CHAPTER 5

RESULTS

5.1 Specimen collection

Eighteen out of twenty three taxa of *Cassia* s.l. were collected throughout the country (Figure 4.1). They are both wild and cultivated plants. The specimen were determined to species based on key to species in Larsen et al., (1984) and arranged within related genus according to Irwin & Barneby (1981) as shown in Table 5.1. In addition a new recorded taxon, *C. obtusifolia* L. was included in this study; it was not included in the flora of Thailand (Larsen et. al., 1984).

5.2 Details of each taxon

The following are the short description, vernacular names and specimens examined for each taxon. Taxa are followed Larsen et al. (1984).

1. *Cassia alata* L., Sp. Pl.: 378. 1753; Craib in Fl. Siam. En. 1: 508. 1928; K & S.S. Larsen and Vidal in Fl. C.L.V. 18: 86. 1980; K & S.S. Larsen and Vidal in Fl. Thailand 4 (1): 108. 1984.

Shrub, hairy. *Leaves* unipinnate; stipules auriculate, persistent, deltoid; pinnae 7-13 pairs, petioles 2-3 cm; pinnae elliptic-oblong, glabrous, apex and base rounded. *Racemes* axillary, densed; bracts caducous. *Flower* zygomorphic; sepals oblong, petals bright yellow, ovate-orbicular to spathulate, short-clawed; stamens 10, filaments thick in the two largest, 4 shorter; 4 reduced in size with minute anthers; ovary and style glabrous. *Pods* winged, thick, glabrous, black in color. (Fig. 5.3)

Vernacular: **Chum het thet (ชุมเห็ดเทศ)**; khi khak (ขี้คาก); mak kaling thet (หมากกะลิงเทศ).

Specimen examined: *S. Pechsri 55, C. Sombongse 7, U. Damsri 47* (BCU); *S.F. Maxwell 94-1220* (BKF)

2. ***Cassia bakeriana*** **Craib.**, Kew Bull. 1911: 45; Craib in Fl. Siam. En. 1: 508. 1928; K & S.S. Larsen and Vidal in Fl. Thailand 4 (1): 105. 1984.

Tree, densely hairy on all young parts. *Leaves* unipinnate; stipules lanceolate, attached in the middle; pinnae 7-11 pairs, petioles pubescent, rachis pubescent; pinnae oblong-oblanceolate, hairy, apex round with a small sharp point and base rounded. *Racemes* lateral; bracts lanceolate, apex long-pointed, hairy. *Flower* zygomorphic, pedicels pubescent; sepals ovate-lanceolate, pubescent, petals pinkish, ovate-lanceolate, short-clawed; stamens 10, filaments swollen in the middle in the three largest, 4 shorter; 4 reduced; ovary pubescent, style short. *Pods* terete, pubescent. (Fig. 5.1)

Vernacular: **Chaiyaphruk (ชัยพฤกษ์)**; kalapapruk (กัลปพฤกษ์).

Specimen examined: *W. Busapavanija 20, S. Pechsri 53* (BCU); *F. Konta* et. al. *4085* (BKF)

3. ***Cassia fistula*** **L.** Sp. Pl. : 377. 1753; Craib in Fl. Siam. En. 1: 509. 1928; K & S.S. Larsen and Vidal in Fl. C.L.V. 18: 79. 1980; K & S.S. Larsen and Vidal in Fl. Thailand 4 (1): 103. 1984.

Tree, glabrous. *Leaves* large; unipinnate; stipules small, caducous, deltoid; pinnae 4-6 pairs, petioles glabrous, rachis terete; pinnae ovate-oblong, glabrous, apex acute, base cuneate. *Racemes* axillary, pendent; bracts caducous. *Flower* zygomorphic, pedicel glabrous; sepals ovate-elliptic, petals yellow, ovate, short-clawed; stamens 10, 3 long, 4 shorter; 3 reduced in size with minute anthers; ovary strigulose, style velutinous. *Pods* terete, glabrous, black in color. (Fig. 5.1)

Vernacular: **Ratchapruk (ราชพฤกษ์)**; lom laeng (ลมแล้ง); chaiyapruk (ชัยพฤกษ์); khun (คูณ); lak khoei lak klua (ลักเคยลักเกลือ).

Specimen examined: *S.Poothong 41, Sinchai 653, S. Pechsri 51* (BCU); *Chararnmayu 434* (BKF)

4. ***Cassia garrettiana*** **Craib**, Kew Bull. 1912: 151; Craib in Fl. Siam. En. 2: 510. 1928; K & S.S. Larsen and Vidal in Fl. C.L.V. 18: 91. 1980; K & S.S. Larsen and Vidal in Fl. Thailand 4 (1): 112. 1984.

Tree. *Leaves* unipinnate; stipules caducous; pinnae 4–11 pairs, petioles 2-3 cm; pinnae lanceolate to ovate, glabrous, apex acuminate, base rounded. *Racemes* leafy on terminal; bracts ovate, caducous. *Flower* zygomorphic, pedicels pubescent; sepals elliptic, petals yellow, ovate, short-clawed; stamens 10, filament fattened in the two largest, 5 shorter; 3 reduced in size with minute anthers; ovary and style glabrous. *Pods* flat, glabrous, black in color. (Fig. 5.4)

Vernacular: **Samae san** (แสมสาร); khi lek khan chang (ขี้เหล็กคันชั่ง); khi lek phae (ขี้เหล็กแพะ); khi lek san (ขี้เหล็กสาร).

Specimen examined: *O. Thaithong 249, B. Na Songkhla 260, S. Pechsri 59* (BCU); FTP. 31411, Luang Vanpruk 53 (BKF)

5. ***Cassia grandis*** **L. f.**, Suppl.: 230. 1781; K & S.S. Larsen and Vidal in Fl. C.L.V. 18: 80. 1980; K & S.S. Larsen and Vidal in Fl. Thailand 4 (1): 105. 1984.

Deciduous tree, trunk with buttress. *Leaves* unipinnate; stipules minute; pinnae 10-20 pairs, petioles woolly; pinnae elliptic-oblong, subcoriaceous, glabrous, apex and base rounded. *Racemes* lateral; bracts caducous. *Flower* zygomorphic; sepals obovate-rounded, pubescent, reflexed, petals first red, later pink, finally orange, obovate, short-clawed; stamens 10, filaments recurved in the three largest, 5 shorter; 2 reduced in size with minute anthers; ovary silky tomentose, style short. *Pods* cylindric, woody, rugose, glabrous, black in color. (Fig. 5.1)

Vernacular: **Kalapruk** (กาฬพฤกษ์).

Specimen examined: *S. Pechsri 52* (BCU); *T. Santisuk 1627, Th. S. et. al. 21* (BKF)

6. ***Cassia hirsuta*** **L.**, Sp. Pl.: 378 1753; K & S.S. Larsen and Vidal in Fl. C.L.V. 18: 92. 1980; K & S.S. Larsen and Vidal in Fl. Thailand 4 (1): 113. 1984.

Herb or undershrub, hirsute. *Leaves* unipinnate; stipules caducous, hairy; pinnae 3–5 pairs, the upper pairs largest, petioles long villous, sessile; pinnae lanceolate, hirsute, apex acute, base rounded. *Racemes* short, axillary; bracts hirsute. *Flower* zygomorphic, pedicels pubescent; sepals pubescent, petals yellow obovate, glabrous, short-clawed; stamens 10, filaments flat in the two largest, 4 shorter; 4 reduced in size with minute anthers; ovary greyish wooly, style glabrous. *Pods* falcate, hirsute. (Fig. 5.3)

Vernacular: **Rang jued ton** (รางจืดต้น); phong pheng (โผงเผง); dap phit (ดับพิษ).

Specimen examined: *S. Pechsri 60 (BCU); FRDU & P.C. van Welzen 77, Prayun 3* (BKF)

7. ***Cassia javanica*** **L. var.** ***javanica*** , Sp. Pl.: 379. 1753, Craib in Fl. Siam. En. 1: 508, 509, 511. 1928; K & S.S. Larsen and Vidal in Fl. C.L.V. 18: 84. 1980; K & S.S. Larsen and Vidal in Fl. Thailand 4 (1): 107. 1984.

Deciduous tree. *Leaves* unipinnate; *Stipules* elliptic, falcate to pointed, attached in the middle; pinnae 7-16 pairs, petioles glabrous; pinnae elliptic-ovate to oblong, hairy, apex and base rounded. *Racemes* lateral, densed; bracts ovate-acute. *Flower* zygomorphic; sepals ovate-acute, dark red to reddish brown, petals first pink later dark red, finally pale, ovate, long-clawed; stamens 10, filaments recurved with a spherical enlargement near the middle in the three largest, 4 shorter; 3 reduced in size with minute anthers; ovary pubescent, style short. *Pods* terete, glabrous, black in color. (Fig. 5.1)

Vernacular: **Kalapapruk** (กัลปพฤกษ์); chaiyaphruk (ชัยพฤกษ์); kalapruk (กาลพฤกษ์); khi lek yawa (ขี้เหล็กชวา).

