Bangladesh J. Bot. **52**(2): 631-638, 2023 (June) Special DOI: https://doi.org/10.3329/bjb.v52i20.68250

A NEW SPECIES OF *HYPODEMATIUM* (HYPODEMATIACEAE) FROM CHINA

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Keywords: Hypodematium chingii, *Hypodematium sinense*, *Hypodematium fordii*, Stipe, Laminae, Indusia, Spore ornamentation, SEM

Abstract

Hypodematium chingii J. X. Li & X. J. Li, sp. nov., a new species of *Hypodematium* Kunze belonging to Hypodematiaceae from Yinan County, Linyi City, China is described and illustrated. It is closer to *H. sinense* K. Iwats and *H. fordii* (Baker) Ching but differs by its stipe sparsely rod-shaped glandular hairs, triangular laminae, sparsely covered indusia with short acicular and glandular hairs, tuberculate perispore with protrusions, and surface with scaly ornamentation. Results of comprehensive studies on morphological, anatomy and Scanning Electron Microscopy (SEM) of these three species are presented, and SEM structures of laminae and spores are provided. A key to the closely related species is also presented.

Introduction

The genus *Hypodematium* Kunze belonging to Hypodematiaceae is distributed by 26 species in subtropical areas of Asia and Africa (Shing *et al*. 1999) and represented in China by 12 species (Zhang *et al*. 2013). Previous research on systematics, palynology and biogeography of *Hypodematium* (Ching 1935, 1940, 1963, 1975, 1978, Li *et al*. 1988, Zhou *et al*. 1999, Wang *et al*. 2010, Li *et al*. 2018, Fan *et al*. 2020, 2021) provided an important background that allowed the recognition of the present new species.

Materials and Methods

Materials were collected from Yinan County, Linyi City (35°29′28.22″N, 118°11′45.43″E, 6 October 2021, J. X. Li & X. J. Li 20-10-2) and deposited in PE (Thiers 2016) (Table 1, Fig. 1).

Scanning Electron Microscopy (SEM) study was carried out to document the micromorphology of spore and fronds. Samples were dehydrated and then placed on aluminium stubs using double-sided adhesive tape and sputter coated with gold in a Hitachi E-1010 Ion Sputter Coater, following the methods used by Wen and Nowicke (1999). The materials were subsequently observed and photographed under a SUPRATM 55 scanning electron microscope.

Table 1. Data on studied material.

Species	Locality	Collection time	Specimen
Hypodematium chingii	Yinan County (Martyrs Cemetery)	2021.10.06	J. X. Li-20-10-2 (typus)
H. sinense	Linyi (Tashan)	2021.10.04	J. X. Li-20-6 (voucher)
H. fordii	Linyi (Mengshan Madianzi)	1987.08.08	J. X. Li-08 (voucher)

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Taxonomy

Hypodematium chingii J. X. Li & X. J. Li, sp. nov.

Diagnosis: The new species, *Hypodematium chingii* is characterized for its stipe sparsely rod-shaped glandular hairs, triangular laminae, and indusia sparsely covered with a few short acicular and glandular hairs, perispore with large and small type tuberculate protrusions, and surface with scaly ornamentation.

Type: China, Yinan County, Linyi City, 35°29′28.22″N, 118°11′45.43″E, 6 October 2021, J. X. Li & X. J. Li 20-10-2 (Holotype: PE). Fig. 1.

Fig. 1. *Hypodematium chingii* **sp. nov.** (type specimen).

Description: An erect rhizomatous herb, 24–30 cm tall. Scales reddish-brown, linear-lanceolate, 10–12 × 2–3 mm, membranaceous, the upper part with microdentate, upper teeth appers unicellular nodes, apex acuminate. Fronds approximate; stipe stramineous, 14–18 cm × 1–1.2 mm, above base sparsely covered with glandular hairs; laminae triangular, 11–12 × 11–13 cm,

