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Taxonomic and nomenclatural novelties in the *Pteris fauriei* group (Pteridaceae)

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ABSTRACT: The *Pteris fauriei* group (Pteridaceae) includes *Pteris* with bipinnatisect laminae and entire pinnules. The taxonomic debate is led by morphological similarity and aggravated by the wide geographic distribution and a large number of involved taxa. We collected more than 500 plants and examined related herbarium specimens. Based on the evidence of morphology, molecular phylogeny, ecology, and reproductive biology, we propose the following taxonomic and nomenclatural novelties. 1) Two new species, *Pteris austrotaiwanensis* Y.S.Chao from Taiwan and *Pteris pseudowulaiensis* Y.S.Chao from China and Taiwan, are described. 2) The occurrence of *Pteris wulaiensis* in Japan is confirmed. 3) *Pteris fauriei* var. *chinensis* was treated as a synonym of *Pteris latipinna* Y.S.Chao & W.L.Chiou. 4) *Pteris fauriei* var. *minor* Hieron. is raised as species, *Pteris minor* (Hieron.) Y.S.Chao *stat. nov.* In this study, we clarify morphology of all known taxa in the *P. fauriei* group and provide a key.

KEY WORDS: *Campteria*, Eastern Asia, new records, new species, phylogeny, *Pteris*, taxonomy.

INTRODUCTION

Pteris fauriei Hieron. (Pteridaceae) has bipinnatisect laminae and falcate, ultimate entire pinnules. *Pteris fauriei* group, belonging to section *Campteria* C.Presl, is composed of taxa resembling *Pteris fauriei*. In Eastern Asia, this group is representative by more than 19 taxa. Although a few taxa are readily distinguishable by morphology, e.g., areolae venation of *P. arisanensis* Tagawa, *P. biaurita* L. and *P. confusa* T.G.Walker, and red-brown stipes of *P. setulosocostulata* Hayata, the species delimitations of most species within this group are unclear (Kobayashi, 1980). Among the species group, two varieties are rather widespread, var. *fauriei* for larger plants and var. *minor* Hieron. for smaller plants. Most of the other taxa in the group have a narrow distribution. *Pteris wulaiensis* C.M.Kuo is endemic to Taiwan (Shieh, 1994; TPG, 2019), *P. latipinna* Y.S.Chao & W.L.Chiou is only recorded in Taiwan and Vietnam (Chao *et al.*, 2017; Chen *et al*., 2020). *Pteris boninensis* H.Ohba, *P. laurisilvicola* Sa.Kurata, *P. natiensis* Tagawa, *P. satsumana* Sa.Kurata, and *P. yakuinsularis* Sa.Kurata are endemic species of Japan (Iwatsuki, 1995). *Pteris fauriei* var. *chinensis* Ching, *P. kiuschiuensis* var. *centrochinensis* Ching & S.H.Wu, and *P. oshimensis* var. *paraemeiensis* Ching ex Ching & S.H.Wu, are confined to China (Liao *et al.*, 2013; Wu, 1990). However, whether the narrow distributions of these taxa are caused by the lack of taxonomic studies of the *P. fauriei* group remains largely unknown.

This study aims to clarify the species delimitation and resolve taxonomic issues of the *P. fauriei* group by integrating morphological and molecular analyses. To overcome the wide geographic distribution and the large amount of encompassed taxa, we enhance sample collection and specimen examination, and compare detailed morphological characters. We also pay special attention to two putative new species similar to *P. latipinna* and *P. wulaiensis*. Finally, the key for identifying the taxa of the *P. fauriei* group is provided.

MATERIALS AND METHODS

Field sampling

Through specimen loans and online databases, we first inspected type materials of 18 known taxa (or scientific names) of the *P. fauriei* group (Table 1, Supplementary Figure 1) preserved B, BM, HAST, KYO, MO, P, PE, TAI, TAIF, TI, TNS, TOFO, and TUSG. We collected *Pteris* resembling *P. fauriei*, more than 500 plants from Eastern Asia and South Asia. In addition to those type specimens, we also examined herbarium specimens under the names of the *P. fauriei* group. We recorded 21 morphological characteristics proposed by Kobayashi (1980) and additional diagnostic characters newly raised for *Pteris* taxa (Table 1). For example, the length ratio of basiscopic pinnules to acroscopic ones of pinnae were newly proposed (Fig. 1D).

Molecular phylogenetic analyses

To clarify the phylogenetic position of the two putative new species, we included most species in *Pteris* sect. *Campteria* (Chao *et al.*, 2014; Zhang and Zhang, 2018) and all known taxa of the *P. fauriei* group, with an exception of *P. kiuschiuensis* var. *centrochinensis* and *P.*

Table 1. The morphological and habitat characters of taxa in the ***Pteris fauriei*** group.

