsangnamdo, Hadong. <i>Pak et al. 3094</i> (KNU) Busan, Bukgu. <i>Pak & Kim 3026</i> (KNU)
<i>Lapsanastrum takasei</i>	Taiwan. Hsinchu, Mt. Izawa. July 8, 1932. <i>Sasaki s.n.</i> (KYO)
<i>Lapsanastrum uncinatum</i>	China. Jiang Xi, Jiou Jiang. <i>Migo 179</i> (KYO)

epappose fruits (Stebbins, 1938). But recent cladistic analysis (Pak and Bremer, 1995) based on 40 morphological characters including unpublished data of fruit wall structure showed that they are distinct from *Lapsana communis* and its five subspecies.

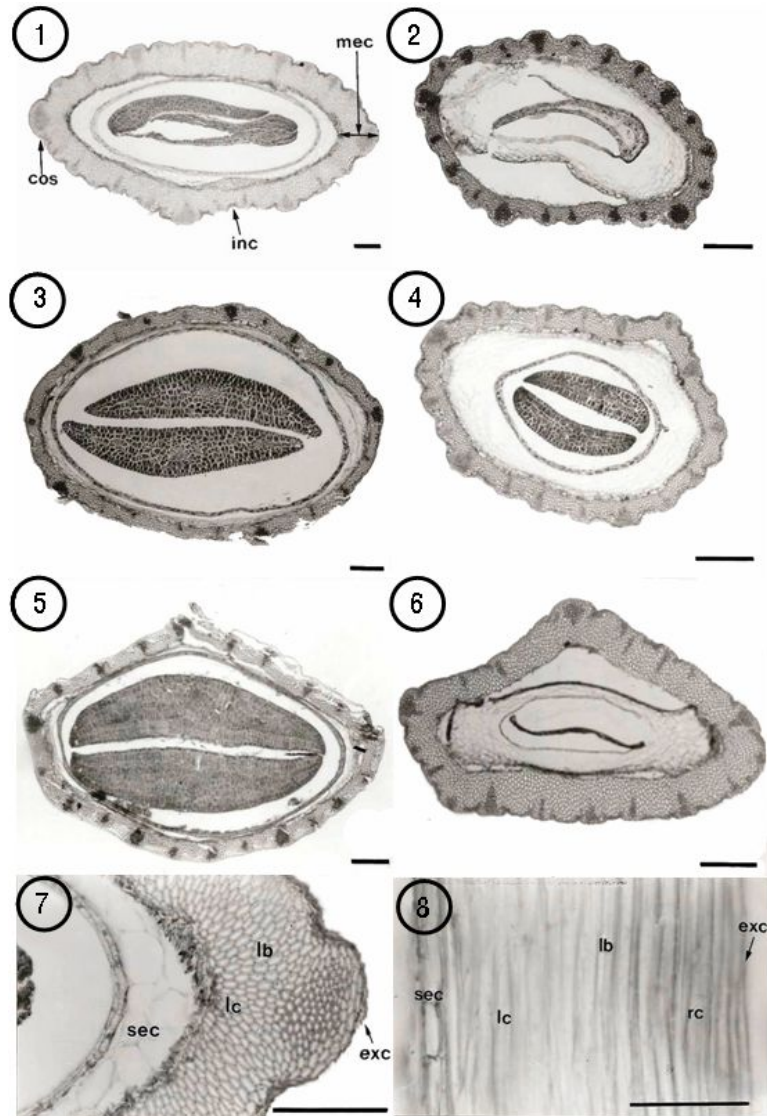
Like other Asteraceae, both genera have inferior ovary; more strictly the “fruit wall” in this paper denotes a cypsela wall comprising a perianth wall over the pericarp (for definition of the cypsela see Spjut, 1994: p.63). The fruit wall structure of related genera such as *Lactuca* L., *Ixeris* Cass., *Crepidiastrum* Nakai, *Paraixeris* Nakai, *Crepis* L., and *Microseris* D. Don (Beliaeva and Boyko, 1980; Pak and Kawano, 1990a, b; Pak, 1991, 1993; Pak *et al.*, 2001) provide significant evidence for their respective distinctness as well as relationship among them. However, no information is available on fruit characters of *Lapsana* and *Lapsanastrum*. The purpose of this study, therefore, is to show the distinct features of fruit wall structure between *Lapsana* and *Lapsanastrum*, and thereby to provide sound basis for the separation of *Lapsanastrum* from *Lapsana s. lat.*

