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The *Pomatocalpa maculosum* Complex (Orchidaceae) Resolved by Multivariate Morphometric Analysis

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ABSTRACT: Principal components analysis (PCA) was employed to analyse the morphological variation among 63 herbarium specimens tentatively identified as *Pomatocalpa andamanicum* (Hook.f.) J. J. Sm., *P. koordersii* (Rolfe) J. J. Sm., *P. latifolium* (Lindl.) J. J. Sm., *P. linearifolium* Seidenf., *P. maculosum* (Lindl.) J. J. Sm., *P. marsupiale* (Kraenzl.) J. J. Sm., *P. naevatum* J. J. Sm., or *P. siamense* (Rolfe ex Downie) Summerh. Thirty-seven quantitative and 5 binary characters were included in the analyses. Taxa were delimited according to the observed clustering of specimens in the PCA plots, diagnostic characters were identified, and the correct nomenclature was established through examination of type material. Four species could be recognized viz, *P. diffusum* Breda (syn. *P. latifolium*), *P. fuscum* (Lindl.) J. J. Sm. (syn. *P. latifolium*), *P. marsupiale* (syn. *P. koordersii*) and *P. maculosum*. For the latter species, two subspecies could be recognized, viz *P. maculosum* (Lindl.) J. J. Sm. subsp. *maculosum* (syn. *P. maculosum*, *P. naevatum* p.p.) and *P. maculosum* (Lindl.) J. J. Sm. subsp. *andamanicum* (Hook.f.) S. Watthana (syn. *P. andamanicum*, *P. linearifolium*, *P. siamense*, *P. naevatum* p.p.). An identification key and a taxonomic synopsis are provided.

KEY WORDS: Orchidaceae, *Pomatocalpa,* Taxonomy, Principal component analysis, Flora of Southeast Asia.

INTRODUCTION

The orchid genus *Pomatocalpa* Breda, distributed from Sri Lanka to Fiji, south to Northern Australia and north to Southern China and Taiwan, is usually considered to encompass 35-40 epiphytic species (Seidenfaden, 1988). It has never been the subject of a proper monograph. In his publication on the "vandoid" orchid genera of Thailand, Seidenfaden (1988) stated that he was still quite uncertain about the circumscription of especially the entities around *P. latifolium* (Lindl.) J. J. Sm. For example, he had some doubt if plants from the Philippines, assigned to *P. latifolium*, really belonged to this species. Additionally, descriptions and measurements of *P. latifolium* seem virtually identical to *P. naevatum* J. J. Sm., the most noticeable differences being the flower colour and the morphology of the tongue-shaped ornament on the back wall of the spur (Comber, 1990). Indeed, in my ongoing work on a monograph of *Pomatocalpa*, preliminary examination of herbarium specimens has suggested overlapping variation in most characters within the "*P. maculosum* complex", i.e. the complex tentatively consisting of *P. andamanicum* (Hook. f.) J. J. Sm., *P. latifolium*, *P. koordersii* (Rolfe) J. J. Sm., *P. linearifolium* Seidenf., *P. maculosum* (Lindl.) J. J. Sm., *P. marsupiale* (Kraenzl.) J. J. Sm., *P. naevatum*, and *P. siamense* (Rolfe ex Downie) Summerh.

In the present study, the morphological variation within the *P. maculosum* complex is summarized by multivariate statistical analysis. The aim is to detect species boundaries, to identify reliable distinguishing characters, and to determine the correct nomenclature according to the accepted classification.

MATERIALS AND METHODS

Sixty-three herbarium specimens from AAU, AMES, BK, BM, K, L, and SING were tentatively identified as *P. andamanicum*, *P. koordersii*, *P. latifolium*, *P. linearifolium*, *P. maculosum*, *P. marsupiale*, *P. naevatum*, or *P. siamense* (Appendix 1). The tentative identifications were based on regional treatments according to the geographic origin of the material – thus Jayaweera (1981) for Sri Lanka, Seidenfaden (1988) for Thailand and the Andaman Islands, Seidenfaden and Wood (1992) for Peninsular Malaysia, Comber (2001) for Sumatra, Comber (1990) for Java, Wood and Cribb (1994) for Borneo, Valmayor (1984) for the Philippines, Thomas and Schuiteman (2002) for Sulawesi and Maluku, and O'Byrne (1994) for New Guinea.

