Korean J. Pl. Taxon.
43(2): 81-89 (2013)
http://dx.doi.org/10.11110/kjpt.2013.43.2.81

ISSN 1225-8318
Korean Journal of
Plant Taxonomy

A review of the taxonomic and ecological characteristics of Korean mistletoe types (*Viscum, Korthalsella, Loranthus* and *Taxillus*)

Chan-Soo Kim, Soo-Young Kim[1]*, Byung-Yun Sun[2] and Jae Seon Yi[3]

Warm-temperate Forest Research Center, Korea Forest Research Institute, Seogwipo 697-050, Korea
[1]Wildlife Genetic Resources Center, National Institute of Biological Resources, Incheon 404-708, Korea
[2]Department of Biological Science, Chonbuk National University, Jeonju 561-756, Korea
[3]College of Forest and Environment Sciences, Kangwon National University, Chuncheon 200-701, Korea
(Received 21 May 2012; Revised 17 December 2012; Accepted 4 March 2013)

한국산 겨우살이류(*Viscum, Korthalsella, Loranthus* and *Taxillus*)의 분류 및 생태학적 특성 고찰

김찬수 · 김수영[1]* · 선병윤[2] · 이재선[3]

국립산림과학원 난대산림연구소, [1]국립생물자원관 야생생물유전자원센터,
[2]전북대학교 생명과학과, [3]강원대학교 산림환경과학대학

ABSTRACT: In general, studies of aerial parasitic plants known collectively as mistletoe have been carried out to investigate their ecological and agricultural characteristics. However, with the recently increased level of interest in medicinal resources, research on different types of Korean mistletoe has also increased. This study was carried out to review the work on the taxonomy and ecology of Korean mistletoe in preparation for the industrial use of these plants in the future. Mistletoe types are flowering plants belonging to Santalales, which exist in the form of parasites on the branches of trees or shrubs. In Korea, five taxa of four genera in two families of mistletoe exist: *Viscum coloratum* (Komarov) Nakai f. *coloratum*, *Viscum coloratum* (Komarov) Nakai f. *rubroaurantiacum* (Makino) Kitagawa and *Korthalsella japonica* (Thunb.) Engl. in Santalaceae, along with *Loranthus tanakae* Franch. et Sav. and *Taxillus yadoriki* (Sieb. ex Maxim.) Danser in Loranthaceae. As taxonomic studies of these species remain insufficient and given that the distribution ranges of these species are very wide, further observations pertaining to the morphological variations in each species are necessary. The distribution of mistletoes is known to be determined by the host specificity, the interval between the hosts, the environmental condition, the habits of the host plant, the eating characteristics of mediators in the area, and their habitat selection features.

Keywords: Santalaceae, Loranthaceae, taxonomy, ecology

적 요: 일반적으로 겨우살이라고 하는 공중기생식물들에 대한 연구는 주로 생태학적 측면과 농업적 측면에서 이루어져 왔다. 그러나 최근 약용자원 측면에서 관심이 높아져 우리나라에 분포하고 있는 겨우살이에 관한 연구도 활발해지고 있다. 본 연구는 앞으로 겨우살이를 산업적으로 이용하기 위한 연구가 진행될 것에 대비하여 한국에 분포하는 겨우살이를 중심으로 지금까지의 분류학 및 생태학 분야의 연구내용을 고찰하고자 수행했다. 겨우살이는 교목이나 관목의 가지에 기생하는 단향목에 속하는 현화식물로서 우리나라에는 단향과의 겨우살이[*Viscum coloratum* (Komarov) Nakai f. *coloratum*], 붉은겨우살이[*Viscum coloratum* (Komarov) Nakai f. *rubroaurantiacum* (Makino) Kitagawa], 동백나무겨우살이[*Korthalsella japonica* (Thunb.) Engl.] 등 3분류군과 꼬리겨우살이과의 꼬리겨우살이*(Loranthus tanakae* Franch. et Sav.)와 참나무겨우살이[*Taxillus yadoriki* (Sieb. ex Maxim.) Danser] 등 2분류군을 합하여

*Author for correspondence: sy7540@korea.kr

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2과 4속 5분류군이 분포하고 있다. 그런데 이 종들에 대한 분류학적 연구가 아직까지는 미진하였으며, 분포범위 또한 광범위하기 때문에 종 내의 형태변이에 대한 관찰도 추가적으로 이루어져야할 것이다. 겨우살이의 분포는 숙주 특이성과 숙주간의 거리, 환경조건, 그리고 숙주식물의 형태, 전파 매개자 섭식특성과 서식지 선택 특성에 따라 결정되었다.