base broad-cordate, apex acuminate and pinnatifid; pinnae 5–6 pairs, slightly oblique, lower 1 pairs sub-opposite, 3 cm apart, upper pairs alternate; basal pinnae largest, ovate–triangular, 5–6.5 × 4.5 cm, 3–pinnate pinnatifid, base cordate, pinnae tapered; pinnules 5–6 pairs, anadromous, alternate, slightly oblique, proximal basiscopic pair largest, long triangular lanceolate, 2.6–3 × 1.3–1.5 cm, sessile, base cuneate, pinnae tapered, 2-pinnate-pinnatifid; secondary pinnules 5–6 pairs, anadromous, alternate, oblong, proximal basiscopic pair largest, 6×4 mm, sessile, base cuneate, pinnae tapered, pinnate-pinnatifid; lobe 3 pairs, ovate, apex obtuse, 2–3 microdentate. Veins obvious on both surfaces, side veins usually single. Fronds sparsely covered with glandular hairs, rachis and costae densely covered with rod-shaped glandular hairs, indusia are sparsely covered with a few short acicular hairs and glandular hairs. Sori orbicular, at middle of veinlets; indusia reniform, small, membranaceous, gray, mature away from each other. Spores reniform, single crack, symmetrical; tuberculate protrusions, and surface with scaly ornamentation.

Results and Discussion

Hypodematium Kunze, a single genus belonging to Hypodematiaceae, is a new family established by Qin Renchang in 1974. It is a special population, stipe base swell, covered with reddish brown large scales, laminae ovate, ovate-pentagonal or ovate-triangular, 3-4 pinnatifid or 5-pinnatifid. It is difficult to identify a population in the genus according to the shape of the leaves and the number of split leaves, so the appendage hairs and curly reddish brown linear scales on the leaves are the most important characteristics and basis for population identification and classification in the genus. The hairs are divided into two types: rod-shaped glandular hairs and non-glandular hairs, the non-glandular hairs are divided into pubescence and acicular hair. This important feature of the hairs is very stable in the species of *Hypodematium*, and the difference between species is significant. Therefore, it is the consensus of the scholars who study *Hypodematium* as an important basis for the species identification and interspecific classification of *Hypodematium*. There are 15 species of the *Hypodematium* according to the type and position of the hairs (Zhang and Iwatsuki 2013, Li *et al*. 2022, Li *et al*. 2022), which are divided into three groups: group 1 includes *H. sinense*, *H. fordii* and *H. glandulosum* with rod-shaped glandular hairs; group 2 includes *H. crenatum*, *H. hirsutum* and *H. glabrum* with pubescence; group 3 includes the remaining 9 species of the *Hypodematium* with glandular hairs and non-glandular hairs. According to the types of hair on plants, the geographical distribution showed that all the other populations were coated with non-glandular hair (pubescence or acicular hair) except for *H. fordii* and *H. glandulosum* with rod-shaped glandular hairs in southwest China. However, in northern China, especially in Shandong Province, the other 12 species were glandular and non-glandular hairs, except for *H. sinense* and *H. fordii*, which were only coated with rod-shaped glandular hairs, which may be related to the dry climate in northern China and less rain. The secretion of glandular hair plays a protective role in plant body and is beneficial to plant survival. *Hypodematium chingii* only has a few short acicular hairs and glandular hairs on the back of the indusia, whereas *H. sinense* and *H. fordii* only have glandular hairs. Therefore, *H. sinense* and *H. fordii* are related species to *H. chingii*. There are no similar characteristics between *H. chingii* and group 3, the relative is distant. Therefore, the type of hairs are an important feature in species identification and interspecific classification, which is of great taxonomic significance (Zhang and Iwatsuki 2013, Li *et al*. 2022, Li *et al*. 2022) (Table 2 and Fig. 2).

The main difference in plant morphology between the *Hypodematium chingii*, *H. sinense* and *H. fordii* are: the plants of *H. sinense* is 17-45 cm tall, stipe 10-25 cm long, glabrous, laminae ovate-pentagonal, the fronds covered with rod-shaped glandular hairs, the indusia sparsely covered with glandular hairs, absent of non-glandular hairs; the plants of *H. fordii* is 35-50 cm tall, laminae

ovate-pentagonal, the whole plant covered with rod-shaped glandular hairs, the indusia densely covered with glandular hairs, absent of non-glandular hairs; while the plants of *H. chingii* is 24-30 cm tall, stipe 14-18 cm long, laminae 11-12 cm, triangular, pinnae 5-6 pairs, close to each other, indusia sparsely covered with a few short acicular and glandular hairs.

