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FOLIAR TRICHOMES OF *CROTON* L. (EUPHORBIACEAE: CROTONOIDEAE) FROM CHINA AND ITS TAXONOMIC IMPLICATIONS

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Abstract

Foliar trichomes of 21 species of the genus *Croton* L. from China have been examined using stereomicroscopy and scanning electron microscopy. Five trichome types characterized by their morphology are identified, *viz.*, stellate, lepidote, simple, dendritic and appressed-rosulate. Only stellate trichome is observed in most species, with only six species that are found to maintain two or three trichome types. Trichome types and density are useful for species identification and sectional classification for Chinese species. Based on the trichome types and other morphological characters, 21 Chinese species are proposed to be placed in five sections. *Croton crassifolius* belongs to sect. *Andrichnia*; *C. cascarilloides* belongs to sect. *Monguia*; *C. mangelong*, *C. kongensis*, *C. laevigatus* and *C. laniflorus* belong to sect. *Argyrocroton*; *C. lauioides*, *C. howii* and *C. damayeshu* belong to sect. *Adenophylli*. The remaining Chinese *Croton* species might be placed into sect. *Croton*. A key for Chinese *Croton* species based on trichome morphology is provided.

Introduction

Croton L. (Euphorbiaceae *s.s.*) is one of the largest genera of flowering plants, with about 1300 species of herbs, shrubs, trees and occasionally lianas that are ecologically prominent and important elements of secondary vegetation in the tropical and subtropical regions worldwide (Webster, 1993; Radcliffe-Smith, 2001). *Croton* belongs to subfamily Crotonoideae (APG, 2009; Wurdack and Davis, 2009), is characterized by mostly lactiferous taxa having pollen with an unusual (crotonoid) exine pattern of triangular supratectal elements attached to a network of muri with short columellae (Nowicke, 1994). The synapomorphy that characterizes *Croton* is the inflexed conformation of the tips of the staminal filaments in bud, which causes the anthers to be introrsely inverted until anthesis (Berry *et al*., 2005).

Because of the large number of species and extensive morphological variation, it has been proved difficult to define and delimit sections and subsections within the genus *Croton* (Webster *et al*., 1996) despite the efforts of many taxonomists (Pax and Hoffmann, 1931; Webster, 1993). Webster (1993) established the most recent infrageneric classification, recognizing 40 sections in the genus mainly based on the New World taxa. Among them, three were reassigned generic status by Radcliffe-Smith (2001). Webster (1993) pointed out that his treatment of Old World taxa was much more cursory than that of New World taxa because of lack of familiarity with the living plants in Africa, Madagascar and Asia. Berry *et al*. (2005) presented a molecular systematic analysis of the genus *Croton* and tribe Crotoneae using nrITS and *trnL-trnF* DNA sequences data to test the validity of Webster's classification. van Ee *et al*. (2011) revised the infrageneric classification and proposed a new system for New World *Croton* dividing into four subgenera and 31 sections including some species described as new ones.

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Trichomes have played an important role in plant taxonomy at generic, infragenetic and specific levels (Hardin, 1979; Theobald *et al*., 1979) in groups of wide taxonomic range, such as *Cuphea* P. Browne (Lythraceae: Amarasinghe *et al*., 1991), *Stachys* L. (Lamiaceae: Salmaki *et al*., 2009) and *Chelonopsis* Miquel (Lamiaceae: Xiang *et al*., 2010).

One of the most significant characters for infrageneric classification of *Croton* is the trichome morphology. Previous studies showed that trichome types have great variation within *Croton* (Webster *et al.* 1996; de Sá-Haiad *et al*., 2009; Senakun and Chantaranothai, 2010). Müller (1866) characterized the taxa as having stellate and lepidote hairs. Solereder (1908) and Metcalfe and Chalk (1950) noted that stellate and lepidote hairs also occur in other genera of subfamily Crotonoideae. Webster *et al.* (1996) identified foliar trichome characteristics for 120 species from 36 sections in *Croton* and established the possible evolutionary relationships among the different sections based on trichome characters. Senakun and Chantaranothai (2010) observed 23 Thai species and recognized seven trichome types.