Materials and methods

Lapsana communis with its five subspecies and the four species of *Lapsanastrum* were all investigated in this study. They are presented in Table 1 along with collection data. The fruit wall structure was observed on the basis of microtome sections. Young and mature fruits were collected from wild growing plants or herbarium specimens and preserved or once soaked (in case of dry herbarium materials) in FAA (5 parts formalin, 5 parts glacial acetic acid, and 90 parts 50% ethanol). They were dehydrated through at butyl alcohol series and embedded in Paraplast with melting point 57~59 °C for microtoming. Microtome sections were cut 8~15 μm transversely and longitudinally, stained with safranin and fastgreen FCF, and mounted with Entellan. The slides were examined and photographed with Karl Zeiss JENAMED II light microscope. For observation of surface sculpturing, the fruits were mounted on aluminum stubs with double-sided adhesive tape and the sputter-coated with Au to a maximum thickness of 20 nm. The stubs were examined and photographed with a Hitachi S-700 scanning electron microscope operated at 15 kV.

Table 2. The anatomical features of fruits were compared among the species of *Lapsana* and *Lapsanastrum*

Taxa	Achenes		Mesocarp						Exocarp		
	Length (mm)	Width (mm)	Costa			Intercoasta					
			No. of wing High (Low)	Libriform fiber cell position	Libriform fiber cell layer	Fiber Sclereid cell layer	Thickness (μ m)	Libriform fiber cell layer		Fiber Sclereid cell layers	Thickness (μ m)
<i>Lapsana communis</i> complex	2.9-4.5	1.0-1.2	0 (18-24)	Entire	8-12	None	80-140	6-8	none	80-90	Non- ciliate
<i>Lapsanastrum</i> <i>apogonooides</i>	4.3-4.4	1.0-1.2	2 (6-7)	Basal	5-7	6-8 (1-2)	190-210 (70-90)	1-2	1-2	40-60	Ciliate
<i>Lapsanastrum</i> <i>humile</i>	2.8-3.1	0.9-1.0	2-3 (7-8)	Basal	5-9	6-8 (1-2)	190-230 (60-70)	2-3	1-2	30-40	Ciliate
<i>Lapsanastrum</i> <i>takasei</i>	3.3-3.8	0.9-1.0	2-3 (11)	Basal	5-10	6-10 (2-3)	220-230 (60-70)	1-3	1-2	20-30	Ciliate
<i>Lapsanastrum</i> <i>uninatum</i>	3.7-4.0	0.7-1.3	2 (10)	Basal	4-7	19-23 (2-3)	220-230 (50-60)	1-2	2-4	20-30	Ciliate



Figs. 1-8. Transverse sections of fruits wall anatomy of *Lapsana*, except Fig. 8. Fig. 1. *L. communis* subsp. *communis*. Fig. 2. *L. communis* subsp. *adenophora*. Fig. 3. *L. communis* subsp. *alpine*. Fig. 4. *L. communis* subsp. *grandiflora*. Fig. 5. *L. communis* subsp. *intermedia*. Fig. 6. *L. communis* subsp. *pisidica*. Fig. 7. A structure of a single costa of *L. communis* subsp. *communis*. Fig. 8. Longitudinal section of costa of *L. communis* subsp. *communis*. cos, costa; exc, exocarp; lb, libriform fiber cells; inc, intercosta; mec, mesocarp; sl, sclerenchymatous fiber cells; sec, seed coat. All scales equal to 100 μ m except Fig. 8, 50 μ m.

