

Notes on the Flora of Taiwan (22) -- The Genus *Ajuga* L. (Lamiaceae)⁽¹⁾

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(Manuscript received 16 May 1995; accepted 13 June 1995)

ABSTRACT: Four native species of *Ajuga* L. (Lamiaceae), i. e., *A. dictyocarpa* Hayata, *A. nippensis* Makino, *A. pygmaea* A. Gray, and *A. taiwanensis* Nakai ex Murata and one naturalized species, *A. decumbens* Thunb. are recorded in Taiwan. SEM micrographs of pollen grains, chromosome counts, a key to species, species descriptions, and distribution maps are provided. The chromosome number of all species is $2n = 32$ except *A. dictyocarpa* Hayata of which is $2n = 64$.

KEYWORDS: Revision, *Ajuga*, Lamiaceae, pollen grains, chromosome number.

INTRODUCTION

According to the Flora of Taiwan, there are 4 species in the genus *Ajuga*, i. e., *Ajuga bracteosa* Wall., *A. dictyocarpa* Hayata, *A. nippensis* Makino, and *A. pygmaea* A. Gray in Taiwan (Huang et Cheng, 1978). However, Murata (1968) confirmed the presence of *A. taiwanensis* Nakai ex Murata in Taiwan which is distinguished from *A. bracteosa* by its thinner, loose hairs on the leaves, smaller flowers (5-8 mm long). It is distributed in the Philippines, Taiwan, and Ryukyu islands.

Recently, we found a naturalized species, *A. decumbens* Thunb., which was collected by some collectors (*Hunag 10465*, *H. J. Chang 2390*, etc.) about 20 years ago from Fenchihu near Alishan, Chiayi county, but these specimens were misidentified as *A. bracteosa*. This naturalized species is characterized by the stems diffuse, decumbent at flowering, with large leaves resupinate near base, flowers generally in axils of normal leaves, the corolla blue (Murata & Yamazaki, 1993). Therefore, a revision for this genus in Taiwan is presented as follows.

MATERIALS AND METHODS

Pollen grains were acetolyzed according to the procedures outlined by Erdtman (1966). The acetolyzed grains were dehydrated in an ethanol series and dried in critical point

1. This work was supported by the research grant to T. C. Huang from the National Science Council (NSC 83-0211-B-002-257).
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drying. Dried grains were coated with gold and examined with SEM. The root tips had been held in a solution of 0.002 M 8-hydroxyquinoline for 3-4 hours at a temperature of 18-20°C, then fixed in 1:3 acetic ethanol for overnight, and hydrolyzed in pectinase and squashed in acetic orcein.

RESULTS

1. External morphology

Table 1 shows the comparison of external morphology of *Ajuga*. The creeping, rooting stem, and flowers arising from nodes of *A. pygmaea* are different to the others (Table 1, Fig 7). The radical leaves of *A. taiwanensis* are larger (6-15 cm long) than the other species. The corolla color of *A. decumbens* and *A. pygmaea* is deep blue; *A. nippensis* is white; and *A. dictyocarpa* and *A. taiwanensis* is bluish white. The corolla lengths of *A. pygmaea* and *A. nippensis* are longer than the others.

Table 1. External morphology of *Ajuga* in Taiwan

Taxa Character	<i>A. decumbens</i>	<i>A. dictyocarpa</i>	<i>A. nippensis</i>	<i>A. pygmaea</i>	<i>A. taiwanensis</i>
Habit	stems diffuse, decumbent or ascending	stems erect, ascending or decumbent	stems tufted, erect or ascending	stems creeping, rooting and flowering stems arising from nodes	stems tufted erect or ascending
Radical leaves (cm)	oblanceolate or spatulate, 4-9 x 0.7-2.5	(absent)	(absent)	oblanceolate or spatulate, 2-4 x 0.5-1	oblong oblanceolate or spatulate, 6-15 x 1.5-4
Cauline leaves (cm)	oblong-oblanceolate, 1.5-4 x 0.5-2	elliptic to broadly elliptic, 4-6 x 2-4	oblong-obovate, or oblanceolate, 3-6 x 1.5-3	(absent)	oblong or oblanceolate, 6-15 x 1.5-4
Corolla color	deep blue	bluish white or pink	white	deep blue	bluish white
Corolla length (mm)	8-10	6-8	10-12	12	6-8
Corolla tube length (mm)	6-8	4-5	6-7	10	4-5
Nutlet size (mm)	1.8-2.0	1.8-2.0	2.0-2.5	1.6-1.7	1.8-2.0

2. Pollen morphology

Pollen grains are isopolar, tricolporate, the equatorial shape is prolate-spheroidal, subprolate to prolate, the tectum is perforate, the exine ornamentation is rugulate to reticulate (Figs. 1 and 2). The size of *A. nippensis* is smaller than the others (Table 2). The width of muri of *A. decumbens* and *A. dictyocarpa* are wider (0.4-0.5 μm) than the other species (below 0.3 μm).

