TAXONOMIC STUDIES OF CHEIROPLEURIA (DIPTERIDACEAE)

MASAHIRO KATO1, YOKO YATABE2, NORIO SAHASHI3 & NORIAKI MURAKAMI2

SUMMARY

Morphological and molecular studies are made on the fern genus *Cheiropleuria*, which was treated in the past as monotypic. We describe *C. parva*, a new species from Borneo, and separate *C. integrifolia*, distributed in Japan and Taiwan and probably in China too, from Southeast Asian *C. bicuspis*. The three species differ from each other in the size, shape and texture of lamina, divergence angles between lobes, frequency of bilobed leaves, and spore size and morphology. *Cheiropleuria parva* is distinct from *C. bicuspis* populations sympatric on Mt Kinabalu in the leaves of juvenile and adult plants, suggesting reproductive isolation. Nucleotide differences in the *rbcL* gene support separation of the three species.

Key words: *Cheiropleuria*, Dipteridaceae, fern, *rbcL*, taxonomy.

INTRODUCTION

*Cheiropleuria* is an isolated fern genus that is generally referred to the monotypic family Cheiropleuriaceae (e.g., Kramer, 1990; Laferrière, 1998), rarely to Dipteridaceae together with *Dipteris* (Parris et al., 1992), or to Polypodiaceae in traditional classifications (Copeland, 1947; Holttum, 1955). Among these different family treatments it is usually agreed that *Cheiropleuria* is more or less closely related to *Dipteris*. Their close intergeneric relationship is supported by recent molecular and morphological studies (Hasebe et al., 1994, 1995; Pryer et al., 1995).

The morphology of *Cheiropleuria* is simple and provides few diagnostic characters for species delimitation. The sterile leaves are simple or bilobed, or rarely tetralobed, and lobed ones are usually seen in old plants (Tagawa, 1959), while the fertile leaves are always simple and much narrower than the sterile. *Cheiropleuria* appears to be so uninterruptedly variable as to have been treated as comprising a single species, *C. bicuspis* (Blume) C. Presl (Copeland, 1947; Holttum, 1955; Tagawa & Iwatsuki, 1989; Kramer, 1990; Iwatsuki, 1992; Nakaide, 1992; Parris et al., 1992; Iwatsuki et al., 1995; Laferrière, 1998; Ling, 2000). Local populations with simple sterile leaves, which are distributed in Japan (including Ryukyu) and Taiwan, were separated as var.

1) Department of Biological Sciences, Graduate School of Science, University of Tokyo, Tokyo 113-0033, Japan; author for correspondence (sorang@biol.s.u-tokyo.ac.jp).
2) Department of Botany, Graduate School of Science, Kyoto University, Kyoto 606-8502, Japan.
3) Department of Biology, School of Pharmaceutical Science, Toho University, Funabashi, Chiba 274-0072, Japan.
integrioflia D.C. Eaton ex Matsum. & Hayata (Nakai, 1928; see also Van Alderwerelt van Rosenburgh, 1908), but this treatment has not been accepted by most pteridologists (e.g., Tagawa, 1959; Kramer, 1990; Iwatsuki, 1992; Nakaike, 1992; De Vol & Shieh, 1994; Iwatsuki et al., 1995; Laferrière, 1998). Cheiropleuria bicuspis s.l. is distributed widely in SE and E Asia ranging from Malesia (Sumatra to New Guinea), Thailand, Vietnam, S China, Taiwan, and Japan. Copeland (1917) and Christensen & Holttum (1934) noted that C. bicuspis of Mt Kinabalu in N Borneo is very variable, and later Holttum (1955) stated that “In Borneo there is a variety with quite small very tough fronds, if bilobed only about 6–8 cm wide.” Iwatsuki & Kato (1984) recorded the same form from northwestern E Kalimantan.

We found the two forms differing distinctly in leaf form; not only of adults but also juveniles, as described below. There are also significant differences in quantitative characters of var. bicuspis and var. integrioflia. Based on these morphologies, along with field observations and molecular data, we propose a new species, C. parva, from Borneo, and a new combination for C. integrioflia.

