

Research paper

## *Asarum yaeyamense* Hatusima (Aristolochiaceae) Newly Found in Northern Taiwan

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### [ Summary ]

*Asarum yaeyamense* Hatusima, a member of the section *Heterotropa*, was formerly reported as an endemic species distributed on Iriomote Island, southern Ryukyus of Japan. During our botanical surveys, this species was newly found in northern Taiwan, representing a new record to the flora of Taiwan. The species is closely related to *A. hypogynum* Hayata in central Taiwan and *A. fudsinoi* T. Ito on Amami Island, the northern Ryukyus. However, it can be distinguished from the former by a smaller flower and less-raised rugosity at the base of the calyx-lobes, and from the latter by the greenish-purple flower. In addition to a taxonomic description, line drawings, and color photos, the chromosome number ( $2n = 24$ ) and pollen morphology of the Taiwanese materials are also provided. Moreover, the relationship of this species with its close allies in Taiwan and the Ryukyus is discussed.

**Key words:** *Asarum*, *Asarum yaeyamense*, *Heterotropa*, new record, Taiwan.

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## 研究報告

## 台灣北部新紀錄植物—八重山細辛

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## 摘要

八重山細辛為細辛屬杜蘅組植物之一員，根據以往的紀錄僅知分布於琉球群島的西表島，為當地之特有種。最近，我們發現其亦分布於台灣北部。此物種與分布於台灣中部的下花細辛及分布於琉球群島奄美大島的藤野細辛十分相似。但是，可由較小的花及萼裂片基部皺摺狀突起較少與前者區別，並可以由紫色帶有綠色的花與後者區分。本文除描述形態特徵、手繪圖及彩色照片外，並提供台灣產該種植物之染色體數目( $2n = 24$ )及花粉形態。另外，並討論此物種與其在台灣及琉球的近緣種之間的關係。

關鍵詞：細辛屬、八重山細辛、杜蘅、新紀錄、台灣。

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## INTRODUCTION

*Asarum* L., a genus of the family Aristolochiaceae, is composed of ca. 90 species in the northern temperate area, especially in eastern Asia (Huang et al. 2003). Based on a cladistic analysis of morphological data and nuclear ribosomal DNA internal transcribed spacer (ITS) sequences, Kelly (1997, 1998) proposed an infrageneric classification system in which the genus was treated as 2 subgenera, *Asarum* and *Heterotropa*, and 4 sections, *Asarum*, *Geotaenium*, *Asiasarum*, and *Heterotropa*. Currently, Kelly's system is widely adopted and is also used in this paper.

According to the second edition of the *Flora of Taiwan* (Huang 1996), 6 species of this genus have been recorded in Taiwan. However, based on extensive exploration and detailed comparisons, 3 new species were recognized and have been added to the flora of Taiwan (Lu and Wang 2009). Most recently in our botanical survey, we found a previously unrecorded *Asarum* species from the low-elevation mountain areas in northern

Taiwan. This species is similar to *A. hypogynum* Hayata, an endemic species restricted to central Taiwan, in having a constricted throat of the calyx-tube, a terminal stigma with no stylar protuberance, and a similar shape of the calyx-tube, but clearly differs from the latter by a smaller flower and less-raised rugosity at the base of the calyx-lobes. By making comparisons with other species of this genus around Taiwan, this previously unrecorded plant is apparently much closer to *A. yaeyamense* Hatusima, a species previously reported as endemic to Iriomote Island in the southern Ryukyus, Japan.

*Asarum yaeyamense* Hatusima was first described by Hatusima (1968) based on the type specimen collected from Iriomote Island by Yamazaki and Usui in 1963 (deposited in the KAG Herbarium, Kagoshima University, Japan). This species is characterized by lustrous leaves adaxially and a greenish and dark-purplish flower with pubescent undulate calyx-lobes (Hatusima 1968). Despite the

type specimen not being available to us, after consulting the diagnostic characters in the original description (Fig. 2G, from Hatusima 1968) and relevant literature (e.g., Hatusima 1971, Sugawara 2006), the species newly found in Taiwan is conclusively recognized as *A. yaeyamense*, which we describe and illustrate herein. In addition, the relationship between this species and 2 close allies in Taiwan and the Ryukyus is also discussed.