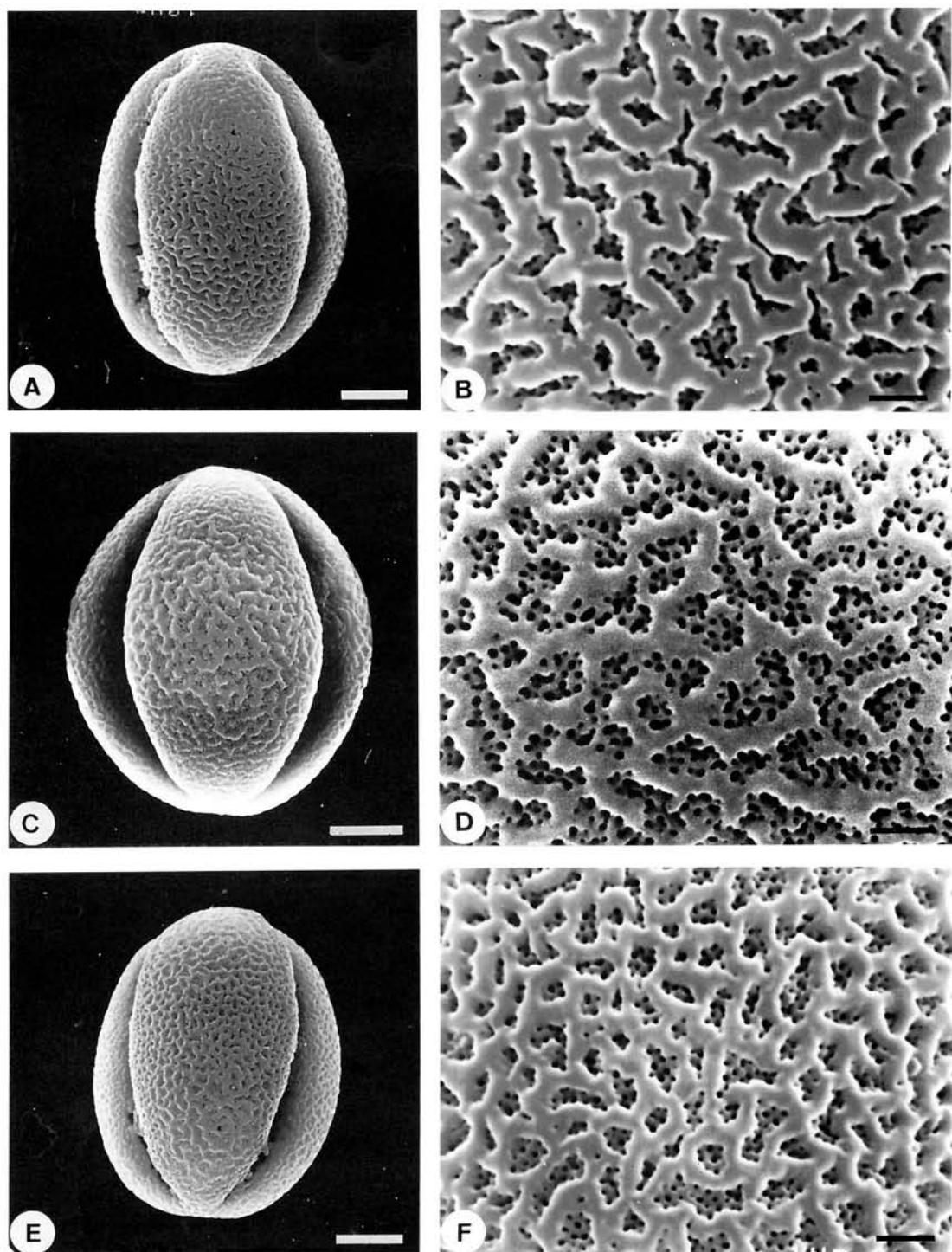


Fig. 1. SEM micrographs of pollen grains of *Ajuga decumbens* Thunb. (A, B), *A. dictyocarpa* Hayata (C, D), and *A. taiwanensis* Nakai ex Murata (E, F). White scale bar = 5 μm . Black scale bar = 1 μm .

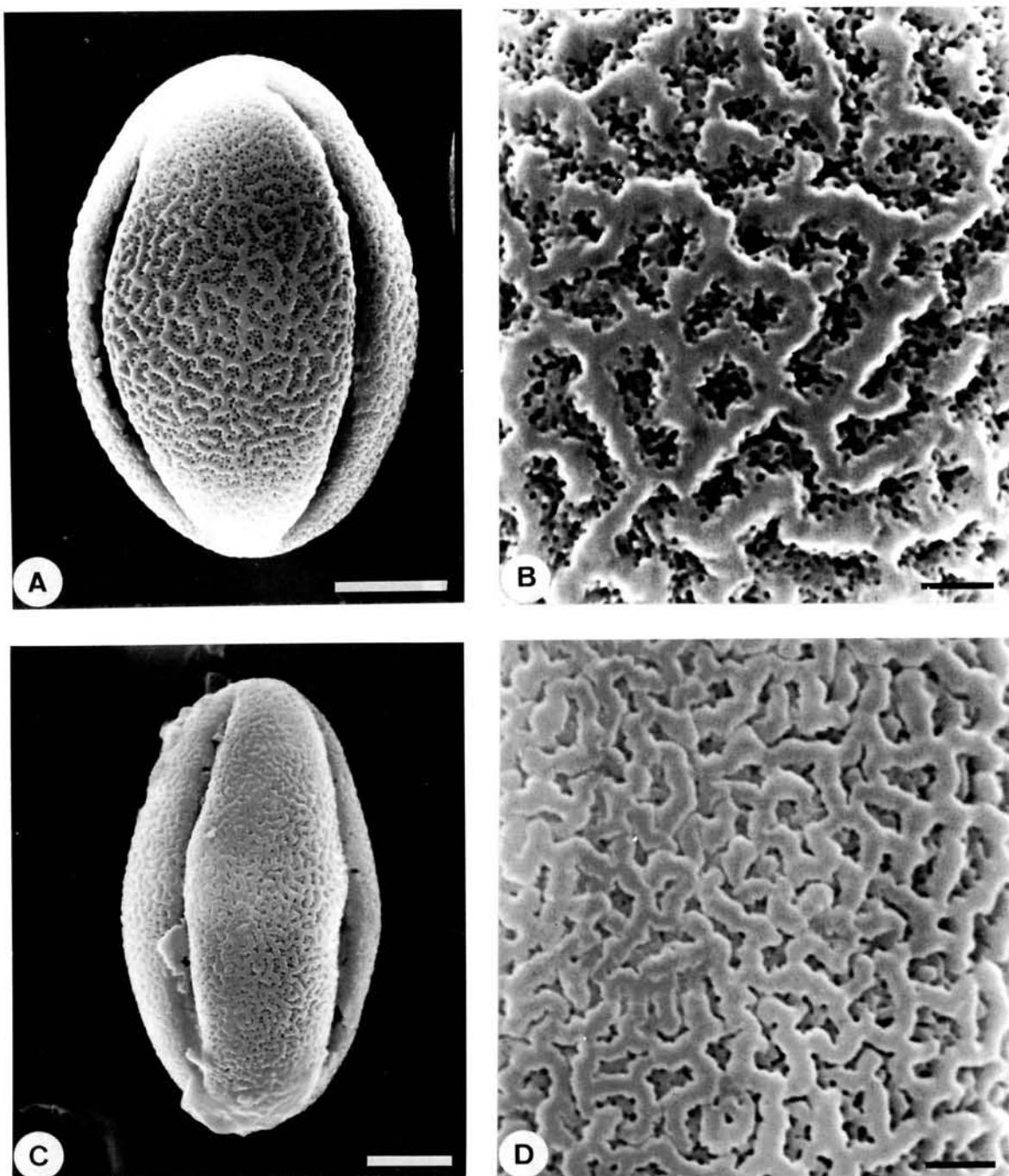


Fig. 2. SEM micrographs of pollen grains of *Ajuga nipponensis* Makino (A, B), and *A. pygmaea* A. Gray (C, D). White scale bar = 5 μm . Black scale bar = 1 μm .