Characters & character states \ Taxa	*P. arisanensis*	*P. austrotaiwanensis*, sp. nov.	*P.biaurita*	*P. boninensis*	*P. confusa*	*P. aff. confusa*	*P. fauriei*	*P. kawabatae*	*P. kiuschiuensis* var. *kiuschiuensis*	*P. kiuschiuensis* var.*centrochinensis*	*P. latipinna*	*P. laurisilvicola*	*P. minor*	*P. natiensis*	*P. oshimensis* var. *oshimensis*	*P. oshimensis* var. *paraemeiensis*	*P. pseudowulaiensis*, sp. nov.	*P. satsumana*	*P. setulosocostulata*	*P. wulaiensis*	*P. yakuinsularis*
1) Lamina texture. Herbaceous: 0; chartaceous:1; coriaceous: 2	1	0	1	1	0	1	1	0	1	1	0	1	2	1	0,1	1	1	1	1	0	1
2) Lamina ratio of length to width. 1.1–1.3: 0; 1.4–1.7: 1; 1.8–2: 2	1,2	1	2	1	1	1	1	0	0	1	0,1	1	0	0	2	2	1	0	1	2	1
3) Stipe color. Green or stramineous: 0; red-brown: 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,1	0,1	0
4) Stipe base thick. 2.5–4 mm: 0; < 2.5 mm: 1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0,1	0	0,1	0	0	1	0
5) Exaggerated basiscopic pinnules. 1 pair: 0; 2 or more pairs: 1; almost tripartite: 2	0	0	0	0	0	0	1	0	0,1	0	0	0	1,2	0	0	1	0	0	1	0	0
6) Number of lateral pinnae. < 6: 0; 6–8: 1; ≥ 9: 2	1	1	1	1	1	1	1	0	0	1,2	0	0	1,2	0	1,2	1	1,2	0	2	1	0
7) Pinna angles against rachis. 60–70°: 0; 71–80°: 1; 81–90°: 2	0	1	0	0	0	0	1	1,2	2	0	0	1	1	1	0	0	1	2	1	0	0
8) Pinna shape. Straight, 0; incurved: 1	0	0	0	0	0	0	0	1	1	1	0	0	0	1	0	1	0	1	1	0	0
9) Pinnule size variation. Gradually reduced toward the pinna terminal: 0; suddenly reduced at terminal: 1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10) Pinnule width. > 3 mm:0; ≤ 3 mm: 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0
11) Pinna stalks. Distinct: 0; sessile: 1; basal pinnules connecting to midrib: 2	1	1	1	1	1	1	1	2	2	1	1	1	1	2	1	0,1	1	2	2	0	1
12) Basal pinnules of lateral pinnae. Not decurrent, falcate: 0; decurrent, triangular: 1	1	0,1	1	1	1	1	0	0	0	1	1	0	0	0,1	1	0	0,1	1	1	1	1
13) Pinnae apexes. Acute or caudate with short tails, < 2.5 cm: 0; caudate, long tails ≥ 2.5 cm: 1	1	0,1	0	1	1	1	0	0	0	0	0	0	0	1	0	1	0	1	0	0	0
14) Pinnae width. < 3cm: 0; 3–4 cm: 1; > 4 cm: 2	1	1	1	1	1	1	1	2	0	2	2	2	1	2	0	0	0,1	1	0	0	2
15) Length ratio of basiscopic pinnules with acroscopic ones. 1–1.4: 0; 1.5–2: 1	0	0	1	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	0	0	0
16) Pinna width. Equal: 0; narrowed at base: 1; widest at base: 2	0,1	0	0,2	0	0,1	0,1	0,2	1#	0	0	1	0	0,2	1	2	0	0,2	1	0	1	1
17) Pinnule apexes of sterile fronds. Acute: 0; round: 1	0	0,1	1	0	0	1	0	1	0	1	0	0	0,1	0	0	0	0	0	1	1	0
18) Angle of pinnules against costae. 60–70°: 0; 71–80°: 1; 81–85°: 2	0	1,2	1	0	1	1	1	2	2	2	1	1	1	1	0	1	0,1	1	2	0	1
19) Venation. Free: 0; costal veins triangular: 1; costal veins areolate: 2	1	0	2	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20) Elevation*. ≤ 1000 m: 0; > 1000 m: 1	0,1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,1	0	0
21) Habitats*. Full sun, seacoast 0; semi-shade, near seacoast: 1; under forest: 2	2	2	2	1	2	2	1	2	1	1	2	2	0	2	1	1	1	1	2	2	2

*Most of the samples and data are from type specimen, except these two characters and two samples.
#The most basal pinnules of lateral pinna sometimes are elongated.

yakuinsularis. Whenever possible, the specimens with the identical morphology to type specimens and their protologues were chosen. *Pteris cretica* L. in section *Creticae* and *P. wallichiana* J.Agardh in section *Tripedipteris* were chosen as outgroups. Voucher information is provided in Table 2.

Following a modified cetyltrimethylammonium bromide (CTAB) method (Doyle and Doyle, 1990), total genomic DNA was extracted from the laminae. Two plastid genes, *rbcL* and *matK*, were amplified with the same polymerase chain reaction primers in Chao *et al.* (2014). We aligned the newly sequenced data with other published data by ClustalW (Thompson *et al.*, 1994) and then edited manually using BioEdit 7.1.3 (Hall, 1999). Gaps were treated as missing characters.

MrModeltest 2.4 (Nylander, 2009) was then used to select the best-fit models under the Akaike Information Criterion (Akaike, 1973). Maximum Likelihood (ML) analyses inferred a phylogeny with GARLI v.2.0.1019 (Zwickl, 2006). Ten independent runs were conducted using automatic termination following 10,000 generations without a significant (a lnL increase of 0.01) topology change. In order to calculate ML bootstrap supports for each node (MLBS), 1,000 bootstrap replicates were performed, each with a single tree search and automatic termination after 10,000 generations.

Table 2. Samples used for the molecular phylogenetic analyses. The scientific name, voucher information, country, GenBank accession numbers (*rbcL* and *matK*), and herbarium are provided for each specimen. New sequences are in bold.