Specimen examined: *Herb. Trip 893, S. Poothong 4, S. Pechsri 54* (BCU); *K. Larsen et. al. 30873, 33596* (BKF)

8. ***Cassia leschenaultiana*** **DC.**, Mem. Soc. Phys. Geneve 2: 132. 1824; Craib in Fl. Siam. En. 1: 511. 1928; K & S.S. Larsen and Vidal in Fl. C.L.V. 18: 106. 1980; K & S.S. Larsen and Vidal in Fl. Thailand 4 (1): 123. 1984.

Small shrub, densely greyish to yellowish pubescent. *Leaves* unipinnate; stipules linear, persistent; pinnae 35-47 pairs, petioles with discoid gland below the lowest pair of leaflets; pinnae falciform, side unequal, glabrous, apex and base rounded; rachis pubescent, canaculate. *Racemes* few, axillary; bracts caducous. *Flower* zygomorphic, pedicels pubescent; sepals oblong, yellow, shortly; stamens 9-10, filaments very short; ovary hairy, style recurved. *Pods* flat, dehiscent. (Fig. 5.5)

Vernacular: **Sa kham khom** (ซ่าขามค่อม)

Specimen examined: *S.Pechsri 50, 68* (BCU); *Deer 331, T. Smitinand 4966* (BKF)

9. ***Cassia obtusifolia*** **L.** Sp. Pl.: 378 1753.

Herb or undershrub, thinly pubescent. *Leaves* unipinnate; stipules caducous; pinnae 3 pairs, petioles 1-4 cm; rachis with 2 subulate gland between the lowermost pair of leaflets; pinnae obovate, glabrous, apex rounded, base acuminate. *Racemes* axillary; bracts linear. *Flower* zygomorphic; sepals ovate, petals orange-yellow, obovate, short-clawed; stamens 7, 3 longer, 4 shorter; 4 staminode; ovary pubescent; style glabrous. *Pods* linear, terete, falcate, glabrous. (Fig. 5.2)

Vernacular: **Chumhet thai** (ชุมเห็ดไทย)

Specimen examined: *S. Pechsri 77* (BCU)

10. ***Cassia occidentalis*** **L.** Sp. Pl.: 378 1753; Craib in Fl. Siam. En. 2: 512. 1928; K & S.S. Larsen and Vidal in Fl. C.L.V. 18: 93. 1980; K & S.S. Larsen and Vidal in Fl. Thailand 4 (1): 113. 1984.

Undershrub, glabrous. *Leaves* unipinnate; linear to acute; pinnae 4-5 pairs, petioles with large gland above the petiole joint; pinnae unequal-side, ovate to oblong; apex acuminate, base rounded. *Racemes* axillary, densed; bracts linear-acute, caducous. *Flower* zygomorphic; sepals ovate, petals yellow with violet veins, ovate, short-clawed; stamens 10, 2 longer, 4 shorter; 4 reduced with minute anthers; ovary tomentose, style glabrous. *Pods* flat, glabrous, brown in color. (Fig. 5.3)

Vernacular: **Phak hket (ผักเค็ด)**; chumhet lek (ชุมเห็ดเล็ก); khi lek phuak (ขี้เหล็กเผือก); phak het (ผักเห็ด); khang khet (คางเค็ด).

Specimen examined: *A. Chutinthorn 20, T. jonganurak 152, S. Pechsri 61* (BCU); *K. Bunchuai 120, D. Bunpheng 1* (BKF)

11. *Cassia pumila* Lamk. Enc. 1: 651. 1785; Craib in Fl. Siam. En. 1: 513. 1928; K & S.S. Larsen and Vidal in Fl. C.L.V. 18: 104. 1980; K & S.S. Larsen and Vidal in Fl. Thailand 4 (1): 120. 1984.

Small shrub, pubescent. *Leaves* unipinnate; stipules linear acute, persistent, rachis grooved in side; pinnae 13-17 pairs, petioles pubescent with a long stipitate gland below the lowest pair of leaflets; pinnae narrow elliptic, sessile, hairy along the midrib, upper glabrous, lower pubescent, apex and base rounded. *Racemes* axillary; bracts as the stipule but shorter. *Flower* zygomorphic, pedicels pubescent; sepals lanceolate, petals bright yellow, oblong-obovate, short-clawed; stamens 5-6; ovary tomentose, style glabrous. *Pods* flat, dehiscent, brown in color. (Fig. 5.5)

Vernacular: **Makham din (มะขามดิน)**; makham bia (มะขามเบี้ย).

Specimen examined: *S. Pechsri 67* (BCU); *G Murata et. al. 3863, J.F. Maxwell 86-1020* (BKF)

12. ***Cassia siamea*** **Lamk.**, Enc. 1: 648. 1785; Craib in Fl. Siam. En. 1: 513. 1928; K & S.S. Larsen and Vidal in Fl. C.L.V. 18: 887. 1980; K & S.S. Larsen and Vidal in Fl. Thailand 4 (1): 110. 1984.

Tree, pubescent on young branches. *Leaves* unipinnate; stipules minute, caducous; pinnae 7-11 pairs, petioles 2-3 cm; pinnae ovate-oblong, glabrous, apex and base rounded. *Racemes* terminal, large; bracts obovate with long acute apex. *Flower* zygomorphic, pedicels valentinous; sepals thick, oblong, petals yellow, broadly ovate, short-clawed; stamens 10, filaments straight in the two largest, 4-5 shorter; 3 reduced in size with minute anthers; ovary pubescent, style glabrous. *Pods* flat, glabrescent, longitudinally waved with raised sutures. (Fig. 5.4)

Vernacular: **Khi lek ban (ขี้เหล็กบ้าน)**; khi lek luang (ขี้เหล็กหลวง); khi lek (ขี้เหล็ก); khi lek yai (ขี้เหล็กใหญ่).

Specimen examined: *C. Siwasilp 9, K. Sridith 183, S. Pechsri 57* (BCU); *J.F. Maxwell 86-495, C Phegklai et. al. 3751* (BKF)

13. ***Cassia sophera*** **L.**, Sp. Pl.: 379. 1753; Craib in Fl. Siam. En. 1: 513. 1928; K & S.S. Larsen and Vidal in Fl. C.L.V. 18: 94. 1980; K & S.S. Larsen and Vidal in Fl. Thailand 4 (1): 115. 1984.

Shrub, glabrous. *Leaves* unipinnate; stipules ovate, caducous; pinnae 7-13 pairs, petioles with gland above the petiole joint; pinnae lanceolate, the upper largest, glabrous, apex acute, base rounded. *Racemes* axillary; bracts ovate, caducous. Flower zygomorphic; sepals ovate-rounded, petals yellow, obovate, short-clawed; stamens 10, 2 longer, 4 shorter; 4 reduced in size with minute anthers; ovary pubescent, style glabrous. *Pods* cylindric, glabrous, brown in color. (Fig. 5.3)

Vernacular: **Phak hket** (ผักเค็ด); phak wan ban (ผักหวานบ้าน); khi lek wan (ขี้เหล็กหวาน).

Specimen examined: *BNS 630, S. Pechsri 78, S.P. 62* (BCU); *S. Unjai 98, H.M. Burkill 1276* (BKF)

14. ***Cassia spectabilis*** **DC.**, Cat. Hort. Monsp.: 90. 1813; K & S.S. Larsen and Vidal in Fl. Thailand 4 (1): 110. 1984.

Tree, hairy on young parts. *Leaves* unipinnate; stipules linear, falcate, caducous; pinnae 9-15 pairs, petioles 2-3 cm; pinnae lanceolate, glabrous, apex acute, mucronate, base rounded. *Racemes* large, leafy on terminal; bracts ovate, caducous. *Flower* zygomorphic, pedicels valentinous; sepals unequal, oblong, petals yellow, ovate to spathulate, the lower one larger broad falcate, short-clawed; stamens 10, 7 large, 4 shorter; 3 reduced in size with reniform minute anthers; ovary and style glabrous. *Pods* terete, glossy, glabrous, black in color. (Fig. 5.4)

Vernacular: **Sawanapruk (สุวรรณพฤกษ์)**; Khi lek American (ขี้เหล็กอเมริกัน).

Specimen examined: *S. Pechsri 56* (BCU); *H. & G.C. 148, N. Fukuoka* 62004 (BKF)

15. ***Cassia surattensis*** **Burm f. subsp.** ***glauca*** **(Lamk.) K. & S.S. Larsen**, Fl. C.L.V. 18: 102. - *C. glauca* Lamk. Craib in Fl. Siam. En. 1: 510. 1928; K & S.S. Larsen and Vidal in Fl. C.L.V. 18: 102. 1980; K & S.S. Larsen and Vidal in Fl. Thailand 4 (1): 120. 1984.

Deviate from var. *surattensis* by having 4-6 pairs of leaflets larger. Also inflorescence, floral parts and pods are larger. (Fig. 5.2)

Vernacular: **Trueng badan** (ตรึงบาดาล); phrueng badan (พรึงบาดาล); song badan (ทรงบาดาล).