Table 2. Pollen grains of *Ajuga* in Taiwan

Taxa Character	<i>A. decumbens</i>	<i>A. dictyocarpa</i>	<i>A. nipponensis</i>	<i>A. pygmaea</i>	<i>A. taiwanensis</i>
Pollen size (um)	26 x 20	25 x 20	20 x 15	30 x 18-20	24- 25 x 20
Lumina	irregular	rugulate to reticulate	circular to elliptic	irregular	circular to elliptic
Width of muri (um)	0.4- 0.5	0.4- 0.5	0.3	0.3	0.2- 0.3
Voucher specimens	<i>Lu 24490</i>	<i>Hsieh 882</i>	<i>Hsieh 1505</i>	<i>Hsieh 854</i>	<i>Yang s. n. Oct. 1994.</i>

3. Chromosome numbers

Hsu (1968) reported that the chromosome number of *A. pygmaea* is $n= 16$, but his voucher specimen (Hsu 4239, TAI!) should be *Mazus flairei* Bonati (Scrophulariaceae). The chromosome number of all species is $2n= 32$ except *A. dictyocarpa* of which is $2n= 64$ (Table 3, Fig 3).

Table 3. Chromosome number of *Ajuga* in Taiwan

Taxon	Locality	Voucher specimen	Diploid number $2n$	Haploid number n	Reference
<i>A. decumbens</i>	Fenchihu	<i>Lu 24490</i>	32		※
<i>A. dictyocarpa</i>	Pali	<i>Hsieh 882</i>	64		※
<i>A. nipponensis</i>	Meifong	<i>Hsieh 1505</i>	32		※
<i>A. pygmaea</i>	Shihmen	<i>Hsieh 854</i>	32		※
<i>A. taiwanensis</i> (identified as <i>A. bracteosa</i>)	Taipei	<i>Chao et al. 1002</i>		16	Chuang et al., 1962
<i>A. taiwanensis</i>	Hsinchu	<i>Yang s. n.</i>	32		※

※: Present authors' counts.

Based on the external morphological and palynological features, and chromosome numbers, the following taxonomical treatments are presented.

Key to the species

1. Stems creeping, rooting and forming rosette-leaved shoots at nodes in flowering *A. pygmaea*
1. Stems erect to decumbent, not creeping and rooting at nodes in flowering
 2. Flowers generally in axils of normal small leaves; corolla blue *A. decumbens*
 2. Flowers generally in axils of reduced or bract-like leaves, generally forming an interrupted or crowded spike
 3. Stems villous, the hairs more than 2 mm long; leaves cauline, the blades elliptic or narrowly ovate, 4- 7 x 1- 2.5 cm *A. nipponensis*
 3. Stems puberulent to minutely hairy, the hairs less than 2 mm long; leaves radical or cauline
 4. Leaves all cauline; blades rhomboidal ovate, 4- 6 x 2- 4 cm *A. dictyocarpa*
 4. Leaves radical and cauline; blades narrowly oblong or oblong-ob lanceolate, as spathulate, 6- 15 x 1- 4 cm..... *A. taiwanensis*

1. ***Ajuga decumbens*** Thunb., Fl. Jap. 243. 1784; Murata & Yamazaki, Fl. Jap. 3: 275. 1993. **匍伏筋骨草** Fig. 4

A perennial herb. Stems decumbent, 5- 20 cm long, with many stems and rosulate leaves at apex, covered with septate hairs. Rosulate leaves oblanceolate or spatulate, 4- 9 cm long, 0.7- 2.5 cm wide, the apex rounded, gradually narrowed to the base, the margins coarsely serrate to sinuate, the caudine leaves oblong-ovate or oblong-oblanceolate, 1.5- 4 cm long, 0.5- 2 cm wide, the apex obtuse, the base acute or cuneate. Cymes axillary, 2 or 3-flowered, opposite, forming a 4- 6 flowered verticillaster; calyx campanulate, 3- 4 mm long,

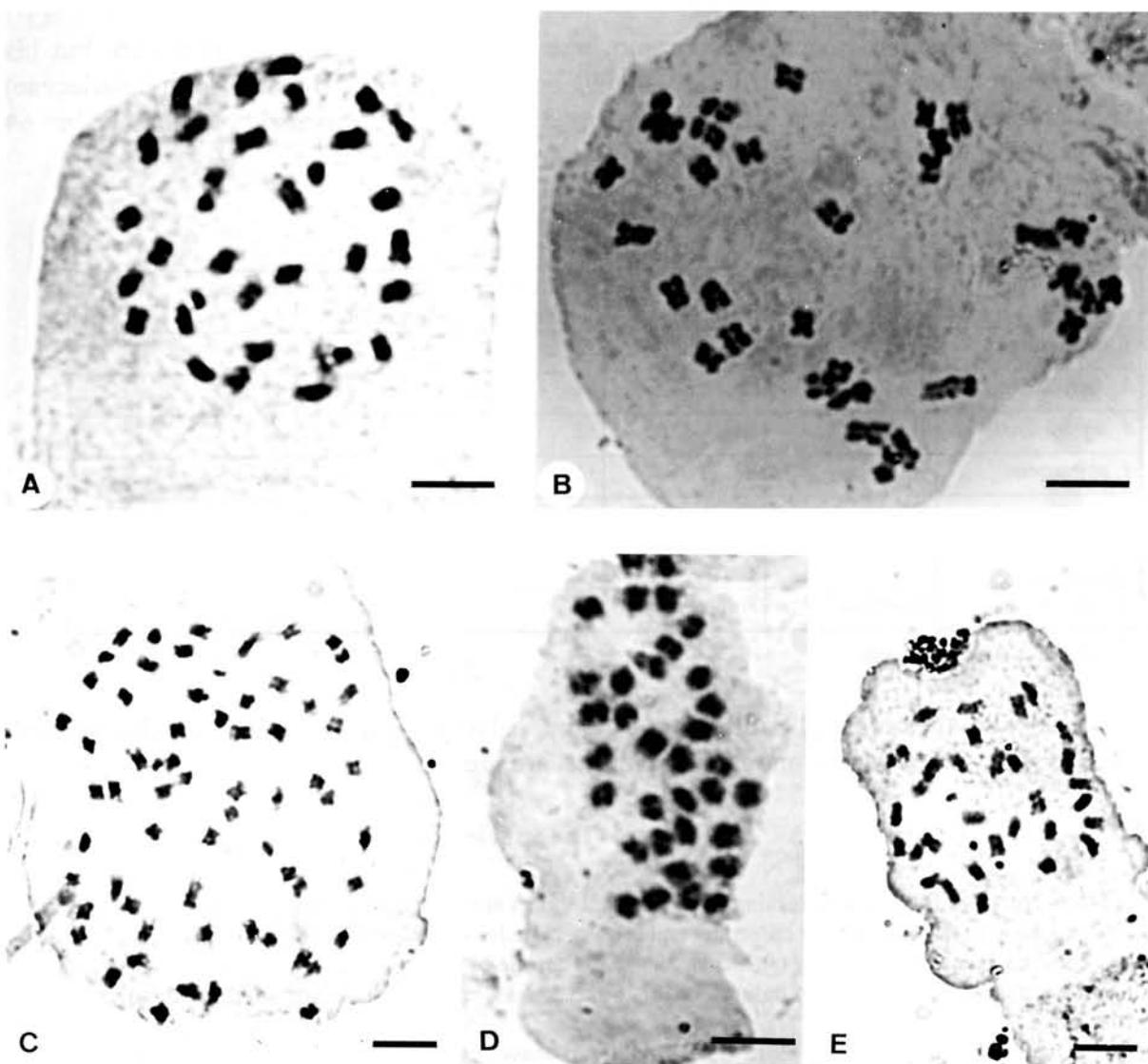


Fig. 3. Mitotic metaphase chromosomes of *Ajuga taiwanensis* Nakai ex Murata (A), *A. nippensis* Makino (B), *A. dictyocarpa* Hayata (C), *A. decumbens* Thunb. (d), and *A. pygmaea* A. Gray (E). Scale bar = 5 μm .