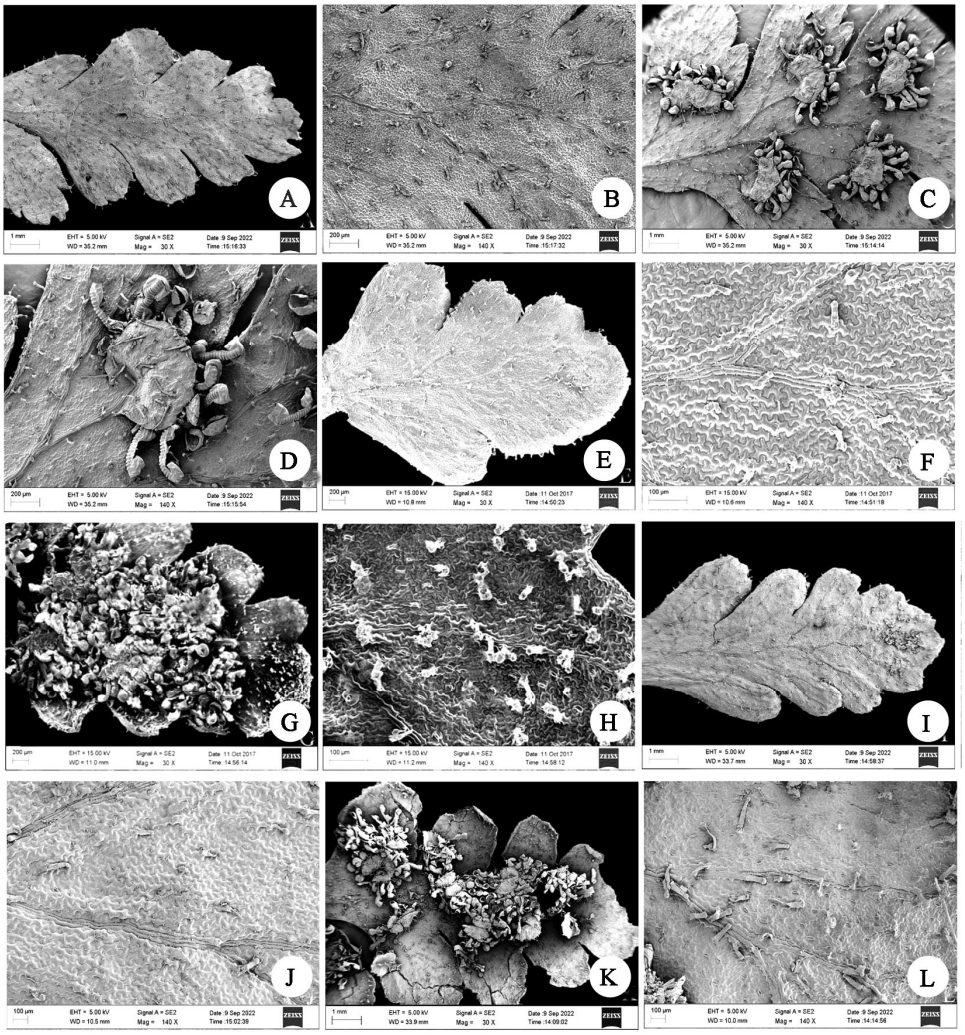

Fig. 2. SEM structures of laminae: A-D. *Hypodematium chingii*; E-H. *H. sinense*; I-L. *H. fordii.*

Fern spores are an important part of the reproductive organs and display the morphology of DNA genetic material. The perispore ornamentation is stable within the species and significantly different between the species, which provides an important palynology basis for the identification and classification of fern species. In 1997, the author of this paper proposed that the palynological characteristics of this species and its related species under scanning electron microscope should be regarded as an important and indispensable feature for the establishment of new taxa, which can

