THAI FOR. BULL. (BOT.), SPECIAL ISSUE: 197–204. 2009.

Notes on Spice Plants in the Genus *Zanthoxylum* (Rutaceae) in Northern Thailand

RATCHUPORN SUKSATHAN[1], CHUSIE TRISONTHI[2], PARITAT TRISONTHI[2] & PRASIT WANGPAKAPATTANAWONG[2]

ABSTRACT. A survey of four spice plants in the genus *Zanthoxylum* L. (Rutaceae) was conducted in Northern Thailand: Ma-Maad (*Zanthoxylum acanthopodium* DC.), Hua-Jiao (*Z. armatum* DC.), Ma-Kwaen (*Z. myriacanthum* Wall. ex Hook. f.), and Ma-Kwuang (*Z. rhetsa* (Roxb.) DC.). The important characters, key to species based on morphological studies, and traditional usages of each species are provided. An interesting plant used for medicinal purpose is *Z. armatum*, the bark of which can be used for pain-relief of toothache. The morphological characters of the four *Zanthoxylum* species were compared and analyzed using principal components analysis (PCA). The results showed that the four *Zanthoxylum* species can be distinguished using leaf and flower characters. The stomatal index (I) was different among species. Anatomical data drawn from young stems show that dendritic crystals are present in the stems of *Z. myriacanthum* and *Z. rhetsa*.

KEY WORDS: *Zanthoxylum*, Rutaceae, Northern Thailand, Anatomy, Morphology, Taxonomy.

INTRODUCTION

Zanthoxylum L. (Rutaceae) consists of ca 200 species with pantropical distribution which are dioecious (rarely monoecious or polygamomonoecious) and grow as shrubs, scramblers, trees or woody climbers. The plants also extend to temperate regions of E Asia and E North America (Hartley, 1966; Zhang and Hartley, 2008). There are 8 or 9 species of *Zanthoxylum* in Thailand (Esser, pers. comm. 2008; Hartley, pers. comm. 2001). Four of these, *Z. acanthopodium* DC., *Z. armatum* DC., *Z. myriacanthum* Wall. ex Hook. f. and *Z. rhetsa* (Roxb.) DC., are commonly used as spices and condiments in the Northern part of the country. Comparisons of these four species were undertaken by multivariate morphometric analysis and anatomical study.

MATERIALS AND METHODS

Specimens of the four spice plant species in the genus *Zanthoxylum* were collected from eight sites in four provinces in Northern Thailand. Most of the study sites are cultivated areas except for *Z. acanthopodium*, which can be found in natural habitats at the Royal Project Ang Khang, Chiang Mai Province, 1,400 m altitude and in Doi Inthanon National Park, Chiang Mai Province, 1,530 m altitude. *Zanthoxylum armatum* was collected from Ban Pang Ma, The Royal Project Ang Khang, Chiang Mai Province, 1,400 m altitude and Ban Mae Hae Tai, Mae Chaem District, Chiang Mai Province, 1,100

[1] Queen Sirikit Botanic Garden, The Botanical Garden Organization, P.O. Box 7, Mae Rim, Chiang Mai 50180, Thailand.
[2] Department of Biology, Faculty of Science, Chiang Mai University, Chiang Mai 50200, Thailand.

m altitude. *Zanthoxylum myriacanthum* was collected from Ban Pa Deng, Mae Tang District, Chiang Mai Province, 920 m altitude and Ban Tei, Pua District, Nan Province, 1,200 m altitude. *Z. rhetsa* was collected from Ban Miang, Mueang District, Chiang Rai Province, 500 m altitude and Ban Dok Bua, Ban Toon, Mueang District, Phayao Province, 400 m altitude.

Samples of these specimens were deposited in the Herbarium, Queen Sirikit Botanic Garden (QBG), and in the Institute for Science and Technology Research and Development, Department of Biology, Faculty of Science, Chiang Mai University (CMU). In addition, additional specimens from several herbaria were studied for variations and distributions, as listed below. Morphological and anatomical characters of stems, leaves, flowers and fruits were compared. Quantitative characters presented below are the mean values of 30 measurements taken from different plants in each site.