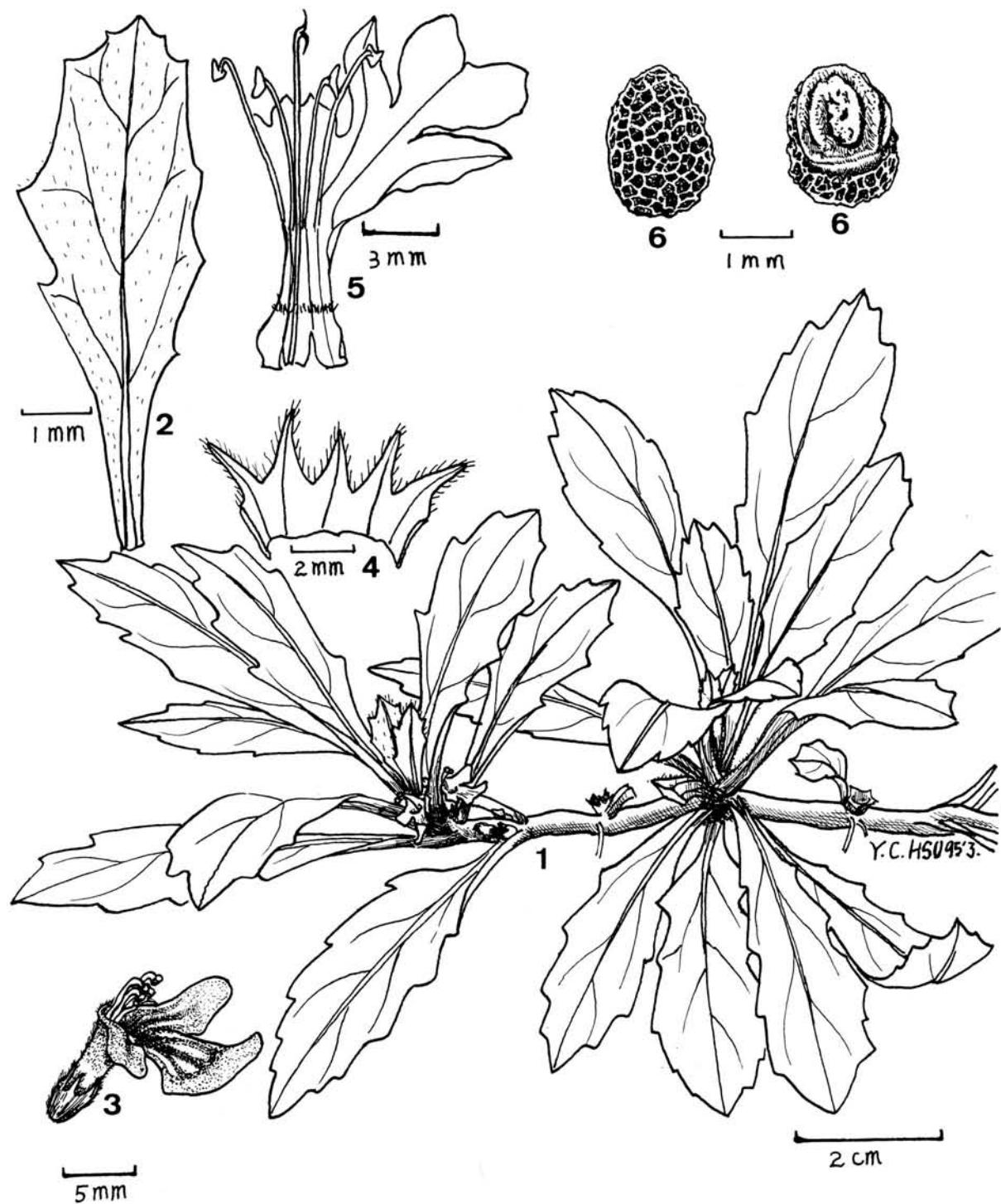


Fig. 4. Illustration of *Ajuga decumbens* Thunb. 1. Habit; 2. Leaf; 3. Flower; 4. Calyx; 5. Corolla; 6. Nutlets.

long pilose outside; upper lip 2 mm long, shallowly 2-lobed; lower lip 3- 4 mm long, 3-lobed; stamens 4, didynamous, exserted; pollen grains tricolporate, subprolate, $26 \times 20 \mu\text{m}$, tectum perforate, the exine reticulate to rugulate. Nutlets ellipsoid, 1.8- 2.0 mm long. Chromosome number $2n= 32$.

Distributed in Japan, Korea, C. to S. China, and Taiwan. In Taiwan; this species growing along the roadside in Fenchihu near Alishan only which might be introduced by Japanese with *Wasabia tenuis* (Miq.) Mastumura and naturalized in this area. (Fig. 5)

Specimens examined:

Chiayi Co.: Fenchihu, T. C. Huang 10465, 13976, S. F. Huang 2592, H. J. Chang 2390 (TAIF), Lu 24490 (TAIF, TAI).

2. **Ajuga dictyocarpa** Hayata, Icon. Pl. Formos. 8: 84. 1919; Kudo in Mem. Fac. Sci. Agr. Taihoku Univ. 2: 248. 1929; Murata in Acta Phytotax. Geobot. 25: 53. 1972; Huang & Cheng, Fl. Taiwan 4: 447. 1978; Murata & Yamazaki, Fl. Japan 3: 277. 1993.

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An erect or procumbent herb, covered with septate hairs. Leaves opposite, petiolate, sparsely elliptic, the base cuneate, the apex obtuse or rounded, the margins coarsely serrate to sinuate, petioles 2-4 cm long. Flower verticillate axillary, sessile or subsessile; calyx campanulate, puberulent, 5-toothed; corolla bluish white or pink, 6- 8 mm long; pollen grains tricolporate, prolate-spheroidal, $25 \times 20 \mu\text{m}$, the tectum perforate, the exine rugulate to reticulate. Nutlets 1.8- 2.0 mm. Chromosome number $2n= 64$.