## MATERIALS AND METHODS

Materials used in the present study were collected from native habitats. Some living materials were transplanted into the greenhouse of the Department of Life Science, National Taiwan Normal University, Taipei, Taiwan for further observations. Most materials were pressed and dried for voucher specimens and are deposited in the TNU herbarium. Voucher specimens for pollen and somatic chromosome observations were also deposited in TNU.

Pollen grains for the scanning electron microscopic (SEM) study were collected from fresh anthers and prepared by the method proposed by Erdtman (1952). Acetolyzed grains were dehydrated through an ethanol series, critical point-dried, coated with gold, and then examined with the SEM, Hitachi SM 2400.

Root tips for the cytological study were pretreated with 0.1% colchicine for 3~4 h at room temperature and fixed with a 3:1 (v:v) mixture of 99.5% ethanol and acetic acid for 1 d. After being macerated in 5% pectinase, the root tips were squashed in an acetic orcein solution.

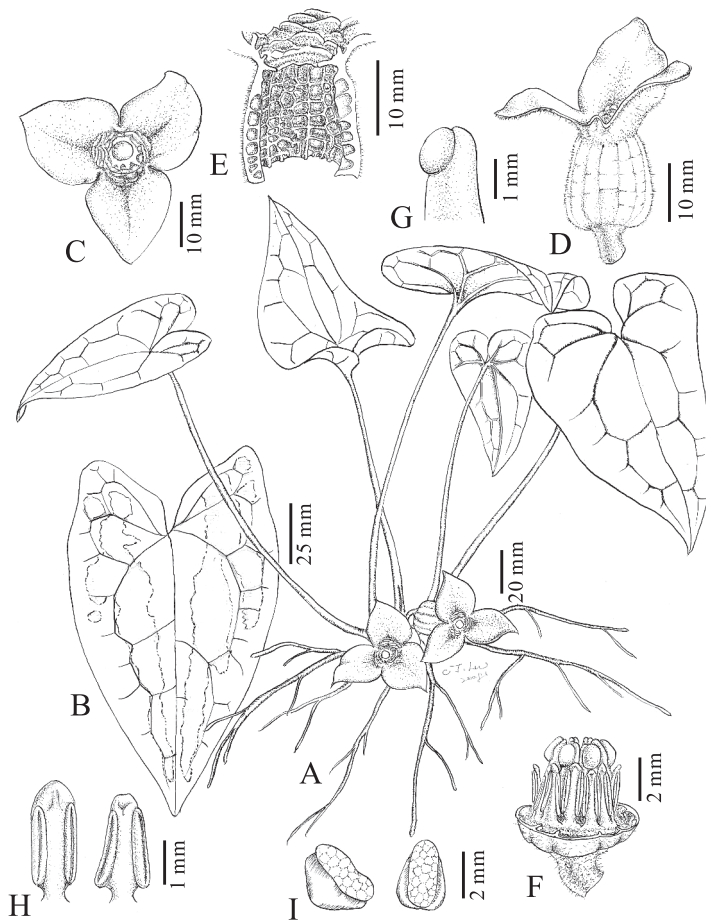
### Taxonomic treatment

*Asarum yaeyamense* Hatusima, J. Jpn. Bot. 43: 429, fig. 1. 1968; Hatusima, Fl.

Ryukyus 246. 1971; Sugawara in Iwatsuki et al., Fl. Japan Iia: 374. 2006.—TYPE: Ryukyus, Island Iriomote, 1963, *Yamazaki & Usui s. n.* (Holotype: KAG, n. v.). 八重山細辛 (Figs. 1, 2).

*Heterotropa yaeyamensis* (Hatusima) F. Maekawa, J. Jpn. Bot. 64: 60. 1989.

