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Floristic Characterization of the Temperate Oak Forests in the Korean Peninsula Using High-rank Taxa

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The order of Rhododendro-Quercetalia mongolicae representing temperate oak forests in Korea was characterized in terms of presence of taxa of different rank. 140 relevés were analysed for percentage contribution of each species, genera and families in syntaxa under consideration as well as extraction of diagnostic genera and families for syntaxa by an ordination technique. The Rhododendro-Quercetalia is characterized by high diversity of tree and shrub species contributing 40% of the total floristic composition as well as by a high contribution of the genus *Rhododendron* and the absence of the genus *Fagus*, characteristic of the Querco-Fagetea *sensu lato*. The character families for the Rhododendro-Quercetalia include Liliaceae and Compositae, whereas *Acer, Carex, Viola, Rhododendron* and *Quercus* are the most common among genera. *Rhododendron* and *Quercus* are regarded as the transgressive character-genera, whereas the families of Pinaceae and Ericaceae are considered companions (in sense of the terminology of the Braun-Blanquet syntaxonomy) for the order. Family appeared to be an inadequate rank for diagnoses of alliances and suballiances. On the other hand, genus was found to be the most effective rank in differentiating the alliances and suballiances. The Lindero-Quercenion shares the same character-genera with the order Rhododendro-Quercetalia. Character genera of the suballiances Callicarpo-Quercenion are *Carpinus, Styrax, Smilax* and *Callicarpa*, and those of the Pino-Quercion list *Euonymus, Saussurea* and *Tilia.*

Keywords: character-family, character-genus, temperate oak forests, net contribution degree, Rhododendro-Quercetalia.

Some of the high taxonomic ranks used in classification of plant kingdom, such as genus and family, can serve as diagnostic characters of high-rank syntaxonomical units (*e.g.* van der Maarel, 1972). They may be adopted as an effective in comparisons among vicariant vegetation types (Gray, 1860). Convergent similarity and functional differences in the species composition in Holarctic deciduous forests (*e.g.* Querco-Fagetea *sensu lato*) have been recognized by many ecologists (Miyawaki, 1960; Medwecka-Komas, 1961; Graham, 1972; Komas, 1972; Li, 1972; Pignatti, 1977; Tüxen, 1981; Campbell, 1982; Hübl, 1988; Wilmanns, 1989). Quantitative match between vegetation structure and climate on a continental level was outlined by Ellenberg (1980) and Box (1988). Floristic comparison with the Amphi-Tonghae forest types (*sensu* Kim and Manyko, 1994) revealed that the temperate oak forests of the Korean Peninsula should be considered as continental types as compared to the marine types typical of the Japanese Archipelago.

The present paper addresses the floristic characterization of the order Rhododendro-Quercetalia mongolicae (Kim, 1990), which is representative of natural and semi-natural forests dominated (monodominant or mixed) by several oaks and other deciduous trees (Kim, 1992). Representativeness of the order has been roughly proved by floristic composition coincident with the whole Korean flora (Kim, 1993) with regard to categories such as ferns, gymnosperms, monocotyledons, dicotyledons and other recognized within the Tracheophyta. The study of importance of high-rank idiotaxonomic categories in relation to the classification of vegetation has never been applied on the vegetation material in Korea.

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MATERIAL AND METHODS

The data considered were extracted from a synoptic table based on 140 phytosociological relevés made in 19 regions all over the country. Braun-Blanquet field sampling methods (Braun-Blanquet, 1964) were used. These data were previously classified as the order Rhododendro-Quercetalia mongolicae, which comprised the Pino koraiensis-Quercion mongolicae and Lindero-Quercion mongolicae (Kim, 1990). The latter alliance has further been divided into two suballiances, such as the Lindero-Quercenion mongolicae and the Callicarpo-Quercenion. The former alliance and those two suballiances correspond to zonal vegetation types designated as the northern/altimontane (NOAL), central/montane (CEMO), and southern/submontane (SOSU) types with regard to their altitudinal/latitudinal amplitude (Kim, 1992; Kim, 1994). The Lindero-Quercenion of the CEMO type, although poorly characterized in qualitative terms, is considered the syntaxonomic and synchorological core of the studied group of syntaxa. The distribution of the NOAL type covers the smallest area in South Korea. The Pino-Quercion occurs mainly at higher altitude as well as in the northern part of the Peninsula (Fig. 1).

Data were analyzed by computing the net percentage contribution of species, genera and families in the syntaxon. From the basic unit (association) blocked and separated by empirical sorting method (Becking, 1957) and TWINSPAN (Hill, 1979), I prepared the smaller data matrices excluding less important species with synoptic value < 4.0. The net contribution degree (NCD; Kim and Manyko, 1994) was applied for synoptic values of variables (species, genus and family). The NCD values for genera and families with regard to the syntaxa (associations, alliances and orders) were obtained by summing up the NCD values for those species belonging to particular higher taxa under consideration. These NCD values were fitted by computing the % contribution score of each genus (G_i') and family (F_i'), as follows

$$G_i' = G_i/\sum G_n) \times 100, \quad F_i' = F_i/\sum F_n) \times 100,$$

where ΣG_n and ΣF_n were the sum of the NCD values for genera and for families, respectively.

The determination of floristic elements of each vegetation type was based on occurrence pattern of the NCD values of each genus and family in each higher syntaxon (Appendices 1 & 2). For example, a certain genus with the NCD values increasing toward the Callicarpo-Quercenion from the Pino-Quercion was grouped as an element of the SOSU type. Such taxon contributed more to the southern/submontane type than to the northern/altimontane type (*vid.* the principles in the 2nd row of Table 2 for further examples on determination of floristic elements).

In order to extract diagnostic genera and families for syntaxa, an ordination technique was used. 68 families, 165 genera, and 6 associations were analyzed by Principal Coordinate Analysis using the program PRINCOOR (Podani, 1988) based on normalized Euclidean distance matrix. First two component ordination axes were considered. Isolines were drawn on the basis of the % contribution score (1, 2.5 and 5%) of a family or a genus to a syntaxon. The range of these scores (<10%) was relatively narrow because of many taxa in forest vegetation differing from those (>10%) of the herb vegetation (*e.g.* van der Maarel, 1972).