Distributed in N. Ryukyu, Taiwan, C. to S. China and Vietnam; Taiwan, growing on open, waste sandy land of Taipei City and Taipei county (Fig. 5).

Specimens examined:

Taipei city: Talungtung, Kawakamii s. n. Jun. 8, 1907 (Type in TAIF!); Tanaka et Shimada s. n. Apr. 13, 1933 (TAI, TAIF). **Taipei Co.:** Chihtsu, Lin s. n. May. 19, 1985; Pali, T. H. Hsieh 882.

3. **Ajuga nipponensis** Makino in Bot. Mag. Tokyo 23: 67. 1909; Huang & Cheng, Fl. Taiwan 4: 447. 1978; Murata & Yamazaki, Fl. Jap. 3: 276. 1993. 日本筋骨草 Fig. 6

Ajuga genevensis auct. non L.: Matsum. & Hayata in J. Coll. Sci. Univ. Tokyo 22: 319. 1906; Kawakami, List Pl. Formos. 85. 1910.

Ajuga macrosperma Kudo in Mem. Fac. Sci. Agr. Taihoku Univ. 2: 290. 1929.

Ajuga matsumurana Kudo in J. Soc. Trop. Agr. 3: 255. 1931.

An erect or procumbent herb, covered with septate hairs; stems tufted. Leaves 2- 5 pairs, the upper ones reduced to leafy bracts, the petioles 1- 3 cm long, winged; blades 4- 7 x 1-

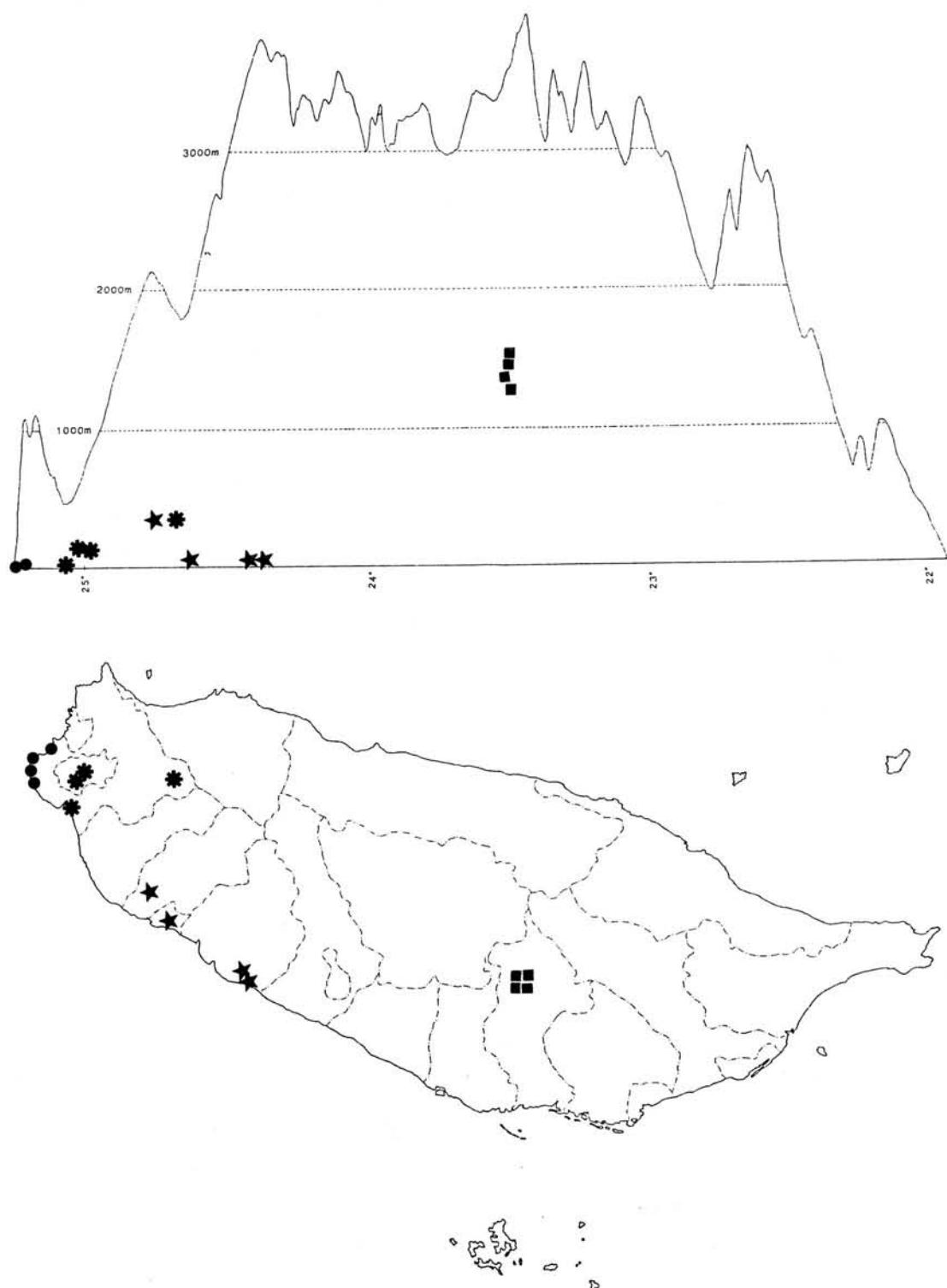


Fig. 5. Latitudinal and altitudinal distribution of *Ajuga decumbens* Thunb. (■), *A. dictyocarpa* Hayata (*), *A. nipponensis* Makino (★), and *A. pygmaea* A. Gray (●).

Fig. 5. Latitudinal and altitudinal distribution of *Ajuga decumbens* Thunb. (■), *A. dictyocarpa* Hayata (*), *A. nipponensis* Makino (★), and *A. pygmaea* A. Gray (●).

2.5 cm, elliptic to narrowly obovate, the base cuneate, the apex obtuse, the margins coarsely crenate-dentate, both surfaces villous. Flower verticillate axillary forming terminal spikes, up to 6 cm long; corolla white, 10- 12 mm long; pollen grains tricolpate, subprolate, $20 \times 15 \mu\text{m}$, the tectum perforate, the exine reticulate. Nutlets 2- 2.5 mm long. Chromosome number $2n = 32$.

Distributed in Japan, Taiwan, and C. China; Taiwan, growing on open, sandy places of seashores of Hsinchu and Miaoli counties (Fig 5).

Specimens examined:

Hsinchu Co.: Hukou, Kudo & Suzuki 148; Seuchiashih, Shimada 4073B. **Miaoli Co.:** Tunghsiao, Sasaki s. n. May 1, 1909; Shimada 35. **Nantou Co.:** Meyfong, Hsieh 1505 (cultivated in shading house).