주요어: 단향과, 꼬리겨우살이과, 분류학, 생태학

Parasites can be defined as plants that are combined with a host plant throughout their lifetime, during which they receive a benefit from the host but give none to it (Douglas, 1994; Thompson, 1994). Parasites are estimated to be 1% angiosperms, of which 40% are shoot parasites and the rest, 60%, are root parasites (Musselman and Press. 1995).

Mistletoe plants are flowering plants belonging to Santalales which are parasitic on the branches of trees or shrubs. Some species of Santalales stick to the root of the host and others to the shoot; in any case, all are hemiparasites (Nickrent, 2002). Mistletoe can obtain carbon sources independently, but it receives water and nutrients from the xylem sap of its host. As dwarf mistletoe types which belong to *Arceuthobium* and *Korthalsella* of Santalaceae (formerly Viscaceae) obtain carbohydrates from the phloem sap of the host, they are basically considered as a heterotrophic plant (Hawksworth and Wiens, 1996). The remaining types are usually considered as autotrophic, obtaining only water and minerals from the host, although there is evidence that they absorb carbon sources from the host as well (Reid et al., 1995).

The aerial parasite plants known as mistletoe are commonly known to number about 1,400 species in the four families of Loranthaceae, Misodendraceae, Santalaceae and Viscaceae, belonging to Santalales, among which Loranthaceae is the largest family with 900 or more species (Reid et al., 1995; Nickrent, 2002). In Korea, there are four species and four genera in the two families: Santalaceae and Loranthaceae (Kim, 2007a, 2007b).

Most studies of parasites have focused on ecological and economic aspects due to the detrimental effects of parasites on orchards and on timber production (Venturelli, 1981; Parker and Riches, 1993; Reid et al., 1994; Musselman and Press, 1995; Pennings and Calloway, 1996; Silva and Martinez, 1996; Sinha and Bawa, 2002). However, they have long been considered as either poisonous or medicinal plants. Some species of mistletoe are used for jaundice, hepatic disturbances, bacillary dysentery, and as an antihypertensive or diuretic (Adsersen and Adsersen, 1997; Novy, 1997; Saleh, 2005).

Recently, interest in the medicinal efficacy of mistletoe has increased such that many studies and analyses of their medicinal components have been published. Among them, there are many studies on the mistletoe types that grow in Korea. As a result of several component analyses, new components with excellent anti-cancer efficacy have been discovered in addition to the already well-known components, greatly elevating the value of mistletoe (Yoon et al., 1995; Jin et al., 2001; Lyu et al., 2002; Hwang et al., 2003; Lee et al., 2003; Lee et al., 2003; Park et al., 2003; Sung et al., 2003; Seo et al., 2004; Ye et al., 2006; Yoon et al., 2009).

Therefore, studies of mistletoe are expected to be more active in the future. Regarding studies of the industrial use of mistletoe, it is necessary to secure a technique to develop new varieties and to increase cultivation. Therefore, initial studies focusing on the taxonomy, ecology and phytogeography of mistletoe should be done. Hence, in this paper the trends pertaining to taxonomic and phytogeographic studies of mistletoe types are surveyed in an effort to contribute to future studies.

Taxonomic studies of mistletoe

Santalaceae R. Br. is known to have 850 species and 45 genera throughout the world. In Korea, there are the two species of *Thesium chinense* Turcz. and *Thesium refractum* C. A. Mey. in *Thesium* L.; two taxa of *Viscum album* L. var. *coloratum* (Kom.) Ohwi and *Viscum album* L. var. *coloratum* (Kom.) Ohwi f. *rubroauratiacum* Ohwi in *Viscum* L.; and one species of *Korthalsella japonica* (Thunb.) Engl. in *Korthalsella* Tiegh. Thus, there are five taxa in three genera (Lee, 1980; Lee, 1996; Lee, 2003; Kim, 2007a).