In China, 23 species of *Croton* are recorded, including 15 endemic species (Li and Esser, 2008). Among them, only five species are placed in the 40 sections of Webster (1993). Moreover, foliar trichomes in *Croton* from China are not well-studied. Chang (1996) and Li and Esser (2008) described two main trichome types in Chinese *Croton* species, peltate scales [same as lepidote of Webster *et al*. (1996)] and stellate. Previously, foliar trichomes of only seven Chinese *Croton* species have been observed (Webster, 1993; Senakun and Chantaranothai, 2010). In the present work, we characterize the foliar trichomes of young to mature leaves of 21 species from China, including 15 endemic species. The objectives of this study are to provide descriptions, illustrations, and a survey of the trichomes in these 21 species using stereomicroscopy and scanning electron microscopy (SEM) and to propose the infrageneric classification for Chinese species.

Materials and Methods

Leaf samples of 21 species of *Croton* were obtained from dry specimens deposited at the herbarium of South China Botanical Garden, Chinese Academy of Sciences (IBSC). Both young and mature leaves were observed for each species. Two to four samples were examined for each species. A list of investigated materials is given in Table 1. Density of foliar trichomes was observed under Zeiss Stemi SV 11 stereomicroscopy, and photographed with an AxioCam MRC digital camera.

Both young and mature leaves were washed in 95% ethanol. Whole sections of young leaves and 0.5 × 0.5 cm of mature leaf fragments were bisected and mounted on copper stubs so that both adaxial and abaxial surfaces faced upwards. The mounts were air-dried, and coated with gold in a JFC-1600 sputter coater (JEOL Ltd, Tokyo, Japan). Observations and digital images were collected with a JEOL JSM-6360LV SEM (JEOL Ltd, Tokyo, Japan). The terminology follows Webster *et al.* (1996) and Senakun and Chantaranothai (2010).

Results

The main types of the trichomes and their density among the *Croton* species studied are summarized in Table 2. Selected SEM micrographs of trichome types are presented in Figure 1. Foliar trichomes of 21 Chinese *Croton* can be separated into five types; stellate, lepidote, simple, dendritic and appressed-rosulate. Glandular trichomes are not observed.

Type I. Stellate trichome. This trichome type is characterized by its star-shaped form in one plane that is usually flattened onto the lamina with 0-30% webbing (Webster *et al.*, 1996; Senakun and Chantaranothai, 2010). Two subtypes are observed. Subtype Ia, appressed-stellate (radii webbed 0-15%), with porrect radius, occurs in *C. dinghuensis* H.S. Kiu, *C. euryphyllus* W.W. Sm.,

C. lachnocarpus Benth. (Fig. 1A), *C. merrillianus* Croizat, *C. tiglium* L., *C. yunnanensis* W.W. Sm., *C. chunianus* Croizat (Fig. 1B), *C. cnidophyllus* Radcl.-Sm. & Govaerts (Fig. 1C), *C. yanhuii* Y.T. Chang (Fig. 1D) and *C. crassifolius* Geiseler (Fig. 1E). Subtype Ib, stellate or stellate-rotate (radii webbed 15-30%) occurs in *C. lauioides* Radcl.-Sm. & Govaerts (Fig. 1F), stellate with porrect radius trichome which occurs in *C. howii* Merr. & Chun *ex* Y.T. Chang (Fig. 1G), and stellate trichome sometimes with porrect radius occurs in *C. damayeshu* Y.T. Chang (Fig. 1H).

Table 1. List of *Croton* species used in the present study.