4. **Ajuga pygmaea** A. Gray in Mem. Amer. Acad. Arts Sci. (Boston), new ser. 6: 402. 1859; Matsum. & Hayata in J. Coll. Sci. Univ. Tokyo 22: 318. 1906; Huang & Cheng, Fl. Taiwan 4: 449. 1978; Murata & Yamazaki, Fl. Jap. 3: 277. 1993. 矮筋骨草 Fig. 7

A procumbent herb. Stems creeping, rooting and flowering stems arising from nodes, sparsely pubescent. Leaves radical, petiolate; petioles 1.5- 3 cm long, winged, sparsely villous; blades oblanceolate or oblong-oblanceolate 2- 4 x 0.5- 1 cm, the apex rounded, gradually narrowed to base, attenuate into petiole, the margins coarsely sinuate. Cyme with 1- 3 flowers in axils, flowers pedicellate; pedicles 5- 8 mm long; calyx campanulate; corolla blue; pollen grains tricolpate, prolate, $30 \times 18- 20 \mu\text{m}$, the tectum perforate, the exine rugulate to reticulate. Nutlets about 1.6 mm long. Chromosome number $2n = 32$.

Distributed in Japan, Ryukyus, and Taiwan; Taiwan, growing on open land of seashores of Taipei county (Fig 5).

Specimens examined:

Taipei Co.: Shiman, Shimada 5414D; Ou & Kao 9098; Wang 1053; Kuo 10960; Lin 714; Hunag 8281; Kao 3955; Chingshan, Huang 2301; Chang 4668. Paishawan, Hsieh 854.

Note: The specimen of Hsu 4239 (identified as *A. pygmaea*) from Yehliu should be *Mazus faurei* Bonati.

5. **Ajuga taiwanensis** Nakai ex Murata in Acta Phytotax. Geobot. 23: 23. 1968; Hatsusima, Fl. Ryukyus 531. 1971; Murata & Yamazaki, Fl. Jap. 3: 275. 1993. 臺灣筋骨草

Ajuga bracteosa auct. non Wall.: Matsum. & Hayata, in Journ. Coll. Sci. Univ. Tokyo 22: 319. 1906; Hayata, Icon. Pl. Formos. 8: 84. 1919; Kudo in Mem. Fac. Sci. Agr. Taihoku Univ. 2: 286. 1929; Huang & Cheng, Fl. Taiwan 4: 445. 1978.

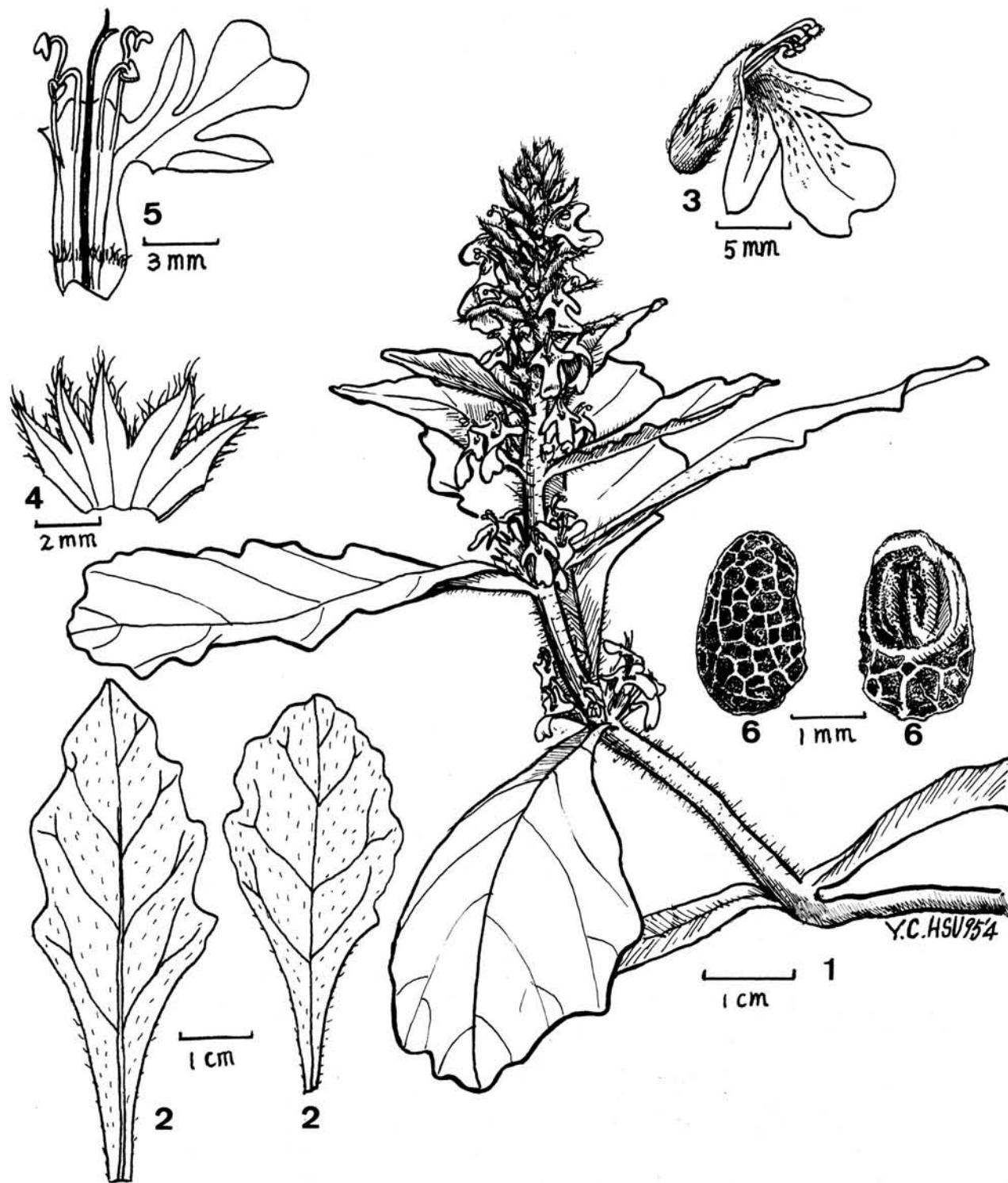


Fig. 6. Illustration of *Ajuga nipponensis* Makino. 1. Habit; 2. Leaves; 3. Flower; 4. Calyx; 5. Corolla; 6. Nutlets.