MATERIALS AND METHODS

Materials and morphological observations

For a comparison of leaf characters, we examined specimens deposited in the herbaria of the University of Tokyo (TI) and Kyoto University (KYO) and plants collected from Mt Kinabalu, Malaysia. A number of young plants of C. bicuspis (Kato et al. 1622) and C. parva (Kato et al. 1620, 1621) were collected from Mt Kinabalu populations 50–100 m apart from each other, and used for a morphological observation of juvenile leaves. We measured the length (mean length if bilobed) and width of lamina, the length from the apex to the point where the lamina is the widest if simple, and the length (mean) of lobes and the divergence angle between lobes if bilobed, and the thickness of lamina between veins (Fig. 1).

Spores were collected from herbarium specimens deposited in KYO and TI. They were coated with a thin layer of carbon and then with gold. Spore morphology was observed in a scanning electron microscope (SEM) JSM-U3 at 15 kV. At least 30 spores per specimen were measured at ×1000 magnification.

For a molecular analysis, two individuals of each of C. bicuspis and C. parva were collected from Mt Kinabalu, and an individual of C. integrioflia was collected from Miyazaki, Japan (Table 1). For comparison Dipteris conjugata Reinw. and D. lobbiana (Hook.) T. Moore were analyzed. One leaf from each individual was used for DNA

<table>
<thead>
<tr>
<th>Species</th>
<th>Locality and voucher</th>
<th>Accession No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>C. bicuspis</td>
<td>Mt Kinabalu, Sabah, Malaysia; Murakami 98M-12, 98M-13</td>
<td>AB042570</td>
</tr>
<tr>
<td>C. integrioflia</td>
<td>Miyazaki Pref., Kyushu, Japan; Suzuki 00-01</td>
<td>AB042569</td>
</tr>
<tr>
<td>C. parva</td>
<td>Mt Kinabalu, Sabah, Malaysia; Murakami 98M-23, 98M-26</td>
<td>AB042572</td>
</tr>
<tr>
<td>D. conjugata</td>
<td>Okinawa, Japan; Hasebe 27618 (Hasebe et al., 1995)</td>
<td>U05620</td>
</tr>
<tr>
<td>D. lobbiana</td>
<td>Tahan National Park, Pahang, Malaysia; Kato 0926</td>
<td>AB042561</td>
</tr>
</tbody>
</table>
extraction, and the remaining part was used for voucher specimen. Vouchers are
deposited in KYO, and sequences are deposited in GenBank (see Table 1 for accession
numbers).

**Molecular phylogenetic analysis**

Total DNA was extracted using 2X CTAB solution according to Doyle & Doyle
(1987). The DNAs were purified using Qiagen Column Tip-20 (Qiagen GmbH) ac-
cording to the manufacturer’s instruction. We conducted Hot Start PCR (Mullis, 1991)
using anti-Taq high (Toyobo). The rbcL gene was amplified and sequenced with the
following eight primers:

- aF (5'-ATGTCAACCACAAACAGAGACTAAGC-3')
- bF (5'-TATCCCTGGATTTATTTGAGGAAGGTTTC-3')
- cF (5'-TGAAAACGTGAATTCCCAACCGTTTATGCG-3')
- sF (5'-ACTGTAGTGGAAATTGGGAAGGCAGACG-3')
- sR (5'-GAACCTTTCCTCAAATAATCCAGGGAATA-3')
- aR (5'-CTTCTGTCTAAATAAGAATCGATCTCTTCCA-3')
- bR (5'-GTTCGCTTTCAAATTTGCCACTACAGT-3')
- cR (5'-GCAGCAGCTAGTTCCGGGCTCCA-3')

[see Hasebe et al. (1994) for details about primer location].

The thermal cycling protocol comprised 35 cycles, each with 1-min denaturation
at 94°C, 2-min annealing at 50°C, an extension of 3 min at 72°C, concluding with
an extension of 7 min at 72°C. The PCR products were purified using QIA quick gel
extraction kit (QIAGEN) after electrophoresis in 1% agarose gel, and then used as
templates for direct sequencing. Sequencing reaction was conducted using a Big Dye
terminator cycle sequencing kit (Perkin Elmer). The reaction mixtures were analyzed
on an Applied Biosystems Model 377 automated sequencer (Perkin Elmer). Sequence
data were aligned using the Sequence Navigator program (Perkin Elmer).