Species	Section	Locality	Voucher
1. *Croton cascarilloides* Raeusch.	*Monguia*	Guangxi	X. W. Gao 55292
2. **C. chunianus* Croizat	*Croton*	Hainan	K. Z. Hou 71927
3. **C. cnidophyllus* Radcl.-Sm. & Govaerts	*Croton*	Yunnan	Menglian Expedition 9214
4. *C. crassifolius* Geiseler	*Andrichnia*	Guangdong	H. G. Ye 7742
5. **C. damayeshu* Y. T. Chang	*Adenophylli*	Yunnan	H. T. Tsai 5003
6. **C. dinghuensis* H. S. Kiu	*Croton*	Guangdong	S. T. Lin 30475
7. **C. euryphyllus* W.W.Sm.	*Croton*	Guangdong	H. S. Kiu 571
8. **C. hancei* Benth.	*Croton*	Guangxi	C. L. Tso 23429
9. **C. howii* Merr. & Chun ex Y. T. Chang	*Adenophylli*	Hainan	L. Tang 3303
10. *C. kongensis* Gagnep.	*Argyrocroton*	Hainan	Z. X. Li & F. W. Xing 1036
11. *C. lachnocarpus* Benth.	*Croton*	Guangdong	B. Y. Chen 2036
12. **C. laevigatus* Vahl	*Argyrocroton*	Hainan	K. Z. Hou 73784
13. *C. laniflorus* Geiseler	*Argyrocroton*	Hainan	S. H. Chun 11196
14. **C. laui* Merr. & F. P. Metcalf	*Croton*	Hainan	Z. X. Li 2540
15. **C. lauioides* Radcl.-Sm. & Govaerts	*Adenophylli*	Hainan	C. Wang 34386
16. **C. mangelong* Y.T. Chang	*Argyrocroton*	Yunnan	K. M. Feng 20258
17. **C. merrillianus* Croizat	*Croton*	Hainan	C. L. Tso 43813
18. **C. purpurascens* Y.T. Chang	*Croton*	Guangdong	H. S. Kiu 562
19. *C. tiglium* L.	*Croton*	Guangxi	Z. S. Chung 808393
20. **C. yanhuii* Y.T. Chang	*Croton*	Yunnan	W. Z. Li 85725
21. **C. yunnanensis* W.W. Sm.	*Croton*	Yunnan	Department of Biology, Yunnan University 757

*Species endemic to China.

Type II. Lepidote trichome. The individual lepidote hair resembles an appressed-stellate hair but has radii that are connected by webbing so that the trichome forms a more or less shield-like scale (Webster *et al.*, 1996). In our study, this type includes three subtypes. Subtype IIa, stellate-lepidote (radii webbed 30-50%), sometimes with porrect radius, occurs in *C. laevigatus* Vahl (Fig. 1I) and *C. laniflorus* Geiseler. Subtype IIb, dentate-lepidote (radii webbed 50-80%), sometimes with porrect radius, occurs on the adaxial surface of *C. cascarilloides* Raeusch. (Fig. 1J). Subtype IIc, lepidote-subentire (radii webbed 80-100%) occurs in *C. kongensis* Gagnep., *C. mangelong* Y.T. Chang and the abaxial surface of *C. cascarilloides* (Fig. 1K).

Type III. Simple trichome. This type is stiffly erect, directed upward from an inclined base (Payne, 1978). This type is only found in *C. crassifolius* (Fig. 1E).

Table 2. Some characteristic features of trichomes in the examined *Croton* species.