An herb, 6- 20 cm long. Leaves radical; blades 6- 15 x 1- 4 cm, narrowly obovate to oblanceolate, the base cuneate, the apex obtuse or rounded; the margins sinuate, both surfaces puberlent. Flowers axillary, forming spike-like racemes, sessile or with pedicels about 5 mm long; corolla 5- 8 mm long; pollen grains tricolpate, prolate spheroidal, 24- 25 x 20 μm , the tectum perforate, the exine structure reticulate. Nutlets 1.8- 2.0 long. Chromosome number $n= 16$, $2n= 32$.

Distributed in the Ryukyus, Taiwan, Kwangtung, and the Philippines; Taiwan, growing throughout the island from lowland to 2000 meters (Fig. 8).

Specimens examined:

Taipei Co.: Kueishan, *Chuang* 3153; *Shimada* 1271; Tatunshan, *Suzuki* s. n. Oct. 21. 1923; Yangmingshan, *Kao* 9581; *Peng* 10456 (HAST); *Tang* 1393; Mientienshan, *Kuo* 5432; Peitou, *Shimada* 984; Pitan, *Chuang* 2589; Shlioufennz, *Peng* 7553 (HAST); Pingling, *Peng* 14685 (HAST); **Ilan Co.:** Sueyuan, *Chuang* & *Kao* 2462; Taipingshan, *Huang* 3977. **Hsinchu Co.:** Wutzeshan, *Shimada* 5415; Sumakusu, *K. C. Yang* s. n. Oct. 1994. **Taoyuan Co.:** Palin, *Cheng* 1272; Paitaochiau, *Cheng* 1275. **Chiayi Co.:** Tafenshan to Chulu, *Huang* & *Hsieh* 8758. **Nantou Co.:** Lushan, *Cheng* 1283; Tungpu, *Peng* 8204 (HAST). **Tainan Co.:** Hsienkungmiao, *Peng* 7093 (HAST). **Miaoli Co.:** Kuanwu, *Peng* 14900 (HAST). **Kaohsiung Co.:** Sanping, *Wang* 589(HAST). **Pingtung Co.:** Santimen, *Hosokawa* 5465. **Hualien Co.:** Tienhsiang, *Shimizu* & *Kao* 120528; *Peng* 9273 (HAST); Lushui, *Peng* 11314 (HAST); Nanhutashan, *Sasaki* s. n. Oct. 1928. **Taitung Co.:** Litao to Tienlung Bridge, *S. F. Huang* 3677.

DISCUSSION

The useful characters for identifying the species of *Ajuga* in Taiwan are summarized in Table 1 and applied in the key to species. The specimens of *A. nipponensis* have been collected since 1896, but misidentified as *A. genevensis* and *A. macroperma*; the former is distributed in Europe, and the latter by having obtuse calyx lobe can be distinguished from *A. nipponensis*. Although Kudo published a new name, *A. matsumurana*, for this species, we hold the same treatment of Huang et Cheng (1978) who made a good comparative study with *A. nipponensis*.

For the distribution pattern, *A. dictyocarpa*, *A. nipponensis*, and *A. pygmaea* are found locally and growing on open land of seashores. The specimens (*Kamakamii* s. n., 1907) of *A. dictyocarpa* collected in Talungtung, Taipei city might suggest that the past distribution area is large, but it is extinct in this area now. *A. nipponensis* has been distributed along the seashores of Hsinchu and Miaoli countries since 1896, but has been transplanted to other areas, such as Meyfong (Nantou Co.), Hualien city (Hualien Co.), and Yichu (Chiayi Co.) and they can survival well in every areas. So, the local distribution need further study.

A. pygmaea is distributing in Chingshan, Shihmam, and Paishawan of Taipei county. The specimen of *Hsu* 4239 (identified as *A. pygmaea*) from Yehliu should be *Mazus faurei* Bonati, although it has the chromosome number $n=16$. There is no record of *A. pygmaea* from Yehliu.