These three genera are different in the following ways (Kim, 2007a). *Thesium* is an herb with alternate and linear leaves; its flowers are bisexual, and it has five perianth lobes. Its fruit is nut-like, unlike that of other genera. *Viscum* and *Korthalsella*. are shrubs with opposite and oblanceolate or scale-like leaves; their flowers are unisexual, and there are 3~4 perianth lobes. Their fruits are berries, unlike that of *Thesium.* Of them, *Viscum* has a terete stem with oblanceolate leaves, four perianth lobes and berry fruits that are about 6 mm in diameter. Meanwhile, *Korthalsella* Tiegh. has a flat stem with reduced scale-like leaves, three perianth lobes and berry fruit that are about 2 mm in diameter.

Of these three genera, the taxa classified to have useful medicinal efficacy are *Viscum* and *Korthalsella.* There are nearly 100 species of *Viscum* in the world, but only one in Korea. However, the citations of the scientific name of this

species and infra-species groups have differed depending on the author, causing some confusion.

The scientific name for Korean mistletoe has generally been *Viscum album* L. var. *coloratum* (Kom.) Ohwi in Korea (Lee, 1980; Lee, 1996; Lee, 2003; Kim, 2007a), but also *Viscum album* L. subsp. *coloratum* Komarov (Ohwi, 1984; Satake et al., 1989)나 *Viscum album* L. var. *lutescens* Makino (Makino, 1989) in Japan and China or sometimes *Viscum coloratum* (Komarov) Nakai (Qiu and Gilbert, 2003), which was elevated to a species. Of those, *Viscum coloratum* (Kom.) Nakai which Nakai announced as combination name in 1919 is the legal name (Qiu and Gilbert, 2003). Therefore, the infra-species group names of this mistletoe are cited differently. *Viscum coloratum* (Kom.) Nakai *sensu lato* has a range of fruit colors, including light yellow, light red, orange and red; the group in Korea has light yellow fruit in general while the red mistletoe specifically on Jeju Island is, unsurprisingly, red in color (Kim, 2005, 2006a, 2006b, 2009; Kim et al., 2006a, 2006b).

These characteristics may be very important regarding breeding science. In Korea, red mistletoe is considered as one form of Korean mistletoe, with the name *Viscum album* L. var. *coloratum* (Kom.) Ohwi f. *rubroauratiacum* Ohwi (Lee, 1980; Lee, 1996; Lee, 2003). Meanwhile, *Viscum album* L. subsp. *coloratum* Komarov f. *rubroauratiacum* (Makino) Ohwi is the name used for it in Japan (Ohwi, 1984; Satake et al., 1989). Furthermore China tends to integrate it into the basic species (Qiu and Gilbert, 2003).

Of the 25 species of *Korthalsella*, only one species is known to grow in Korea. The scientific name of this species is occasionally *Pseudodixus japonicus* Hayata (Makino, 1989) but *Korthalsella japonica* (Thunb.) Engl. more generally, which has caused some confusion. In spite of this, its name has undergone diverse changes, as has its classification, including the following: *Viscum japonicum* Thunberg, *Bifaria davidiana* Tieghem, *B. fasciculata* Tieghem, *B. japonica* (Thunberg) Tieghem, *B. opuntia* Merrill, nom. illeg. superfl. and *Korthalsella-fasciculata* (Tieghem) Lecomte (Qiu and Gilbert, 2003). This situation in which the scientific names of Korean mistletoe types are not yet fixed implies that studies in this field remain insufficient.

In the APG Ⅲ classification, Santalales R. Br. ex Bercht. & J. Presl. has seven families, with two new families of Balanophoraceae Rich. and Schoepfiaceae Blume as well as five families in the former APG Ⅱ classification: Olacaceae Juss. ex R. Br., Opiliaceae Valeton, Loranthaceae Juss., Santalaceae R. Br., Lora-nthaceae Juss. and Misodendraceae Juss. (Angiosperm Phyl-ogeny Group, 2003; Chase and Reveal. 2009; Reveal and Chase, 2011). Of those, the 17 families listed below are treated as Santalaceae.