Specimens examined

1. Zanthoxylum acanthopodium DC. Prodr. 1: 727. 1824. Type: Nepal, 1821, *Wallich* s.n (**K-W**, not seen)

Thailand.— NORTHERN: Chiang Mai [Doi Inthanon, 30 Jan. 1996, *BGO Staff* 8 (**QBG**); Doi Inthanon at km 35, 27 Nov. 1996, *BGO Staff* 14 (**QBG**); Doi Inthanon, route to Mae Jaem, 26 Aug. 1997, *BGO Staff* 9557 (**QBG**); Kew Mae Paan, Doi Inthanon, ♀ 25 Jan. 1998, *Hara & an Zaki* B653 (**CMU**); Doi Suthep, 11 April 1910, *Kerr* 1103 (**BM**); Doi Chiang Dao, 4 June 1921, *Kerr* 5585 (**BK**, **BM**); Doi Chiang Dao, 5 Nov. 1922, *Kerr* 6584 (**BK**, **BM**); Doi Suthep, 23 Oct. 1910, *Kerr* 11034 (**BM**); Chom Thong District, along the road ca 10 km from HQ to Mae Ya Noi via King's Project Farm, 9 Feb. 1998, *Konta, Phengklai and Khao-Iam* 4139 (**BKF**); Doi Inthanon, ♂ 8 Oct. 1998, *La-ongsri* 61 (**QBG**); Doi Suthep, ♀ 9 Jan. 1988, *Maxwell* 88-27 (**CMU**); Doi Suthep, ♂ 13 Nov. 1988, *Maxwell* 88-1314 (**BKF, CMU**); Doi Suthep-Pui, fr. 17 July 1994, *Maxwell* 94-775 (**BKF**, **CMU**); Ba Kia, Doi Chiang Dao, ♂ 10 Nov. 1996, *Maxwell* 96-1523 (**BKF**, **CMU**); Doi Chiang Dao Wildlife Sanctuary, Upper Valley, fr. 10 Nov. 1995, *Maxwell* 95-1143 (**BKF**, **CMU Biology**); Kew Mae Paan, Doi Inthanon, 21 Dec. 1997, *Niyomdham* 5238 (**BKF**); Doi Chiang Dao, 8 July 1998, *Pongamornkul* 391 (**QBG**); Doi Angkhang., ♂ & ♀ 8 Nov. 1973, *Sadakorn* 299 (**BK**); Doi Inthanon, ♂ 9 Dec. 2000, *Spanuchat* 10 (**CMU**, **QBG**); Doi Angkhang, ♂ 9 Jan. 2001, *Spanuchat* 12 (**CMU**, **QBG**); Doi Inthanon, ♀ 11 Jan. 2001, *Spanuchat* 13 (**CMU**, **QBG**); Doi Angkhang, ♀ 2 Dec. 2001, *Spanuchat* 22 (**CMU**, **QBG**); Doi Angkhang, fr. 1 Aug. 2000, *Spanuchat* 3 (**CMU**, **QBG**); Doi Inthanon, fr. 7 July 2001, *Spanuchat* 19 (**CMU**, **QBG**); Doi Chiang Dao, 9 July 1998, *Suksathan* 1100 **(QBG)**; Doi Pha Hom Pok, Summit area off of the border (with Burma) highway, ♀ 7 Dec. 1999, *Wynn-Jones* 7170 (**CMU**); Chiang Rai [Doi Nang Ka, ♂ 13 Nov. 1930, *Put* 3442 (**BK**, **BM**); Kamphaengphet [Klong Lan, Chong Yen, Mae Wong National Park, fr. 6 July 1999, *van de Bult* 367 (**CMU**); Chong Yen, Mae Wong National Park, fr. 24 Oct. 2001, *Watthana* 1476 (**QBG**); Mae Wong NP, in route from HQ, 12 July 1999, *Wongprasert* 997-101 (**BKF**)].

2. Zanthoxylum armatum DC. Prodr. 1: 727. 1824. Lectotype (selected by Hartley, 1966): India (*Lumbert* 1816, not seen) non *Z. armatum* (Thunb.) (Druce 1917, not

seen).—*Z. alatum* Roxb. Hort. Beng. 72. 1814, nomen nudum; Roxb. Fl. Ind. 3: 768. 1832. Lectotype (selected by Hartley, 1966): cult. Bot. Gard. Calcutta (*Roxburgh* Icones 1916, not seen).