Taxon	Specimen collection number	Collection locality	GenBank accession for *rbcL*	*matK*	Herbarium
P. aff. confusa	*CRFJ FN215*	Nepal	KF289736	KF289606	TAIF
P. argyraea	*CRFJ FN145*	India	KF289684	KF289554	TAIF
P. arisanensis	*Y.-S. Chao 2135*	Taiwan	MZ291651	MZ340403	TAIF
P. aspericaulis	*CRFJ FN36*	India	KF289685	KF289555	TAIF
P. asperula	*Y.-C. Liu 9870*	Philippines	KF289702	KF289572	TAIF
P. assamica	*CRFJ FN5*	Nepal	KF289686	KF289556	TAIF
P. austrotaiwanensis, sp. nov.	***Y.-S. Chao 3255***	**Taiwan**	**MZ291667**	**MZ340419**	**TAIF**
P. bella	*Y.-S. Chao 1649*	Taiwan	KF289635	KF289502	TAIF
P. biaurita	***Y.-S. Chao 2484***	**Taiwan**	**MZ291655**	**MZ340407**	**TAIF**
P. biaurita	***T.-D. Kao 03037***	**Chile**	**MZ357984**	**MZ357987**	**TAIF**
P. biaurita L. subsp. ***fornicata***	***CRFJ FN181***	**India**	**MZ291662**	**MZ340414**	**TAIF**
P. biaurita subsp. *walkeriana*	*CRFJ FN160*	India	KF289672	KF289542	TAIF
P. boninensis	*Y.-S. Chao 1941*	Japan	KF289743	KF289613	TAIF
P. confusa	***P.-F. Lu32448***	**Sri Lanka**	**MZ291671**	**MZ340423**	**TAIF**
P. dataensis	*Y.-C. Liu 9973*	Philippines	KF289703	KF289573	TAIF
P. fauriei	***Y.-S. Chao 2082***	**Taiwan**	**MZ291650**	**MZ340402**	**TAIF**
P. flava	*M. Kurutok 23*	Sabah	KF289731	KF289601	KEP
P. formosana	*Y.-S. Chao 951*	Taiwan	KF289630	KF289491	TAIF
P. giasii	*CRFJ 30176*	Bangladesh	KF289660	KF289530	TAIF
P. himalayensis	*CRFJ FN361*	India	KF289662	KF289532	TAIF
P. hirtula	*CRFJ FN180*	India	KF289687	KF289557	TAIF
P. kathmanduensis	*CRFJ FN35*	Nepal	KF289663	KF289533	TAIF
P. kawabatae	*Y.-S. Chao 1637*	Vietnam	KF289655	KF289525	TAIF
P. keysseri	*Y.-S. Chao 1403*	Philippines	KF289640	KF289510	TAIF
P. khasiana	*CRFJ FN129*	India	KF289688	KF289558	TAIF
P. kidoi	*S.-S. Dai 1917*	Taiwan	HM582613	KF289500	TAIF
P. kiuschiuensis var. *kiuschiuensis*	*Y.-S. Chao 1852*	Japan	KF289739	KF289609	TAIF
P. latipinna	*Y.-S. Chao 2092*	Taiwan	MF416322	MF416326	TAIF
P. laurisilvicola	***Y.-S. Chao 2555***	**Japan**	**MZ291659**	**MZ340411**	**TAIF**
P. linearis	***E. Grangaud s.n.***	**Reunion**	**MZ357983**	**MZ357986**	**TAIF**
P. longipes	*Y.-H. Chang 20100115-002*	Taiwan	KF289728	KF289598	TAIF
P. longipinna	*P.-F. Lu 11383*	Taiwan	HM582603	KF289495	TAIF
P. longipinnula	*C.-W. Chen Wade1981*	Indonesia	KF289679	KF289549	TAIF
P. minor	*Y.-S. Chao 2078*	Taiwan	MF416320	MF416327	TAIF
P. mucronulata	*Y.-S. Chao 1410*	Philippines	KF289641	KF289511	TAIF
P. natiensis	***Y.-S. Chao 1842***	**Japan**	**MZ291644**	**MZ340396**	**TAIF**
P. oshimensis	*Y.-S. Chao 1881*	Japan	KF289741	KF289611	TAIF
P. oshimensis var. ***paraemeiensis***	***J.-B. Zhang sn. 20100430109***	**China**	**MZ291663**	**MZ340415**	**TAIF**
P. otaria	*CRFJ FN26*	India	KF289666	KF289536	TAIF
P. pacifica	*P.I. Forster 27643*	Australia	KF289647	KF289517	MEL
P. praetermissa	*CRFJ FN64*	India	KF289692	KF289562	TAIF
P. pseudowulaiensis, sp. nov.	***T.-C. Hsu 8437***	**Taiwan**	**MZ291670**	**MZ340422**	**TAIF**
P. roseililacina	*CRFJ FN31911*	Nepal	KF289669	KF289539	TAIF
P. satsumana	***Y.-S. Chao 1925***	**Japan**	**MZ291645**	**MZ340397**	**TAIF**
P. scabristipes	*P.-F. Lu s.n.*	Taiwan	KF289699	KF289569	TAIF
P. setulosocostulata	*Y.-S. Chao 1146*	Taiwan	KF289634	KF289501	TAIF
P. subindivisa	*CRFJ FN266*	Bhutan	KF289700	KF289570	TAIF
P. venusta	*Y.-S. Chao 873*	Taiwan	HM582650	KF289486	TAIF
P. wallichiana	*Y.-S. Chao 951*	Taiwan	KF289630	KF289491	TAIF
P. wulaiensis	*P.-F. Lu 26667-1*	Taiwan	MF537503	MF537504	TAIF

Fig. 1. Morphology of ***Pteris austrotaiwanesis*** (holotype *Y.S. Chao 3255*, **A**–**C**) and *P. latipinna* (**D**) in Taiwan. **A**, **D**. Habitat. The basiscopic pinnules (**y**) are longer than acroscopic ones (**x**). **B**. Scales on stipes. **C**. A fertile frond. scale 3 cm. Photographed by Yi-Shan Chao.

RESULTS AND DISCUSSION

Morphological analyses

Based on the morphological study of type specimens and related specimens, the distinguishable characteristics of all known taxa in the *P. fauriei* group are clarified (Table 1, Fig. S1). We find that two putative new species are different from other known taxa in the *P. fauriei* group. The first putative new species resembles *P. latipinna* but has more slender and smaller laminae (Fig. 1). They can be further separated by laminae size, pinna width, and pinnule width. In Taiwan, this taxon is only found in the

Fig. 2. Morphology of ***Pteris pseudowulaiensis*** and ***P. wulaiensis*** in Taiwan. **A**. Habitat (holotype *T.C. Hsu 8437*). **B**. Scales on stipes (scale 3 mm). **C**. Habitat of ***P. wulaiensis***. Photographed by Tian-Chuan Hsu (A, B) and Pi-Fong Lu (C).

southern part of the main island, whereas *P. latipinna* is recorded in the north. The second putative new species was formerly misidentified as *P. wulaiensis* in Taiwan or *P. oshimensis* Hieron. var. *oshimensis* in China (Fig. 2). This taxon differs from *P. wulaiensis* by having different shapes in their stipe cross sections (round vs. quadrangular), pinna width (equal or widest at base vs. narrowed at base), and pinnule apexes of sterile fronds (acute vs. round).