Santalaceae R. Br., Prodr.: 350. 27 Mar 1810, *nom. cons*.

Amphorogynaceae Nickrent & Der in D. L. Nickrent et al., Taxon 59: 552. 4 Apr. 2010

Anthobolaceae Dumort., Anal. Fam. Pl.: 15, 17. 1829

Arjonaceae Tiegh., Just's Bot. Jahresber. 24(2): 279. 1898

Canopodaceae C. Presl, [Epimel. Bot.: 248], Abh. Knigl. Bhm. Ges. Wiss., ser. 5, 6: 608. ante Oct. 1851

Cervantesiaceae Nickrent & Vidal-Russell in D. L. Nickrent et al., Taxon 59: 551. 4 Apr. 2010

Comandraceae Nickrent & Vidal-Russell in D. L. Nickrent et al., Taxon 59: 550. 4 Apr. 2010

Dendrophthoraceae Tiegh., Just's Bot. Jahresber. 24(2): 291. 1898

Eremolepidaceae Tiegh. ex Nakai, Bull. Natl. Sci. Mus. Tokyo 31: 48. Mar. 1952

Exocarpaceae J. Agardh, Theoria Syst. Pl.: 317. Apr.-Sep. 1858

Ginalloaceae Tiegh., Just's Bot. Jahresber. 25(2): 405. 19 Jan. 1900

Lepidocerataceae Nakai, Bull. Natl. Sci. Mus. Tokyo 31: 45. Mar. 1952

Nanodeaceae Nickrent & Vidal-Russell in D. L. Nickrent et al., Taxon 59: 552. 4 Apr. 2010

Osyridaceae Raf., Ann. Gn. Sci. Phys. Bruxelles 5: 348. Jul.-Sep. 1820

Phoradendraceae H. Karst., Fl. Coomb. 1: 73. 13 Feb. 1860

Thesiaceae Vest, Anleit. Stud. Bot. 270, 289, 1818

Viscaceae Batsch, Tab. Affin. Regni Veg.: 240. 2 May 1802

The Loranthaceae Juss. family is known to have 940 species and 70 genera throughout the whole world, among which there are two species of two genera in Korea: *Loranthus tanakae* Franch. et Sav. of *Loranthus* Jacq. and *Taxillus yadoriki* (Sieb. ex Maxim.) Danser of *Taxillus* Tiegh.(23) (Lee, 1996; Kim, 2007b).

Two Korean genera of Loranthaceae can be distinguished in the following ways (Kim, 2007b). *Loranthus* has no hair on the whole; its inflorescence is spiked and terminal; and its petals are free, spreading and green. Meanwhile, *Taxillus* has stellate hairs throughout, its inflorescence is cymes and axillary, and its petals are connate, reflexed, and dark purple. The scientific names of these two genera are often cited differently according to the author. In addition, research is necessary on how to consider the two, as some authors hold that they should be separate and considered as independent (Lee, 1996; Kim, 2007b), while others believe they should be integrated (Lee, 1980, 2003).

There also is the opinion that *Taxillus yadoriki* (Sieb. ex Maxim.) Danser belongs to *Scurrula* L. rather than to *Taxillus*; thus, its scientific name is occasionally cited as *Scurrula yadoriki* (Sieb.) Danser (Makino, 1989; Satake et al., 1989).

In addition, *Loranthus tanakae* Franch. et Sav. is sometimes called *Hyphear tanakae* (Franch. et Sav.) Hosokawa (Makino, 1989; Satake et al., 1989). Like *Viscum* of Santalaceae, Korean Loranthaceae also has no set scientific name, which shows that studies in this area are not sufficient. In the APG Ⅲ classification, the five families as below are treated as Loranthaceae (Reveal. and Chase, 2011).

Loranthaceae Juss., Ann. Mus. Natl. Hist. Nat. 12: 292. 1808, nom. cons.