Perennial herb. Adventitious roots few, glabrous. Rhizome glabrous, elongated; annual vegetative branch with 2~4 cataphylls at base, cataphylls membranous, hyaline, sessile, oblong, glabrous on both surfaces, margin hairy, obtuse at apex, 1~2 cm. Leaves long-petiolate; petiole 8~20 cm long, glabrous above, grooved, greenish-purple; blade ovate to lanceolate-ovate, cordate and 2-lobed at base, acute at apex, 7~20 cm long, 5~8 cm wide, lobes 2~5 cm long, 2.5~5 cm wide; adaxial surface usually deep-green, sometimes variegated, lustrous, glabrous, abaxial surface pale-green; young leaves usually short-hairy above and on margin. Flowering branch with 2 or 3 cataphylls at base, cataphylls ovate, glabrous on both surfaces, margin hairy; flowers solitary, emerging from branch or a young leaf, purple with greenish-yellow margin, decumbent on ground; pedicel 7~20 mm long; calyx-tube trapeziform, 10~15 mm long, 12~15 mm wide, throat constricted, with a orifice ring, pubescent outside, tessellate ridged inside, longitudinal ridges 12; limb 3-lobed; calyx-tube entrance < 3 mm in diameter; orifice ring well-developed; calyx-lobe spreading obliquely, triangular to ovate, ca. 16 mm long, ca. 13 mm wide, both surfaces pubescent; rugosity present between orifice and calyx-lobes; 12 stamens in 2 whorls, 3~3.8 mm long, filament very short, anthers extrorse, ca. 2.0 mm long, apex of connectives rounded; ovary superior or half-superior, 6-locular, fused; styles 6, free, erect; stylar protuberances absent or very short; stigma elliptical, extrorse, terminal. Chromosome



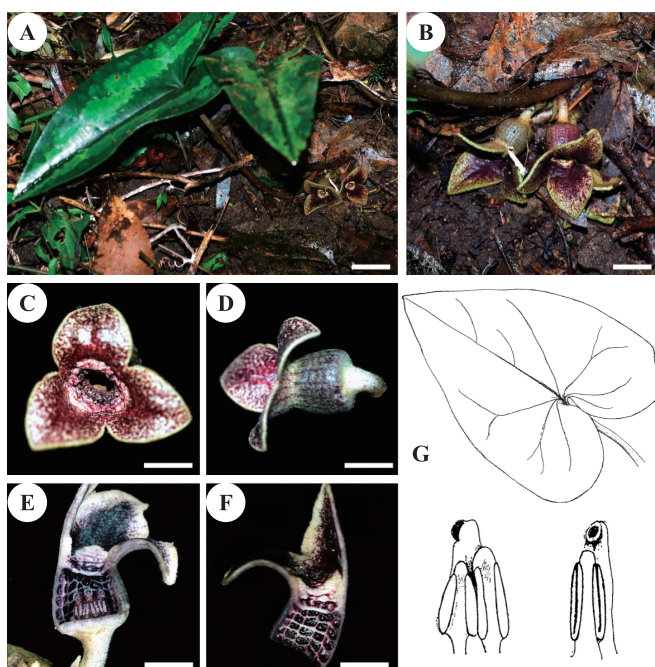
**Fig. 1.** *Asarum yaeyamense* Hatusima. 八重山細辛 (A) Habit; (B) leaf; (C, D) flowers, front and lateral views, respectively; (E) longitudinal section of calyx-tube, showing the inner tessellated ridge; (F) dissected flower, showing the position of stamens and gynoecium; (G) stigma; (H) stamens, outer whorl (left) and inner whorl (right); (I) seeds. (C. T. Lu 1035).

number  $2n = 24$ .

Distribution and habitat: *Asarum yaeyamense* is so far known to be distributed in low mountainous areas of Iriomote Island (Ryukyus, Japan) (Hatusima and Amano 1994, Shimabuku 1997, Sugawara 2006) and northern Taiwan (Fig. 3). Its habitat resembles that of *A. fudsinoi* T. Ito which occurs on mountain slopes under dense evergreen broadleaf forests, but differs from that of *A. hypogynum* which often inhabits the understory of bamboo plantations.