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Thirty-seven quantitative and 5 binary morphological characters (Table 1) were scored from the specimens. Vegetative characters were measured by a ruler on the herbarium sheet. Leaf measurements were taken from the longest leaf on the sheet. For each specimen, one fresh, fully expanded flower from the proximal part of the inflorescence was soaked in hot water with a few drops of detergent added. The floral characters were then scored by means of an object micrometer and a low-power binocular microscope. For paired organs, the one to the right was consistently designated for measurement. Some of the measurements are defined in Fig. 1.

Table 1. List of the five binary characters (marked with asterisks) and the thirty-seven quantitative characters examined.

1. Leaf sheath index (cf. Fig. 1A).
2. Length of leaf (cm).
3. Maximum width of leaf (cm).
4. Length of leaf in relation to its maximum width.
5. Length of floral bract (mm).
6. Length of dorsal sepal (mm).
7. Width of dorsal sepal 1/4 from the base (mm).
8. Width of dorsal sepal at the middle (mm).
9. Width of dorsal sepal 1/4 from the apex (mm).
10. Length of dorsal sepal in relation to its maximum width.
11. Length of lateral sepal (mm).
12. Width of lateral sepal 1/4 from the base (mm).
13. Width of lateral sepal at the middle (mm).
14. Width of lateral sepal 1/4 from the apex (mm).
15. Length of lateral sepal in relation to its maximum width.
16. Length of petal (mm).
17. Width of petal 1/4 from the base (mm).
18. Width of petal at the middle (mm).
19. Width of petal 1/4 from the apex (mm).
20. Length of petal in relation to its maximum width.
21. Length of labellum mid-lobe (mm).
22. Maximum width of labellum mid-lobe (mm).
23. Length of labellum mid-lobe in relation to its maximum width.
*24. Apex of labellum mid-lobe acute (1) or subtruncate (0).
25. Maximum thickness of the labellum mid-lobe (mm).
*26. Mid-lobe (sub)erect (1) or curved (0).
*27. Papillae at base of the labellum mid-lobe present (1) or absent (0).
28. Length of front edge of labellum side lobe (mm), cf. Fig. 1B.
29. Length of hind edge of labellum side lobe (mm), cf. Fig. 1B.
30. Side lobe index (char. 28/29).
*31. Apex of side lobe rounded (1) or (sub)acute (0), cf. Fig. 1C.
*32. Hind edge of labellum sidelobe, producing a distinct sinus (1) or entire to irregular (0), cf. Fig. 1C.
33. Length of spur (mm), cf. Fig. 1B.
34. Maximum thickness of the spur front wall (mm), cf. Fig. 1B.
35. Total length of the tongue on the back-wall of the spur (mm), cf. Fig. 1D.
36. Width of back-wall tongue 1/4 from the base (mm).
37. Width of back-wall tongue at the middle (mm), cf. Fig. 1D.
38. Width of back-wall tongue 1/4 from the apex (mm).
39. Length of back-wall tongue in relation to its maximum width.
40. Length of junction between the back-wall tongue and the spur wall (mm), cf. Fig. 1D.
41. Depth of the sinus in the apex of the back-wall tongue (mm).
42. Length of ovary including pedicel (mm).

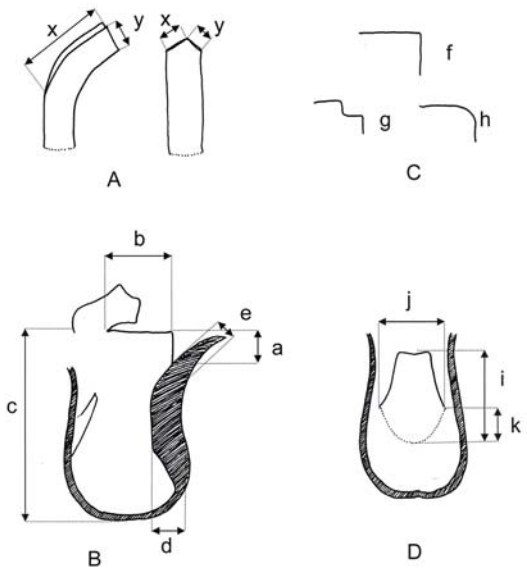

Fig. 1. Definitions of selected measurements. A: Leaf sheath index (x/y; where x = length of the opening of the leaf sheath, y = half the length of the abscission zone). B: longitudinal section through the labellum: a = length of front edge of side lobe; b = length of hind edge of side lobe; c = length of spur; d = maximum thickness of the spur front wall; e = maximum thickness of the labellum midlobe. C: apex of side lobe: f and g = (sub)acute; h = rounded; hind edge of labellum sidelobe producing a distinct sinus (g). D: transversal section through labellum: i = total length of the back wall tongue; j = width of back wall tongue; k = length of junction between the back wall tongue and the spur wall.