Phylogenetic analysis was performed by the maximum parsimony method using
PAUP version 3.1.1 (Swofford, 1993). Branch and bound searches were performed
with character states specified as unordered and equally weighted, further sequence
addition and MULPARS on. To evaluate the relative robustness of the clades found in
the most parsimonious tree, bootstrap analyses (Felsenstein, 1985) were conducted.

![Fig. 1. Leaf-lamina characters measured. A = divergence angle between lobes; D = length from the
widest point to the apex; E = entire length; L = length from the base of lobe to the apex; W = width.](image-url)
on 10,000 replicates using a general heuristic search with equally weighted and simple sequence addition. All minimal trees were held for each replicate. We used Dip teris conjugata and D. lob biana as outgroups to root the tree. Its relevance as an outgroup was shown by a comprehensive molecular work on most fern families by Hasebe et al. (1995).

COMPARATIVE LEAF MORPHOLOGY

*Cheiroleuria parva* vs. *C. bicuspis* and *C. integrifolia*

In mature or semimature plants, the simple lamina of *C. parva* is much shorter and moderately wider than that of *C. bicuspis* and *C. integrifolia*, and consequently the ratio of lamina length to width in *C. parva* is smaller (Table 2). The bilobed lamina of *C. parva* is also much shorter. The ratio of the lobe length to the entire lamina length is a little smaller than in *C. bicuspis* and a little larger than in *C. integrifolia*, but without a significant difference (Table 3). The divergence angles of the lobes of *C. parva* are larger than those of the other two species.

The thickness of lamina and the distinctness of veins also differ. In *C. parva* the laminae are 0.5–0.7 mm thick in a dried condition and thick-coriaceous, while they are 0.2–0.4 mm and firm-papyraceous in *C. bicuspis* distributed in Mt Kinabalu together with *C. parva*. In *C. parva* the veinlets are hardly or not visible on the abaxial side of laminae, while in *C. bicuspis* and *C. integrifolia* they are visible.

There is another difference in leaf morphology between juvenile plants of *C. bicuspis* and *C. parva*, which are sympatric in Mt Kinabalu (Fig. 2). There is a heteroblastic change of leaves in both species, but the heteroblastic patterns differ. In *C. parva* the youngest or occasionally the second youngest leaves of the juvenile plants examined

Table 2. Measurements (means ± SDs) of leaf-lamina characters* in simple-leaved *Cheiroleuria.*

<table>
<thead>
<tr>
<th>Species (populations)</th>
<th>Length (E) (mm)</th>
<th>Width (W) (mm)</th>
<th>Length (D) (mm)</th>
<th>Ratio: E/W</th>
<th>Ratio: D/E</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>C. integrifolia</em> (N = 165)</td>
<td>155 ± 31</td>
<td>52 ± 16</td>
<td>101 ± 21</td>
<td>3.2 ± 0.8</td>
<td>0.65 ± 0.06</td>
</tr>
<tr>
<td><em>C. integrifolia</em> (Japan; N = 150)</td>
<td>155 ± 31</td>
<td>50 ± 15</td>
<td>101 ± 21</td>
<td>3.3 ± 0.7</td>
<td>0.65 ± 0.06</td>
</tr>
<tr>
<td><em>C. integrifolia</em> (Japan excl. Ryukyu; N = 80)</td>
<td>147 ± 26</td>
<td>44 ± 13</td>
<td>95 ± 17</td>
<td>3.5 ± 0.7</td>
<td>0.65 ± 0.06</td>
</tr>
<tr>
<td><em>C. integrifolia</em> (Ryukyu; N = 70)</td>
<td>164 ± 35</td>
<td>57 ± 15</td>
<td>108 ± 24</td>
<td>3.0 ± 0.7</td>
<td>0.66 ± 0.06</td>
</tr>
<tr>
<td><em>C. integrifolia</em> (Taiwan; N = 15)</td>
<td>152 ± 28</td>
<td>73 ± 17</td>
<td>103 ± 20</td>
<td>2.2 ± 0.5</td>
<td>0.68 ± 0.05</td>
</tr>
<tr>
<td><em>C. bicuspis</em> (N = 21)</td>
<td>118 ± 22</td>
<td>58 ± 16</td>
<td>86 ± 16</td>
<td>2.1 ± 0.5</td>
<td>0.73 ± 0.06</td>
</tr>
<tr>
<td><em>C. bicuspis</em> (SE Asia excl Mt Kinabalu; N = 8)</td>
<td>124 ± 29</td>
<td>66 ± 18</td>
<td>85 ± 21</td>
<td>2.0 ± 0.4</td>
<td>0.68 ± 0.07</td>
</tr>
<tr>
<td><em>C. bicuspis</em> (Mt Kinabalu; N = 13)</td>
<td>113 ± 16</td>
<td>53 ± 13</td>
<td>87 ± 13</td>
<td>2.3 ± 0.6</td>
<td>0.76 ± 0.03</td>
</tr>
<tr>
<td><em>C. parva</em> (Borneo; N = 16)</td>
<td>77 ± 15</td>
<td>60 ± 12</td>
<td>57 ± 10</td>
<td>1.3 ± 0.2</td>
<td>0.74 ± 0.05</td>
</tr>
</tbody>
</table>