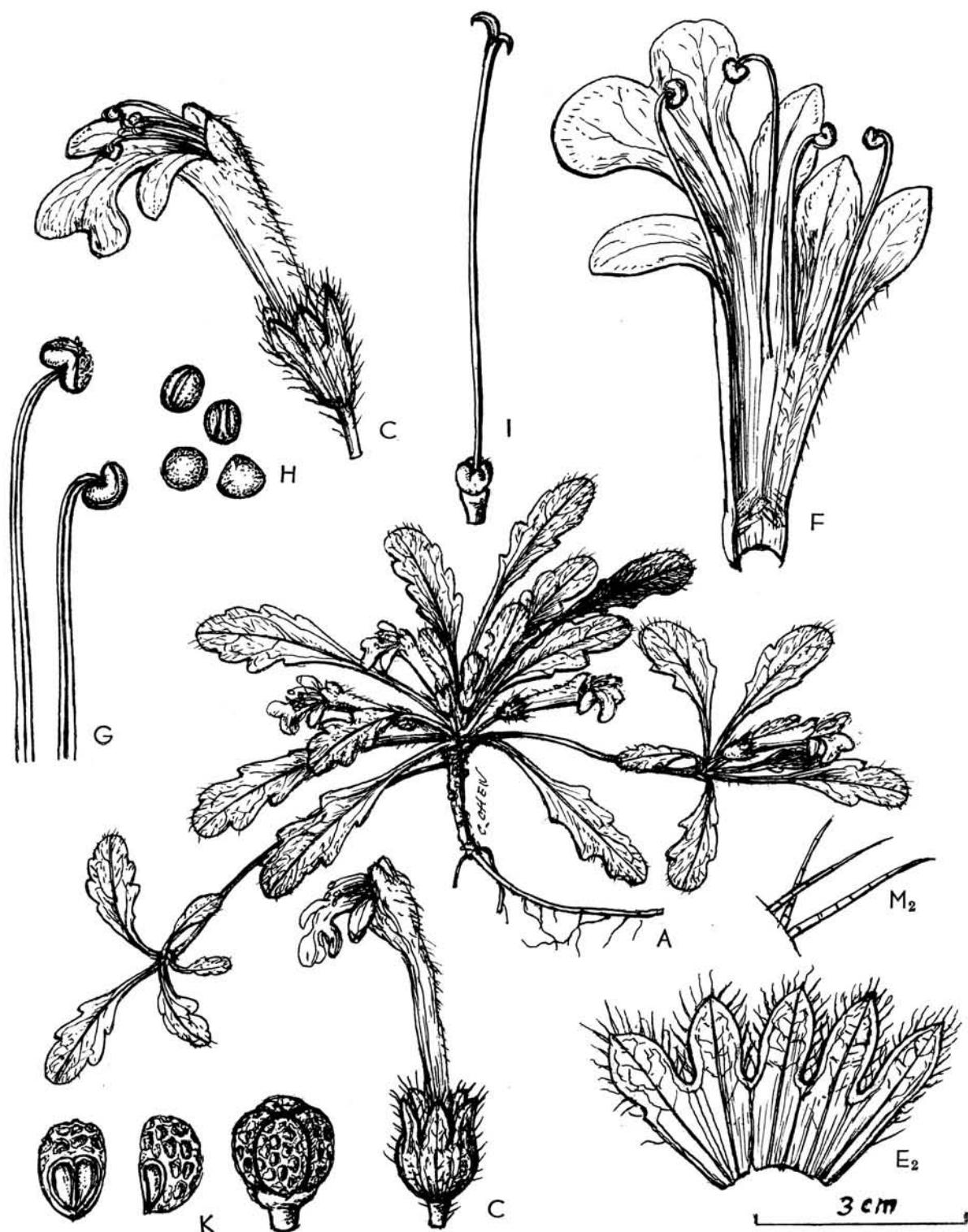


Fig. 7. Illustration of *Ajuga pygmaea* A. Gray. 1. Habit; 2. Hairs on the leaf; 3. Flower; 4. Calyx; 5. Corolla; 6. Portion of stamen; 7. Pollen grains; 8. Nutlets (Huang 1993).

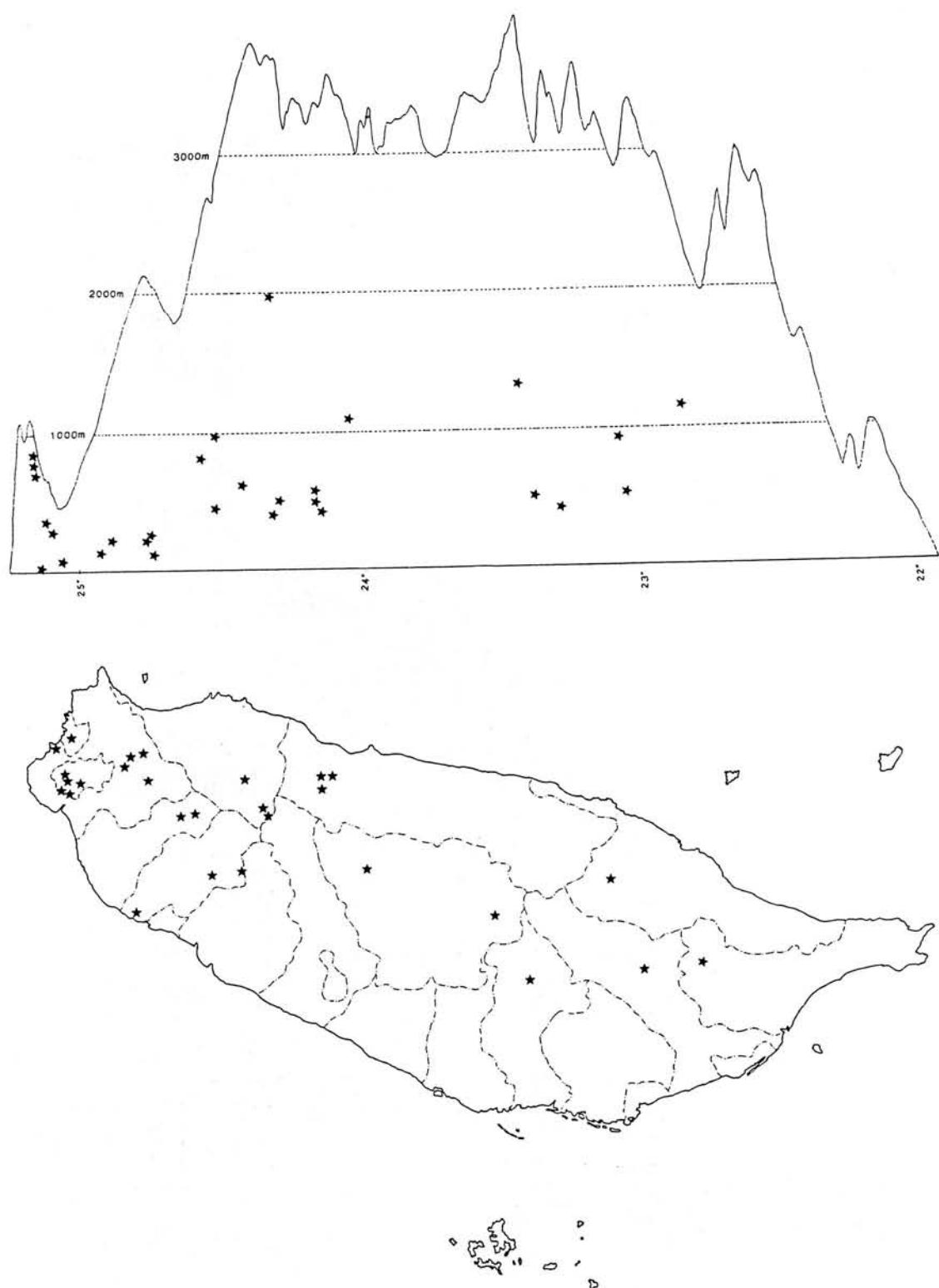


Fig. 8. Latitudinal and altitudinal distribution of *Ajuga taiwanensis* Nakai ex Murata (★).

Fig. 8. Latitudinal and altitudinal distribution of *Ajuga taiwanensis* Nakai ex Murata (★).

The distribution pattern of *A. taiwanensis* is very different from the others. *A. taiwanensis* is widely distributed throughout the island from lowland up to elevation 2000 m high, but the other species confined to small areas. This phenomenon need further studies.

ACKNOWLEDGMENT

We want to thank Mr. S. Y. Lu and K. C. Yang, Provincial Taiwan Forestry Research Institute, and Dr. C. I. Peng, curator of HAST Herbarium for supplying the materials and literatures.

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臺灣植物誌之觀察(22)----筋骨草屬(唇形科)⁽¹⁾

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(收稿日期：1995年5月16日；接受日期：1995年6月13日)

摘要

本文訂正臺灣產筋骨草屬植物為4種，分別為網果筋骨草(*Ajuga dictyocarpa* Hayata)，日本筋骨草(*A. nipponensis* Makino)，矮筋骨草(*A. pygmaea* A. Gray)和臺灣筋骨草(*A. taiwanensis* Nakai ex Mmurata)及一新歸化種匍伏筋骨草(*A. decumbens* Thunb.)。文中比較各種的外部形態、花粉特徵、染色體數目和地理分佈等特徵。並提供檢索表做為鑑定之用。在染色體數目方面，除網果筋骨草為 $2n=64$ 外，其餘種類皆為 $2n=32$ 。

關鍵字：筋骨草屬，唇形科，分類訂正，花粉形態，染色體數目。

1. 本文承國科會計劃補助 (NSC83-0211-B-002-257)。

2. 國立臺灣大學植物系。

3. 通信聯絡員。