Thailand.—NORTHERN: Chiang Mai [Samueng District, 20 Oct. 1922, *Kerr* 6402 **(BK**, **BM)**; Angkhang, ♀ 4 May 2001, *Spanuchat* 18 **(CMU**, **QBG)**; Ban Mae Hae Tai, Mae Chaem District, ♀ 31 July 2001, *Spanuchat* 21 **(CMU**, **QBG)**; Ban Mae Hae Tai, Mae Chaem District, fr. 30 June 2000, *Spanuchat* 1 **(CMU**, **QBG)**; Doi Angkhang, fr. 4 Jan. 2001, *Spanuchat* 11 (**CMU**, **QBG)**].

3. Zanthoxylum myriacanthum Wall. ex Hook.f. Fl. Brit. Ind.1: 496. 1875. Type: Penang, Malay Peninsula [*Porter* in *Wallich* cat. no. 1214) **(BM**, **K)**].—*Z. rhetsoides* Drake, Jour. Bot. Paris 6: 275, 1892. Syntypes: North Vietnam [Dec. 1888, *Balansa* 4044 **(K)**, 8 Oct. 1888, *Balansa* 4045 **(K)**].—*Z. diabolicum* Elmer, Leafl. Phillip. Bot. 2: 477. 1908. Type: Philippines, Island of Negros [May 1908, *Elmer* 10217 **(BM**, **K)**].—*Fagara myriantha* (Wall. ex Hook.f.) Engl. Nat. Pflanzenfam. III. 4: 118. 1896. Type: Fiji [Mathuata, Southern base, 1–4 Dec. 1947, *Smith* 6769 (**K**)]

Thailand.—NORTHERN: Chiang Mai [Chang Khian, 5 June 1994, *BGO.Staff* 0832 (**QBG**); Ban Pa Kar, Samoeng, 8 July 2008, *Jatupol K.*08-368 (**QBG**); Mae Chaem District, Top area of Doi Inthanon, Doi Inthanon NP, 20 Dec. 1998, *Konta, Phengklai and Khao-Iam* 4887 (**BKF**); Pagoda-Top, Doi Inthanon NP, 20 Dec. 1998, *Konta & Khao-Iam* 11401 (**BKF**); Ban Kong Hae, Pong Yaeng, Mae Rim, 18 Oct. 2007, *Pongamornkul* 2109 **(QBG**); Ban Pa Pae, Mae Tang District, ♂ 26 Aug. 2000, *Spanuchat* 5 (**CMU**, **QBG**); Ban Pa Pae, Mae Tang District, ♀ 30 July 2000, *Spanuchat* 2 (**CMU**, **QBG**); Ban Pa Pae, Mae Tang District, fr. 12 Oct. 2000, *Spanuchat* 9 (**CMU**, **QBG**)]; Chiang Rai [Wieng Bah Bao District, Doi Luang NP, ♂ 8 Sept. 1997, *Maxwell* 97-979 (**CMU, BKF**)]; Nan [Ban Tei, Doi Phukha, ♂ 3 Sept. 2000, *Spanuchat* 6 (**CMU**, **QBG**); Ban Tei, Doi Phukha, ♀ 3 Sept. 2000, *Spanuchat* 7 (**CMU**, **QBG**); Ban Tei, Doi Phukha, ♂ 3 Sept. 2000, *Spanuchat* 6 (**CMU**, **QBG**); Ban Tei, Doi Phukha, fr. 3 Sept. 2000, *Spanuchat* 8 (**CMU**, **QBG**)].

4. Zanthoxylum rhetsa (Roxb.) DC. Prodr. 1: 728. 1824.—*Fagara rhetsa* Roxb. Fl. Ind. ed. Carey & Wall. 1: 438. 1820. Lectotype (selected by Hartley, 1966): cult. Bot. Gard.Calcutta (*Roxburgh Icones* 185, **K**). —*Zanthoxylum budrunga* (Roxb.) DC. Prodr. 1: 728. 1824, sub *"species non satis notae."*.—*Fagara budrunga* Roxb. Fl. Ind. ed. Carey & Wall. 1: 437. 1820. Lectotype (selected by Hartley, 1966): cult. Bot. Gard.Calcutta (*Roxburgh Icones* 2113, **K**).