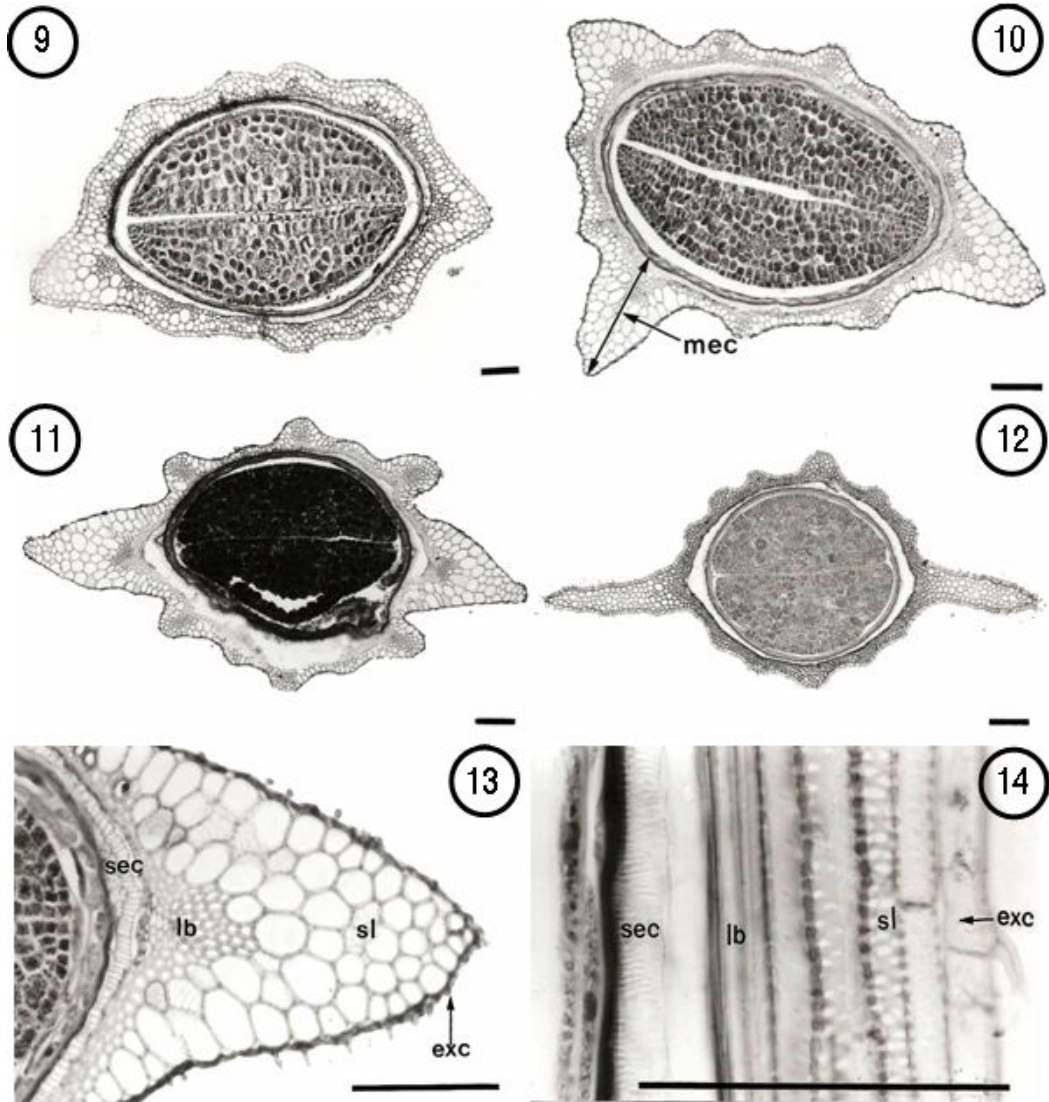
Results

Lapsana L.