Specimen examined: *Sinchai 663, S. Pechsri 66* (BCU); *J.F. Maxwell 88-1181, De 230* (BKF)

16. *Cassia surattensis* Burm f. subsp. *surattensis* K. & S.S. Larsen, Fl. Ind.: 97. 1768; Craib in Fl. Siam. En. 1: 511. 1928; K & S.S. Larsen and Vidal in Fl. C.L.V. 18: 100. 1980; K & S.S. Larsen and Vidal in Fl. Thailand 4 (1): 119. 1984.

Shrub, puberulous. *Leaves* unipinnate; linear-falcate, subpersistent; pinnae 7-9 pairs, petioles 1.5-3 cm; rachis with gland between the 2-3 lower pairs of leaflets, pinnae ovate-oblong, glabrous, apex and base rounded. *Racemes* axillary, densed; bracts ovate-acute. Flower zygomorphic; sepals ovate, petals yellow, obovate, short narrow clawed; stamens 10, filaments thick; ovary puberulous, filiform, recurved, style glabrous. *Pods* flat, glabrous, dehiscent. (Fig. 5.2)

Vernacular: **Song badan** (ทรงบาดาล); khi lek ban (ขี้เหล็กบ้าน); khi lek wan (ขี้เหล็กหวาน).

Specimen examined: *C. Thanakorn 5, S. Pechsri 66, S.P. 74* (BCU); *P. Suvarnkoses, P. Hampanond* (BKF)

17. *Cassia timorensis* DC. , Prod. 2: 499. 1825**;** Craib in Fl. Siam. En. 1: 514. 1928; K & S.S. Larsen and Vidal in Fl. C.L.V. 18: 88. 1980; K & S.S. Larsen and Vidal in Fl. Thailand 4 (1): 111. 1984.

Tree with golden hairy throughout. *Leaves* unipinnate; stipules large, auriculate; pinnae 16-22 pairs, petioles 2-3 cm; rachis pubescent ; pinnae oblong; apex subacute to mucronate, base rounded; golden pubescent. *Racemes* axillary; pedicels pubescent; bracts ovate, caducous. Flower zygomorphic; sepals oblong-ovate with rounded apex, yellowish pubescent, petals yellow, ovate, short-clawed; stamens 10, 2 largest, 5 shorter; 3 reduced in size with minute anthers; ovary and style glabrous. *Pods* flat, glabrous, dehiscent, brown in color. (Fig. 5.4)

Vernacular: **Khi lek luat** (**ขี้เหล็กเลือด**); khi lek dang (ขี้เหล็กแดง); khi lek khan chang (ขี้เหล็กคันชั่ง); khi lek pa (ขี้เหล็กป่า); khi lek dong (ขี้เหล็กดง); khi lek nang chi (ขี้เหล็กนางชี).

Specimen examined: *Herb. Trip 638, BNS 520, S. Pechsri 79* (BCU); *P.B. 65, T. Smitinand 8651* (BKF)

18. ***Cassia tora*** **L.**, Sp. Pl.: 376. 1753; Craib in Fl. Siam. En. 1: 514. 1928; K & S.S. Larsen and Vidal in Fl. C.L.V. 18: 96. 1980; K & S.S. Larsen and Vidal in Fl. Thailand 4 (1): 117. 1984.

Undershrub, hairy. *Leaves* unipinnate; stipules setaceous, caducous; pinnae 3 pairs, petioles 1-4 cm; rachis with gland between the 2 lower pairs of leaflets, pinnae obovate; apex rounded, base cuneate. *Racemes* axillary, densed; bracts linear-acute. Flower zygomorphic; sepals ovate, petals yellow obovate, short-clawed; stamens 7, 2 largest, 5 shorter; 3 staminode; ovary pubescent, style glabrous. *Pods* terete. (Fig. 5.2)

Vernacular: **Chumhet thai** (**ชุมเห็ดไทย**); Chumhet na (ชุมเห็ดนา); Chumhet lek (ชุมเห็ดเล็ก); Chumhet khwai (ชุมเห็ดควาย).

Specimen examined*: O. Thaithong 201, V. Srisuvanatach 4, S. Pechsri 77* (BCU); *C. Phengklai et. al. 3320, K. Larsen et. al. 34189* (BKF)

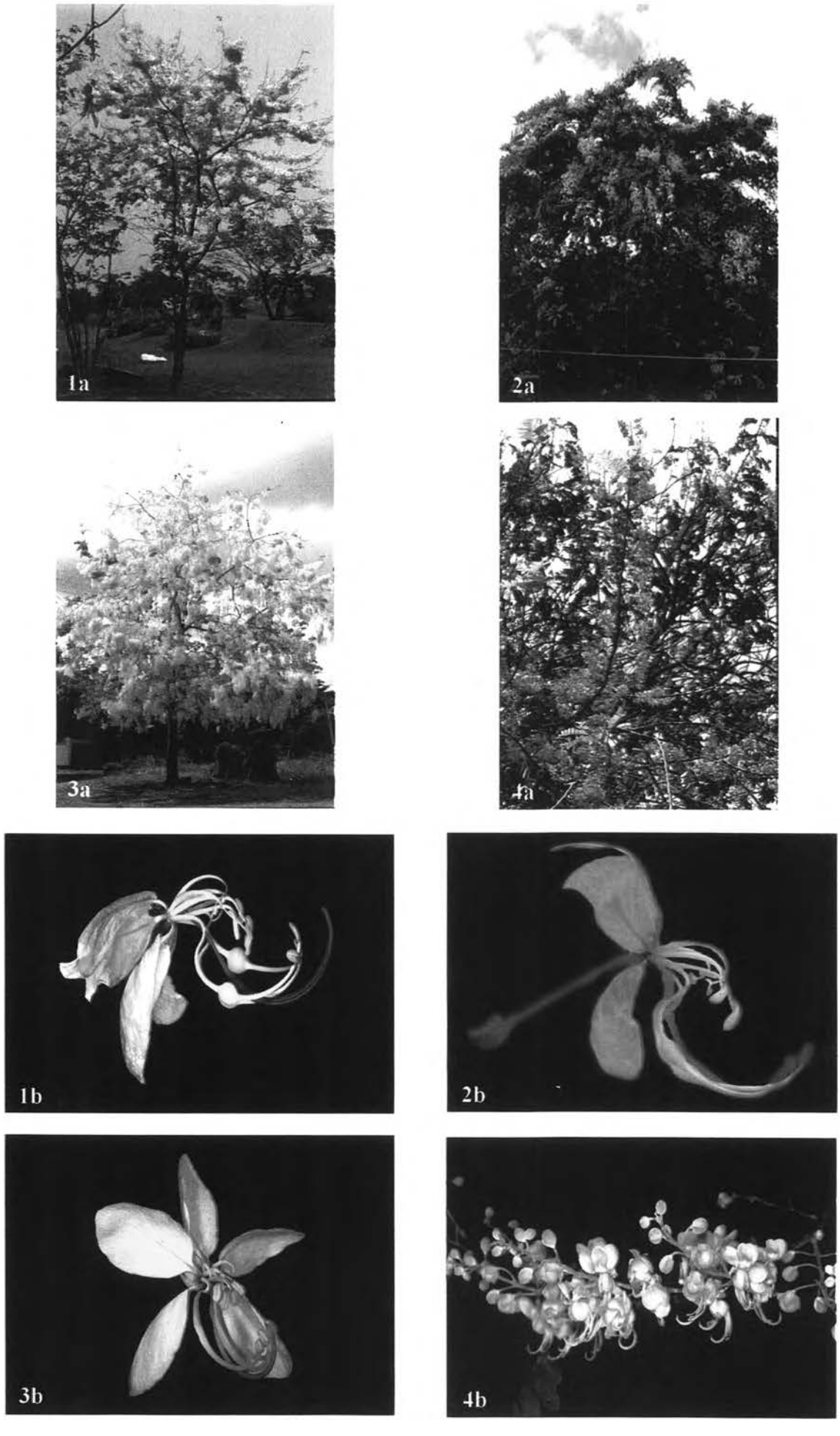


Figure 5.1 Habit (a) and flower (b) of *Cassia* s. s., 1-*C. bakeriana* Craib; 2-*C. javanica* L.; 3-*C. fistula* L.; 4-*C. grandis* L.f. (Photo: coustesy of C. Khunwasi-1a, 2a, 3a)