*) Length (E) = entire length; length (D) = length from the widest point to the apex (see Fig. 1).
Table 3. Measurements (means ± SDs) of leaf-lamina characters* in bilobed-leaved *Cheiroleuria*.

<table>
<thead>
<tr>
<th>Species (populations)</th>
<th>Length (E) (mm)</th>
<th>Length (L) (mm)</th>
<th>Angle (A) (°)</th>
<th>Ratio: L/E</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>C. integrifolia</em> (N = 19)</td>
<td>156 ± 20</td>
<td>57 ± 12</td>
<td>33 ± 9.1</td>
<td>0.37 ± 0.07</td>
</tr>
<tr>
<td><em>C. integrifolia</em> (Japan excl. Ryukyu; N = 7)</td>
<td>144 ± 16</td>
<td>53 ± 15</td>
<td>34 ± 3.5</td>
<td>0.37 ± 0.09</td>
</tr>
<tr>
<td><em>C. integrifolia</em> (Ryukyu) (N = 12)</td>
<td>162 ± 20</td>
<td>60 ± 10</td>
<td>33 ± 11</td>
<td>0.37 ± 0.05</td>
</tr>
<tr>
<td><em>C. bicuspis</em> (N = 63)</td>
<td>146 ± 29</td>
<td>88 ± 26</td>
<td>81 ± 21</td>
<td>0.60 ± 0.09</td>
</tr>
<tr>
<td><em>C. bicuspis</em> (SE Asia excl. Mt Kinabalu; N = 44)</td>
<td>147 ± 30</td>
<td>90 ± 27</td>
<td>85 ± 18</td>
<td>0.60 ± 0.08</td>
</tr>
<tr>
<td><em>C. bicuspis</em> (Mt Kinabalu; N = 19)</td>
<td>143 ± 28</td>
<td>85 ± 24</td>
<td>68 ± 23</td>
<td>0.58 ± 0.10</td>
</tr>
<tr>
<td><em>C. parva</em> (Borneo; N = 41)</td>
<td>80 ± 17</td>
<td>37 ± 11</td>
<td>106 ± 23</td>
<td>0.47 ± 0.10</td>
</tr>
</tbody>
</table>

*) Length (E) = entire length; length (L) = length from the base of lobe to the apex; angle (A) = divergence angle between lobes (see Fig. 1).

Fig. 2. Silhouettes of selected leaves of Mt Kinabalu sympatric juvenile plants of *Cheiroleuria*. a. *C. parva* M. Kato, Y. Yatabe, Sahashi & N. Murak.; b. *C. bicuspis* (Blume) C. Presl. Arrowheads indicate attachment of lamina to petiole. — Scale bar = 1 cm.
are usually round. Their laminae are not more than 7 mm long and wide, and are round at the apex. The older leaves are longer with the apices subacute, then acute to acuminate. In Mt Kinabalu populations of *C. bicuspis*, the young leaves with laminae up to 11 mm (rarely 13 mm) long and wide still have round apices (see also Wagner, 1952) and are much larger than those of *C. parva* at comparable heteroblastic stages. Then the leaves change to those with acute to acuminate apices.