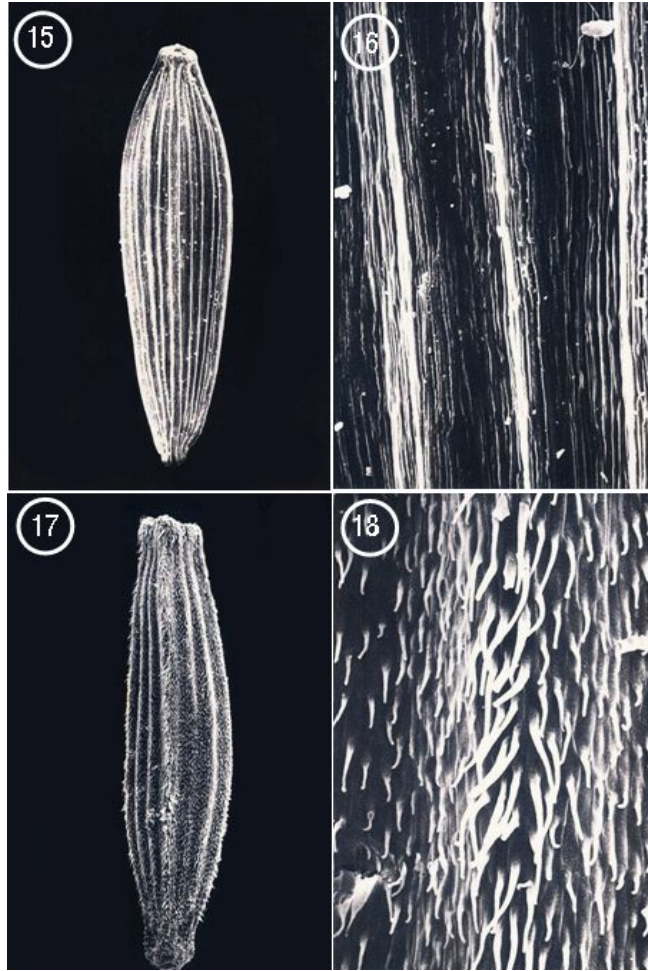
The mature fruit wall structure is very similar in *Lapsana communis* (Figs. 1, 7, 8) and five subspecies of *Lapsana communis* subsp. *adenophola* (Boiss.) Rech. F. (Fig. 2), *L. communis* subsp. *alpine* (Boiss. & Balansa) P. D. Sell (Fig. 3), *L. communis* subsp. *grandiflora* (M. Bieb.) P. D. Sell. (Fig. 4), *L. communis* subsp. *intermedia* (M. Bieb.) Hayek (Fig. 5), *L. communis* subsp. *pisidica* (Boiss. & Heldr.) Rech. F. (Fig. 6). *Lapsana* has 18~24 longitudinal costae on a mature fruit that are more or less similar in size. In transverse section the thickness of the costae is usually 80~140 μm while that of intercostae is 80~90 μm . The wall is about 6~20 cell layers thick and composed as described by Lavialle (1912). The fibers with round cavity form in the middle to outer part of the costae while those with linear cavity form in the inner part of the costae and the whole part of intercostae. Sclenchymatous fibers are not found anywhere. The exocarp is collapsed, and any of them does not develop into a unicellular hair (Figs. 15, 16). The seed coat is composed of cells with loosely helical thickenings (Fig. 7).

Lapsanastrum J. H. Pak & K. Bremer

The structure of fruit wall is similar each other in the *Lapsanastrum apogonoides* (Fig. 9), *L. humile* (Figs. 10, 13, 14), *L. takasei* (Fig. 11) and *L. nucinatum* (Fig. 12), but clearly distinct from that of costae. In transverse section, the high costae are 190~320 μm thick, and the low ones 50~90 μm thick. Intercostae are 20~60 μm thick. The wall is about 11~30 cell layers thick in costae and 2~6 cell layers thick in intercostae. The mesocarp is composed of libriform and sclerenchymatous fiber cells. High costae have 4~10 libriform fiber cell layers thick in the basal part and 6~8 (*Lapsanastrum apogonoides*, *L. humile*), or 6~10 (*L. takasei*), or 19~23 (*L. uncinatum*) fiber sclereid cell layers with helical thickening. Low costae also have 4~10 libriform fiber cell layers in the basal part and 1~2 (*L. apogonoides*, *L. humile*), or 2~3 (*L. takasei* and *L. uncinatum*) fiber sclereid cell layers thick in the upper part. The intercostae tissue is 1~3 libriform fiber cells thick in the basal part and 1~4 fiber sclereid cell layers in the upper part. The outer epidermal cells, exocarp, have a unicellular hair (Figs. 17, 18). The seed coat is composed of cells with densely helical thickenings.