Our morphological analyses show that all the studied characters between *P. fauriei* var. *chinensis* and *P. latipinna* are identical, suggesting the synonymization of the former under the latter. In addition, we confirm the distribution of *P. wulaiensis* in Japan for the first time. We provide the key to the *P. fauriei* group adopting the newly proposed diagnostic characters.

Molecular phylogenetic analyses

The combined data matric of *rbcL* (1278 bp) and *matK* (900 bp) regions contained 2184 characters with 159 parsimony-informative sites. The log-likelihood score of the ML tree was -6281.2437. The best-fitting evolutionary model was GTR+I+Γ (Rodriguez *et al.*, 1990). The accession numbers of the DNA sequences are listed in Table 2.

The ML tree is presented in Fig. 3. The clade of *Pteris* sect. *Campteria* is supported (BS = 100), and most taxa of the *P. fauriei* group belong to one subclade (BS = 57). Morphological and genetic differentiation of the taxa in the *P. fauriei* group seems small, while the integrated results corresponded to the species/taxa delimitation clearly. The two putative new species have their specific phylogenetic positions and are separated from their

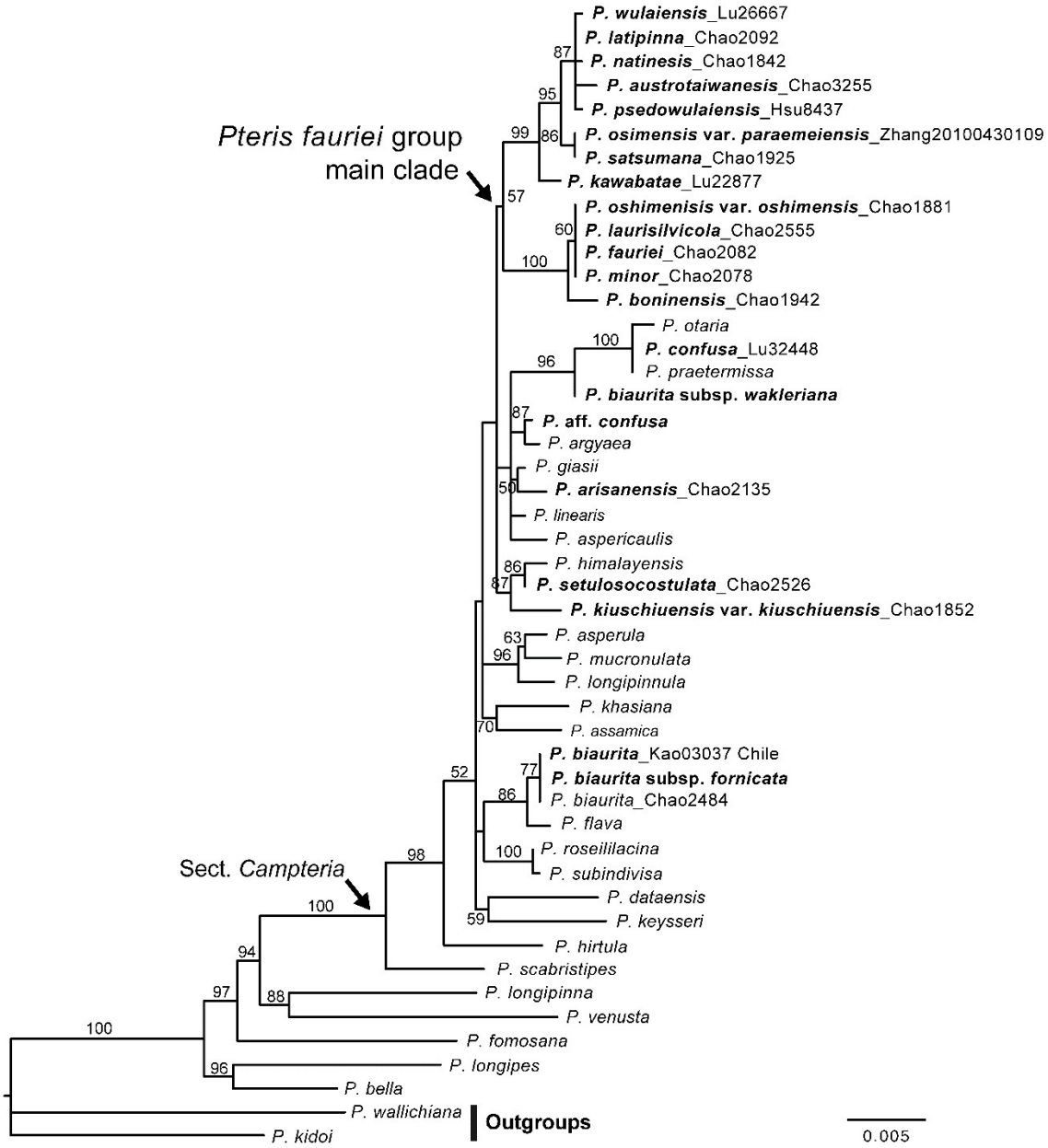

Fig. 3. Chloroplast DNA phylogenetic tree of ***Pteris austrotaiwanensis*** and ***P. pseudowulaiensis***, and related taxa in the ***P. fauriei*** group. Branch support is displayed in ML bootstrap. Taxa of the ***P. fauriei*** group are in bold.

morphologically similar species (Fig. 3). There are 3 and 2 bp differences between *P. latipinna*/*P. wulaiensis* and their resembles, respectively. The differentiation also supported by nuclear DNA data (Fig. S2; Chao *et al.*, unpublished). Comparing with other taxa within the *P. fauriei* group in the phylogenetic tree, the genetic divergence is distinct. Their systematic uniqueness is supported by both morphological and molecular evidence. We, therefore, describe them as the new species, *P. austrotaiwanensis* Y.S.Chao and *P. pseudowulaiensis* Y.S.Chao.