Bifariaceae Nakai, Bull. Natl. Sci. Mus. Tokyo 31: 46. Mar. 1952

Elytranthaceae Tiegh., Oesterr. Bot. Z. 46: 368. Oct. 1896

Gaiadendraceae Tiegh. ex Nakai, Bull. Natl. Sci. Mus. Tokyo 31: 45. Mar. 1952

Nuytsiaceae Tiegh., Oesterr. Bot. Z. 46: 368. Oct. 1896

Psittacanthaceae Nakai, Bull. Natl. Sci. Mus. Tokyo 31: 46. Mar. 1952

Based on the phylogenetic tree obtained from the DNA sequence of the nucleus and chromosomes, Nickrent (2002) held that root parasitism evolved just once in Olacaceae of the paraphyletic assemblage, which has been classified traditionally as a single family in Santalales, and that shoot parasitism evolved four or five times or more from its root parasite ancestors. Therefore, the term 'mistletoe' can refer to not only the monophyletic shrub but also to the branch parasites which evolved independently of the four families of Santalales. All of the species belonging to Misodendraceae and Viscaceae are types of mistletoe, but those belonging to Loranthaceae and Santalaceae with root parasitism are not all mistletoe. Moreover, this phylogenetic tree shows that *Schoepfia* is a sister of *Misodendrum* but that it is not closely related to Olacaceae, suggesting that the common ancestor of *Misodendrum* and Loranthaceae is a shoot parasite rather than a root parasite. In addition, among Korean Santalaceae, *Thesium chinense* Turcz. and *Thesium refractum* C. A. Mey. are semi-parasite plants but should not be considered as mistletoe because they are parasites of the roots of wood plants and herb plants such as *Artemisia capillaris* Thunb. (Suetsugu et al., 2008).

Therefore, Korean mistletoe types include five taxa of four genera in two families: *Viscum coloratum* (Kom.) Nakai f. *coloratum*, *Viscum coloratum* (Kom.) Nakai f. *rubroauratiacum* Ohwi and *Korthalsella japonica* (Thunb.) Engl. of Santalaceae family and *Loranthus tanakae* Franch. et Sav. and *Taxillus yadoriki* (Sieb. ex Maxim.) Danser of Loranthaceae.

Key to four taxa from Korean Mistletoe.

1. Flower bisexual
   2. Dichotomously branched deciduous parasitic shrub; leaves opposite; sepals free, flowers small in spike ····· *Loranthus tanakae*
   2. Much-branched evergreen parasitic shrub; leaves subopp-osite; sepals connate below to tube, flowers rather large in cyme ····· *Taxillus yadoriki*
1. Flowres unisexual, small
   3. Stem terete; branching apical, di-, tri-, or polychotomous; leaves prominent, opposite or ternate, sepals deciduous ····· *Viscum coloratum*
   3. Stem internodes flattened; branches usually opposite; leaves reduced to minute scale, opposite; sepals persistent ····· *Korthalsella japonica*

Morphological studies of mistletoe

Loranthaceae is the largest family among the branch-parasitic flowering plants known as mistletoe. This family originated in the southern hemisphere. It seems to have been specialized at and dispersed from a part of Gondwana at an early age (Raven and Axelrod, 1974). Among the 75 genera of this family, three are aerial-root-parasitic, which is considered to be the ancestral type of this family (Hamilton and Barlow, 1963; Kuijt, 1969; Nickrent and Duff, 1996; Wilson and Calvin, 2006).

Other genera include parasitic woody plants. All of the plants in this family come into contact directly with the host through the haustorium. Basically, the haustorium of this family is one of the following four types (Calvin and Wilson, 1998): (1) epicortical roots (ERs) which grow along the branch surface of the host and at intervals from haustorial attachments to the host; (2) clasping unions where the parasite haustorium enlarges and partially encircles the host branch; (3) wood roses where the host tissue proliferates and forms a placenta onto which the haustorium of the parasite is attached; and (4) bark strands which spread within the host bark and which at intervals tap the host xylem.