Principal components analysis (PCA) was chosen to summarize the morphological variation patterns. For general descriptions of this method, see e.g. Dunn and Everitt (1982), Manly (1986), Everitt and Dunn (1991). PCA has previously proved useful in morphometric studies of orchids (e.g., Reinhammar, 1995, 1998; Pelser et al., 2000; Palestina and Sora, 2002; Pedersen, 2004). It was preferred to other ordination methods, mainly because it allows for inclusion of binary and quantitative characters in the same analysis (Gower, 1966).

The program NTSYSpc (Rohlf, 2000) was used to perform PCA by extracting eigenvectors and eigenvalues from a correlation matrix after linear standardization (Gower, 1971) of the original data. The program Sigma Plot 8.01 was used for graphic display.

First, an analysis incorporating all tentative species and all 42 characters from Table 1 was conducted. Subsequently, separate analyses were made on the main subsets of specimens (designated according to the initial analysis) in order to enhance resolution in these groups. In all analyses incorporating all characters, it turned out that considerably less than 70% of the total variation was explained by the first two principal components in

the plots. In each of these cases, therefore, the characters of least importance for the first two principle components were identified (according to the coefficients of latent vectors during the analysis incorporating all characters), and a new PCA based on a reduced number of characters was conducted. In this way, the share of variation explained by the first two principal components was increased considerably. In cases where the tentatively accepted taxa did not separate well in the plots, a set of symbols representing the geographic origin of the specimens were plotted to check for geographically correlated variation.

Taxa were delimited according to the observed clustering of specimens in the PCA plots, and reliably distinguishing quantitative characters were identified by Student's t-test in the program PractiStat (Ashcroft and Pereira, 2003). A quantitative character was considered to distinguish reliably between two taxa, if the test result was significant at the 99.9% level. Binary characters were considered to distinguish reliably between taxa, if the variation did not overlap between taxa. Finally, the correct nomenclature could be established, partly through examination of type specimens.

RESULTS

The PCA that included all specimens revealed two main clusters of specimens (Fig. 2), completely separated along the second axis. One cluster, the "*P. latifolium* subcomplex", consists of *P. latifolium*, *P. marsupiale*, and *P. koordersii*, while the other cluster, the "*P. maculosum* subcomplex", consists of *P. andamanicum*, *P. linearifolium*, *P. maculosum*, *P. naevatum* and *P. siamense*. Loading on the first component was contributed mainly by the following characters: width of petal 1/4 from apex (95%), length of lateral sepal (94%), width of lateral sepal at the middle (94%), width of petal 1/4 from base (94%), width of dorsal sepal at the middle (93%), width of lateral sepal 1/4 from apex (93%), width of dorsal sepal 1/4 from apex (92%), width of petal at the middle (92%), width of dorsal sepal 1/4 from base (91%), and width of lateral sepal 1/4 from base (91%). Loading on the second component was contributed mainly by the apex of side lobe rounded or (sub) acute (83%), the maximum width of leaf (69%) and the length of labellum mid-lobe in relation to its width (62%). Ten characters were found to distinguish significantly between the two subcomplexes (Table 2: column A).

The PCA conducted on the *P. latifolium* subcomplex (defined according to Fig. 2, see above) revealed that Philippine and non-Philippine

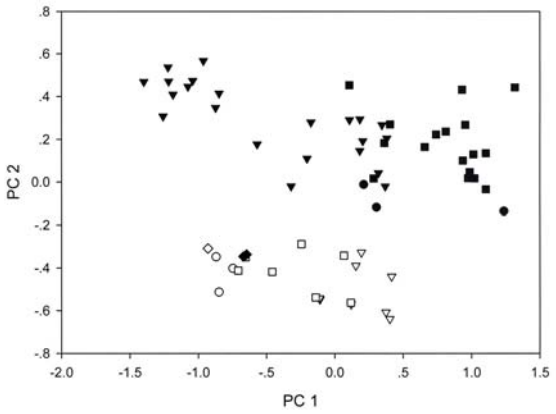

Fig. 2. Plot from the first two principal components from the PCA conducted on all examined specimens of all tentatively recognized taxa in the *Pomatocalpa latifolia*/*maculosa* complex. The variation was 55.9% along PC axis 1 and 13.8% along PC axis 2. The analysis was based on characters 1-3, 6-9, 11-14, 16-20, 22-23, 25, 27, 29, 31-35, 37-38, 40-42 (cf. Table 1). ● = *P. koordersii*; ○ = *P. andamanicum*; ▼ = *P. latifolium*; ▽ =*P. maculosum*; ■ = *P. marsupiale*; □ = *P. naevatum*; ♦ = *P. siamense*; ◇ = *P. linearifolium*.