Pteris arisanensis, *P. biaurita, P. biaurita* subsp. *fornicata* Fraser-Jenk., *P. biaurita* subsp. *walkeriana* Fraser-Jenk. & Rajkumar, *P. confusa*, *P. kiuschiuensis*, *P.* aff. *confusa* and *P. setulosocostulata* are phylogenetically distinguished from the main group. *Pteris arisanensis* and *P. biaurita* can be classified by their venations, with triangular or arched costal areolae, respectively, and also be separated in the cpDNA phylogenetic tree. *Pteris arisanensis* was misidentified as *P. linearis* Poir. in the past until being reinstated by Chao *et al.* (2013) based on morphology. Here, we provide molecular support for its distinctness for the first time. Furthermore, *P. confusa*, distributed in south Asia, was thought a synonym of *P. arisanensis* (Fraser-Jenkins, 2008). The molecular data supports that *P. confusa* and another similar taxon *P.* aff. *confusa* are different from *P. arisanensis*.

Pteris biaurita is more phylogenetically distant from other taxa in the *P. fauriei* group. The samples of *P. biaurita* from Eastern Asia (Taiwan) and Chile (near Martinique or Jamaica where type collected) and *P. biaurita* subsp. *fornicata* from India show identical sequences. *Pteris biaurita* subsp. *walkeriana* is phylogenetically close to *P. confusa* and *P. praetermissa*.

We found some contradictions between morphological and molecular analyses. Specifically, species pairs with similar morphology are resolved distantly the phylogenetic tree, such as *P. boninensis* vs. *P. laurisilvicola*, and *P. kiuschiuensis* vs. *P. natiensis*. Vice versa, species pairs with distinct morphology were shown to be genetically close related, including *P. natiensis* vs. *P. latipinna*; *P. fauriei*, *P. laurisilvicola*, *P. minor*, and *P. oshimensis* var. *oshimensis*; *P. oshimensis* var. *paraemeiensis* vs. *P. satsumana*; *P. confusa* vs. *P. praetermissa*. In these cases, hybridization might account for the inconsistency between morphology and phylogeny based on our unpublished data (Chao *et al.*, unpublished).

Pteris fauriei var. *minor* and *P. fauriei* var. *fauriei* have the same cpDNA characters but different nuclear data (Chao *et al.*, unpublished). Furthermore, they are different in habitats (Huang *et al*., 2007) and reproductive mode (Huang *et al*., 2006), sexual and apogamous, respectively. *Pteris fauriei* var. *minor* is raised as a species *P. minor stat. nov.*, separated from *P. fauriei*.

The taxonomic challenge of the *P. fauriei* group arises from morphological similarity. We conduct morphological analysis in detail, by examining a large number of specimens, to reveal their key differences. Section *Campteria*, containing about 60 species, shows minor interspecific morphological and genetic variation (Zhang and Zhang, 2018). The morphological traits applied in this study will further contribute to other species' taxonomy in this section.

TAXONOMIC TREATMENT

1. *Pteris austrotaiwanensis* Y.S.Chao, ***sp. nov.***

南台灣鳳尾蕨 Figs. 1A–C

***Type*: TAIWAN**. Kaohsiung: Mt. Meilun, 700 m, 11 January 2021, *Y.S. Chao 3255* (holotype TAIF 535166; isotypes TAIF 535167)

***Diagnosis*:** Its herbaceous laminae and lamina shape are similar to *P. latipinna*. They are different in the sterile lamina size (15–40 cm vs. 20–50 cm in length), fertile laminae size (20–40 cm long vs. 25–60 cm), pinna width (1.8–4 cm vs. 2–6 cm), and pinnule width (3–5 mm vs. 4–6 mm). Its laminae are green to dark green, darker than *P. latipinna* when fresh (Fig. 1).

***Description*: Rhizomes** short-creeping, densely covered with concolorous, linear lanceolate, black-brown scales. **Fronds** clustered, 50–80 cm long, nearly monomorphic; stipes 20–40 cm long, 2–2.5 mm thick, stramineous or abaxially red, sparsely scaly at base, grooved on adaxial surface; laminae green to dark green, herbaceous, single-axis, ovate, 15–40 cm long, 15–30 cm wide, bipinnatisect; lateral pinnae 3–6 pairs, opposite, pinna angle against rachis 71–80°, straight, bearing one pair of exaggerated basiscopic pinnules; pinnae straight, lanceolate, 1.8–4 cm wide, pectinate, sessile, pinnules gradually reduced toward the terminal, apex caudate, 2–3 cm long, basal pinnules as long as the other pinnules, length of basiscopic pinnuls and acroscopic ones almost the same, basal pinnules of lateral pinnae not decurrent; pinnules against costae 71–80°; pinnules falcate, 3–5 mm wide, apex acute or obtuse, margins entire; veins forked, free. **Sori** along pinna margins; pseudoindusia entire; spore number 32.

***Distribution and conservation status*:** It is endemic to Taiwan and only restricted in southern areas of the main island. It grows under evergreen forests; below 1000 m. The populations are stable but only found in five localities. Here we assign it as "Near Threatened" (IUCN, 2017).

***Etymology*:** The epithet is named after the location where this species distributed, viz. South Taiwan.

***Specimens examined*: TAIWAN.** Kaohsiung: Chaishan, *Y.H. Chang 20130726-005* (TAIF), *Y.S. Chao 2908* (TAIF); Mt. Meilun, 700 m, *Y.S. Chao 3254*, *3257*, *3258* (TAIF). Pingtung: Mt. Laofo, *T.T. Chen et al. 788* (TAIF), *L.Y. Kuo 934* (TAIF), *P.F. Lu 20120429* (TAIF); Mt. Lilung, 600–700 m, *T.C. Hsu s.n.20130315* (TAIF), 600–700 m, *S.M. Ku 1477* (TAIF), 300–1062 m, *P.F. Lu 7765* (TAIF), *Y.H. Tzeng 869* (TAIF); Tachin Waterfall, *L.Y. Kuo 4250* (TAIF).