Figs. 9–14. Transverse sections of fruits wall anatomy of *Lapsanastrum*, except Fig. 14. Fig. 9. *L. apogonoides*. Fig. 10. *L. humile*. Fig. 11. *L. takasei*. Fig. 12. *L. uncinatum*. Fig. 13. A structure of a single costa of *L. humile*. Fig. 14. Longitudinal section of costa of *L. humile*. cos, costa; exc, exocarp; lb, libriform fiber cells; inc, intercosta; mec, mesocarp; sl, sclerenchymatous fiber cells; sec, seed coat. All scales equal to 100 μ m except Fig. 14, 50 μ m.



Figs. 15–18. SEMs of fruit shape and surface sculpturing of *Lapsana* and *Lapsanastrum*.
 Figs. 15, 16. *Lapsana communis* subsp. *communis*., Figs. 17, 18. *Lapsanastrum humile*.

Discussion

The anatomical features of fruit wall of individual species in *Lapsana* and *Lapsanastrum* are summarized in Table 2. It is evidence that *Lapsanastrum* is distinct from *Lapsana* in some features, i.e., in shape and numbers of costa, mesocarp, and hair of exocarp. Fruit anatomy has proved to be very variable within subtribe Crepidinae, comprising *Chondrilla* L. (Pak and Bremer, 1995), *Crepis* L. (Pak, 1993), *Crepidiastrum*

Nakai (Pak and Kawano, 1990b), *Ixeris* (Cass.) Cass. (Pak and Kawano, 1990a), *Ixeridium* (A. Gray) Tzvelev (Pak and Kawano, 1990a), *Microseris* D. Don (Pak *et al.*, 2001), *Taraxacum* F. H. Wigg. (Pak and Bremer, 1995), *Youngia* Cass. (Pandy *et al.*, 1978; Pak, 1991). On the basis of the above results, fruits wall structures such as the shape and number of costae in the transverse section appear to provide many informative characters to evaluate their relationships. The fruit walls commonly have a seed coat of one cell layer, a crushed endocarp, thick mesocarp, and one cell layer of exocarp. In the mesocarp, there is a apparently diversity with respects to the presence of sclerenchymatous fiber cells, position of two kinds of fibers both between and within costae. *Lapsana communis* has no sclerenchymatous fiber cells in wings. Costae without sclerenchymatous fiber cells has been observed in the genus *Ixeridium* (Pak and Kawano, 1990a) and some *Crepis* species (Pak and Bremer, 1995). It is very difficult to evaluate the significance of lacking sclerenchymatous fiber cells in the above taxa because of the unclearness of the origin of the taxa. However, the previous cladistic analysis (Pak and Bremer, 1995) suggest that *Lapsana communis*, some species of *Crepis* and *Ixeridium* are nested the same clade.

Both *Lapsanastrum* and *Youngia japonica* (Pandy *et al.*, 1978; Pak, 1991) have some common characters of fruit anatomy, i.e., 2~3 high and 7~8 low costae in transverse section, densely helical seed coat, libriform fiber cells situated in the basal parts, and fiber sclereid cells in the upper parts in the costa and intercosta. Pak and Bremer (1995) suggested that *Lapsanastrum* forms a sister group of *Youngia japonica*. The close affinity between *Lapsanastrum* and *Youngia* might be supported by the fact that × *Lapsyoungia*, a tentative intergeneric cross between *Lapsanastrum humile* (= *Lapsana humilis*) and *Youngia japonica*, was reported by Hiyama (1953). The differences in fruit wall structure between *Lapsana* and *Lapsanastrum* obviously support the separation of *Lapsanastrum* from *Lapsana s. lat.*

Acknowledgements

We thank the directors and curators of K, KNU, KYO, MAK, S, TAT, TI, TNS and UPS for sending material on loan of as gift. We appreciate two anonymous reviewers for many helpful comments on earlier drafts of the manuscript. We also grateful to many people James Bissel, Sue Thompson, Kevin C. Seavey, David E. Boufford, Steven Seavey, Tatsundo Fukuhara, and Shinfi Fujii) for sending some materials. H. Tobe read earlier versions of the manuscript and made helpful suggestions.