specimens of *P. latifolium* s.l., respectively, form separate clusters, both of which are distinct from *P. marsupiale* and *P. koordersii* (Fig. 3). On the other hand, extensive overlap was found between *P. koordersii* and *P. marsupiale*. Loading on the first component was contributed mainly by the following characters: width of lateral sepal 1/4 from apex (96%), width of dorsal sepal 1/4 from apex (95%), width of petal 1/4 from apex (95%), width of dorsal sepal 1/4 from base (94%), width of dorsal sepal at the middle (94%), length of lateral sepal (94%), width of lateral sepal at the middle (94%), width of petal 1/4 from base (94%), width of petal at the middle (93%), and width of lateral sepal 1/4 from base (92%). Loading on the second component was contributed mainly by the mid-lobe (sub)erect or curved (93%), the apex of mid-lobe acute or subtruncate (93%), the maximum width of the mid-lobe (79%), and apex of side lobe rounded or (sub)acute (62%). Twenty-five characters were found to distinguish reliably between Philippine and non-Philippine *P. latifolium* s.l. (Table 2: column B). For nine of these characters, the variation did not overlap between the two geographic groups of specimens.

The geographically focused PCA conducted only on specimens tentatively identified as *P. marsupiale* or *P. koordersii* did not provide a clear resolution of the group (Fig. 4). Loading on the first component was contributed mainly by the width of lateral sepal at the middle (96%), and the width of dorsal sepal 1/4 from the apex (89%). Loading on the second component was contributed mainly by the length of

Table 2. The ability (n.s. = non significant, *= p<0.05, **= p<0.01, *** = p<0.001; o = overlap; n.o.= non overlap) of each character to distinquish correctly between various groups designated according to PCA analyses (S1: *Pomatocalpa latifolium* subcomplex; S2: *P. maculosum* subcomplex). For each of the columns B-H, the finally accepted names are indicated (dif: *P. diffusum*; fus: *P. fuscum*; mac: *P. maculosum*; mar: *P. marsupiale*; ma: *P. maculosum* ssp. *maculosum*; an: *P. maculosum* ssp. *andamanicum*). Characters are numbered according to Table 1. Bold numbers designate binary characters. Underlining indicates non-overlapping variation.

Char.no.	A S1><S2	B dif><fus	C ma><an	D mac><dif	E mac><fus	F mac><mar	G dif><mar	H fus><mar
1	***	***	n.s.	**	***	***	*	n.s.
2	***	*	n.s.	*	**	***	*	n.s.
3	***	n.s.	*	***	***	***	n.s	n.s.
4	**	n.s.	n.s.	*	n.s.	*	n.s	n.s.
5	n.s.	n.s.	n.s.	n.s	n.s.	*	**	*
6	**	***	***	*	n.s.	***	***	***
7	n.s.	***	***	***	n.s.	***	***	**
8	n.s.	***	***	***	n.s.	***	***	**
9	n.s.	***	***	***	n.s.	***	***	***
10	***	***	n.s.	***	n.s.	***	n.s	**
11	n.s.	***	***	***	n.s.	***	***	***
12	n.s.	***	***	**	n.s.	***	***	***
13	n.s.	***	***	**	n.s.	***	***	***
14	n.s.	***	***	**	n.s.	***	***	***
15	n.s.	n.s.	n.s.	n.s	n.s.	n.s.	*	n.s.
16	***	n.s.	***	n.s	n.s.	***	***	***
17	n.s.	***	***	***	*	***	***	**
18	n.s.	***	***	***	*	***	***	**
19	n.s.	***	***	***	n.s.	***	***	**
20	**	***	n.s.	***	n.s.	**	***	**
21	n.s.	***	**	*	***	n.s.	**	***
22	***	***	n.s.	***	***	***	n.s	***
23	***	n.s.	*	***	***	n.s.	**	**
24	o	n.o.	o	o	n.o.	o	o	n.o.
25	***	*	**	n.s	**	***	***	**
26	o	n.o.	o	o	n.o.	o	o	n.o.
27	o	o	o	o	o	o	o	o
28	*	*	n.s.	n.s	n.s.	**	**	n.s.
29	n.s.	*	*	***	n.s.	n.s.	***	*
30	**	n.s.	n.s.	*	**	*	n.s	n.s.
31	o	o	o	n.o.	o	n.o.	n.o.	o
32	o	o	o	n.o.	o	o	o	o
33	n.s.	***	***	***	n.s.	***	***	***
34	n.s.	***	**	***	n.s.	**	***	n.s.
35	n.s.	***	***	***	n.s.	n.s.	***	n.s.
36	n.s.	*	**	n.s	n.s.	**	***	n.s.
37	n.s.	***	**	***	n.s.	*	***	n.s.
38	n.s.	***	**	**	n.s.	*	***	n.s.
39	n.s.	ns	n.s.	n.s	n.s.	n.s.	n.s	n.s.
40	n.s.	***	***	***	**	n.s.	***	n.s.
41	***	ns	n.s.	***	**	***	n.s	n.s.
42	***	***	**	n.s	***	***	***	***