***Taxonomic notes*:** *Pteris austrotaiwanensis* is morphologically much similar to *P. latipinna* and also distributed in shady environments, but *P. austrotaiwanensis* prefers drier habitats. Laminae size is the most obvious difference between the two species; however, it seems difficult to apply in practice because of possible variation. Indeed, the smaller sterile lamina of *P. latipinna* is almost as long as common *P. austrotaiwanensis*, but the former is widely ovate and not ovate like *P. austrotaiwanensis*. Furthermore, molecular data from both cpDNA and nrDNA sequences provide addional evidence, that the two species are distinct (Chao *et al.*, unpublished).

2. *Pteris latipinna* Y.S.Chao & W.L.Chiou, PhytoKeys 85: 100, f. 1, 3, 4 (map). 2017. ***Type*: TAIWAN**. Hsinchu: Zhudong Town, Wuchihshan, 3 March 2013, *Y.S. Chao 2092* (holotype TAIF513634!; isotype TAIF513635!, TAIF513636!, TNS!)

寬羽鳳尾蕨 Figs. 1D, S1I

Pteris fauriei Hieron. var. *chinensis* Ching et S.H.Wu in Acta Bot. Austro Sin. 1: 10, 1983. ***Type*:** CHINA. Guangdong, Kook Kiang, Lung Tau Shan, 19 December 1931, *C. Wang 31659* (lectotype PE00049447!, isolectotype PE00049448!, here designated) [百越鳳尾蕨]; Wu, Fl. Reipubl. Pop. Sinicae. 3(1): 69. 1990 [百越鳳尾蕨]; Liao *et al*., Fl. China 2-3: 204. 2013 [百越鳳尾蕨].

***Specimens Examined*: CHINA.** Hainan: Shamaoling, *W.S. Wu 855* (TAIF), Diaoluoshan, *Y.S. Chao 1769* (TAIF). **TAIWAN.** Nantou: Xitou, *Z.X. Chang 1673* (TAIF). **VIETNAM.** Lam Dong: Lam Ha District, Phi To Commune, Nam Ban Protection Forest, *Y.S. Chao 3058* (SGN, TAIF), *C.W. Chen Wade5727* (PHH, SGN, SING, TAIF).

Taxonomic notes*: *Pteris fauriei var. *chinensis* was only reported in China and thought to be similar to *P. fauriei* but different in width of lateral pinnae (Liao *et al*., 2013). In practice, specimens named as var. *chinensis* show diverse morphologies because most of them are misidentified. We found the type materials are identical to *P. latipinna*. Here we design its lectotypes to emphasize its morphology. Its isolectotype resembles *P. fauriei* more than the lectotype.

Pteris latipinna is rare in Taiwan, having only five known populations and fewer than ten specimens. Widely ovate sterile lamina (the ratio of length to width approximately 5:4) is its critical diagnosis character (Chao *et al.*, 2017). Its triangular basal pinnules of lateral pinnae similar to the holotype *P. yakuinsularis*. *Pteris yakuinsularis* is endemic to Japan and has even fewer records in Japan. Because the holotype contains only a fertile frond, we tentatively regard *P. yakuinsularis* as an insufficiently known taxon until its morphological range could be clarified. The voucher of *P. yakuinsularis* (specimen *Y.S.Chao 1906*) cited in Chao *et al.* (2017) is misidentified and actually corresponded to *P. natiensis*.

3. *Pteris minor* (Hieron.) Y.S.Chao, ***stat. nov.***

海岸鳳尾蕨 Fig. S1F

Pteris fauriei Hieron. var. *minor* Hieron., Hedwigia 55(4): 347, 1914. ***Type*: FORMOSA (TAIWAN).** Kelung: *U. Faurie 685* (lectotype B 20 0128121!; isolectotype P00608401!, P00608402!, P00608403!, TI!)

Pteris quadriaurita Retz. var. *abbreviata* Rosenst., Hedwigia 56(4): 333. 1915; ***Type*: FORMOSA (TAIWAN)**, in rupibus littoris Kelung, *U. Faurie 122* (lectotype TI! isolecotypes KYO!)

***Description*: Rhizomes** short-creeping, densely covered with concolorous, linear lanceolate, black-brown scales. **Fronds** clustered, 30–60 cm long , nearly monomorphic; stipes 10–25 cm long, 2.5–4 mm thick, stramineous or abaxially red, scaly at base, grooved on adaxial surface; laminae green, coriaceous, widely ovate to lanceolate, single-axis to tripartite, 15–40 cm long, 15–30 cm wide, bipinnatisect; lateral pinnae 3–9 pairs, opposite, pinna angle against rachis 71–80°, straight, bearing 1–4 pairs of exaggerated basiscopic pinnules; pinnae straight, oblong lanceolate, 2–2.5 cm wide, pectinate, sessile, pinnules gradually reduced toward the terminal, apex caudate, 0.5–2 cm long, basal pinnules as long as the other pinnules, length of basiscopic pinnules and acroscopic ones almost the same, basal pinnules of lateral pinnae not decurrent; pinnules against costae 71–80°; pinnules of pinnae falcate, 3–5 mm wide, apex acute to round, margins entire; veins forked, free. **Sori** along pinna margins; pseudoindusia entire; spore number 64.

***Distribution and conservation status*:** It occurs in open environments and is exposed to full sunlight, especially along seacoasts. More than ten stable populations in Japan and Taiwan are classified as "Least Concern" of IUCN category (2017).

***Etymology*:** Dr. Georg Hieronymus named *P. fauriei* var. *minor* because of its smaller plant sizes than *P. fauriei* var. *fauriei*. Here we provide a new Chinese name based on its seashore distribution.

***Specimens examined*: JAPAN.** Okinawa: Iriomote Isl., Funaura, *K. Mitui s.n.* (TNS 315108). **TAIWAN.** Hualian: Fengpin, Shihtiping, *Y.S. Chao 2649–2652, 2654* (TAIF). Keelung: Badortz, *Y.S. Chao 2078*, *2079* (TAIF). Pingdung: Chialoshui, *Y.S. Chao 2492–2504* (TAIF). New Taipei: Chihshan, Shihtoushan Park, *Y.S. Chao 2792* (TAIF). Taitung: Chengkung, Sanhsientai, *Y.S. Chao 2642–2647* (TAIF); Hsiaolanyu Is. *C.Y. Yen s.n.* (TAIF); Lanyu, *J.H. Kuo s.n.* (TAIF), *T.C. Hsu 8425* (TAIF).