Hartley (1966) noted that *Z. rhetsa* used in the revision, *Z. limonella* (Dennst.) Alston, is invalid since the basionym, *Tippalia limonella* Dennst., presents a combined new generic name and specific epithet listed with only a reference to a plate and description in *Hortus Indicus Malabaricus* with lists of the valid and invalid names were given in a paper by H. Manitz (Taxon 17: 496–501. 1968). The choice of the name *Z. rhetsa* over *Z. budrunga* (Roxb.) DC., the basionyms of which are published on the same date, follows Hooker (1875).

Thailand.— NORTHERN: Chiang Mai [Doi Inthanon NP, 20 Sept. 1995, *Unknown*

collector s.n.., QBG No.4625 (**QBG**); Chiang Rai [Doi Luang, Mae Suai, fr. 6 June 1998, *Sidisunthorn & Gardner* 2722 (**CMU**); Khun Korn Waterfall, Mueang District, ♂ 22 April 2001, *Spanuchat* 14 (**CMU**, **QBG**); Khun Korn Waterfall, Mueang District, ♀ 22 April 2001, *Spanuchat* 15. (**CMU**, **QBG**); Khun Korn Waterfall, Mueang District, fr. 24 Aug. 2000, *Spanuchat* 4 (**CMU**, **QBG**)]; Mae Hong Son [Hue Pang Dan, 16 May 1921, *Kerr* 5464 (**BK**, **BM**); Hue Pang Hung, ♂ 21 May 1921, *Kerr* 5473 (**BK**, **BM**); Nan [Mueang District, 21 June 1983, *Vacharee* 558 (**BK**)]; Phayao [Ban Toon, Mueang District, ♂ 2 May 2001, *Spanuchat* 17 (**CMU**, **QBG**); Ban Toon, Mueang District, ♀ 28 April 2001, *Spanuchat* 16 (**CMU**, **QBG**); Ban Toon, Mueang District, fr. 11 July 2001, *Spanuchat* 20 (**CMU**, **QBG**)]; CENTRAL: Saraburi [Sam Lan National Park, Mueang District, infl. 13 April 1974, *Maxwell* 74-267 (**BK**); Sam Lan National Park, Mueang District, fr. 9 Aug. 1974, *Maxwell* 74-754 (**BK**); SOUTH-EASTERN: Chachoengsao [Khao Ang Rue Nai, fr. 6 May 1997, *Niyomdham* 5012 (**BKF**)]; Rayong [Ban Pe, 23 Feb. 1930, *Put* 2750 (**BK**, **BM**, **C**)]; PENINSULAR: Krabi [Lanta Island, fl. 15 April 1930, *Kerr* 18973 (**BK**, **BM**, **C**)]; Krabi [Khao Pra-Bang Khram Wildlife Sanctuary, Khlong Thom District, 27 March 2006, *Maxwell* 06-220 (**QBG**)]; Nakhorn Si Thamarat [Khao Chong, 28 April 1955, *Unknown collector s.n.* in *Thavorn* 228 **(C)**]; Trang [Khao Chong, 12 April 1966, *Bunnab* 475 (**BKF**, **C**)].

To confirm the characteristics of each species, principal components analysis (PCA) was employed to analyze the morphological variation of leaves, stems, flowers and fruits among four *Zanthoxylum* species from two sites in each species [SPSS Production Facility Release 15.0.0 (SPSS Inc., 2001)].

The Stomatal Index (I) of each taxon from each site, was calculated from 5 points on lower surface of 6 leaves taken from different 5 plants, using the following formula proposed by Cutter (1969).

$$\text{Stomatal Index (I)} = \frac{\text{number of stomata /mm2(S)}}{\text{number of stomata /mm2(S) + number of epidermal cells/mm2 (E)}} \times 100$$

RESULTS AND DISCUSSION

The differences among four *Zanthoxylum* species from the studies are provided in Table 1 and Fig. 2.

Multivariate Analysis

The PCA result showed that 4 groups of the specimens form particularly well-defined clusters (Fig. 1). It was, therefore, deemed appropriate to recognize them as separate species.