*Phenology:* Flowering and fruiting from late October to March in Taiwan.

*Specimens examined:* Taipei Co.: Pinglin Township: Changchiachuang, Wantan abandoned trail, C. T. Lu 1035 (TNU); Pinghsi Township: en route to Mt. Hsiaotzu, C. T. Lu 920 (TNU), 1039 (TNU), 1244 (TNU); Shihting Township: Mt. Huangtieten Tung-Feng, C. T. Lu 902 (TNU), 1040 (TNU); Mt. Pichia, C. T. Lu 1317 (TNU), 1318 (TNU). Taoyuan Co.: Fuhshing Township: Ssuling, W. L. Chiou s. n. (TAIF); Hsinchu Co.: Wufeng Township:



**Fig. 2.** *Asarum yaeyamense* Hatusima. (A) Habit; (B) flower; (C, D) flowers, front and lateral views, respectively; (E) dissected flower, showing the stamens and stigma; (F) longitudinal section of calyx-tube, showing the inner tessellated ridges; (G) line drawings of the leaf, stamen, and stigma from Hatusima (1968). (A: bar = 3 cm; B~F: bar = 1 cm).



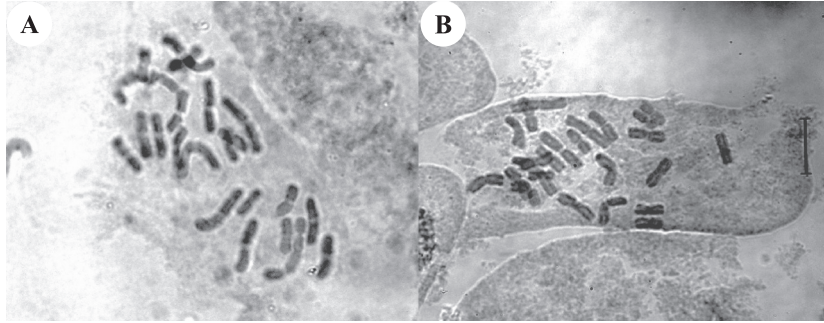
**Fig. 3.** Geographical distribution of *Asarum yaeyamense* Hatusima.

Hsiakelo abandoned trail, en route from Yanglao to Liyuan, *P. F. Lu 10998* (TNU); same loc., *Y. Y. Huang 942* (HAST); same loc., *C. T. Lu et al. 820* (TNU), *1314* (TNU).

**Chromosome numbers:** The somatic chromosome number  $2n = 24$  of *A. yaeyamense* in the Ryukyus was reported by Yuasa and Maekawa (1976). In this study, we also observed the same somatic chromosome number (Fig. 4) from Taiwanese material. This number is the same as all other species of *Asarum* sect. *Heterotropa* in Taiwan (Sugawara and Ogisu 1992, Huang et al. 1995, Lu 2001) and the Ryukyus (Yuasa and Maekawa 1976).

**Pollen morphology:** The present study first describes the pollen morphology of *A. yaeyamense*. The shape of pollen grains is suboblate with 4 or 5 colpoids, and its size is about  $27 \times 31.7 \mu\text{m}$  (P  $\times$  E). The tectum