The nomenclature of plants and syntaxa follows Lee (1979) and Kim (1990, 1992), respectively.

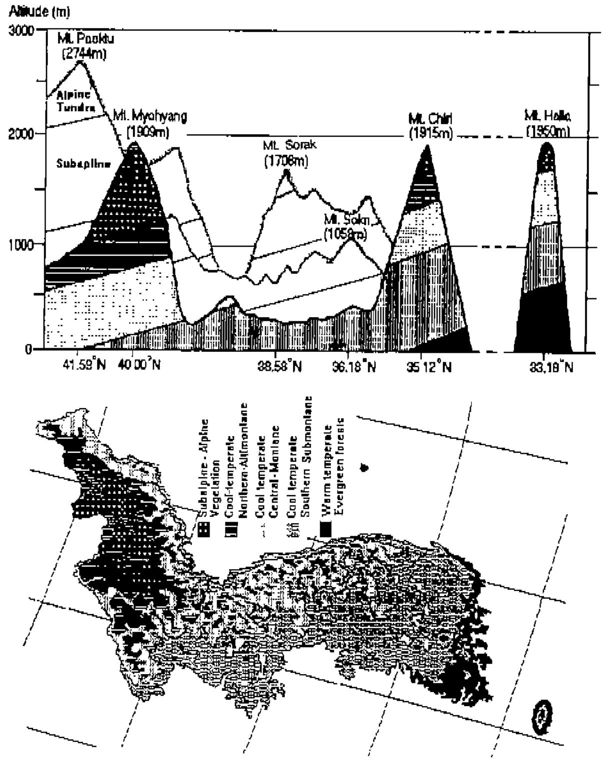

Fig. 1. Horizontal and vertical distribution of the forest vegetation in the Korean Peninsula.

Table 1. Number of taxa of the whole Korea (KOR) and in the Rhododendro-Quercetalia mongolicae (RQ). Data of whole Korea include garden flora as well

	Family				Genus				Species			
	KOR	(%)	RQ	(%)	KOR	(%)	RQ	(%)	KOR	(%)	RQ	(%)
Ferns	16	8.4	6	6.5	61	5.9	14	4.8	223	5.7	23	3.7
Gymnosperms	7	3.7	4	4.3	21	2.0	7	2.4	64	1.6	11	1.8
Monocotyledons	26	13.7	8	8.7	231	22.2	50	17.2	830	21.1	116	18.8
Dicotyledons	136	71.6	72	78.3	720	69.2	218	74.9	2789	70.9	464	75.2
Others	5	2.6	2	2.2	7	0.7	2	0.7	28	0.7	3	0.5
Total	190	100	92	100	1040	100	291	100	3934	100	617	100

Others contain Psilopsida, Lycopsida and Sphenopsida. Floral data of the whole Korea and Rhododendro-Quercetalia were arranged from Lee (1977) and Kim (1990), respectively.

RESULTS AND DISCUSSION

Floristic diagnosis of the Rhododendro-Quercetalia mongolicae

The order of Rhododendro-Quercetalia mongolicae is considered a representative Korean vegetation type due to analogous features of floristic composition mirroring the whole Korean flora (Kim, 1993). The Rhododendro-Quercetalia was approximately composed of 92 families, 291 genera and 617 species (Kim, 1990), while the whole Korean flora (incl. cultivated flora) contained 190 families, 1040 genera and 3934 species (174 families, 979 genera, 3706 species excluding ferns in Lee 1979; 178 families, 971 genera, 3585 species excluding ferns in Anonymous 1979). Composition ratio of dicotyledons in both floras attained more than 70%, which differs only slightly from 68% for Japan (Maekawa, 1974; Shimizu, 1988). The ratio of dicotyledons (75.2%) in this order was larger than that (70.9%) of all the Korean flora (Table 1).

This results from a high species diversity of trees in this order. In fact, the composition ratio of trees is around 40% in the Rhododendro-Quercetalia, but *ca.* 30% in the whole Korean flora, and *ca.* 21% in Japanese flora.

The genera of trees showed the following ranking in frequency: *Acer* > *Quercus* > *Rhododendron* > *Fraxinus* > *Lindera* > *Carpinus* > *Lespedeza* > *Prunus* > *Pinus*. In the corresponding forests in Northeast America the ranking reads: *Acer* > *Quercus* > *Fagus* > *Fraxinus* > *Tilia* > *Nyssa* > *Ulmus* (Monk *et al.*, 1989). The cool-temperate forests in the Korean Peninsula can be characterized by a high rank of the genus *Rhododendron* (Kim, 1992) and the lack of the genus *Fagus* in floras since the Middle Miocene (Tanai, 1974). I assume that these floristic characteristics may go on the account of continentality, more or less dry monsoon periods, and slightly acidic soils derived from metamorphic rocks which are predominant in most parts of the Korean Peninsula.

Diagnostic families and genera

The ordination is depicted in a diagram showing the positions of the genera and families in two dimensional space of syntaxa (Fig. 2). Most of the isolines are running parallel to the ordination axis 2. Positive coordinating value on the horizontal axis (rightward) means the increment of contribution of objectives (families and genera) to the Rhododendro-Quercetalia.

Liliaceae (#36) and Compositae (#20) in Fig. 2A, and *Acer* (#2), *Carex* (#19), *Viola* (#93) and *Quercus* (#66) in Fig. 2 (B) are the character-families and character-genera for the Rhododendro-Quercetalia. *Rhododendron* (#67) and *Quercus* (#66) should be regarded as transgressive character-genera for this order.

The genus *Athyrium* (Fig. 2B, #14), having comparatively high contribution value, is ambiguous as a character-genus for the Lindero-Quercenion, because it is included into the SOSU vegetation type owing to its synoptic value (Table 2). *Athyrium* can be regarded as a differential genus to the Lindero-Quercenion. Such a differential higher taxon is applicable as presenting relatively high contribution value (more than 2.5%), but still having a important distribution in different vegetation. A good example is the genus *Abies* (Fig. 2B, #1). Despite *Abies* occurs characteristically in the Pino-Quercion, it is mainly limited (as to its habitat) to the subalpine belt.