Among them, the plants of the wood rose type, clasping union type and bark strand type are usually characterized by their solitary unions with the host. On the other hand, plants of the ER type are haustorium connectors with a complex and visible host (Barlow, 1997; Fineran, 2001). In relation to this, there have been numerous studies, especially of five species of the *Securrulea* family, which is closely related to *Taxillus* (Blakely, 1922; Hamilton and Barlow, 1963; Kuijt, 1969; Calvin and Wilson, 1998; Devkota and Glatzel, 2007).

According to an analysis of the anatomic features of Korean mistletoe tissues, the stem is specialized in the way it forms successive branches two by two from the original stem; the leaves are opposite two by two at the terminal, and the fruits

are light-yellow berries that are 7-8 mm in diameter. In the specialization of the flower bud, a round dome-type flower bud forms first on the top, after which one or two leaf primordia are specialized one after another to develop into a heart shape; a perianth lobe breaks out first from the central part and then two are formed at both sides. In the leaf, stomata and guard cells are observed on 2~3 epidermises below, on the back. The mistletoe penetrates from the adsorb part on the host tree to the cork layer of the host and becomes rooted into the wood tissue, branching and growing on it (Park et al., 2003). For the four species of *Viscum album* L. var. *coloratum* (Kom.) Ohwi, *Taxillus yadoriki* (Sieb. ex Maxim.) Danser, *Korthalsella japonica* (Thunb.) Engl. and *Loranthus tanakae* Franch. et Sav., there have been studies of the anatomic features of their leaves and stems and of the secondary haustorium morphology of the host plants (Choi et al., 2009). As a result, the anatomic features of the leaves and stems were distinguished at the level of species and genera. In their leaves, at the axes of the adaxial surface and abaxial surface, the vascular bundle that develops on the midrib and the development level of the sclerenchyma cell are considered as diagnostic characteristics. In the stems, the haustorium of the stem on the cross-section, the development level of the cuticle layer, the arrangement of the vascular bundle, and the number and development level of the sclerenchyma cells are considered as diagnostic characteristics. According to the research on the secondary haustorium structure of *Taxillus yadoriki* (Sieb. ex Maxim.) Danser and *Korthalsella japonica* (Thunb.) Engl., the penetration area and the short tracheid of the haustorium are meaningful charac-teristics as they pertain to systematics. In addition, there have been morphological studies of the vegetative characteristics and floral forms of African mistletoe (Hutchinson and Dalziel, 1958; Keay, 1958; Takht and Zimmen, 1996) and the morphological studies of 30 genera of Loranthaceae (Nickrent and Musselman, 2004).

There have also been detailed observations of the level of infra-species variation as opposed to inter-species variation. Among these studies, there were significant findings related to five varieties of mistletoe, with interesting results about the differences among the varieties (Nkem and Kingsley, 2007). As such, it is necessary to examine the characteristics that may be important standards in the selection of new breeds.

Distributional studies of mistletoe

Loranthaceae and Viscaceae are distributed in almost every area, from frigid zones (except extremely cold zones) to temperate, tropical and arid zones in Europe, the Americas, Africa, Asia and Australia (Kuijt 1969; Barlow 1983). Of these zones, the main distribution areas of Loranthaceae are the southern temperate parts of tropical zones in Africa, Indomalaya-Australia and South America. Viscaceae also lives widely in the tropical areas but somewhat more in higher zones and northern temperate zones (Barlow, 1987).

The geographical distribution of *Viscum album* L. var. *coloratum* (Kom.) Ohwi covers the Korean Peninsula, Japan, Taiwan, China and Manchuria according to a Korean author (Lee, 1996) or China, Taiwan, Japan, Korea and east Russia in another report (Qiu and Gilbert, 2003). In the case of *Korthalsella japonica* (Thunb.) Engl., there are reports that it is distributed on Jeju Island and in Jeonnam province of Korea as well as in Japan, Taiwan, China, India, Malaysia and Australia (Lee, 1996) or in China, Taiwan, Bhutan, India, Indonesia, Japan, Malaysia, Myanmar, Pakistan, Philippines, Sri Lanka, Thailand, Vietnam, east Africa and Madagascar, Australia and on several islands in the Indian Ocean (Qiu and Gilbert, 2003).