**Cheiroleuria integrifolia** vs. **C. bicuspis**

A quantitative comparison shows that the two species are separable in the relative length of simple sterile leaves and the frequency of bilobed-leaved plants. The leaves of *C. integrifolia* are longer and relatively narrower than those of *C. bicuspis* (Table 2) and simple-leaved plants are more frequent in *C. integrifolia* than in *C. bicuspis* (Fig. 3). All three species take a heteroblastic change from simple young leaves toward bilobed old leaves. Northern or temperate plants of *C. integrifolia* show a tendency toward having generally simple-leaves, as pointed out by Tagawa (1959), indicating that plants become reproductively mature at heteroblastically young stages.

It is noted that no Taiwanese materials examined are bilobed-leaved, as described in a local flora (De Vol & Shieh, 1994), but Taiwanese *C. integrifolia* is similar to *C. bicuspis* in the relative length of leaves.

**SPORE MORPHOLOGY**

The spore morphology is similar among the species, except for the length of the laesurae. Those of *C. parva* are longer relative to spore size than those of the other species, which are 2/3 of the equatorial radius. There is a difference in spore size between *C. integrifolia* and the other two species. Erdtman & Sorsa (1971) noted that *C. bicuspis* from Sumatra has smaller spores (23 by 38 μm for acetolyzed spores) than *C. integrifolia* from Taiwan (as var. *integrifolia*; 39 by 49 μm). Other reports verify the difference [Kawasaki, 1963 for Taiwanese *C. integrifolia*; Nayar & Devi,
1964 for Bornean *C. bicuspis*; Kremp & Kawasaki, 1972 for Japanese (Ryukyu, Honshu) *C. integrifolia*; Botanical Institute of Beijing, 1976 for Chinese (Hainan) *C. integrifolia*; Huang, 1981 for Taiwanese *C. integrifolia*. Our observations also show such a spore size difference. Spores of *C. integrifolia* are 26 (23–29) by 35 (31–40) \( \mu m \), while spores of *C. bicuspis* are 22.4 (20.3–24.8) by 29.6 (26.5–32.7) \( \mu m \) (for *C. parva*, see description).

The difference in spore size may be correlated to ploidy level, as in many other plants. Nakato (1996) reported that *C. integrifolia* (as *C. bicuspis* s.l.) from the Ryukyu, Japan, has 232 chromosomes in mitosis (2\( n = 232 \), 4\( x \)), while Walker (1984, pers. comm.) reported \( n = c. 57 \) (57–60) for *C. bicuspis* (2\( x \)) collected from Mulu National Park, Sarawak. Taken together, it might be possible that *C. bicuspis* and *C. parva* are diploid and different from the tetraploid *C. integrifolia*, pending further chromosomal study.

**SEQUENCE VARIATION AND MOLECULAR PHYLOGENETIC ANALYSIS**

Boundaries of the *rbcL* gene were estimated according to Hasebe et al. (1994). The final alignment has a total length of 1250 sites (see Fig. 5), of which 13 are variable. The two individuals of *C. parva* and those of *C. bicuspis* from Mt Kinabalu each showed the same sequences. Seven sites of the *rbcL* sequences were variable between *C. parva* and *C. bicuspis*. The *C. integrifolia* plant showed 10 and 9 nucleotide differences from *C. bicuspis* and *C. parva*, respectively.

The single most parsimonious tree (length = 63 steps; CI = 0.968; RI = 0.951) was obtained by the Wagner parsimony method (Fig. 4). *Cheiropleuria parva* and *C. bicuspis* from Mt Kinabalu did not make a clade. The *rbcL* sequence variation at 7 nu-