Key to species

An identification key to four *Zanthoxylum* species (after Hartley, 1966; Zhang and Hartley, 2008) is presented below:

KEY TO THE COMMMONLY USED *ZANTHOXYLUM* SPECIES IN NORTHERN THAILAND

1. Shrub or small tree 1.5–5 m. Branchlets armed with flattened prickles. Leaf rachises winged. Leaves pinnate or trifoliolate. Flowers unisexual; perianth uniseriate, with 4–9 similar segments
   2. Veins conspicuous, 10-25 on each side of midrib. Inflorescence an axillary panicle, 0.5–1 cm long; anthers reddish before anthesis; carpel(s) 1–4 **1. Z. acanthopodium**
   2. Veins inconspicuous, 7–14 on each side of midrib. Inflorescence a terminal or axillary panicle, 4–10 cm; anthers yellow before anthesis; carpel(s) 1–3 **2. Z. armatum**
1. Tree 10-30 m. Stem with conical spines. Leaf rachises not winged. Leaves pinnate. Perianths biseriate, with 4–5 sepals and 4–5 petals
   3. Inflorescence a terminal cyme, 25–43 cm. Perianth and androecium 5-merous; carpel(s) 1–4 **3. Z. myriacanthum**
   3. Inflorescence a terminal panicle, 12–18 cm. Perianth and androecium 4-merous; carpel 1 **4. Z. rhetsa**

ACKNOWLEDGEMENTS

We would like to thank Dr. Hans-Joachim Esser and Dr. Thomas G. Hartley for advice and information of *Zanthoxylum*. This study was financially supported by The Royal Project Foundation and Chiang Mai University. The authors are indebted to the Royal Forest Department and Department of National Parks, Wildlife and Plant Conservation for permission to work in various National Parks. We are very grateful to the curators and staff of the following herbaria information and their assistance during visits to their institutions: BK, BKF, BM, CMU, K, and QBG.

REFERENCES

Cutter, E.G. (1969). Plant Anatomy: Experiment and Interpretation Part I. Cell and Tissue. London; Edward Arnold. 168 pp.

Hartley, T.G. (1966). A Revision of The Malesian Species of *Zanthoxylum* (Rutaceae). Journal of the Arnold Aboretum 47: 171–221.

_____. (1970). Additional notes on the Malesian Species of *Zanthoxylum* (Rutaceae). Journal of the Arnold Aboretum 51: 424–425.

_____. (2001). (pers. comm.). *Zanthoxylum* collections in Thailand.

Hooker, J.D. (1875). Flora of British India Vol. 1: 495. London, L. Reeve.

Metcalfe, C.R. & Chalk, L. (1950). Anatomy of the Dicotyledons, Vol. I: 305–316. Oxford, Clarendon Press.

Thai Industrial Standards Institute (TISI), Ministry of Industry. (2009). Community Product Standard 2006. http://www.tisi.go.th/otop/otop.html

Zhang, D. & Hartley, T.G. (2008). *Zanthoxylum*. In: Z. Wu, & P.H. Raven (eds), Flora of China Vol. 11: 53–66. Beijing, Science Press; St Louis, Missouri Botanical Garden Press.

Table 1. Comparisons among four Zanthoxylum species.

Scientific names	Vernacular names	Uses	Habit	Leaf length	Number of leaflets	Hairs on leaf surface	Secretory duct on leaf surface	Stomatal index (I)	Secretory duct in stem tissue	Crystal type in stem tissue
1. *Z. acanthopodium*	Ma-Maad	Leaves: condiment	Shrub 1.5-3 m	7-22 cm	4-9	Uniseriate	Glandular hair	16	Present	Rosette
2. *Z. armatum*	Hua-Jiao	Leaves, barks: boiled with water for pain- relief of toothache- Fruits: condiment, boiled with water for toothache-pain relief	Shrub-small tree to 5 m	10-22 cm	4-9	Absent	Glandular hair	15	Present	Rosette
3. *Z. myriacanthum*	Ma-Kwaen	Fruits: condiment (commercial*)	Tree 10-20 m	12-54 cm	6-17	Absent	Glandular hair	13	Present	rosette, prism, dendritic crystal*
4. *Z. rhetsa*	Ma-Kwuang	Fruits: condiment (commercial**)	Tree 15-30 m	6-60 cm	6-35	Absent	Absent	9.5	Present	rosette, dendritic crystal*

dendritic crystal* : crystal of diosmin, recorded in some genera in Rutaceae (Metcalfe and Chalk, 1950)
commercial* : Fresh and dried fruits are sold in markets by local people under Community Product Standard 2006 (Thai Industrial Standards Institute (TISI), Ministry of Industry, 2009)
commercial** : Fresh and dried fruits are sold in markets as local condiment