In the case of *Viscum album* L. which has been studied relatively well in terms of its phytogeography, it is known to be distributed throughout Europe, with the boundaries of the Mediterranean to the south and the Atlantic Ocean to the west. It is also found in southern England, but not in Ireland. Its northern boundary is the southern part of Sweden, and its eastern boundary is around the Black Sea and the southern mountainous district of the Caspian Sea. Its general distribution area is considered to be 10° W~80° E and 60° N (max. 59° 38N) ~35° S (Zuber, 2004). It is also known to grow on some of islands of Scotland (up to max. 55° N), Sicily, Crete and some islands in Lake Malar of Sweden (Walldn 1961; Hegi 1981; Pignatti 1982; Cataln and Aparicio 1997). The distribution of Viscaceae is also reported to include North America: *Arceuthobium* in Canada, Mexico and the USA; *Phoradendron* in Mexico and the USA; the *Viscum* in Canada and the USA (Geils and Collazo. 2002).

Studies of the distribution of Loranthaceae are scant. Loranthaceae has been reported to grow on Jeju Island, Mt. Jiri of Gyeongnam, Yeongju of Gyeongbuk, Chungbuk, and Mt. Seorak and Taegi respectively of Gangwon and Pyeongnam (Lee, 1996). Geographically, it grows in Gansu, Hebei, SE Inner Mongolia, Shaanxi, Shandong, Shanxi, north Sichuan of China and in Japan (Qiu and Gilbert, 2003). *Taxillus yadoriki* (Sieb. ex Maxim.) Danser is known to be distributed only in Korea and China (Satake et al., 1989). Plants in this family have also been reported to grow in North America; among them, the plants of *Cladocolea*, *Struthanthus* and *Psittacanthus* have been found in Mexico (Geils and Collazo. 2002). In addition, the distributional features of *Alepis flavida, Peraxilla*

colensoi, and *Peraxilla tetrapetala* were reported in New Zealand (Norton et al., 1997).

Ecological studies of mistletoe

In general, Loranthaceae are semi-parasitic species that grow on the branches, twigs or roots of tropical and temperate trees (Calder and Bernhardt, 1983; Overton, 1994; Norton and Carpenter, 1998). These parasitic plants intrude into the phloem tissues of the host plant through a special structure known as a haustorium to absorb water and diverse nutrients (Venturelli, 1981; Venturelli and Kraus, 1989; Sargent, 1995; Calvin and Wilson, 2006).

These features are known to be similar in Santalaceae R. Br. (Zuber, 2004), but some species of Loranthaceae compress the nutrient bodies strongly. Therefore, their intrusion into the host occurs only in the phloem parts (Mauseth et al., 1984, 1985; Martinez del Rio et al., 1995, 1996; ; Silva and Martinez del Rio, 1996; Medel et al., 2002). Although mistletoe types undergo photosynthesis, they cause damages to the host plant, influencing fruit production and quality of the host and sometimes ending its life (Venturelli, 1981; Reid et al., 1994; Silva and Rio, 1996; Sinha and Bawa, 2002). Mistletoe is recognized as a disease (Norton and Reid, 1997; Norton and Carpenter, 1998). However, the species are not common on non-cultivated plants (Silva and Martinez del Rio, 1996). In addition, many species have been thought of as key species for animals which eat honey and fruit (Watson, 2001; Aukema, 2003).

The distribution of mistletoe is known to be determined accounting to the host specificity, the interval between hosts and related environmental conditions (Garcia-Franco and Rico-Gray, 1996), the characteristics of the host plant (Monteiro et al., 1992; Martinez del Rio et al., 1995; Sargent, 1995) and the eating characteristics of nearby mediators and their habitat-selection characteristics (Davidar, 1983; Reid, 1989; Monteiro et al., 1992; Murphy et al., 1993; Martinez del Rio et al., 1996).

These up-to-date study results suggest that the distributions of Loranthaceae and Santalaceae R. Br. can change according to host peculiarities and/or environmental conditions. These findings can serve as important clues related to the cultivation of these plant families.

Acknowledgement

This work was supported by the Korea Environmental Industry and Technology Institute (KEITI) of Eco Innovation project (project number 416-111-006) for “Development of bio-active functional ingredient based wellness products” to Byung Yun Sun

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