***Taxonomic notes*:** This species is a sexual diploid, different from the apogamous triploid *P. fauriei*. They can be distinguished by spore number per sporangium, 64 and 32, respectively. Mitui (1976) reported sexual diploid "*P. fauriei*" in Iromate Isl., actually representing the first record of *P. minor* in Japan. Furthermore, its sunny and open habitat is unique in the *P. fauriei* group, related to its coriaceous laminae.

The lectotype designated by Chang *et al*. (2018) is a specimen with a smaller plant; its laminae have only one or two pairs of exaggerated basiscopic pinnules. However, the laminae of the larger or more mature individuals can have two or more pairs of exaggerated basiscopic pinnules, even to present tripartite; the basal pinnae can be further divided and are like another bipinnatifid laminae. Because Chang *et al*. (2018) misplaced the type photo as P00608401, we correct it here (Fig. S1D).

Type specimens of *P. quadriaurita* var. *abbreviata* is collected from "rupibus littoris Kelung", meaning rocky shore of Keelung, where *P. minor* grows. Furthermore, the specimens exhibit coriaceous laminae identical to *P. minor*. Here it is treated as a synonym (also see Chang *et al*., 2018).

4. *Pteris pseudowulaiensis* Y.S.Chao, ***sp. nov.***

擬烏來鳳尾蕨 Figs. 2A & B

***Type*: TAIWAN**. New Taipei: Mt. Pataoerh. 29 April 2016, 600-700 m, *T. C. Hsu 8437* (holotype TAIF497137; isotype TAIF497138).

Pteris oshimensis var. *oshimensis* auct. non Hieron.: Wu, Fl. Reipubl. Pop. Sinicae. 3(1): 66. 1990 [斜羽鳳尾蕨], pro parte; Liao *et al*., Fl. China 2-3: 186, 203. 2013 [斜羽鳳尾蕨], pro parte.

***Diagnosis*:** The species resembles *P. wulaiensis* in having pinnae narrower than 3 cm and against costae 60–70°, but it has green or stramineous and thicker stipes (2–3 mm) rather than reddish-brown and thin stipes (ca. 2 mm) of *P. wulaiensis*. Lateral pinnae are widest at base in *P. pseudowulaiensis* but narrower at base in *P. wulaiensis* (Fig. 2).

***Description*: Rhizomes** short-creeping, densely covered with concolorous, linear lanceolate, black-brown scales. **Fronds** clustered, 60–90 cm long , nearly monomorphic; stipes 30–40 cm long, 2–3 mm thick, stramineous or abaxially red, sparsely scaly at base, grooved on adaxial surface; laminae green, chartaceous, ovate to lanceolate, single-axis, 15–50 cm long, 15–25 cm wide, bipinnatisect; lateral pinnae 5–9 pairs, subopposite, pinna angle against rachis 65–80°, straight, bearing one

pair of exaggerated basiscopic pinnules; pinnae straight, oblong lanceolate, 2–3.5 cm wide, pectinate, sessile, pinnules gradually reduced toward the terminal, apex caudate, 0.5–2 cm long, basal pinnules as long as the other pinnules, length of basiscopic pinnules and acroscopic ones almost the same, basal pinnules of lateral pinnae not decurrent; pinnules against costae 60–70°; pinnules of pinnae falcate, 3–5 mm wide, apex acute, margins entire; veins forked, free. **Sori** along pinna margins; pseudoindusia entire; spore number 32.

***Distribution and conservation status*:** It occurs in north Taiwan and south China, growing along paths or under forests, asl < 1300m. Considering the abundant specimen records, it can be classified as "Least Concern" based on IUCN category (2017).

***Etymology*:** In Taiwan, the species was misidentified as *P. wulaiensis* previously. The epithet is based on the morphological similarity of the two species.

***Specimens examined*: CHINA.** Guangdong: Yuanfou, *Y.K. Wang 341* (PE). Guangxi: Guangxi Zhuang Autonomous Region, Chinese Botanic Team in Guangxi 2471 (PE), Yongfu County, Qingshui Village, 515m, *C.W. Chen Wade 2499* (TAIF); Wuming County, Mt. Daming, 1243 m, *C.W. Chen Wade 2408* (TAIF). Guixhou: Pingtang County, *H.Y. Ho 1835* (PE). Fujian: Nanjing County, Huboliao National Nature Reserve, *Y.S. Chao 1288* (TAIF); Sanming City, Jianning, *Y.S. Fan, JN084* (TAIF); Yanping District, Mt. Mangdang, *H.M. Chang 9638* (TAIF). Hunan: Xiangxi Tujia and Miao Autonomous Prefecture, Jishou, *Y.H. Yan & B.R. Liu 4291, 4299* (PE), Huaihus, Hongjiang, Bamian Mt. Farm, *X.L. Zhou & Y.Q. Yao 1601* (PE), Sangzhi, Shuoheping, 432 m, *J.B. Zhang & Y.Q. Yan 20101016138, 20110126041* (TAIF). Jiangxi: Chongyi Conuty, Shuinan, *L.Y. Wang W.023* (PE), Quannan County, *J.F. Cheng 64372* (PE), Sichuan: Nanchuan, *Z.Y. Liu 15461* (TAIF); Dujiangyan, Mt. Qingcheng, *T.P. Yi 75039* (PE), Emei, Mt. Emei, 1300 m, *W.P. Fang 19124* (PE), 900 m, *K.H. Shing & K.Y. Lang 1128* (PE). **TAIWAN.** Ilan: Fushan Botanical Garden, *S.Y. Lu 35001* (TAIF). New Taipei: Yunxian Holiday Resort. *Y.S. Chao 1743* (TAIF).