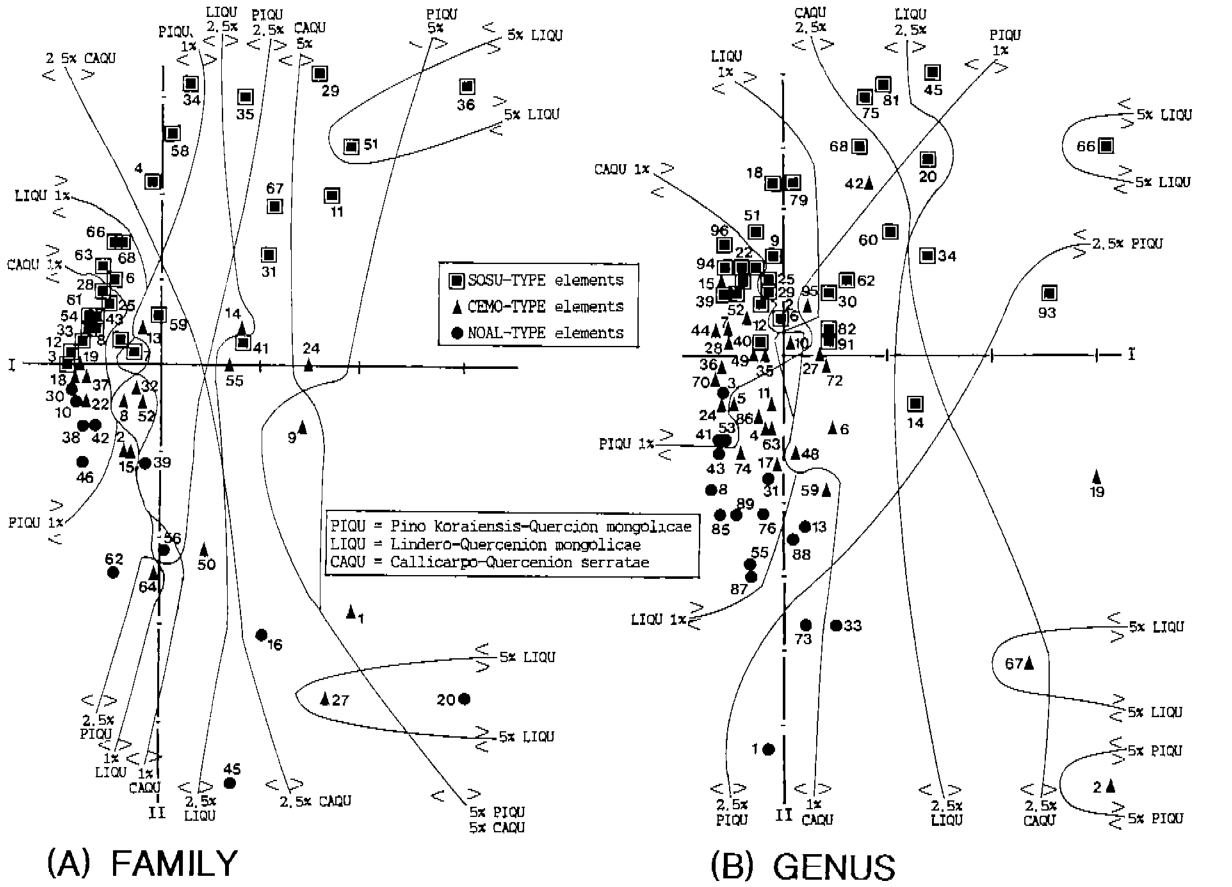

Fig. 2. Two-dimensional scatter diagram of PCA (Euclidean distance) of 68 families (A) and 96 genera (B). The numbering corresponds to the families and genera listed in Table 2.

All genera and families were classified into elements of the considered vegetation types on the basis of occurrence pattern (Table 2, row 2) of synoptic value in each higher syntaxon (Appendices 1 & 2). The genera and families are scattered along axis 2, which positive (above) and negative (bellow) co-ordinating scores of the genus and family correspond to the SOSU and NOAL vegetation type, respectively. The CEMO type shows more or less irregular scattering of elements. On the other hand, the taxon diversity of the NOAL type is smaller than with the other two types because only the data of South Korean forests were used in this paper (Table 2).

Character families

Families showed well separated plots for synecological interpretation rather than syntaxonomic correspondence (Fig. 2A). It appeared as improper to define a character-family for both alliance and suballiance owing to its weak discriminating power. Tiliaceae (#62) to the Pino-Quercion, Ericaceae (#27) to the Lindero-Quercenion, Betulaceae (#11), Fagaceae (#29), Lauraceae (#34), Styracaceae (#58), Anacardiaceae (#4) to the Callicarpo-Quercenion, show also a weak discimination. In the same way, Pinaceae (#45) with negative coordinating values on the vertical axis seems to characterize the Callicarpo-Quercenion. But the families Betulaceae, Fagaceae and Pinaceae for the Lindero-Quercenion contain the allochorous genera/species in altitudinal and latitudinal distribution. *Quercus mongolica* occurs mainly in the central/montane and northern/altimontane zone, *Q. serrata* is found in the southern/submontane zone. *Pinus densiflora* grows preferably in a southernmost cool-temperate zone and *P. koraiensis* is found in the cool-temperate/northern altimontane zone (Kim, 1994). The family of Betulaceae includes two genera -*Betula* and *Carpinus* growing in different synchorological habitats: *Betula* in the central/montane to subalpine zone and *Carpinus* in the southern/sub-

Table 2. The groups of taxa recognized within the vegetation types. The numbering corresponds to the families and genera listed in Fig. 2 and Table 2.