Species		Adaxial surface										Abaxial surface									
		I		II			III	IV	V	p	density	I		II			III	IV	V	p	density
		a	b	a	b	c						a	b	a	b	c					
1. *C. cascarilloides*	YL	-	-	-	+	-	-	-	-	St +	dense	-	-	-	-	+	-	-	-	-	dense
	ML	-	-	-	-	-	-	-	-	-	0	-	-	-	-	+	-	-	-	-	dense
2. **C. chunianus*	YL	-	-	-	-	-	-	-	-	-	0	+	-	-	-	-	-	-	+	+	sparse
	ML	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0
3. **C. cnidophyllus*	YL	+	-	-	-	-	-	+	-	+	dense	-	-	-	-	-	-	+	-	-	dense
	ML	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-	-	+	-	-	dense
4. *C. crassifolius*	YL	+	-	-	-	-	+	+	-	+	dense	-	-	-	-	-	-	+	-		dense
	ML	+	-	-	-	-	+	+	-	+	dense	-	-	-	-	-	-	+	-		dense
5. **C. damayeshu*	YL	-	+	-	-	-	-	-	-	+	im	-	+	-	-	-	-	-	-	St +	dense
	ML	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0
6. **C. dinghuensis*	YL	+	-	-	-	-	-	-	-	+	sparse	-	-	-	-	-	-	-	+	-	sparse
	ML	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0
7. **C. euryphyllus*	YL	+	-	-	-	-	-	-	-	+	im	+	-	-	-	-	-	-		+	dense
	ML	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0
8. **C. hancei*	YL	-	-	-	-	-	-	-	+	-	dense	-	-	-	-	-	-	-	+	+	dense
	ML	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-	-	-	+	+	sparse
9. **C. howii*	YL	-	-	-	-	-	-	-	-	-	0	-	+	-	-	-	-	-		+	sparse
	ML	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0
10. *C. kongensis*	YL	-	-	-	-	+	-	-	-	-	im	-	-	-	-	+	-	-	-	-	dense
	ML	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-	sparse
11. *C. lachnocarpus*	YL	+	-	-	-	-	-	-	-	+	dense	-	-	-	-	-	-	+	-	-	dense
	ML	+	-	-	-	-	-	-	-	+	im	-	-	-	-	-	-	+	-	-	dense

Table 2. contd.

Species		Adaxial surface										Abaxial surface									
		I		II			III	IV	V	p	density	I		II			III	IV	V	p	density
		a	b	a	b	c						a	b	a	b	c					
12. **C. laevigatus*	YL	-	-	-	-	-	-	-	-	-	0	-	-	+	-	-	-	-	-	St+	dense
	ML	-	-	-	-	-	-	-	-	-	0	-	-	+	-	-	-	-	-	St+	sparse
13. *C. laniflorus*	YL	-	-	-	-	-	-	-	-	-	0	-	-	+	-	-	-	-	-	St+	im
	ML	-	-	-	-	-	-	-	-	-	0	-	-	+	-	-	-	-	-	St+	im
14. **C. laui*	YL	-	-	-	-	-	-	+	-	-	dense	-	-	-	-	-	-	+	-	-	dense
	ML	-	-	-	-	-	-	-	-	-	0	+	-	-	-	-	-	+	-	+	sparse
15. **C. lauioides*	YL	-	+	-	-	-	-	-	-	-	im	-	+	-	-	-	-	-	-	-	dense
	ML	-	+	-	-	-	-	-	-	-	sparse	-	+	-	-	-	-	-	-	-	im
16. **C. mangelong*	YL	-	-	-	-	-	-	-	-	-	0	-	-	-	-	+	-	-	-	-	dense
	ML	-	-	-	-	-	-	-	-	-	0	-	-	-	-	+	-	-	-	-	sparse
17. **C. merrillianus*	YL	-	-	-	-	-	-	-	-	-	0	+	-	-	-	-	-	-	-	+	dense
	ML	-	-	-	-	-	-	-	-	-	0	+	-	-	-	-	-	-	-	+	dense
18. **C. purpurascens*	YL	-	-	-	-	-	-	-	+	+	im	-	-	-	-	-	-	-	+	+	im
	ML	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0
19. *C. tiglium*	YL	+	-	-	-	-	-	-	-	+	im	+	-	-	-	-	-	-	-	+	dense
	ML	+	-	-	-	-	-	-	-	+	sparse	+	-	-	-	-	-	-	-	+	sparse
20. **C. yanhuii*	YL	+	-	-	-	-	-	+	-	+	dense	+	-	-	-	-	-	+	-	+	dense
	ML	+	-	-	-	-	-	+	-	+	im	+	-	-	-	-	-	+	-	+	dense
21. **C. yunnanensis*	YL	+	-	-	-	-	-	-	-	+	dense	+	-	-	-	-	-	-	-	+	dense
	ML	+	-	-	-	-	-	-	-	+	sparse	+	-	-	-	-	-	-	-	+	sparse