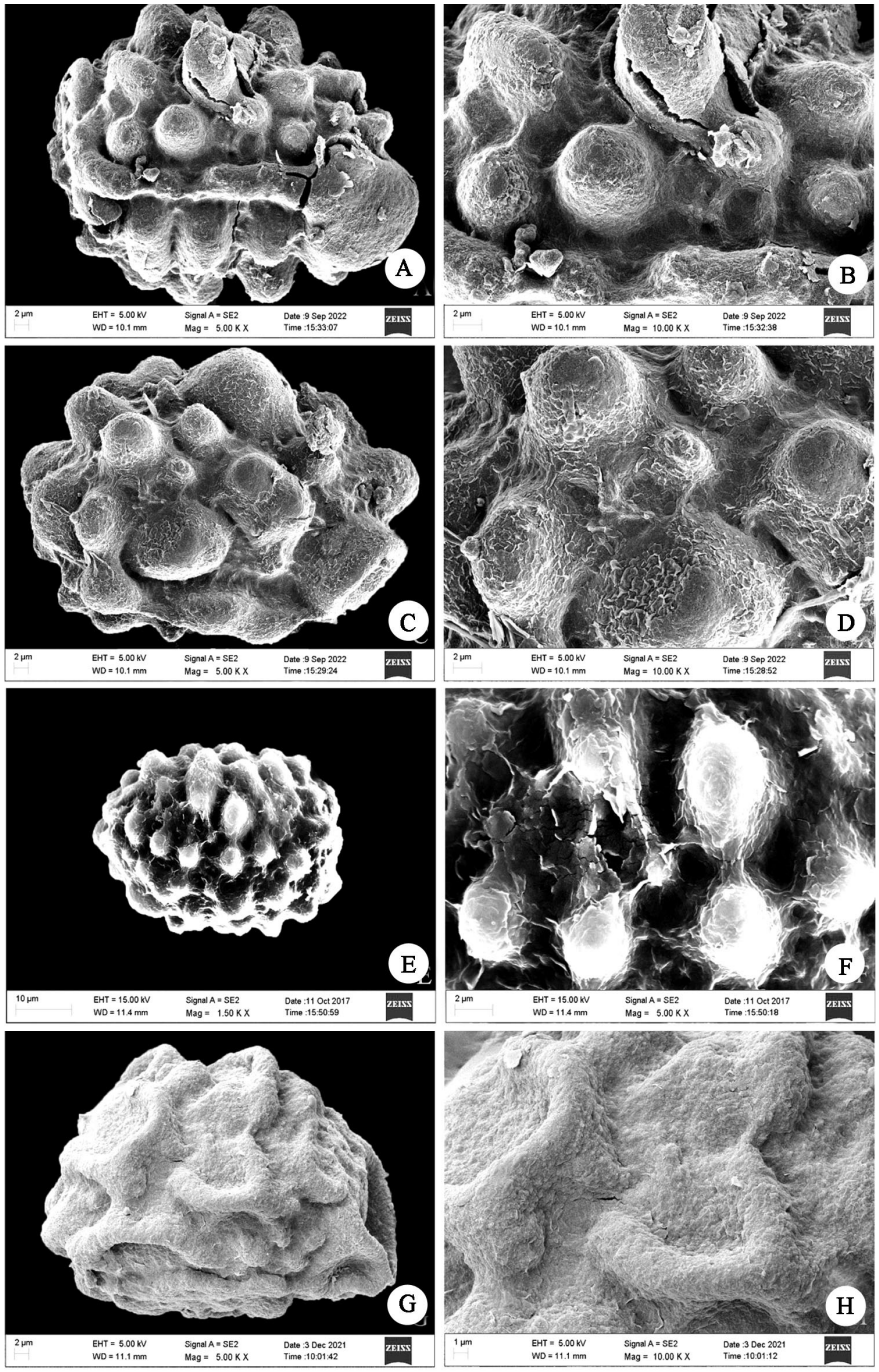

Fig. 3. SEM structures of spores: A-B. *H. chingii* polar view (5000×) (10000×); C-D. *H. chingii* equatorial view (5000×) (10000×); E-F. *H. sinense* equatorial view (1500×) (5000×) and G-H. *H. fordii* equatorial view (5000×) (10000×).

Table 2. Comparative characteristics of *H. chingii, H. sinense* and *H. fordii.*

Species name	Scales	Stipe	Lamina	Plant hair types	Indusia	Ornamentation of perispore SEM	Figure
Hypodematium chingii	Linear-lanceolate, microdentate above the middle, upper teeth appers unicellular nodes	Sparsely rod-shaped glandular hairs	Triangular	Plant with rod-shaped glandular hairs, only indusia sparsely covered with a few short acicular hairs	Sparsely covered with a few short acicular hairs and glandular hairs	Tuberculate protrusion, scaly ornamentations	2: A-D 3: A-D
H. sinense	Lanceolate, apex long acuminate, margin occasionally fine-toothed	Glabrous	Ovate-pentagonal	Plant with glandular hairs, non-glandular hairs absent	Sparsely glandular hairs	Verrucate protrusion, nearly smooth	2: E-H 3: E-F
H. fordii	Narrowly lanceolate, entire	Sparsely rod-shaped glandular hairs	Broad ovate-pentagonal	Plant with glandular hairs, absent non-glandular hairs	Sparsely glandular hairs at margin	Ring-shaped protrusions	2: I-L 3: G-H