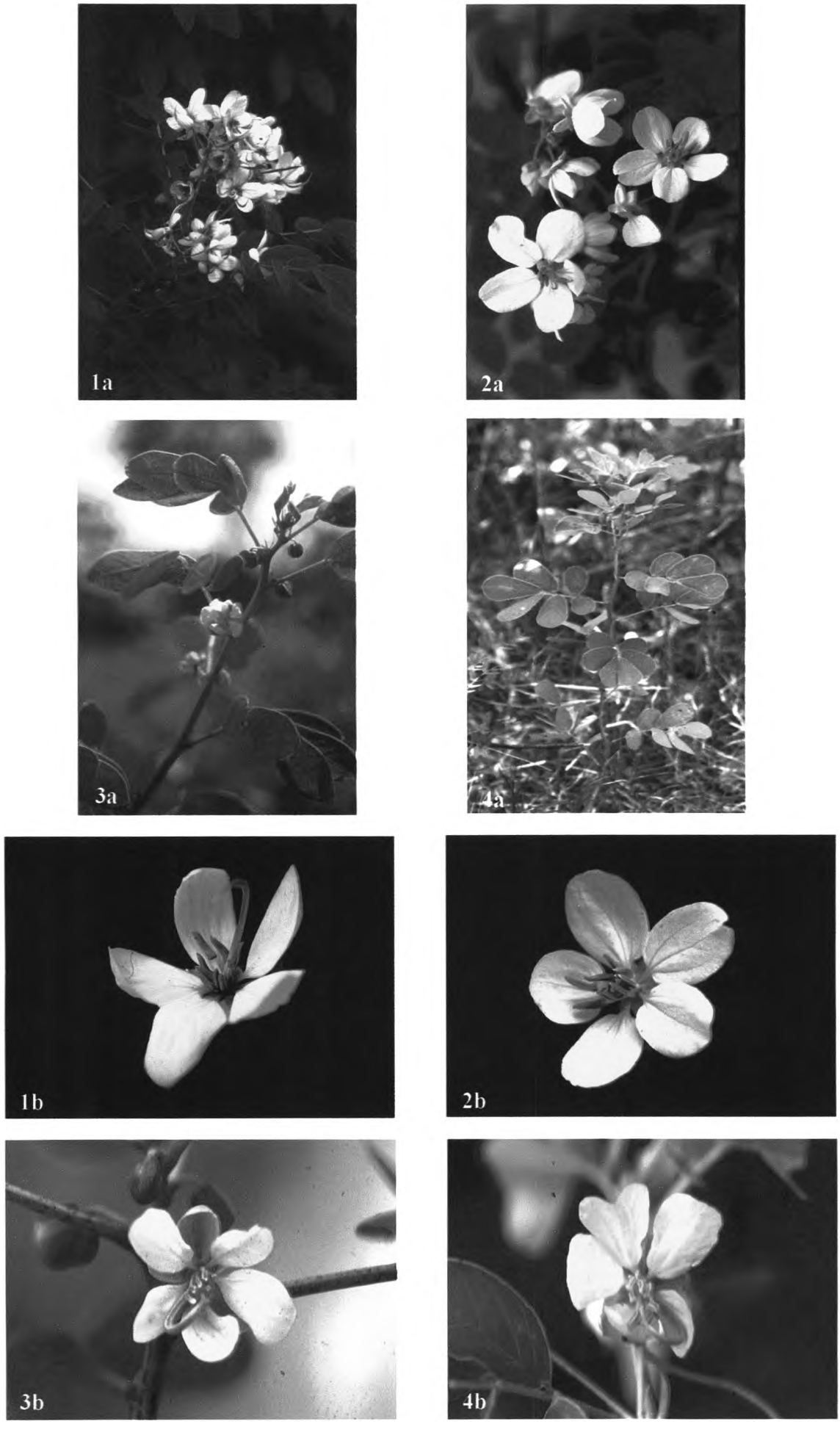


Figure 5.2 Habit (a) and flower (b) of *Cassia* (*Senna*), 1-*C. surattensis* Brum.f. subsp. *glauca* (Lamk.) K. & S.S. Larsen; 2-*C. suratttensis* Brum.f. subsp. *suratttensis*; 3-*S. tora* (L.) Roxb.; 4-*C. obtusifolia* L. (Photo: coustesy of M. kidyue)

Figure 5.3 Habit (a) and flower (b) of *Cassia* (*Senna*) 1-*C. alata* L.; 2-*C. sophera* L.; 3-*C. occidentalis* L.; 4-*C. hirsuta* L. (Photo: courtesy of M. kidyue-1b, 2b, 3b, 4b, C. Khunwasi-1a)

Figure 5.4 Habit (a) and flower (b) of *Cassia* (*Senna*), 1-*C. spectabilis* DC.; 2-*C. garettiana* Craib; 3-*C. timoriensis* DC.; 4-*C. siamea* Lamk. (Photo: courtesy of C. Khunwasi-3a, 4a)

Figure 5.5 Habit (a) and flower (b) of *Cassia* (*Chamaecrista*) 1-*C. leschenaultiana* DC.; 2-*C. pumila* Lamk. (Photo: courtesy of M. kidyue-1b)

5.3 Data analysis

5.3.1 Factor analysis

A principle components analysis (PCA) was applied to the 32 characters of 18 taxa of the *Cassia* s.l. with no *a priori* grouping. It was found that the total variance in the data described by these component was 85.6% (Table 5.2). Table 5.5 shows seven factor components. All characters have communality more than 0.5 (Table5.5). The next step was to identify these seven categories. The first component consisted of 9 characters, i.e. RCD, TLL, TWL, LMW, DBLP, BTWP, POLL, PET, and NOL. The second component also composed of 9 characters, viz. PCL, FLD, PTL, FTL, OVL, FML, OSL, PTW, and STD. The following characters:- BTW, BTL, PED, RCL, AND, and ANL confined to the third component. While the fourth component consisted of 3 characters, i.e. SPW, PSL, and SPL. The fifth component composed of FTD, FMD, and OVD. Whilst the members of the sixth component were LS and LWR. The last component composted by only one character, namely STL. It was found that the 1st and 6th components were represented vegetative characters (size) while the 2nd, 4th, 5th and 7th components were represented reproductive characters (size). Whilst the third component were the remainder of vegetative and reproductive characters (size). Factor loading of all characters in each component before rotation and after rotation is showed in Table 5.3 and 5.4.

5.3.2 Cluster analysis

The result of cluster analysis is showed in Figure 5.6. It can be seen that the dendrogram separated the 508 specimens into 4 groups at the 1.30 of average taxonomic distance. The first group is consisted of 2 species, i.e. *Cassia* (*Chamaecrista*) *pumila* and *Cassia* (*Chamaecrista*) *leschanaultiana*. The second group is solely *Cassia* (*Senna*) *alata*. While the third group is composed of 10 species of *Cassia* (*Senna*) which excluded *Cassia* (*Senna*) *alata* and *Cassia* (*Senna*) *spectabilis*. The last group is comprised of 5 species:- *Cassia fistula*, *C. javanica* var. *javanica*, *C. grandis*, *C. bakeriana* and *Cassia* (*Senna*) *spectabilis*.

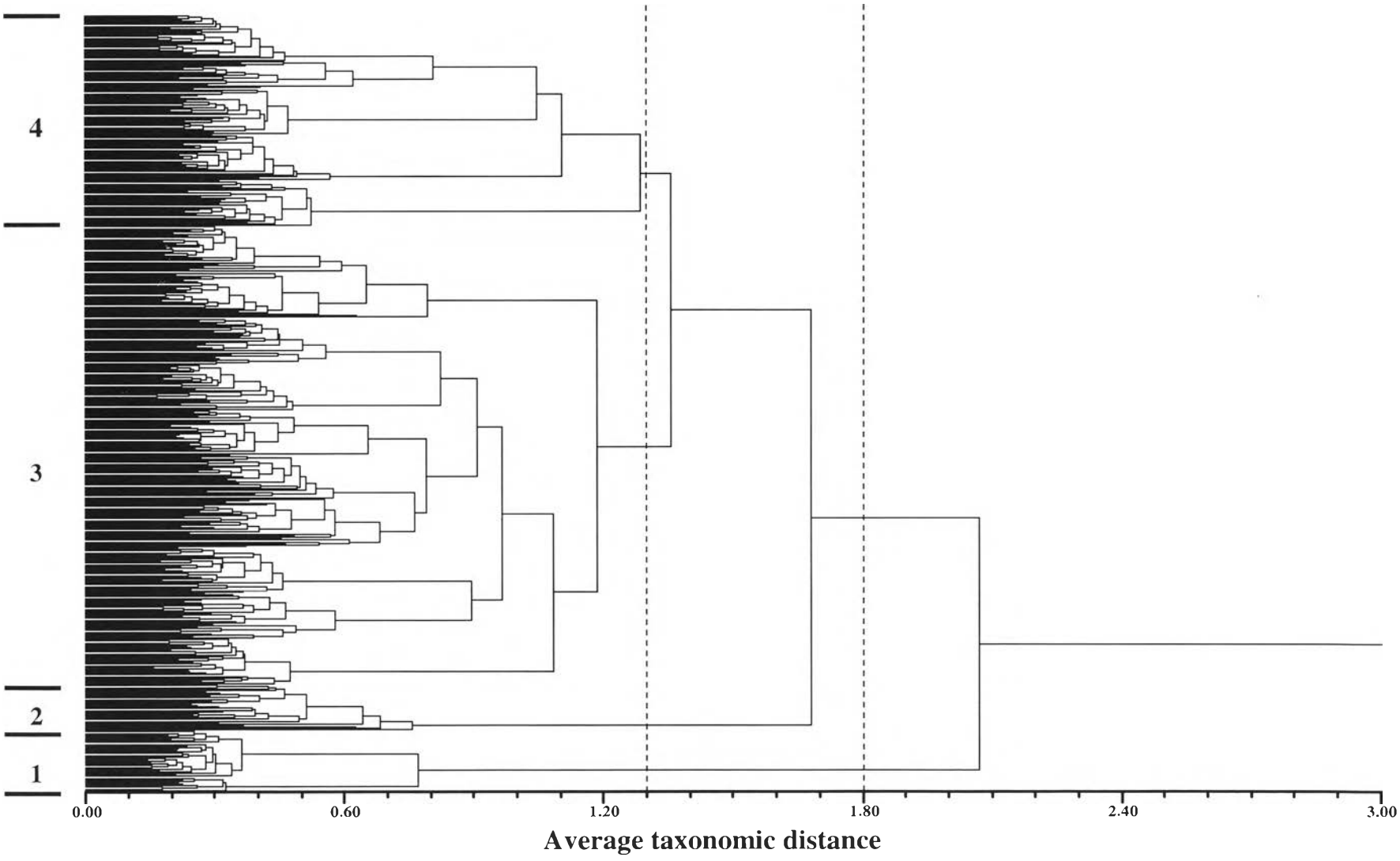


Figure 5.6 UPGMA clustering of 508 OTUs based on 32 Characters of *Cassia* s.l. in Thailand (1- *Cassia (Chamaecrista)*, 2- *C.(Senna) alata,* 3- *Cassia (Senna),* 4- *Cassia* s.s. and *C.(Senna) spectabilis*,)