![Fig. 4. The single most parsimonious tree (length = 63 steps; CI = 0.968; RI = 0.951) from analysis of *rbcL* sequence data of *Cheiropleuria* species. Numbers above and below branches indicate numbers of nucleotide substitutions (ACCTRAN optimization) and bootstrap percentages, respectively. *Dipteris conjugata* Reinw. and *D. lobbiana* (Hook.) T. Moore were treated as outgroup.](image-url)
<table>
<thead>
<tr>
<th>C. bicuspis (Kinabalu)</th>
<th>C. parva (Kinabalu)</th>
<th>C. integrifolia (Japan)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CTCACTACAC TCCCGATTAT GAGCACAAG ATACTGACAT CTGGGCAACCT TCCCGATGAA CTCCGACCC CGGGGATCCG CTCGGGAAGA CTCGAGCTTG</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AGTAGTACGC GAATTTCAAG GACGGATGG GACGATCTG TCCCGATGG AATTTCAAG GACGGATCC TCCCGATGAG GACGATCTG</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GGTTGGAAGAAG GGAGGAATGG GACGATCTG TCCCGATGAG GACGATCTG</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CTCCGACCC CGGGGATCCG CTCGGGAAGA CTCGAGCTTG</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CTCCGACCC CGGGGATCCG CTCGGGAAGA CTCGAGCTTG</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Fig. 5.** Alignment of three *rbcL* sequences of *Cheiropleuria parva* M. Kato, Y. Yatabe, Sahashi & N. Murak., *C. bicuspis* (Blume) C. Presl, and *C. integrifolia* (D.C. Eaton ex Hook.) M. Kato, Y. Yatabe, Sahashi & N. Murak., showing different nucleotides. Dots indicate the same nucleotides.
cleotide positions and a remote relationship between C. parva and C. bicuspis suggest a strong isolation between the two populations even though they are sympatric, and support a taxonomic segregation of C. parva from C. bicuspis.

Cheiropleuria integrifolia has 6 unique nucleotide changes and 9 and 10 nucleotide differences from C. parva and C. bicuspis. rbcL is estimated to be a slowly evolving gene. Yatabe et al. (1999) reported that the rbcL gene of Osmunda changed at the rate of one nucleotide substitution per five million years. Thus, the pattern of the nucleotide changes supports a proposed taxonomic segregation of C. integrifolia from C. bicuspis.

If C. integrifolia, like C. parva, is a derivative from local (northern) populations of C. bicuspis, the last species is a paraphyletic group. Samples of C. bicuspis from two other localities show similarly large nucleotide differences not only from C. bicuspis of Mt Kinabalu but also from C. integrifolia and C. parva (data not shown), suggesting more genetic variations of C. bicuspis than we are aware. Further morphological and molecular studies may find variations that merit separation of local species in Cheiropleuria, even if morphological differences are small.

TAXONOMIC TREATMENT

CHEIROPLEURIA


Terrestrial. Rhizomes creeping with leaves narrowly spaced, branched, covered by pale-brown multicellular hairs. Leaves dimorphic; petioles glabrous except at the hairy base; sterile laminae simple or bilobed or rarely tetralobed, acuminate or caudate at apex, cuneate, round to cordate at base, firm-papyraceous to thick-coriaceous, glabrous on both surfaces; veins reticulate, main veins digitate and parallel, sometimes forked, visible, fine veinlets between them visible or hardly visible; fertile laminae simple, linear, gradually narrowed to both ends. Sori acrostichoid, sporangia entirely covering the abaxial surface of lamina except the margin, mixed with club-shaped unicellular paraphyses, exindusiate. Spores tetrahedral, trilette, surface psilate by light microscopy (LM).

KEY TO THE SPECIES

1a. Simple laminae 6–11 by 4–8.5 cm (L/B = 1–1.5), bilobed laminae 6–11 by 6–12 cm, thick-coriaceous, divergence angles (70–)90–130(–140)°, veinlets invisible .......................................................... 3. C. parva
b. Simple laminae 10–20 by 3–8 cm (L/B = 2 or more), firm-papyraceous, in lobed lamina divergence angles 30–110°, veinlets visible ............................ 2
2a. Laminae often simple, sometimes bilobed, divergence angles 30–40° (Japan, Taiwan, China) ........................................ 2. C. integrifolia
b. Laminae usually bilobed, divergence angles more than 70°, rarely (in young plants) simple (SE Asia) ................................................ 1. C. bicuspis