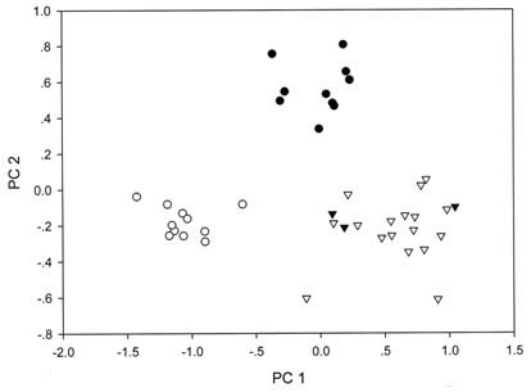

Fig. 3. Plot from the first two principal components from the PCA conducted on all examined specimens of the *Pomatocala latifolium* subcomplex. The variation was 54.6% along PC axis 1 and 14.4% along PC axis 2. The analysis was based on characters 1-2, 5-29, 31-38, 40, 42 (cf. Table 1). ● = *P. latifolia* (Philippines); ○ = *P. latifolium* (non Philippines); ▼ = *P. koordersii*;▽ = *P. marsupiale*.

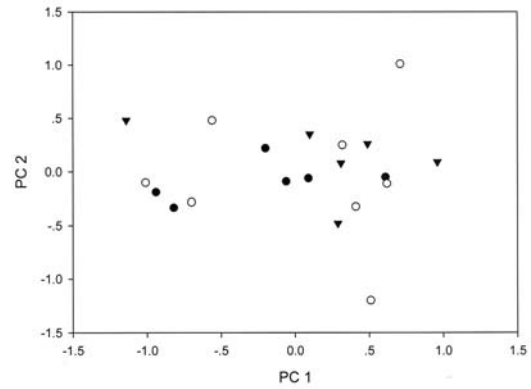

Fig. 4. Plot from the first two principal components from the PCA conducted on all examined specimens tentatively identified as *Pomatocalpa koordersii* or *P. marsupiale*, indicating the geographic origin of specimens. The variation was 43.3% along PC axis 1 and 22.8% along PC axis 2. The analysis was based on characters 1, 3-4, 6-20, 25, 28, 36-38, 41 (cf. Table 1). ▼ = specimens from Sulawesi; ○ = specimens from Maluku; ● = specimens from New Guinea.

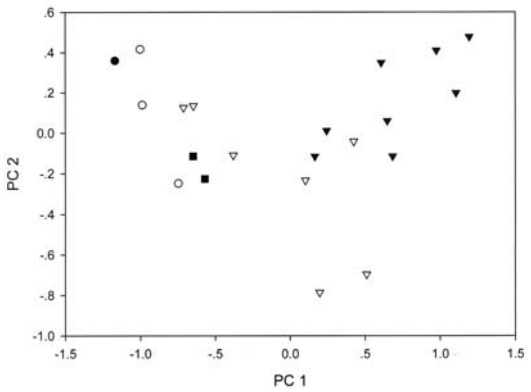

Fig. 5. Plot from the first two principal components from the PCA conducted on all examined specimens of the *Pomatocalpa maculosa* subcomplex. The variation was 57.4% along PC axis 1 and 12.3% along PC axis 2. The analysis was based on characters 2-4, 6-9, 11-19, 25, 30, 33-38, 40, 42 (cf. Table 1). ● = *P. linearifolium*; ○ = *P. andamanicum*; ▼ = *P. maculosum*;▽ = *P. naevatum*; ■ = *P. siamense.*