5.3.3 Canonical discriminant analysis

In this analysis, four groups criteria were used. In the first criterion, the 18 taxa were divided into 18 categories. The second criterion using a priori results from the cluster analysis, i.e. 4 categories. The third criterion, the 18 taxa were divided into 4 categories according to results on stem, leaf and flower anatomy of *Cassia* s.l. (Kidyue, 2001). Finally, the 18 taxa were divided into 3 categories according to Irwin and Barneby (1981).

5.3.3.1 Discriminant analysis of 18 categories

1.) reproductive characters

Nineteen reproductive characters were used in this analysis. The linear discriminant function classification results showed 100% correctly classified. For this reason, the linear discriminant function (Table 5.6) can be used for identification of specimens of the *Cassia* s. l. in Thailand. The nature of the entries differences is showed by the pooled within canonical structure (Table 5.7). Canonical variable 1 is 99.6% correlated with the nineteen characters and the variance explained by it is 52.7% (Table 5.8). It is most highly associated with character FTL (19). Canonical variable 2 can explained 17.9 % of the total variance. This axis is most highly associated with character BTW(2) and ATL(12). Canonical variable 3 can explained 9.7 % of the total variance. This axis is most highly associated with character FML(10) (Table 5.7).

The ordination plot on the two canonical axes (Figure 5.7) shows that the eighteen categories are not distinct. The 18 categories separated into 3 groups in canonical axis 1. Group 1 consists of 3 species of *Cassia* s.s.; and only 1 species *C. grandis* is member of group 2. Group 3, the largest group, composed of *Cassia* (*Senna*) and *Cassia* (*Chamaecrista*). In canonical axis 2, however, 18 categories can be divided into 3 groups, which is differed to canonical axis 1. This axis separated *Cassia* (*Chamaecrista*) *pumila* to a single species for group 1. Similarly, group 2 composed of only one species, *Cassia* (*Senna*) *alata*. The third group composed of 4 *Cassia* taxa, 1 *Cassia* (*Chamaecrista*) taxon and 11 *Cassia* (*Senna*) taxa.

2.) Vegetative characters

Thirteen vegetative characters were used in this analysis. The linear discriminant function classification results showed 96.3% correctly classified. For this reason, the linear discriminant function (Table 5.9) can be used for identification of specimens of the *Cassia* s. l. in Thailand. The nature of the entries differences is showed by the pooled within canonical structure (Table 5.10). Canonical variable 1 is 99.2% correlated with the thirteen characters and the variance explained by it is 57.4% (Table 5.11). It is most highly associated with character TLW (8). Canonical variable 2 can explained 18.4 % of the total variance. This axis is most highly associated with character RCL(3) and NOL(6). Canonical variable 3 can explained 10.2 % of the total variance. This axis is most highly associated with character DBLP(5) (Table 5.10).

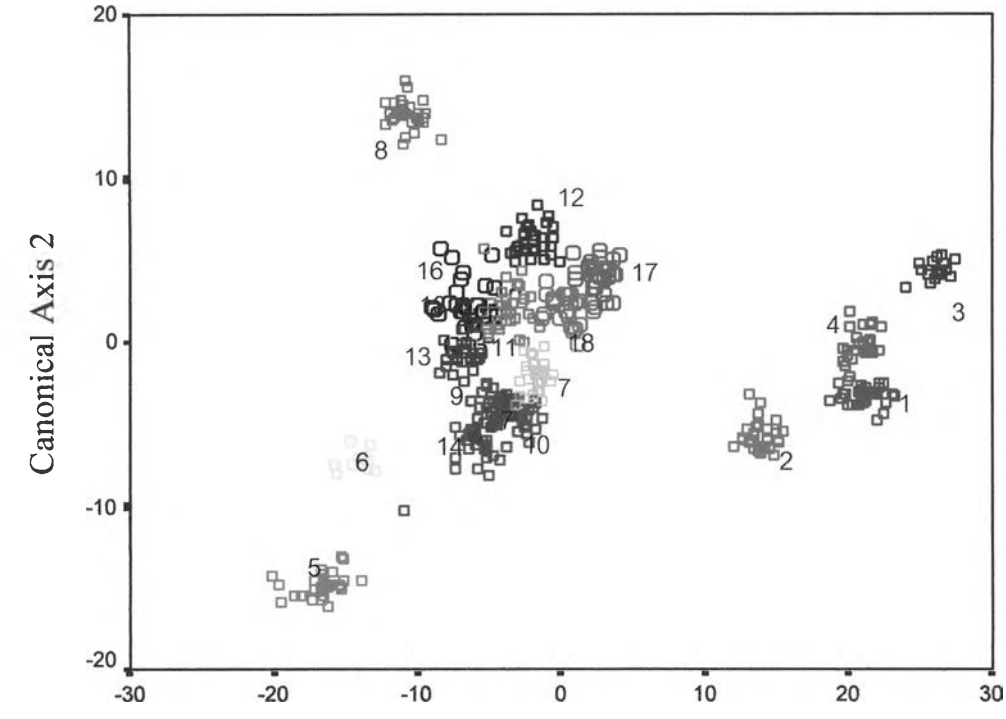
The ordination plot on the two canonical axes (Figure 5.8) shows that the eighteen categories are not distinct. The 18 categories separated into 2 groups in canonical axis 1. Group 1, the largest group, composed of 4 species of *Cassia* s.s. and 12 *Cassia* (*Senna*) taxa. Group 2 consists of 2 species of *Cassia* (*Chamaecrista*). In canonical axis 2, however, 18 categories can be divided into 2 groups which is differed to canonical axis 1. This axis separated *Cassia* (*Senna*) *gluaca* and *C.* (*Senna*) *surattensis* for group 1. Similarly, group 2 composed of 4 *Cassia* taxa, 2 *Cassia* (*Chamaecrista*) taxon and 10 *Cassia* (*Senna*) taxa.

3.) Vegetative and reproductive characters

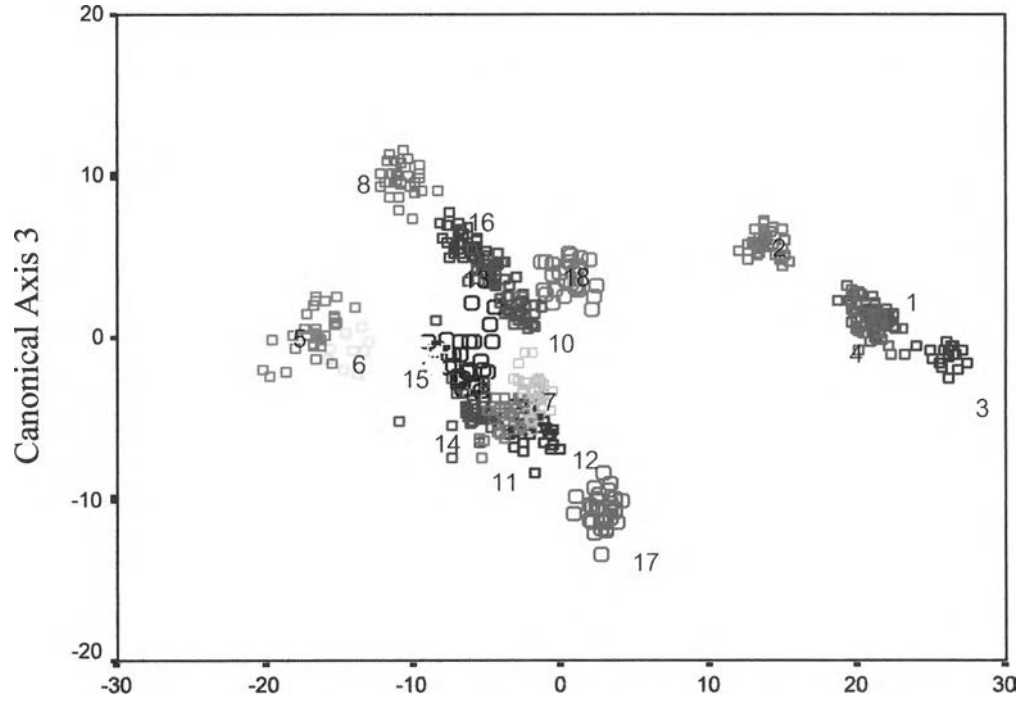
Thirty-two characters were used in this analysis. The linear discriminant function classification results showed 100% correctly classified. For this reason, the linear discriminant function (Table 5.12) can be used for identification of specimens of the *Cassia* s. l. in Thailand. The nature of the entries differences is showed by the pooled within canonical structure (Table 5.13). Canonical variable 1 is 99.7% correlated with the thirty-two characters and the variance explained by it is 42.1% (Table 5.14). It is most highly associated with character FML (23). Canonical variable 2 can explained 19.0% of the total variance. This axis is most highly associated with TLW (8), ATL (25), POLL (13) and PED (2). Canonical variable 3 can explained 11.8% of the total variance. This

axis is most highly associated with character NOL (6), BTW (16) and RCL (3). The two variables LMW (12) and RCD (4) not used in the analysis (Table 5.13).