Vegetation types	SOSU type (32 families, 35 genera)	CEMO type (23 families, 42 genera)	NOAL type (13 families, 19 genera)
Occurrence pattern*	PIQU < LIQU < CAQU	PIQU < LIQU =. CAQU	PIQU > LIQU > CAQU
	PIQU =. LIQU < CAQU	PIQU < LIQU > CAQU	PIQU > LIQU =. CAQU
		PIQU =. LIQU > CAQU	
		PIQU > LIQU < CAQU	
Families	3 Alangiaceae	1 Aceraceae	10 Berberidaceae
	4 Anacardiaceae	2 Actinidiaceae	16 Celastraceae
	5 Aquifoliaceae	8 Aristolochiaceae	20 Compositae
	6 Araceae	9 Aspidiaceae	30 Geraniaceae
	7 Araliaceae	13 Campanulaceae	38 Lycopodiaceae
	11 Betulaceae	14 Caprifoliaceae	39 Magnoliaceae
	12 Borraginaceae	15 Caryophyllaceae	42 Orchidaceae
	17 Cephalotaxaceae	18 Chloranthaceae	44 Oxalidaceae
	21 Cornaceae	19 Commelinaceae	45 Pinaceae
	25 Dioscoreaceae	22 Crassulaceae	46 Polygonaceae
	28 Euphorbiaceae	23 Cruciferae	56 Scrophulariaceae
	29 Fagaceae	24 Cyperaceae	62 Tiliaceae
	31 Gramineae	26 Equisetaceae	65 Valerianaceae
	33 Lardizabalaceae	27 Ericaceae	
	34 Lauraceae	32 Labiatae	
	35 Leguminosae	37 Loranthaceae	
	36 Liliaceae	40 Moraceae	
	41 Oleaceae	48 Pteridaceae	
	43 Osmundaceae	50 Ranunculaceae	
	47 Primulaceae	52 Rubiaceae	
	49 Pyrolaceae	55 Saxifragaceae	
	51 Rosaceae	60 Taxaceae	
	53 Rutaceae	64 Umbelliferae	
	54 Sabiaceae		
	57 Staphyleaceae		
	58 Styracaceae		
	59 Symplocaceae		
	61 Theaceae		
	63 Ulmaceae		
	66 Verbenaceae		
	67 Violaceae		
	68 Vitaceae		
Genera	9 Arisaema	2 Acer	1 Abies
	14 Athyrium	4 Actinidia	3 Actaea
	18 Callicarpa	5 Adenophora	8 Angelica
	20 Carpinus	6 Ainsliaea	13 Astilbe
	21 Castanea	7 Ampelopsis	23 Cephalanthera
	22 Celastrus	10 Artemisia	31 Dryopteris
	25 Codonopsis	11 Asarum	33 Euonymus
	26 Cornus	12 Aster	41 Lepisorus
	29 Dioscorea	15 Atractylodes	43 Ligularia
	30 Disporum	16 Betula	53 Paris
	34 Fraxinus	17 Calamagrostis	55 Pedicularis
	39 Ilex	19 Carex	61 Polystichum
	40 Kalopanax	24 Cimicifuga	73 Saussurea
	45 Lindera	27 Corylus	76 Solidago
	46 Lysimachia	28 Deutzia	85 Syringa

Table 2. Continued

Vegetation types	SOSU type (32 families, 35 genera)	CEMO type (23 families, 42 genera)	NOAL type (13 families, 19 genera)
Occurrence pattern*	PIQU < LIQU < CAQU PIQU =. LIQU < CAQU	PIQU < LIQU =. CAQU PIQU < LIQU > CAQU PIQU =. LIQU > CAQU PIQU > LIQU < CAQU	PIQU > LIQU > CAQU PIQU > LIQU =. CAQU
Genera	47 Maackia 51 Oplismenus 52 Osmunda 54 Parthenocissus 57 Philadelphus 60 Polygonatum 62 Prunus 65 Pyrola 66 Quercus 68 Rhus 75 Smilax 78 Staphylea 79 Stephanandra 80 Stewartia 81 Styrax 82 Symplocos 83 Syneilesis 91 Viburnum 93 Viola 96 Zelkova	32 Erythronium 35 Galium 36 Hepatica 37 Hosta 38 Hydrangea 42 Lespedeza 44 Lilium 48 Magnolia 49 Meehania 50 Melampyrum 56 Phegopteris 58 Pimpinella 59 Pinus 63 Pseudostellaria 64 Pteridium 67 Rhododendron 69 Rubia 70 Sambucus 71 Sapium 72 Sasa 74 Smilacina 77 Sorbus 84 Synurus 86 Thalictrum 92 Vicia 94 Vitis 95 Weigela	87 Tilia 88 Tripterygium 89 Vaccinium 90 Veratrum

Remarks: SOSU=Southern/Submontane, CEMO=Central/Montane, NOAL=Northern/Altimontane; PIQU=Pino koraiensis-Quercion mongolicae, LIQU=Lindero-Quercenion mongolicae, CAQU=Callicarpo-Quercenion serratae.
*Occurrence patterns were identified according to the % contribution score of genus and family in syntaxa.

montane up to bottom of the central/montane zone. The resemblance between family containing two or more genera and that with only one genus will be less than it between genus with allochorous species and that with only one species (van der Maarel, 1972). The Korean oak forests are supposed that the ecological range of family is too wide to characterize such alliances of the hierarchy of the Braun-Blanquet system. The family level had better be considered to the order Rhododendro-Quercetalia or the upper syntaxonomical units.

Liliaceae (#36), Compositae (#20) showing high contributing scores are the most frequent taxa in the Korean flora. Pinaceae and Ericaceae are positively associated with more or less acidic and partly nutrient-deficient metamorphic habitats prevailing over the Korean Peninsula. Those families attaining over 2.5% of contributing scores in relation to the Lindero-Quercenion are simultaneously character-families to the Rhododendro-Quercetalia, because this suballiance is the core of the alliances, which is in turn the core of the whole order. The best characterizing family group to the Rhododendro-Quercetalia are Aceraceae (#1), Ericaceae (#27), Leguminosae (#35), Violaceae (#67), Oleaceae (#41), Saxifragaceae (#55), Pinaceae (#45), and as weak also Caprifoliaceae (#14).

Character genera

Genera far more effectively characterized the alliances than the order (Fig. 2B). The genera limited to the SOSU type include: *Lindera, Styrax, Carpinus, Callicarpa, Smilax, Zelkova, Rhus, Lespedeza, Polygonatum, Fraxinus, Prunus, Stephanandra, Oplismenus, Athyrium etc*. On the other hand, *Abies, Saussurea, Euonymus, Tilia, Pedicularis, Vaccinium, Syringa, Angelica, Ligularia* and 10 other genera characterize the NOAL type. The other genera characterize the CEMO type (Appendix 2). The genus group of the CEMO type characterizes the Rhododendro-Quercetalia of Korean oak forests as described above.