Literature Cited

- Beliaeva, T.M. and E.V. Boyko. 1980. Morphology anatomical structure of the achenes of the far east species of *Lactuca s. l.* (Asteraceae) in relation to their systematics. Bot. Zh. (Moscow & Leningrad) 65: 409-413.
- Hiyama, K. 1953. On some Japanese plant. J. Jap. Bot. 28: 217-218.
- Lavialle, P. 1912. Rechers sur le developpement de l ovarire en fruit chez les Composees. Ann. Sci. Nat. Bot. 15: 39-152.
- Pak, J.-H. 1991. A taxonomical review of *Ixeris s. l.* (Compositae; Lactuceae): karyological and fruit wall characteristics. Korean J. Pl. Taxon. 21: 71-82.
- . 1993. Taxonomic implications of fruit wall anatomy and karyology of *Crepis* sect. *Ixeridopsis* (Compositae Lactuceae). Korean J. Pl. Taxon. 23: 11-20.
- and S. Kawano. 1990a. Biosystematic studies on the genus *Ixeris* (Compositae; Lactuceae). I. Fruit wall anatomy and its taxonomic implications. Acta Phytotax. Geobot. 41: 43-60.
- and S. Kawano. 1990b. Biosystematic studies on the genus *Ixeris* and its allied genera (Compositae; Lactuceae) III. Fruit wall anatomy and karyology of *Crepidiastrum* and *Paraixeris* and their taxonomic implications. Acta Phytotax. Geobot. 41: 109-128.
- and K. Bremer. 1995. Phylogeny and reclassification of the genus *Lapsana* (Asteraceae; Lactuceae). Taxon 44: 13-21.
- , J.K. Park and S.S. Whang. 2001. Systematic implications of fruit wall anatomy and surface sculpturing of *Microseris* (Asteraceae; Lactuceae) and relatives. Int. J. Pl. Sci. 162: 209-220.
- Pandy, A.K, R.P. Singh, and S. Chopra. 1978. Development and structure of seeds and fruits in Compositae Cichorieae. Phytomorphology 28: 198-206.
- Sell, P.D. 1981. *Lapsana intermedia* Bieb. or *Lapsana communis* L. subsp. *intermedia* (Bieb.) Hayek. Watsonia 13: 299-302.
- Spjut, R.W. 1994. A systematic treatment of fruit types. Memoirs of the New York Botanical Garden 70: 1-182.
- Stebbins, G.L. 1938. An anomalous new species of *Lapsana* from China. Madrono 4: 154-157.

개보리뽕이속과 서양개보리뽕이속(국화과; 상치족)의 과피벽 구조 비교 연구

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국화과 상치족에 속하는 서양개보리뽕이(*Lapsana communis*) 내의 6아종과 개보리뽕이속(*Lapsanastrum*) 4종에 대해 과피의 해부학적 구조를 조사하였다. 그 결과, 개보리뽕이속은 서양개보리뽕이와 외과피의 털의 유무, costa의 모양, 종피의 비후 등 몇 가지 형질에서 차이가 나타났다. 게다가 서양개보리뽕이속은 costae와 intercostae에 sclerenchymatous cell이 없는 반면에 개보리뽕이속은 sclerenchymatous cell로 이루어져 있다. 과실벽 구조에서의 차이는 명백하게 개보리뽕이속이 광의의 서양개보리뽕이속에서 분리됨을 지지한다.

주요어: 국화과, costae, 과피해부학, *Lapsana*, *Lapsanastrum*

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