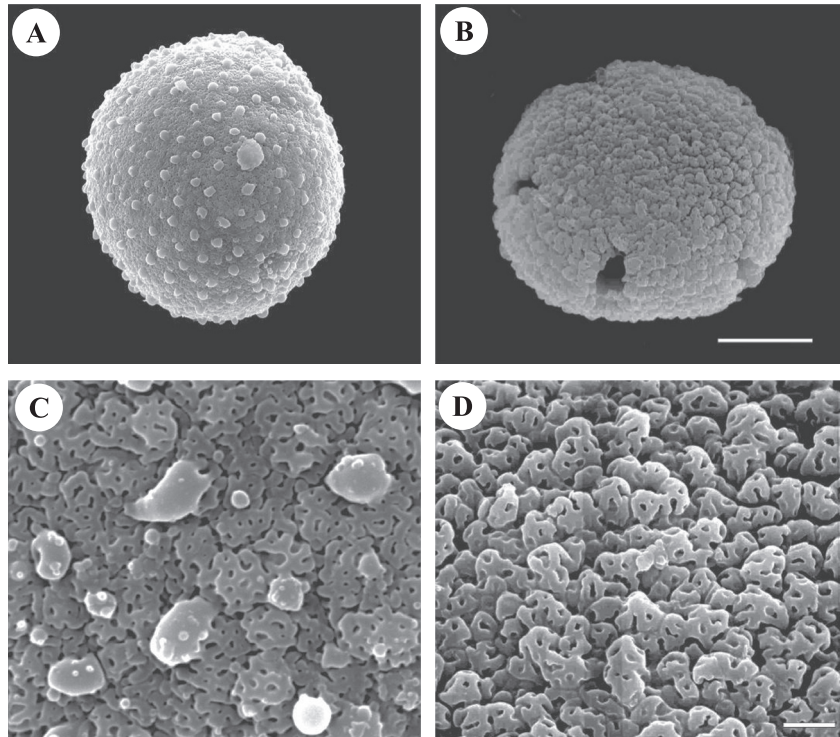


**Fig. 4.** Somatic chromosomes of *Asarum yaeyamense* Hatusima (A) and *A. hypogynum* Hayata (B), both showing the chromosome number  $2n = 24$ . (bar = 10  $\mu\text{m}$ ).

of the grains is rugulato-perforate with large supratectate warts; thus it resembles *A. macranthum* Hook f. rather than *A. hypogynum* (Fig. 5), although its gross morphology is more closely related to *A. hypogynum* than *A. macranthum*.

## DISCUSSION

In earlier studies (e.g., Liu and Lai 1976, Maekawa 1978, Huang et al. 1995, Lu 2001), only 1 species *A. macranthum* belonging to the *Asarum* section *Heterotropa* was reported



**Fig. 5.** Pollen grains of *Asarum yaeyamense* Hatusima (A, C) and *A. hypogynum* Hayata (B, D). (A, B: bar = 10  $\mu\text{m}$ ; C, D: bar = 1  $\mu\text{m}$ ).

from low elevations of northern Taiwan along the Hsuehshan Mountain Range. This newly recorded species, *A. yaeyamense*, can be easily distinguished from *A. macranthum* by both leaves and floral characters. The leaves of *A. yaeyamense* are ovate to lanceolate-ovate, the adaxial surface is deep-green and lustrous, and the abaxial surface is pale-green and glabrous, while leaves of *A. macranthum* are widely ovate to ovate, the adaxial surface is green, not lustrous, and the abaxial surface is pale-green with purple veinlets. The floral characters of *A. yaeyamense* differ from those

of *A. macranthum* in having trapeziform (vs. urceolate) calyx-tubes and elliptical and terminal (vs. hook-like and sub-terminal) stigmas.

In his original description of *A. yaeyamense*, Hatusima (1968) indicated that this species is very close to *A. fudsinoi* (as "*A. fujinoi*") of Amami Island in vegetative characters, but differs by its greenish and dark-purple flowers with pubescent undulate calyx-lobes. By a detailed comparison (Table 1), however, we found that *A. yaeyamense* is closer to *A. hypogynum* than to *A. fudsinoi*. The former 2 species have similar vegetative