The Lindero-Quercenion itself had no character-genus but differential-genera such as *Lespedeza* (#42) and *Artemisia* (#10). Clearly *Rhododendron* (#67), *Acer* (No.2), *Viola* (#93), *Carex* (#19) and *Quercus* (#66) are character-genera to the Rhododendro-Quercetalia. The Callicarpo-Quercenion could be described by the character-genera such as *Carpinus* (#20), *Styrax* (#81) and *Smilax* (#75). The genera *Callicarpa* (#18), *Stephandra* (#79), *Oplismenus* (#51), *Arisaema* (#9), *Codonopsis* (#25), *Dioscorea* (#29) and *Cornus* (#26) are weakly characterizing the suballiance with their 1% and above in contribution scores (Fig. 2B). On the other hand, *Euonymus* (#33) and *Saussurea* (#73) could be considered as the character-genera of the Pino-Quercion. This alliance is also weakly characterized by the genera such as *Ligularia* (#43), *Dryopteris* (No.31), *Angelica* (#8), *Syringa* (#85), *Vaccinium* (#89), *Solidago* (#76), *Phegopteris* (#55), *Tilia* (#87), and *Abies* (#1). Many of these diagnostic genera are not monotypic and they possess different species within a given order Rhododendro-Quercetalia. But monotypic genera with a single species were 46.9% of 96 genera drawing a hollow curve (*e.g.* Solbrig 1994). Therefore, monotypic genera with the higher contribution score within a given syngeographical zone is likely to be regarded as a keystone character-genus for the corresponding syntaxon. The best instances are the genus *Callicarpa* for the Callicarpo-Quercenion serratae of the southern/submontane belt, *Ainsliaea* for the Lindero-Quercenion mongolicae of the central/montane belt, and *Tilia* for the Pino koraiensis-Quercion mongolicae of the northern/altimontane belt.

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Appendix 1. Synoptic value of 68 families according to syntaxa