1. Cheiropleuria bicuspis (Blume) C. Presl


Petioles 20–50 cm long in sterile leaves, equally long or longer in fertile leaves; sterile leaves bilobed, rarely tetralobed or sometimes simple; simple sterile laminae ovate-lanceolate or ovate, 8–15 by 3–8 cm, L/B = 1.5–2.5, bilobed ones 10–20 cm long, as wide as long, lobed more than 1/2 from the apex, widely cuneate to widely round or sometimes subcordate at base, 0.2–0.4 mm thick, firm-papyraceous, divergence angles 70–110°; fine veinlets visible; fertile laminae 10–25 by 1–1.5 cm. Spores 22 by 30 μm, laesurae 2/3 of the equatorial radius.

Distribution — Vietnam, Thailand, throughout Malesia.


Petioles 20–50 cm long in sterile leaves, longer in fertile leaves; sterile leaves simple or sometimes bilobed; simple sterile laminae oblong- or ovate-lanceolate, 10–22 by 3–8 cm, L/B = 2–4.5, bilobed ones 13–19 by up to 9 (–12) cm, lobed less than 2/5 from the apex, cuneate to round-cuneate at base, 0.2–0.4 mm thick, firm-papyraceous, divergence angles 30–40°; fine veinlets visible; fertile laminae 10–25 by 1–1.5 cm. Spores 26 by 35 μm, laesurae 2/3 of the equatorial radius.

Distribution — Japan, Taiwan, China.


— Fig. 6, 7

Ab C. bicuspe laminis parvis, solidissimis, lobis brevibus, basi rotundatis vel subcordatis, venis aegre visibilibus differt. — Typus: Kato et al. 1488 (holotype UKMS; isotypes HYO, KYO, TI), Mt Kinabalu, summit trail, open slope, 2100 m, 22 Dec. 1997.
Rhizomes 2.8–4.6 mm thick. Leaves 3–6 mm apart; petioles 10–23 cm long in sterile leaves, 15–23 cm long in fertile leaves; simple sterile laminae deltoid-ovate, 6–11 (mean: 7.7) cm long, 4–8.5 (mean: 6) cm wide, L/B = 1–1.5, bilobed ones 6–11 (mean: 8) cm long, 6–12 cm wide, lobed less than 1/2 from the apex, acuminate or caudate at apex, round to cordate at base, thick-coriaceous, 0.5–0.7 mm thick in dried condition, thick-coriaceous, divergence angles (70–)90–130(–140)° (mean: 105°); veins reticulate, fine veinlets between main veins hardly visible on the abaxial surface of laminae; fertile laminae 10–12 by 0.8–1.4 cm. Spores 20–25.5 (mean: 22.5) μm in polar diameter, 27–33 (mean: 30) μm in equatorial diameter, laesurae 3/4 of the equatorial radius and bordered by distinct margo, surface psilate by LM, perine more or less smooth and fragile by SEM (Fig. 7).

Habitat — Open or semi-open slopes or ground in montane or mossy forests. In Mt Kinabalu, Sabah (N Borneo), Malaysia, populations occur in patches on open or semi-open, gentle or steep slopes (often along trails), sympatric with C. bicuspis. The two species seem to be reproductively isolated.

Distribution — Borneo (Sabah, northwestern E Kalimantan).

Note — Lau 27379 (KYO) from Hainan is similar to C. parva rather than to C. bicuspis, and further collecting and observation are needed for Hainan populations.

Other specimens examined:
Kato et al. 1620 (TI), Mt Kinabalu, summit trail, open steep slope, 2100 m; Kato et al. 1621 (TI), Mt Kinabalu, summit trail, open steep slope, 1900 m; Suehiro F-814 (KYO), Yamada 1675 (KYO), Kokawa & Hotta 5543 (KYO), Mt Kinabalu; Kato et al. 9510 (KYO), E Kalimantan, Gunung (= Mt) Batu Harun, mossy forests; Kato et al. 11115 (KYO), E Kalimantan, Gunung (= Mt) Buduk Rakik, mossy forests.

Fig. 6. Cheirolepria parva M. Kato, Y. Yatabe, Sahashi & N. Murak. (holotype Kato et al. 1488).
— Scale bar = 5 cm.
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