**Table 1. Comparison of *Asarum yaeyamense* with *A. fudsinoi* and *A. hypogynum***

Character	<i>A. fudsinoi</i> *	<i>A. hypogynum</i>	<i>A. yaeyamense</i>
<b>Leaf</b>			
<b>Shape</b>	Widely ovate to ovate, triangular-ovate	Triangular to triangular-ovate	Ovate to lanceolate-ovate
<b>Size</b>	Base deeply cordate, apex acute 10~22 × 6~15 cm	Base cordate, apex acuminate 13~27 × 7~15 cm	Base cordate, apex acute 7~20 × 5~8 cm
<b>Calyx-tube</b>			
<b>Shape</b>	Globular-tubular	Trapeziform	Trapeziform
<b>Size</b>	1.5~3 × 1.5~2 cm	ca. 1.5 × 1.5 cm	1.0~1.5 × 1.2~1.5 cm
<b>Throat</b>	Slightly constricted	Obviously constricted	Constricted
<b>Outer surface</b>	Glabrous	Glabrous	Pubescent
<b>Inner surface</b>	Reticulate, more than 12 longitudinal ridges	Tessellate with 12 longitudinal ridges	Tessellate with 12 longitudinal ridges
<b>Calyx-lobe</b>			
<b>Color</b>	Greenish purple	Purple with greenish-yellow margin	Purple with greenish-yellow margin
<b>Shape</b>	Broadly ovate	Triangular to ovate	Triangular to ovate
<b>Size</b>	1.5~2.0 cm long	ca. 2 cm long and wide	ca. 1.6 cm long and 1.3 cm wide
<b>Surface</b>	Both surfaces glabrous	Adaxial surface glandular-hairy, abaxial surface glabrous	Both surfaces pubescent
<b>Stamen</b>	Sessile	Subsessile	Subsessile
<b>Stigma</b>	Extrorse	Terminal	Terminal
<b>Pollen morphology</b>	No data	Tectum perforate, without supracteate warts	Tectum rugulato-perforate with large supracteate warts
<b>Distribution</b>	Ryukyu (Amami Island)	Taiwan (Alishan of the Central Mountain Range)	Ryukyu (Iriomote Island) and Taiwan (Hsuehshan Mountain Range)

\* All characteristics of *A. fudsinoi* are from the description of Hatusima (1971) and Sugawara (2006) because fresh materials were not available.

and floral characters, such as a constricted throat of the calyx-tube, a terminal stigma without a stylar protuberance, and the same shape of the calyx-tube and inner surface character of the calyx-tube. Maekawa (1978) pointed out that *H. hayatana* (= *A. hypogynum*) was closely related to *H. yaeyamensis* (= *A. yaeyamense*). Our observations further confirmed his opinion.

These 2 species are so similar that they are very difficult to distinguish from each other when lacking fresh materials. That has caused some researchers to confuse these 2 species. Walker (1976) recorded the presence of *H. hayatana* (= *A. hypogynum*) instead of *H. yaeyamensis* on Iriomote Island probably because he regarded them as synonymous, although he did not formally treat them as such. One of the specimens cited by Walker (1976) under the name *H. hayatana* was annotated “this specimen is cited with the original description of *Asarum yaeyamense* Hatus.” Yinger (1983) even thought these 2 species might be conspecific. However, according to our detailed comparison, we found that there are still some stable differences: *A. yaeyamense* has smaller flowers, less-raised rugosity at the base of the calyx-lobes, and a pubescent (vs. glabrous) outer surface of the calyx-tube. Their pollen grains also differ: the tectum in the former is rugulato-perforate with large supratectate warts, but lacking warts in the latter. Besides these morphological differences, these 2 species are allopatrically distributed and occupy difference habitats: *A. yaeyamense* occurs under broadleaf forests in the Hsuehshan Mountain Range and on Iriomote Island, while *A. hypogynum* occurs under bamboo plantations in the Alishan area of the Central Mountain Range.

Furthermore, the disjunctive distribution of this species in northern Taiwan and Iriomote seems to suggest the close geographical

history of these 2 areas. Chiang and Schaal (2006) supposed that Taiwan and the Ryukyus Archipelago’s alignment with the Asian mainland could have presented a pattern of step-wise colonization among these continental island systems, such as the cases of Hawaii and the Canary archipelago. However, unlike the oceanic island systems of Hawaii and the Canary archipelago, the continental island systems of Taiwan and the Ryukyus Archipelago lack a historically sequential emergence. If their hypothesis is right, we could predict a phylogeographical pattern that ancestor species on the Asian mainland would first colonize Taiwan and then subsequently the islands of the Ryukyu Archipelago. The case of *A. yaeyamense* seems to be an opportunity to test this hypothesis. Therefore, the phylogeographical study of this species would be intriguing to explore this issue.

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