Family	LYMO	VAMO	SAMO	ARMO	MESE	CASE	PIQU	LIQU	CAQU	RHQU
1 Aceraceae	15.5	13.5	09.0	06.5	12.0	11.0	29.0	15.5	23.0	067.5
2 Actinidiaceae	01.5	03.5	02.0	00.5	02.0	02.0	05.0	02.5	04.0	011.5
3 Alangiaceae	00.0	00.0	00.0	00.0	01.0	00.0	00.0	00.0	01.0	001.0
4 Anacardiaceae	00.0	00.5	05.0	02.5	07.0	04.0	00.5	07.5	11.0	019.0
5 Aquifoliaceae	00.5	00.0	01.0	00.0	01.0	02.0	00.5	01.0	03.0	004.5
6 Araceae	01.0	00.0	02.0	02.5	04.0	01.0	01.0	04.5	05.0	010.5
7 Araliaceae	02.0	02.0	03.0	01.5	03.0	03.0	04.0	04.5	06.0	014.5
8 Aristolochiaceae	03.5	02.0	02.0	01.0	03.0	02.0	05.5	03.0	05.0	013.5
9 Aspidiaceae	15.5	07.0	09.0	06.0	09.0	10.0	22.5	15.0	19.0	056.5
10 Berberidaceae	00.5	00.5	00.0	00.0	00.0	00.0	01.0	00.0	00.0	001.0
11 Betulaceae	06.5	07.5	12.0	08.0	12.0	14.0	14.0	20.0	26.0	060.0
12 Borraginaceae	00.0	00.0	00.0	00.5	00.0	01.0	00.0	00.5	01.0	001.5
13 Campanulaceae	04.5	01.0	03.0	02.0	04.0	03.0	05.5	05.0	07.0	017.5
14 Caprifoliaceae	06.5	06.0	05.0	04.5	08.0	10.0	12.5	09.5	18.0	040.0
15 Caryophyllaceae	07.0	02.0	02.0	00.5	01.0	03.0	09.0	02.5	04.0	015.5
16 Celastraceae	10.5	10.5	08.0	04.0	04.5	07.5	21.0	12.0	12.0	045.0
17 Cephalotaxaceae	00.0	00.0	00.0	00.0	02.0	00.0	00.0	00.0	02.0	002.0
18 Chloranthaceae	00.5	00.0	00.0	00.5	00.0	00.0	00.5	00.5	00.0	001.0
19 Commelinaceae	00.0	00.0	01.0	00.5	00.0	00.0	00.0	01.5	00.0	001.5
20 Compositae	27.0	16.5	12.0	17.5	12.0	15.0	43.5	29.5	27.0	100.0
21 Cornaceae	02.0	01.5	02.0	01.5	04.0	02.0	03.5	03.5	06.0	013.0
22 Crassulaceae	01.0	01.0	00.0	00.5	00.0	01.0	02.0	00.5	01.0	003.5
23 Cruciferae	00.5	00.0	01.0	00.5	00.5	00.5	00.5	01.5	00.5	002.0
24 Cyperaceae	11.0	08.5	07.0	09.0	10.0	12.0	19.5	16.0	22.0	057.5
25 Dioscoreaceae	01.0	00.5	03.0	00.5	02.0	03.0	01.5	03.5	05.0	010.0
26 Equisetaceae	00.5	00.0	00.0	00.5	00.0	00.0	00.5	00.5	00.0	001.0
27 Ericaceae	06.5	14.5	12.0	10.5	06.0	05.0	21.0	22.5	11.0	054.5
28 Euphorbiaceae	00.5	00.0	02.0	01.5	01.0	03.0	00.5	03.5	04.0	008.0
29 Fagaceae	05.5	04.5	09.0	12.0	13.0	14.0	10.0	21.0	27.0	058.0
30 Geraniaceae	01.5	00.0	00.0	00.0	00.0	00.0	01.5	00.0	00.0	001.0
31 Gramineae	07.5	04.5	09.0	08.0	11.0	07.0	12.0	17.0	18.0	047.0
32 Labiatae	04.5	02.0	02.0	02.0	03.0	03.0	06.5	04.0	06.0	016.5
33 Lardizabalaceae	00.0	00.0	00.0	00.0	01.0	01.0	00.0	00.0	02.0	002.0
34 Lauraceae	00.5	01.0	05.0	05.0	09.0	08.0	01.5	10.0	17.0	028.5
35 Leguminosae	02.5	02.5	06.0	10.5	07.0	11.0	05.0	16.5	18.0	039.5
36 Liliaceae	15.5	11.0	17.0	14.5	22.0	21.5	26.5	31.5	43.5	101.5
37 Loranthaceae	00.0	00.5	01.0	00.5	01.0	00.5	00.5	01.5	01.0	. 003.0
38 Lycopodiaceae	01.0	01.0	00.0	00.0	00.0	00.0	02.0	00.0	00.0	002.0
39 Magnoliaceae	03.0	04.0	04.0	01.5	04.0	01.0	07.0	05.5	05.0	017.5
40 Moraceae	00.5	00.5	00.0	00.5	01.0	01.0	01.0	00.5	02.0	003.5
41 Oleaceae	07.0	05.5	06.0	07.0	08.0	07.0	12.5	13.0	15.0	050.0
42 Orchidaceae	02.5	01.5	01.0	01.5	00.0	01.0	04.0	02.5	01.0	007.5
43 Osmundaceae	00.5	00.0	02.5	00.5	01.0	02.0	00.5	02.5	03.0	006.0
44 Oxalidaceae	00.5	00.0	00.0	00.0	00.0	00.0	00.5	00.0	00.0	000.5
45 Pinaceae	07.0	12.0	08.0	03.5	03.0	02.0	19.0	11.5	05.0	035.5
46 Polygonaceae	01.5	02.0	00.0	00.5	00.0	00.0	03.5	00.5	00.0	004.0
47 Primulaceae	01.0	00.0	01.0	02.0	02.0	02.0	01.0	03.0	04.0	008.0
48 Pteridaceae	00.0	00.0	00.5	02.0	01.0	01.0	00.0	02.5	02.0	004.5
49 Pyrolaceae	00.0	00.5	01.0	00.5	02.0	02.0	00.5	01.5	04.0	006.0
50 Ranunculaceae	09.5	06.5	04.0	03.0	05.0	04.0	16.0	07.0	09.0	032.0
51 Rosaceae	11.0	05.5	13.0	08.5	14.0	14.0	16.5	21.5	28.0	066.0
52 Rubiaceae	03.5	03.0	01.0	03.0	02.0	04.0	06.5	04.0	06.0	016.5
53 Rutaceae	00.0	00.0	00.0	00.0	02.0	01.0	00.0	00.0	03.0	003.0
54 Sabiaceae	00.0	00.0	00.0	00.0	02.0	00.0	00.0	00.0	02.0	002.0
55 Saxifragaceae	08.0	05.0	07.0	04.5	07.0	07.0	13.0	11.5	14.0	038.5
56 Scrophulariaceae	04.5	06.0	03.0	04.5	03.0	01.0	10.5	07.5	04.0	022.0
57 Staphyleaceae	00.5	00.0	00.0	01.0	01.0	02.0	10.5	07.5	04.0	038.5
58 Styracaceae	00.0	01.0	04.0	04.0	07.0	07.0	00.5	01.0	03.0	022.0
59 Symplocaceae	04.0	01.5	03.0	02.5	04.0	04.0	01.0	08.0	14.0	004.5
60 Taxaceae	00.0	00.5	00.0	00.0	00.0	01.0	05.5	05.5	08.0	023.0
61 Gheaceae	00.0	00.0	01.0	00.5	02.0	01.0	00.5	00.0	01.0	019.0
62 Tiliaceae	03.0	05.0	01.0	01.0	01.0	00.0	00.5	01.5	03.0	001.5
63 Ulmaceae	00.5	00.0	01.0	00.0	03.0	04.0	08.0	02.0	01.0	004.5
64 Umbelliferae	09.5	04.5	02.0	01.5	03.0	01.0	00.5	01.0	07.0	011.0
65 Valerianaceae	01.0	00.0	00.0	00.5	00.0	00.0	14.0	03.5	04.0	008.5
66 Verbenaceae	00.5	00.0	01.0	00.5	04.0	04.0	01.0	00.5	00.0	021.5
67 Violaceae	09.0	04.0	07.0	09.0	08.0	12.0	00.5	01.5	08.0	001.5
68 Vitaceae	00.5	00.5	02.0	02.0	03.0	05.0	13.0	16.0	20.0	010.0

Abbreviation: LYMO= Lychno-Quercetum mongolicae, VAMO=Vaccinio-Quercetum mongolicae, SAMO=Saso-Quercetum mongolicae, ARSE=Artemisio-Quercetum mongolicae, MESE=Meliosmo-Quercetum serratae, CASE=Staphyleo-Quercetum serratae, PIQU=Pino koraiensis-Quercion mongolicae, LIQU=Lindero-Quercenion mongolicae, CAQU=Callicarpo-Quercenion serratae, RHQU=Rhododendro-Quercetalia mongolicae. 4