- = absent, + = present, YL = young leaf, ML = mature leaf, p = porrect, St^{+} = sometimes with porrect radius, im = intermediate, I = stellate trichome, Ia = appressed-stellate, Ib = stellate, II = lepidote trichome, IIa = stellate-lepidote, IIb = dentate-lepidote, IIc = lepidote- subentire, III = simple trichome, IV = dendritic trichome, V = appressed-rosulate trichome,* species endemic to China.

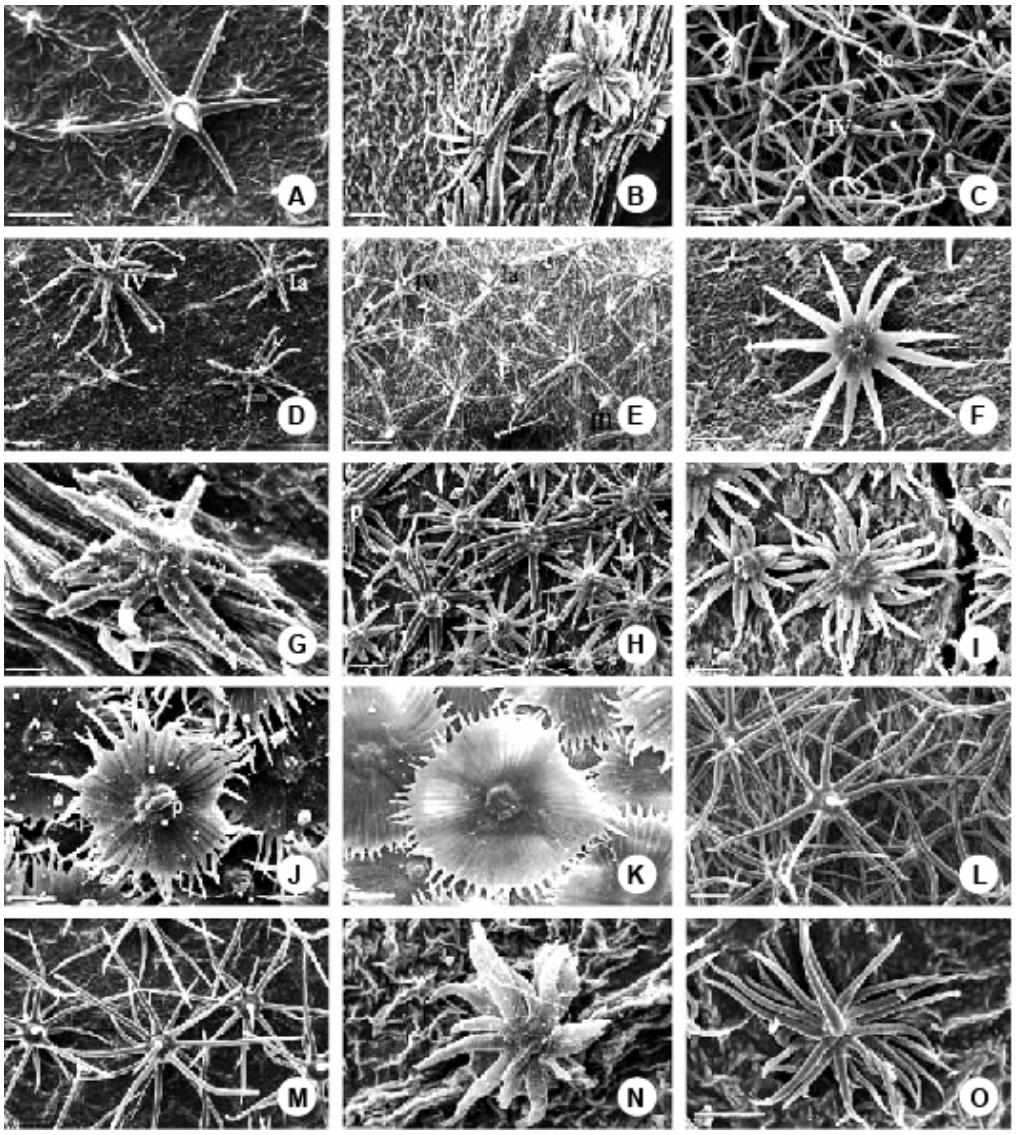

Fig. 1. SEM micrographs of trichomes in *Croton*: (A) Appressed-stellate with porrect radius trichome in *C. lachnocarpus* on Adm; (B) Appressed-stellate with porrect radius (Ia) and appressed-rosulate (V) trichomes in *C. chunianus* on Aby; (C) Appressed-stellate with porrect radius (Ia) and dendritic (IV) trichomes in *C. cnidophyllus* on Adm; (D) Appressed-stellate with porrect radius (Ia) and dendritic (IV) trichomes in *C. yanhuii* on Adm; (E) Appressed-stellate with porrect radius (Ia), simple (III) and dendritic (IV) trichomes in *C. crassifolius* on Abm; (F) Stellate trichome in *C. lauioides* on Ady; (G) Stellate with porrect trichome in *C. howii* on Aby; (H) Stellate with sometimes porrect radius (p) trichome in *C. damayeshu* on Aby; (I) Stellate-lepidote with sometimes porrect radius (p) trichome in *C. laevigatus* on Aby; (J) Dentate-lepidote with sometimes porrect radius (p) trichome in *C. cascarilloides* on Ady; (K) Lepidote-subentire trichome in *C. cascarilloides* on Abm; (L) Dendritic trichome in *C. crassifolius* on Abm; (M) Dendritic trichome in *C. lachnocarpus* on Abm; (N) Appressed-rosulate trichome in *C. dinghuensis* on Aby; (O) Appressed-rosulate with porrect trichome in *C. purpurascens* on