give people an obvious effect and improve the reliability and credibility of the new taxa. It promoted plant taxonomy and palynology to a new stage and a new level of scanning electron microscopy, and promoted fern research into a new era of palynology. Subsequently scholars published related articles on palynology. The spore perispore of *H. chingii* is tuberculate protrusion, and its surface is decorated with scaly ornamentations (Fig. 3 A-D), which was clearly different from the verrucate protrusion of the spore perispore of *H. sinense* (Fig. 3 E-F) and the ring-shaped protrusions of the spore perispore of *H. fordii* (Fig. 3 G-H).

A key to the species of *Hypodematium* from China

1a. Fronds covered with rod-shaped glandular hairs; or rod-shaped glandular hairs and non-glandular hairs.
  2a. Fronds covered with rod-shaped glandular hairs, without non-glandular hairs.
    3a. Indusia densely covered with rod-shaped glandular hairs.
      4a. Stipe glabrous; indusia sparsely covered with glandular hairs; the spore perispore with verrucate ornamentation ..... 1. *H. sinense*
      4b. Middle and upper stipe sparsely covered with short-stalk glandular hairs; indusia densely covered with rod-shaped glandular hairs; the spore perispore with ringed ornamentation ..... 2. *H. fordii*
    3b. Indusia covered with 1-2 glandular hairs occasionally; the spore perispore with verrucate-massive ornamentation ..... 10. *H. glandulosum*
  2b. Fronds covered with rod-shaped glandular hairs and non-glandular hairs.
    5a. Fronds, rachis and costae covered with rod-shaped glandular hairs, indusia sparsely covered with a few short acicular hairs; the spore perispore with tuberculate ornamentation ..... 12. *H. chingii*
    5b. Fronds, rachis, costae and indusia covered with rod-shaped glandular hairs and non-glandular hairs.

6a. Fronds densely covered with long pubescence and sparsely rod-shaped glandular hairs.
7a. Lower rachis with reddish brown curly linear scales; the spore perispore with verrucate-massive ornamentation ..... 7. *H. squamulosopilosum*
7b. Lower rachis without reddish brown curly linear scales; the spore perispore with tuberculate ornamentation ..... 5. *H. confertivillosum*
6b. Fronds densely covered with rod-shaped glandular hairs and non-glandular hairs.
8a. Fronds without non-glandular hairs adaxially, except the veins which occasionally are a few acicular hairs; the spore perispore with irregularly ridged ornamentation, granular surface ..... 4. *H. gracile*
8b. Fronds densely covered with non-glandular hairs adaxially.
9a. Fronds covered with acicular hairs and glandular hairs.
10a. Fronds sparsely covered with long acicular hairs; the spore perispore with semicircular ornamentation ..... 13. *H. shandongense*
10b. Fronds covered with short acicular hairs.
11a. Plants 60-70 cm tall, broad ovate-pentagonal; the spore perispore with tuberculate ornamentation .....…..…… 14. *H. jianxiuii*
11b. Plants 20-30 cm tall, ovate-triangular; the spore perispore with auricular ornamentation ..... 3. *H. mengshanense*
9b. Fronds covered with fine pubescence and glandular hairs; the spore perispore with tuberculate ornamentation ..... 9. *H. glanduloso-pilosum*
1b. Fronds covered with non-glandular hairs.
12a. Stipe and costae covered with pubescence.
13a. Fronds densely covered with long pubescence; the spore perispore with long curved ridge ornamentation …….. 6. *H. crenatum*
13b. Fronds sparsely covered with pubescence; the spore perispore with reticulate ornamentation ..... 11. *H. guilinense*
12b. Stipe and lower rachis glabrous; the spore perispore with tuberculiform ornamentation …..... 8. *H. hirsutum*

Acknowledgments

This work was supported by the Shandong Provincial Natural Science Foundation Project (ZR2020QC021).

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(Manuscript received on 16 March, 2023; revised on 17 July, 2023)