The ordination plot on the two canonical axes (Figure 5.7) shows that the eighteen categories are distinct. The 18 categories separated into 3 groups in canonical axis 1. Group 1 consists of 2 species of *Cassia* (*Chamaecrista).* Group 2, the largest group, composed of 12 species of *Cassia* (*Senna*). Group 3 composed of 4 *Cassia* s.s. taxa. In canonical axis 2, however, 18 categories can be divided into 3 groups, which is similar to canonical axis 1. This axis separated *Cassia* (*Chamaecrista*) *pumila* and *Cassia* (*Chamaecrista*) *leschenaultiana* to group 1. Similarly, group 2 composed of 12 species, *Cassia* (*Senna*) *alata.* The third group composed of 4 *Cassia* s.s. taxa namely *C. javanica*, *C. fistula*, *C. bakeriana* and *C. grandis*.



(a)



(b)

Figure 5.7 The ordination plot of 18 taxa (reproductive character) using 18 categories as priori groups, (a) - the ordination plot on the canonical axes 1 and 2, (b) - the ordination plot on the canonical axes 1 and 3 (1-4 *Cassia* s.s, 5-6 *Cassia* (*Chamaecrista*). 7-18 *Cassia* (*Senna*))

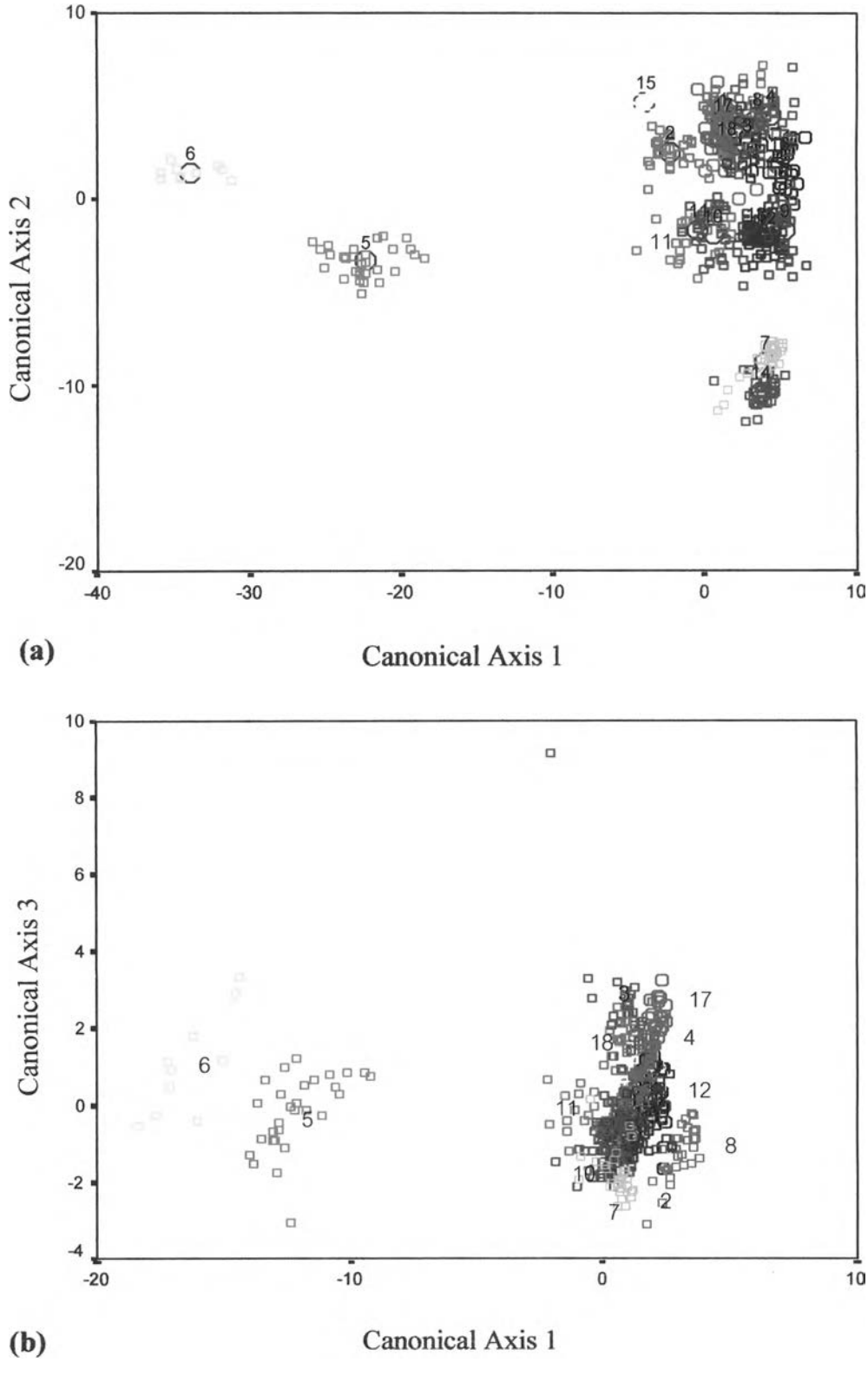


Figure 5.8 The ordination plot of 18 taxa (vegetative character) using 18 categories as priori groups, (a) - the ordination plot on the canonical axes 1 and 2, (b) - the ordination plot on the canonical axes 1 and 3 (1-4 *Cassia* s.s, 5-6 *Cassia* (*Chamaecrista*). 7-18 *Cassia* (*Senna*))