Ady. Abm = the abaxial surface of mature leaf; Aby = the abaxial surface of young leaf; Adm = the adaxial surface of mature leaf; Ady = the adaxial surface of young leaf. Scale bars = 200 μm (E), 100 μm (A-D, H, J-K, L-M, O), 50 μm (F-G, I, N).

Type IV. Dendritic trichome. This type has the radii inserted at different levels on an axis (Webster *et al*., 1996). Dendritic trichome with porrect radius occurs in *C. cnidophyllus*, *C. crassifolius* (Figs 1E, L**)**, *C. lachnocarpus* (Fig. 1M), *C. laui* Merr. & F.P. Metcalf and *C. yanhuii* (Fig. 1D).

Type V. Appressed-rosulate trichome. This type resembles stellate ones, but differs in the larger number of radii that are not all in a single whorl (Webster *et al*., 1996). This type includes appressed-rosulate and appressed-rosulate with porrect radius. Appressed-rosulate trichome occurs in *C. dinghuensis* (Fig. 1N) and *C. hancei* Benth. Appressed-rosulate trichome with porrect radius occurs in *C. chunianus* (Fig. 1B), *C. hancei* and *C. purpurascens* Y.T. Chang (Fig. 1O).

Density of trichome distribution is variable on different surfaces even within the same species. In general, trichomes are much denser on the abaxial surface than on the adaxial surface. Among 21 observed species, six species are glabrous on the adaxial surface even when they are at very young stage: *C. chunianus*, *C. howii*, *C. laevigatus*, *C. laniflorus*, *C. mangelong* and *C. merrillianus*. The density of trichomes decreases drastically with leaf development on both surfaces of *C. yunnanensis* and on the abaxial surface of *C. hancei*, *C. kongensis*, *C. laevigatus*, *C. laui*, *C. mangelong* and *C. tiglium*.