Appendix 2. Synoptic value of 96 genera according to syntaxa

Genus (No. Sp.)	LYMO	VAMO	SAMO	ARSE	MESE	CASE	PIQU	LIQU	CAQU	RHQU
1 *Abies* (3)	04.5	07.5	03.0	01.0	00.0	00.0	12.0	04.0	00.0	16.0
2 *Acer* (10)	15.5	13.5	09.0	06.5	12.0	11.0	29.0	15.5	23.0	67.5
3 *Actaea* (1)	01.5	01.0	01.0	00.5	01.0	00.0	02.5	01.5	01.0	05.0
4 *Actinidia* (3)	01.5	03.5	02.0	00.5	02.0	02.0	05.0	02.5	04.0	11.5
5 *Adenophora* (2)	03.5	00.5	01.0	00.5	01.0	01.0	04.0	01.5	02.0	07.5
6 *Ainsliaea* (1)	03.5	04.0	03.0	03.0	04.0	03.0	07.5	06.0	07.0	20.5
7 *Ampelopsis* (1)	00.5	00.5	01.0	01.0	01.0	01.0	01.0	02.0	02.0	05.0
8 *Angelica* (2)	02.5	02.5	00.0	00.5	00.0	00.0	05.0	00.5	00.0	05.5
9 *Arisaema* (4)	01.0	00.0	02.0	02.5	04.0	01.0	01.0	04.5	05.0	10.5
10 *Artemisia* (3)	02.0	01.5	02.0	04.5	01.0	03.0	03.5	06.5	04.0	14.0
11 *Asarum* (1)	03.0	02.0	02.0	01.0	02.0	02.0	05.0	03.0	04.0	12.0
12 *Aster* (2)	01.5	01.0	00.0	01.0	01.0	03.0	02.5	01.0	04.0	07.5
13 *Astilbe* (2)	04.0	04.5	03.0	02.0	02.0	02.0	08.5	05.0	04.0	17.5
14 *Athyrium* (5)	06.5	03.0	06.0	04.5	05.0	06.0	09.5	10.5	11.0	31.0
15 *Atractylodes* (1)	00.0	00.0	00.0	02.5	01.0	01.0	00.0	02.5	02.0	04.5
16 *Betula* (3)	02.5	01.5	03.0	02.0	01.0	01.0	04.0	05.0	02.0	11.0
17 *Calamagrostis* (1)	03.0	03.5	02.0	01.5	02.0	02.0	06.5	03.5	04.0	14.0
18 *Callicarpa* (1)	00.5	00.0	01.0	00.5	04.0	04.0	00.5	01.5	08.0	10.0
19 *Carex* (8)	11.0	08.5	07.0	09.0	10.0	12.0	19.5	16.0	22.0	57.5
20 *Carpinus* (3)	01.5	03.0	05.0	04.0	07.0	09.0	04.5	09.0	16.0	29.5
21 *Castanea* (1)	00.0	00.0	01.0	00.0	01.0	02.0	00.0	01.0	03.0	04.0
22 *Celastrus* (1)	00.0	00.5	01.0	00.5	01.0	03.0	00.5	01.5	04.0	06.0
23 *Cephalanthera* (1)	01.5	01.0	01.0	01.0	00.0	01.0	02.5	02.0	01.0	05.5
24 *Cimicifuga* (1)	01.5	01.5	00.0	00.5	01.0	00.0	03.0	00.5	01.0	04.5
25 *Codonopsis* (1)	01.0	00.5	02.0	01.5	03.0	02.0	01.5	03.5	05.0	10.0
26 *Cornus* (2)	02.0	01.5	02.0	01.5	04.0	02.0	03.5	03.5	06.0	13.0
27 *Corylus* (3)	02.5	03.0	03.0	01.5	04.0	04.0	05.5	04.5	08.0	18.0
28 *Deutzia* (3)	01.0	00.5	01.0	01.0	02.0	00.0	01.5	02.0	02.0	05.5
29 *Dioscorea* (3)	01.0	00.5	03.0	00.5	02.0	03.0	01.5	03.5	05.0	10.0
30 *Disporum* (3)	02.5	01.5	03.0	03.0	04.0	04.0	04.0	06.0	08.0	18.0
31 *Dryopteris* (3)	05.0	02.0	02.0	01.0	01.0	02.0	07.0	03.0	03.0	13.0
32 *Erythronium* (1)	00.5	00.5	01.0	00.5	01.0	01.0	01.0	01.0	02.0	04.0
33 *Euonymus* (6)	06.0	06.0	04.0	01.5	02.5	02.5	12.0	05.5	05.0	22.5
34 *Fraxinus* (3)	05.0	01.5	05.0	06.5	07.0	06.0	06.5	11.5	13.0	31.0
35 *Galium* (4)	02.0	01.5	01.0	02.0	02.0	02.0	03.5	03.0	04.0	10.5
36 *Hepatica* (1)	01.0	01.5	00.0	00.5	01.0	01.0	02.5	00.5	02.0	05.0
37 *Hosta* (1)	02.0	00.0	01.0	01.0	01.0	00.0	02.0	02.0	01.0	05.0
38 *Hydrangea* (1)	00.5	00.0	01.0	00.5	01.0	02.0	00.5	01.5	03.0	05.0
39 *Ilex* (1)	00.5	00.0	01.0	00.0	01.0	02.0	00.5	01.0	03.0	04.5
40 *Kalopanax* (1)	01.0	01.5	02.0	00.5	02.0	02.0	02.5	02.5	04.0	09.0
41 *Lepisorus* (1)	01.5	02.0	00.0	00.5	00.0	00.0	03.5	00.5	00.0	04.0
42 *Lespedeza* (4)	01.0	01.0	04.0	06.5	05.0	05.0	02.0	10.5	10.0	22.5
43 *Ligularia* (2)	04.0	00.5	00.0	00.5	00.0	00.0	04.5	00.5	00.0	05.0
44 *Lilium* (1)	01.0	00.5	00.0	00.5	01.0	01.0	01.5	00.5	02.0	04.0
45 *Lindera* (3)	00.5	01.0	05.0	05.0	09.0	08.0	01.5	10.0	17.0	28.5
46 *Lysimachia* (2)	01.0	00.0	01.0	02.0	02.0	02.0	01.0	03.0	04.0	08.0
47 *Maackia* (1)	00.5	01.0	02.0	01.0	02.0	02.0	01.5	03.0	04.0	08.5
48 *Magnolia* (1)	02.0	04.0	03.0	01.0	04.0	01.0	06.0	04.0	05.0	15.0
49 *Meehania* (1)	02.0	01.5	01.0	00.5	02.0	02.0	03.5	01.5	04.0	09.0
50 *Melampyrum* (2)	00.5	01.5	02.0	03.5	01.0	01.0	02.0	05.5	02.0	09.5
51 *Oplismenus* (1)	00.0	00.0	01.0	01.0	02.0	03.0	00.0	02.0	05.0	07.0
52 *Osmunda* (2)	00.5	00.0	02.0	00.5	01.0	02.0	00.5	02.5	03.0	06.0
53 *Paris* (1)	01.5	02.0	01.0	00.5	00.0	00.5	03.5	01.5	00.5	05.5
54 *Parthenocissus* (1)	00.0	00.0	01.0	00.0	01.0	02.0	00.0	01.0	03.0	04.0
55 *Pedicularis* (2)	04.0	04.0	01.0	01.0	01.0	00.0	08.0	02.0	01.0	11.0
56 *Phegopteris* (2)	01.5	01.0	00.0	00.0	01.0	01.0	02.5	00.0	02.0	04.5
57 *Philadelphus* (2)	01.0	00.0	01.0	01.0	02.0	02.0	01.0	02.0	04.0	07.0
58 *Pimpinella* (1)	03.0	01.0	00.0	00.5	01.0	01.0	04.0	00.5	02.0	06.5
59 *Pinus* (2)	02.5	04.0	05.0	02.5	02.0	02.0	06.5	07.5	04.0	18.0
60 *Polygonatum* (5)	02.5	02.0	05.0	04.0	05.0	07.0	04.5	09.0	12.0	25.5
61 *Polystichum* (1)	02.0	01.0	01.0	00.0	01.0	00.0	03.0	01.0	01.0	05.0
62 *Prunus* (4)	03.0	01.5	04.0	02.0	06.0	04.0	04.5	06.0	10.0	20.5
63 *Pseudostellaria* (2)	04.0	02.0	02.0	00.5	01.0	03.0	06.0	02.5	04.0	12.5
64 *Pteridium* (1)	00.0	00.0	00.5	02.0	01.0	01.0	00.0	02.5	02.0	04.5
65 *Pyrola* (1)	00.0	00:5	01.0	00.5	02.0	02.0	00.5	01.5	04.0	06.0
66 *Quercus* (6)	05.5	04.5	08.0	12.0	12.0	12.0	10.0	20.0	24.0	54.0
67 *Rhododendron* (5)	05.5	10.5	10.0	10.0	06.0	05.0	16.0	20.0	11.0	47.0
68 *Rhus* (3)	00.0	00.5	05.0	02.5	07.0	04.0	00.5	07.5	11.0	19.0
69 *Rubia* (2)	01.5	01.5	00.0	00.5	00.0	01.0	03.0	00.5	01.0	04.5
70 *Sambucus* (1)	01.5	01.0	00.0	00.5	00.0	01.0	02.5	00.5	01.0	04.0
71 *Sapium* (1)	00.0	00.0	01.0	01.5	01.0	01.0	00.0	02.5	02.0	04.5
72 *Sasa* (1)	03.5	01.0	05.0	02.5	05.0	01.0	04.5	07.5	06.0	18.0