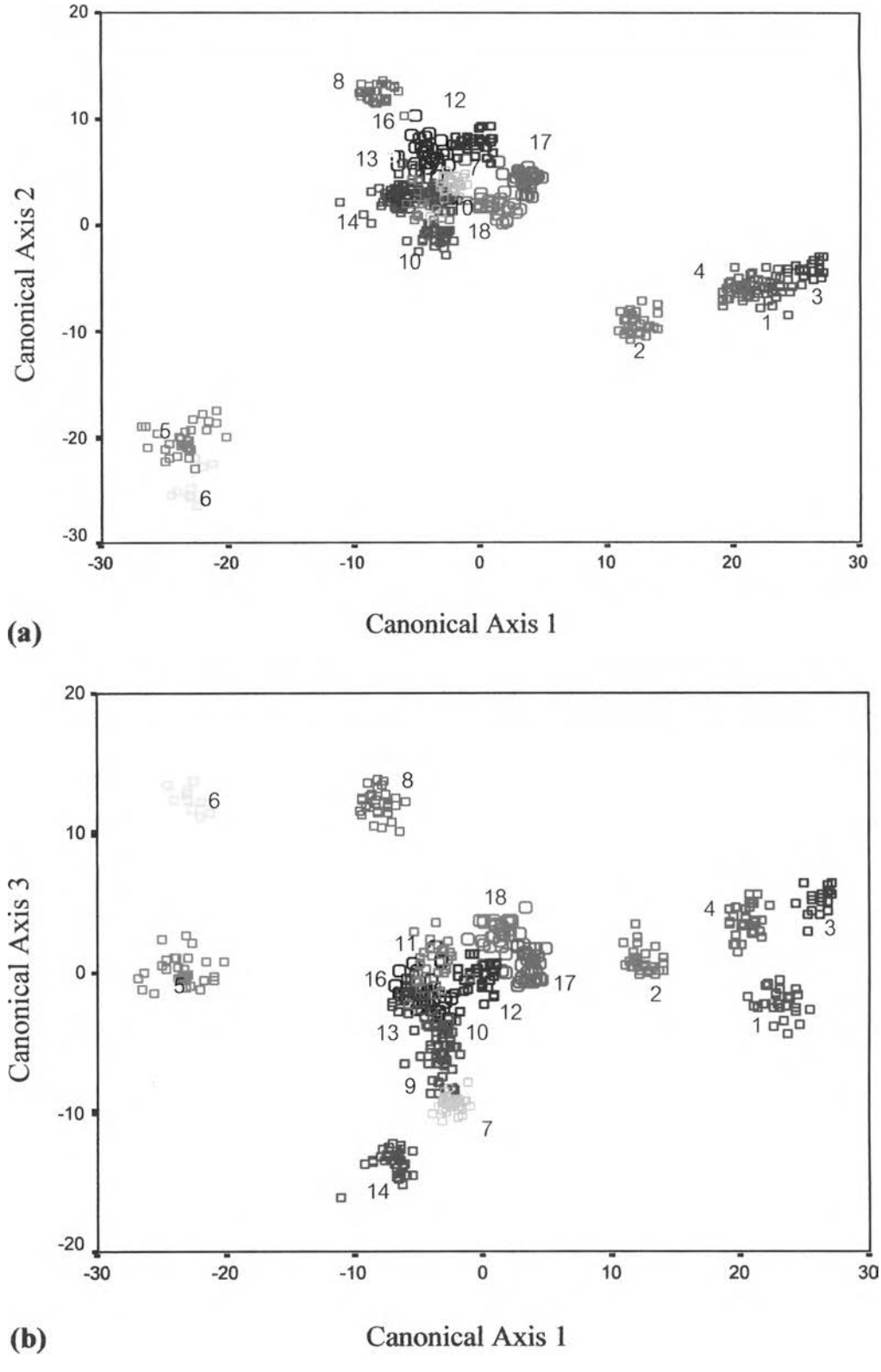


Figure 5.9 The ordination plot of 18 taxa (reproductive and vegetative character) using 18 categories as priori groups, (a) - the ordination plot on the canonical axes 1 and 2, (b) - the ordination plot on the canonical axes 1 and 33 (1-4 *Cassia* s.s, 5-6 *Cassia* (*Chamaecrista*). 7-18 *Cassia* (*Senna*))

5.3.3.2 Discriminant analysis of 4 categories according to the result of cluster analysis

Thirty-two characters were used in this analysis. The linear discriminant function classification results showed 100% correctly classified. For this reason, the linear discriminant function (Table 5.15) can be used for identification of specimens of the *Cassia* s. l. in Thailand. The nature of the entries differences is showed by the pooled within canonical structure (Table 5.16). Canonical variable 1 is 98.9% correlated with the thirty-two characters and the variance explained by it is 60.2% (Table 5.17). It is most highly associated with 12 characters FTL (32), OVL (28), POLL (13), OSL (27), PCL (17), FML (23), PTL (20), FLD (14), STD (31), PTW (21) and PSL (22). Canonical variable 2 can explained 23.8 % of the total variance. This axis is most highly associated with 11 characters ATL (25), TLW (8), PED (2), BTWP (9), SPL (18), STL (30), ATD (26), BTW (16), TLL (7), SPW (19) and LWR (10). Canonical variable 3 can explained 16.0 % of the total variance. This axis is most highly associated with character NOL (6), PET (1), RCL (3) and OVD (29). The 6 variables (FMD (24), DBLP (5), LS (11), LMW (12), BTL (15) and RCD (4) not used in the analysis (Table 5.16).

The ordination plot on the two canonical axes (Figure 5.10) shows that the four categories are not distinct. The 4 categories separated into 3 groups in canonical axis 1. Group 1 composts of 2 species of *Cassia (Chamaecrista)*). Group 2, the largest group, composed of category 3 and 4; and the category 1 is member of group 3. In canonical axis 2, however, 4 categories can be divided into 2 groups, which is differed to canonical axis 1. This axis separated only one species *Cassia* (*Senna*) *alata* into group 2. While group 1 consist of the remainder.

5.3.3.3 Discriminant analysis of 4 categories according to Kidyue's (2001)

The linear discriminant function classification results showed 100% correctly classified. For this reason, the linear discriminant function (Table 5.18) can be used for identification of specimens of the *Cassia* s. l. in Thailand.

The nature of the entries differences is showed by the pooled within canonical structure (Table 5.19). Canonical variable 1 is 98.8% correlated with the thirty-two characters and the variance explained by it is 56.3% (Table 5.20). It is most highly associated with character FML (23), FTL (32), OSL (27), OVL (28), FLD (14), PTL (20), PTW (21) and DBLP (5). Canonical variable 2 can explained 33.4% of the total variance. This axis is most highly associated with 14 characters (Table 5.19). Canonical variable 3 can explained 10.3 % of the total variance. This axis is most highly associated with 7 characters. The 4 variables OVD (29), PED (2), BTWP (8) and RCL (3) not used in the analysis.

The ordination plot on the two canonical axes (Figure 5.11) shows that the four categories are not distinct. The 4 categories separated into 3 groups in canonical axis 1. Group 1 consists of 2 species of *Cassia (Chamaecrista).* Group 2 composed of *Cassia* (*Senna*) taxa. Group 3 composed of 4 species of *Cassia* s.s. taxa. In canonical axis 2, however, 4 categories can be divided into 3 groups which is similar to canonical axis 1. This axis separated of *Cassia (Chamaecrista) pumilar* and of *Cassia (Chamaecrista) leschenaultiana* to group 1. Similarly, group 2 composed of 12 species of *Cassia* (*Senna*) taxa. The third group composed of 4 species of *Cassia* s.s. taxa , i.e., *C. fistula, C. javanica, C. grandis* and *C. bakeriana.*

5.3.3.4 Discriminant analysis of 3 categories according to Irwin and Barneby (1981)

The linear discriminant function classification results showed 100% correctly classified. For this reason, the linear discriminant function (Table 5.21) can be used for identification of specimens of the *Cassia* s. l. in Thailand. The nature of the entries differences is showed by the pooled within canonical structure (Table 5.22). Canonical variable 1 is 99.6% correlated with the thirty-two characters and the variance explained by it is 63.8% (Table 5.23). It is most highly associated with 10 characters. Canonical variable 2 can explained 36.2% of the total variance. This axis is most highly associated with 16 characters (Table 5.22).

The 6 variables namely FMD (24), RCL (3), STD (31), SPW (19), PED (2) and ATD (26) not used in the analysis.

The ordination plot on the two canonical axes (Figure 5.12) shows that the three categories are distinct. The 3 categories separated into 3 groups in both of canonical axis 1 and canonical axis 2. Group 1 consists of 4 species of *Cassia* s.s. namely *C. fistula, C. javanica, C. grandis* and *C. bakeriana.* Group 2 composed of 12 species of *Cassia* (*Senna*) taxa. Group 3 composed of 2 *Cassia* (*Chamaecrista*).