***Taxonomic notes*:** In the *P. fauriei* group, *P. wulaiensis* is the slenderest. *Pteris pseudowulaiensis* has an intermediate plant size, larger than *P. wulaiensis* but smaller than both *P. fauriei* and *P. latipinna*. In Taiwan, it is confined to northern areas and more common than *P. wulaiensis*. *Pteris oshimensis* var. *oshimensis* was recorded in China (Liao *et al.*, 2013; Wu, 1990). No *P. oshimensis* var. *oshimensis* is found in this study. Some plants identified as this name could be *P. pseudowulaiensis* or *P oshimensis* var. *paraemeiensis*. However, the latter more resembles *P. setulosocostulata*.

5. *Pteris wulaiensis* C.M.Kuo, Bot. Bull. Acad. Sin. 30: 143–145. 1989. ***Type*: TAIWAN**. New Taipei: Wu-lai, Ta Tao Shan, 14 June 1988, 500 m, *S. J. Moore 4383* (holotype TAI283138!, isotypes: Z000002240!)

烏來鳳尾蕨 Figs. 2C, S1Q

***Specimens Examined*: JAPAN.** Kagoshima: Kimotsuki, Sata, *K. Takesako 2951* (TNS); Kagoshima-shi, Hida, *K. Takesako 23* (TNS), Aira, *K. Takesako 2746* (TNS); Aira, Shigetomi, *M. Heki 4148* (TNS), Kamou, *M. Heki 5732* (TNS); Satsuma, Tsuruta, *T. Yamanaka s.n.* 11 Sep. 1960 (TNS). Miyazaki: Saito-shi, Minoh, 59 m, *A. Ebihara, et al. 3234* (TAIF, TNS). Wakayama: Shirahama, Shagawa, *T. Iwasaki 553*, *1180* (TNS). **TAIWAN.** Hsinchu: Pawushan, *Y.S. Chao 3137* (TAIF), *P.F. Lu 28429* (TAIF).

***Taxonomic notes*:** *Pteris wulaiensis* is newly recorded in Japan and no more endemic to Taiwan. Comparatively, it is more common in Japan and scarce in north Taiwan. This species could inhabit cooler environments. We have counted the spore number of plants from Taiwan, *Y.S. Chao 3137* and *P.F. Lu 28429* (TAIF); they have 32 spores per sporangia. It is apogamous diploids in both Taiwan (Kuo, 1989) and Japan (*Ebihara et al. 3234*; Nakato and Ebihara, 2016).

Key to the *Pteris fauriei* group

1a. Laminae coriaceous ……..…….…… ***P. minor***
1b. Laminae chartaceous or herbaceous …… 2
2a. Pinnules width ≤ 3 mm 3
3a. Stipe bases red-brown, cross section quadrangular; pinnae narrow at base …….. ***P. wulaiensis***
3b. Stipe bases green or stramineous, cross section round; pinnae widest at base ……..…… ***P. oshimensis*** var. ***oshimensis***
2b. Pinnules width > 3 mm 4
4a. Exaggerated basiscopic pinnules >1 pair …… 5
5a. Pinnules falcate ……..…… ***P. fauriei***
5b. Pinnules oblong …….. 6
6a. Stipes green or stramineous; lateral pinnae 6–8 pairs .... ***P. oshimensis*** var. ***paraemeiensis***
6b. Stipes red-brown; lateral pinnae > 9 pairs ..... ***P. setulosocostulata***
4b. Exaggerated basiscopic pinnules 1 pair ……..…… 7
7a. Sterile laminae lanceolate, ratio of length to width approximately 3:2 …… 8
8a. Pinnules suddenly reduced at terminal; pinnules size irregular …… ……..……. ***P. confusa***
8b. Pinnules gradually reduced toward the terminal; pinnules size regular ……..…….. 9
9a. Laminae bipinnatifid; the sinus between 2 adjacent pinnules extending to 2/3–4/5 of the way toward the costae; venation free or with costal areolae …….. 10
10a. Venations with costal areolae arched, few triangular, connective veins with free veinlets ……. ***P. biaurita***
10b. Venations with costal areolae triangular or absent; if present, connected by a pair of furcated veinlets …… ***P. arisanensis***
9b. Laminae bipinnatisect; the sinus between 2 adjacent pinnules extending almost to the costae; venation completely free, no costal areolae …… 11
11a. Angle of pinnules against costae ≤ 80°……..... ***P. pseudowulaiensis***
11b. Angle of pinnules against costae > 80° …… 12
12a. Lateral pinnae ≥ 6 pair ..... ***P. boninensis***
12b. Lateral pinnae < 6 pair ..... ***P. laurisilvicola***
7b. Sterile laminae widely ovate, ratio of length to width approximately 5:4 ……..…….. 13
13a. Pinnae not perpendicular to rachis …….. 14
14a. Laminae chartaceous; pinnae incurved, width < 3 cm …… …… ***P. kiuschiuensis*** var. ***kiuschiuensis***
14b. Laminae herbaceous; pinnae straight, width > 3 cm …… 15
15a. Laminae light green; basal pair of fertile pinnae width > 3.5 cm ….. …… ***P. latipinna***, ***P. yakuinsularis***
15b. Laminae green to dark green; basal pair of fertile pinnae width < 3 cm …… ***P. austrotaiwanensis***
13b. Pinnae almost perpendicular to rachis …… 16
16a. Pinnae apexes acute or caudate with short tail, <2.5 cm; length ratio of basiscopic pinnules to acroscopic ones 1–1.2 …… 17
17a. Pinnae width > 4 cm, sometimes suddenly wider at base ……. …….. ***P. kawabatae***
17b. Pinnae width < 3 cm, width equally …….. ……..…….. ***P. kiuschiuensis*** var. ***centrochinensis***
16b. Pinnae apexes caudate, long tail ≥ 2.5 cm; length ratio of basiscopic pinnules to acroscopic ones 1.3–1.6: 1 …… 18
18a. Lateral pinnae 5–6 pairs, pinna angle against rachis 70–80°; pinnae width 3–4 cm ..... ***P. satsumana***

18b. Lateral pinnae 2–5 pairs; pinna angle against rachis 60–70°; pinnae width > 4 cm ..... ***P. natiensis***

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Supplementary materials are available from Journal Website.