In some species, trichomes are observed on both surfaces when young, but fall off completely on either both surfaces or on a single surface when mature. For example, trichomes fall off completely on both surfaces in *C. damayeshu*, *C. dinghuensis*, *C. euryphyllus* and *C. purpurascens*, or on the adaxial surface in *C. cascarilloides*, *C. cnidophyllus*, *C. hancei*, *C. kongensis* and *C. laui*, or on the adaxial surface in *C. chunianus* and *C. howii*.

Variation in trichome type can be used to differentiate the *Croton* species examined in this study. In most species, only stellate trichome is observed. Only six species are found to have two or three trichome types. In *C. chunianus*, a few appressed-rosulate and few appressed-stellate with porrect radius trichomes are observed on the abaxial surface (Fig. 1B) and its adaxial surface is glabrous even very young. In *C. cnidophyllus*, a few dendritic and few appressed-stellate trichomes occur on the adaxial surface (Fig. 1C), and only dendritic trichome occurs on the abaxial surface. In *C. crassifolius*, three types of trichomes (appressed-stellate with porrect radius, simple and dendritic) are observed on the adaxial leaf surface (Fig. 1E), and only dendritic trichome occurs on the abaxial surface (Fig. 1L). This species can also be easily distinguished from other Chinese *Croton* species by possessing simple trichome which is not found in any other species. In *C. dinghuensis*, appressed-stellate with porrect radius trichome is found on the adaxial surface and appressed-rosulate trichome is observed on the abaxial surface (Fig. 1N). In *C. lachnocarpus*, it is observed that appressed-stellate with porrect radius trichome occurs on the adaxial surface (Fig. 1A) and dendritic trichome occurs on the abaxial surface (Fig. 1M). The dendritic with porrect radius trichome type and few appressed-stellate with porrect radius trichomes are found in *C. yanhuii* (Fig. 1D). In addition, two subtypes of trichomes are found in *C. cascarilloides*; dentate-lepidote trichome sometimes with porrect radius occurs on the adaxial surface (Fig. 1J), and leptidote-subentire trichome occurs on the abaxial surface (Fig. 1K).

Discussion

Among the 21 species we observed, seven species were also observed earlier by Webster *et al*. (1996) and Senakun and Chantaranothai (2010). Compared to their works, trichomes of *C. lachnocarpus*, *C. laevigatus* and *C. tiglium* are characterized as identical to their observation. Webster (1993) reported that *C. kongensis* had stellate trichome and was accordingly placed into Sect. *Cascarilla*, but we observed the lepidote-subentire trichome type as observed by Senakun and Chantaranothai (2010) based on Thai material. We cannot discuss more about the differences

of the observation between our studies and Webster (1993), because we did not see the material observed by them. Only lepidote-subentire trichome was observed in *C. cascarilloides* by Senakun and Chantaranothai (2010), but we find that dentate-lepidote trichome sometimes with porrect radius occurs on the adaxial surface and lepidote-subentire trichome occurs on the abaxial surface. Senakun and Chantaranothai (2010) observed three types of trichomes (fasciculate, dendritic and glandular) in *C. crassifolius*, but we find that appressed-stellate with porrect radius, simple, and dendritic trichomes occur on the adaxial surface, and dendritic trichome occurs on the abaxial surface. Our observation accords with the previous studies (Webster *et al*., 1996; Chayamarit and van Welzen, 2005; Li and Esser, 2008). We could not check their voucher specimen of *C. crassifolius* observed by Senakun and Chantaranothai (2010) and therefore presume that their material was misidentified. Webster *et al.* (1996) indicated that the number and length of radii of trichomes could vary considerably on different leaves of a single specimen. It is supported by our observation. It also showed that the number and length of radii vary considerably even on same leaf of a single specimen. For example, it has 6-17 radii, 0.18-1.1 mm in diam. in *C. yanhuii* (Fig. 1D).