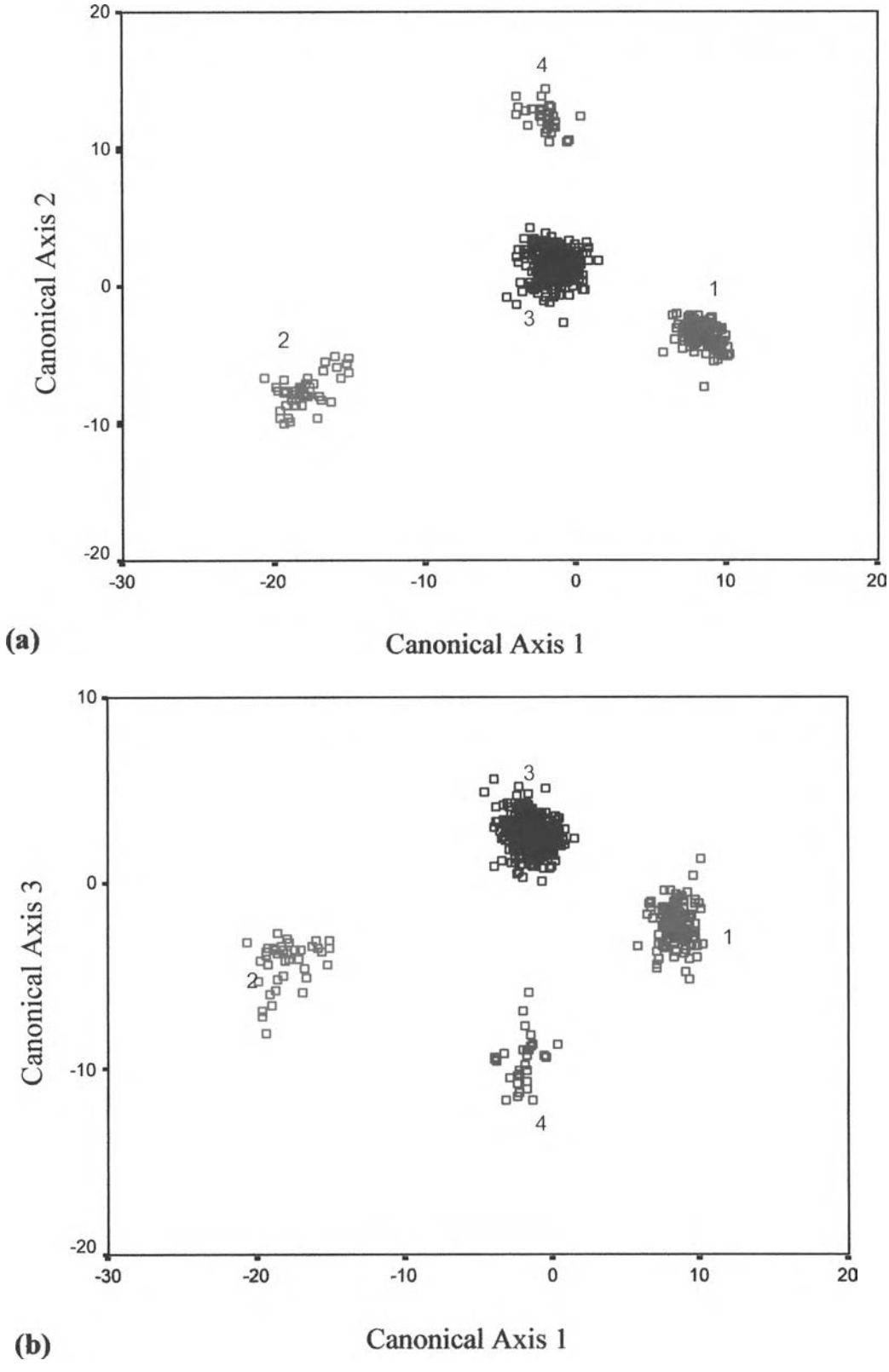


Figure 5.10 The ordination plot of 18 taxa, using 4 categories as priori groups (cluster analysis), (a) - the ordination plot on the canonical axes 1 and 2, (b) - the ordination plot on the canonical axes 1 and 3 (1- *Cassia* s.s, 2-*Cassia (Chamaecrista)*, 3-*Cassia (Senna)*, 4-*Cassia (Senna) alata*)

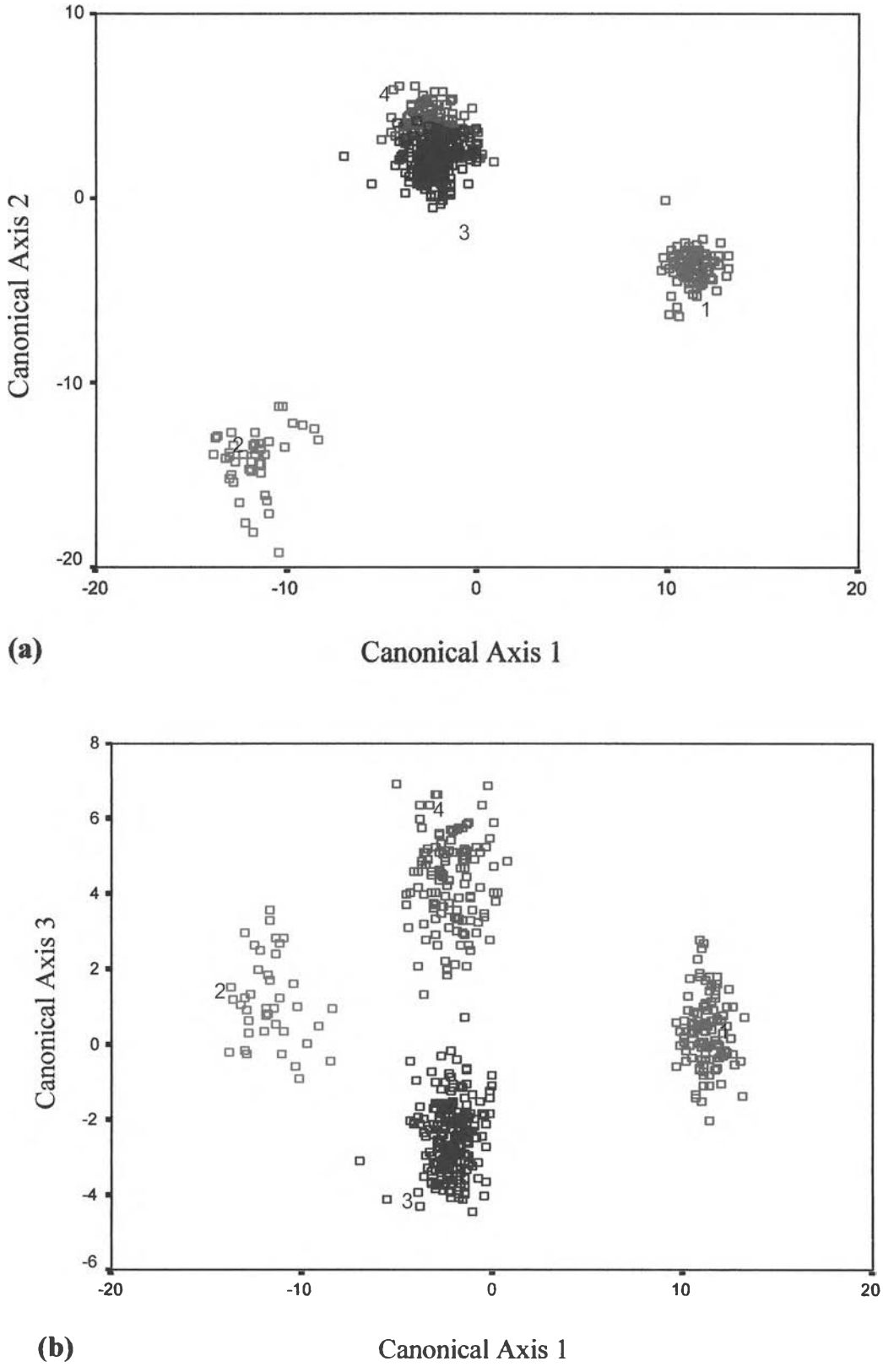


Figure 5.11 The ordination plot of 18 taxa, using 4 categories as priori groups according to Kidyu (2001), (a) - the ordination plot on the canonical axes 1 and 2, (b) - the ordination plot on the canonical axes 1 and 3 (1-*Cassia* s.s, 2-*Chamaecrista*, 3-*Senna* 1, *4-Senna* 2)

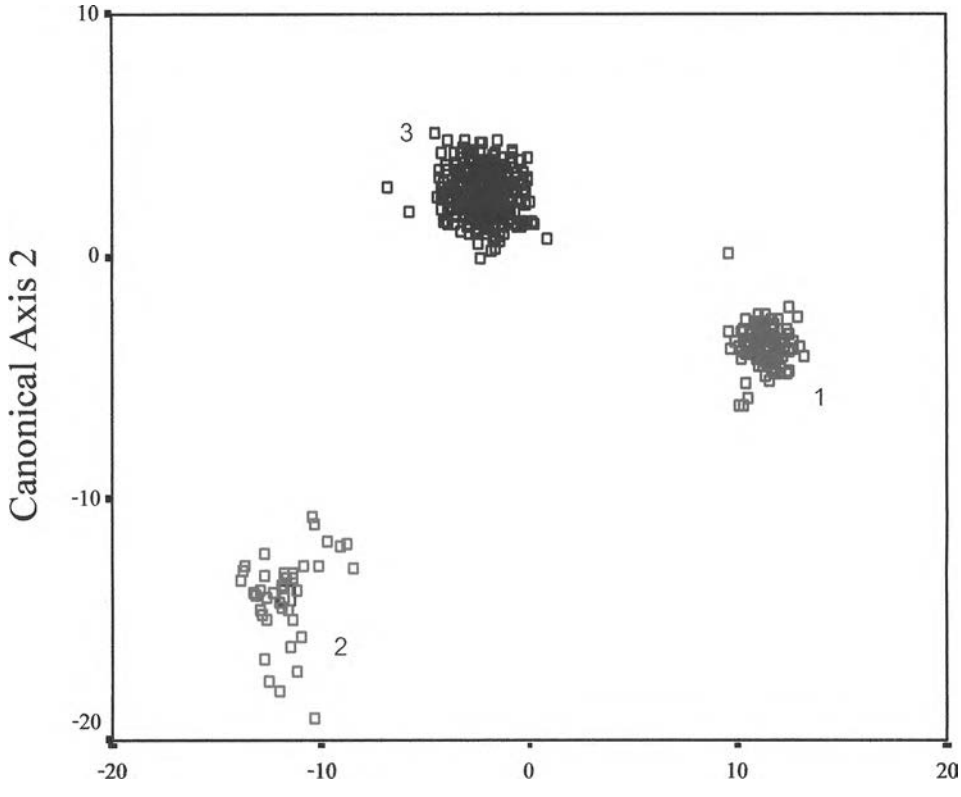


Figure 5.12 The ordination plot 18 taxa, using 3 categories as priori groups according to Irwin and Barneby (1981) on the canonical axes 1 and canonical axis 2 (1-*Cassia* s.s, 2-*Chamaecrista*, 3-*Senna*)

5.4 Comparision of qualitative morphological characters of the *Cassia* s. l.

Cassia L. is one of the largest genus of flowering plants including about 600 species, distributes worldwide in tropical regions (Kidyu, 2001). Table 5.26 shows comparison of 13 qualitative morphological characters. It can be seen that there are three habits, i.e. tree, shrub, undershrub, an smallshrub. Most species have yellow flowers. Filaments are straight or recurved. Indumentum on branch, style, and ovary also differ among species. Pods are various in forms, such as terete, cylindrical, flat, etc.