Table 1. (continued)

Scientific names	No.sepals	No.of petals	No.of stamens (fl. ♂)	Rudimentary ovary (fl. ♂)	No.of carpels (fl. ♀)	No.of staminodes (fl. ♀)	No. of fruit lobe	Diameter of fruitlet (mm)	Flowering time	Fruiting time	Coll. No.
1. *Z. acanthopodium*	6-9	Absent	4-8	Absent	2-4	Absent	1-4	3-5	Nov – Jan.	Jan. –Nov.	RS 10♂, RS 12♂, RS 13♀, RS 22♀, RS 3 fr., RS 19 fr.
2. *Z. armatum*	4-8	Absent	N/A *	N/A *	1-3	Absent	1-3	3.5-6.5	Apr –Sept.	April – Jan.	RS 18♀, RS 21♀, RS 1 fr., RS 11 fr.
3. *Z. myriacanthum*	5	5	5	Present	3-4	0-5	3-4	3-4	June–Sept.	July – Oct.	RS 5♂, RS 6♂, RS 2♀, RS 7♀ , RS 8 fr. RS 9 fr.
4. *Z. rhetsa*	4	4	4(3)	Present	1	2-4	1	6.6-9.3	Apr.	April– Aug.	RS 14♂ RS 17♂, RS 15♀, RS 16♀, RS 4 fr. RS 20 fr.

Coll. No: RS = R. Spanuchat Number; N/A *: not found in this study

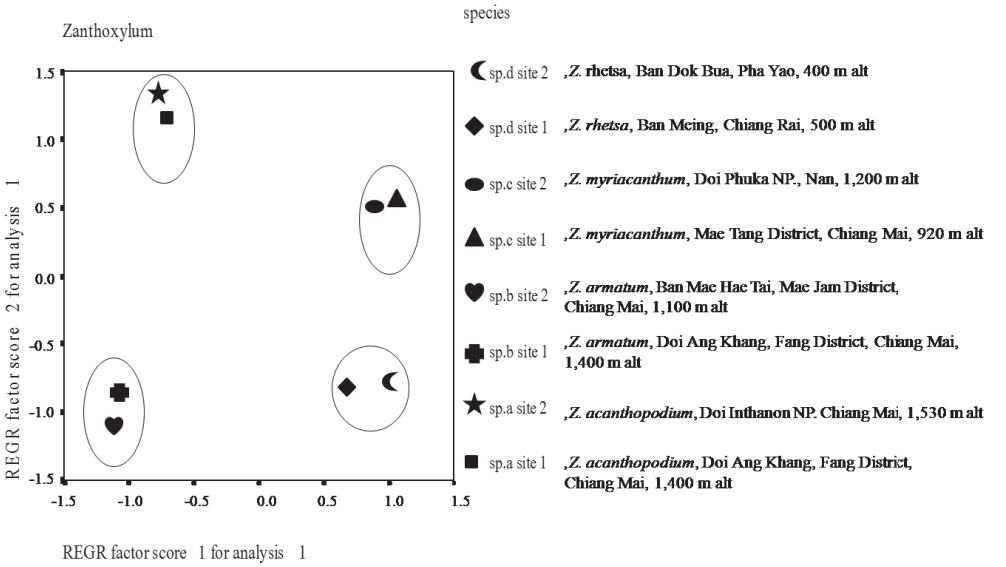

Figure 1. PCA plot based on the morphology of leaves and flowers of four *Zanthoxylum* species.

Figure 2. *Z. acanthopodium* : A. staminate flower, B. infructescences; *Z. armatum*: C. carpellate flowers, D. infructescences; *Z. myriacanthum*: E. carpellate flowers, F. infructescences, L. pericarp; *Z. rhetsa*: G. staminate flower, H. female inflorescences, I. infructescences, J. secretory ducts in stem tissue, K. dendritic crystals in stem tissue.