The foliar trichome is one of the most important characters to define sections in the genus *Croton* (Webster, 1993). According to the trichome types and other morphological characters, Chinese *Croton* species can be divided into five sections. Two species, *C. cascarilloides* and *C. crassifolius*, have multifid styles. They can be easily distinguished from each other by foliar trichome type. Webster (1993) placed *C. crassifolius* into sect. *Croton*, which had lepidote trichome. However, *C. crassifolius* has stellate trichome and it might be a member of sect. *Andrichnia*. Webster (1993) uncertainly listed *C. cascarilloides* under both sect. *Anisophyllum*, having appressed-stellate trichome, and sect. *Monguia*, having lepidote trichome. This is the same as Senakun and Chantaranothai (2010) observed, *C. cascarilloides* has lepidote trichome and it is suggested to be placed in sect. *Monguia*. Among species with bifid styles, *C. mangelong*, *C. kongensis*, *C. laevigatus* and *C. laniflorus* are different from other Chinese species in having lepidote trichome and belong to sect. *Argyrocroton* which is characterized by the bifid style and lepidote trichomes. *Croton laevigatus* and *C. laniflorus* were placed by Müller (1866) in sect. *Decapetalon*, however, they are not related to the species of sect. *Decapetalon* because they have glands on the leaf blades while eglandular in sect. *Decapetalon*. *Croton lauioides*, *C. howii* and *C. damayeshu* have stellate trichome and belong to sect. *Adenophylli*. *Croton hancei* and *C. purpurascens* with appressed-rosulate trichomes and the remaining Chinese *Croton* species having appressed-stellate trichomes might be placed into sect. *Tiglium* according to the classification of Webster (1993). However, the correct name for sect. *Tiglium* is sect. *Croton* because the section including *C. tiglium*, the type of the genus. Although Webster *et al.* (1996) superseded Small's (1913) choice of *C. tiglium* as the lectotype of *Croton* and designated *C. aromaticus* L., the valid lectotype of the genus is *C. tiglium* (Britton, 1918; van Ee and Berry, 2010).

A key to species of *Croton* from China is provided as follows.

1. With simple trichome — *C. crassifolius*
1. Without simple trichome
  2. With dentritic trichome
    3. Only dentritic trichome — *C. laui*
    3. With dentritic and appressed-stellate trichome
      4. Dentritic trichome only on abaxial surface — *C. lachnocarpus*
      4. Dentritic trichome on both surfaces
        5. Without appressed-stellate trichome on abaxial surface — *C. cnidophyllus*
        5. With appressed-stellate trichome on abaxial surface — C. *yanhuii*

2. Without dentritic trichome
  6. With lepidote trichome
    7. With dentate-lepidote trichome — *C. cascarilloides*
    7. Without dentate-lepidote trichome
      8. With lepidote-subentire trichome
        9. With lepidote-subentire trichome on the adaxial surface — *C. kongensis*
        9. Without lepidote-subentire trichome on the adaxial surface — *C. mangelong*
      8. Without lepidote-subentire trichome
        10. Stellate-lepidote trichome is intermediate when mature — *C. laniflorus*
        10. Stellate-lepidote trichome is sparse when mature — *C. laevigatus*
  6. Without lepidote trichome
      11. Glabrous on adaxial surface
        12. With appressed-rosulate trichome — *C. chunianus*
        12. Without appressed-rosulate trichome
          13. With stellate trichome — *C. howii*
          13. Without stellate-trichome — *C. merrillianus*
      11. With trichome on adaxial surface
        14. With appressed-rosulate trichome
          15. Only appressed-rosulate trichome
            16. All trichome fallen down when mature — *C. purpurascens*
            16. Trichome not fallen down when mature — *C. hancei*
          15. With appressed-rosulate and appressed-stellate trichome — *C. dinghuensis*
        14. Without appressed-rosulate
            17. With stellate trichome
              18. All trichome fallen down when mature — *C. damayeshu*
              18. Trichome not fallen down when mature — *C. lauioides*
            17. Without stellate trichome
              19. All trichome fallen down when mature — *C. euryphyllus*
              19. Trichome not fallen down when mature
                20. Trichome is dense on adaxial surface when young — *C. yunnanensis*
                20. Trichome is intermediate on adaxial surface when young — *C. tiglium*

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