Appendix 2. Continued

Genus (No. Sp.)	LYMO	VAMO	SAMO	ARSE	MESE	CASE	PIQU	LIQU	CAQU	RHQU
73 *Saussurea* (7)	06.5	04.5	03.0	03.0	01.0	01.0	11.0	06.0	02.0	19.0
74 *Smilacina* (1)	02.5	02.5	01.0	00.5	01.0	01.0	05.0	01.5	02.0	08.5
75 *Smilax* (3)	00.5	00.5	03.0	04.0	07.0	06.0	01.0	07.0	13.0	21.0
76 *Solidago* (1)	04.0	03.0	02.0	01.5	01.0	01.0	07.0	03.5	02.0	12.5
77 *Sorbus* (2)	02.0	02.0	04.0	02.5	02.0	04.0	04.0	06.5	06.0	16.5
78 *Staphylea* (1)	00.5	00.0	00.0	01.0	01.0	02.0	00.5	01.0	03.0	04.5
79 *Stephanandra* (1)	00.5	00.0	02.0	01.5	04.0	04.0	00.5	03.5	08.0	12.0.
80 *Stewartia* (1)	00.0	00.0	01.0	00.5	02.0	01.0	00.0	01.5	03.0	04.5
81 *Styrax* (2)	00.0	01.0	04.0	04.0	07.0	07.0	01.0	08.0	14.0	23.0
82 *Symplocos* (1)	04.0	01.5	03.0	02.5	04.0	04.0	05.5	05.5	08.0	19.0
83 *Syneilesis* (1)	00.5	00.0	01.0	00.5	02.0	02.0	00.5	01.5	04.0	06.0
84 *Synurus* (2)	02.5	01.0	00.0	00.5	00.0	01.0	03.5	00.5	01.0	05.0
85 *Syringa* (2)	02.0	03.5	00.0	00.5	00.0	00.0	05.5	00.5	00.0	06.0
86 *Thalictrum* (2)	02.5	02.0	02.0	00.5	01.0	02.0	04.5	02.5	03.0	10.0
87 *Tilia* (1)	03.0	05.0	01.0	01.0	01.0	00.0	08.0	02.0	01.0	11.0
88 *Tripterygium* (1)	04.5	04.0	03.0	02.0	01.0	02.0	08.5	05.0	03.0	16.5
89 *Vaccinium* (1)	01.0	04.0	02.0	00.5	00.0	00.0	05.0	02.5	00.0	07.5
90 *Veratrum* (1)	01.5	01.0	01.0	00.5	01.0	00.0	02.5	01.5	01.0	05.0
91 *Viburnum* (4)	02.0	03.0	03.0	02.5	04.0	04.0	05.0	05.5	08.0	18.5
92 *Vicia* (2)	01.0	00.5	00.0	01.0	00.0	02.0	01.5	01.0	02.0	04.5
93 *Viola* (12)	09.0	04.0	07.0	09.0	08.0	12.0	13.0	16.0	20.0	49.0
94 *Vitis* (2)	00.0	00.0	00.0	01.0	01.0	02.0	00.0	01.0	03.0	04.0
95 *Weigela* (2)	02.5	02.0	02.0	01.5	04.0	04.0	04.5	03.5	08.0	16.0
96 *Zelkova* (1)	00.0	00.0	00.0	00.0	02.0	02.0	00.0	00.0	04.0	04.0

Abbreviation: LYMO=Lychno-Quercetum mongolicae, VAMO=Vaccinio-Quercetum mongolicae, SAMO=Saso-Quercetum mongolicae, ARSE=Artemisio-Quercetum mongolicae, MESE=Meliosmo-Quercetum serratae, CASE=Staphyleo-Quercetum serratae, PIQU=Pino koraiensis-Quercion mongolicae, LIQU=Lindero-Quercenion mongolicae, CAQU=Callicarpo-Quercenion serratae, RHQU=Rhododendro-Quercetalia mongolicae.