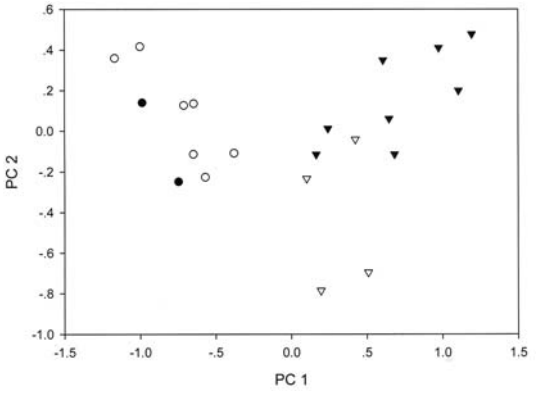

Fig. 6. Plot from the first two principal components from the PCA conducted on all examined specimens of the *Pomatocalpa maculosum* subcomplex, indicating the geographic origin of specimens. The variation was 57.4 % along PC axis 1 and 12.3 % along PC axis 2. The analysis was based on characters 2-4, 6-9, 11-19, 25, 30, 33-38, 40, 42 (cf. Table 1). ● = specimens from the Andaman Islands; ○ = specimens from Mainland Asia (Thailand to Peninsular Malaysia); ▼ = specimens from Sri Lanka; ▽ = specimens from Java.

petal in relation to its maximum width (87%), the length of dorsal sepal (84%), the length of leaf in relation to its maximum width (83%), the length of lateral sepal (67%), and the length of petal (60%). No characters were found to distinguish significantly between the tentatively recognized species.

The PCA conducted on the *P. maculosum* subcomplex (defined according to Fig. 2, see above) demonstrated two loose clusters with overlapping variation between *P. maculosum* and *P. naevatum* (Fig. 5). The few specimens of *P. andamanicum*, *P. linearifolium*, and *P. siamense* assumed peripheral positions in the same group, clustering most closely together with specimens of *P. naevatum* from Thailand. Loading on the first component was contributed mainly by the following characters: the width of lateral sepal ¼ from apex (94%), the length of petal (94%), the width of petal 1/4 from apex (93%), the width of dorsal sepal 1/4 from apex (92%), the width of dorsal sepal at the middle (91%), and the width of lateral sepal at the middle (91%). Loading on the second component was contributed mainly by the length of leaf in relation to it maximum width (91%), the maximum width of leaf (74%), the length of leaf (73%) and the side lobe index (65%).

When the symbols indicating tentative identifications in Fig. 5 were substituted with symbols indicating the geographic origins of specimens (Fig. 6), the two loose clusters separated along the first axis reflected the geography. The left-hand group consists of specimens from a rather

coherent area including the Andaman Islands and Mainland Asia (Thailand to Peninsular Malaysia). The right-hand group is composed of specimens from Java and Sri Lanka (incompletely separated along the second axis). This distinction between two groups is corroborated when observing the plot of PC axes 1 and 3 against each other (Fig. 7). Fifteen characters were found to distinguish significantly between the two geographically defined groups (Table 2: column C). For three of these characters, the variation did not overlap between the two groups of specimens.

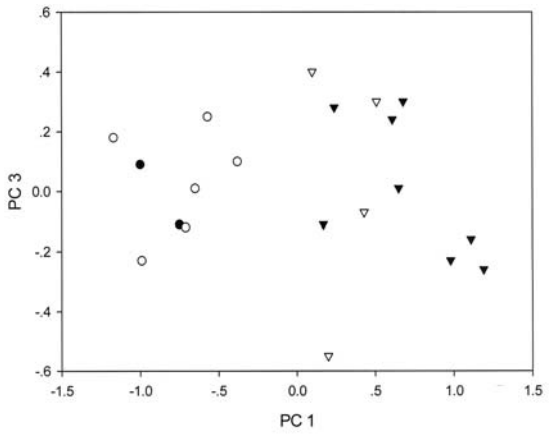

Fig. 7. Plot from the first and third principal components from the PCA conducted on all examined specimens of the *Pomatocalpa maculosum* subcomplex, indicating the geographic origin of specimens. The variation was 57.4% along PC axis 1 and 6.6% along PC axis 3. The analysis was based on characters 2-4, 6-9, 11-19, 25, 30, 33-38, 40, 42 (cf. Table 1). ● = specimens from the Andaman Islands; ○ = specimens from Mainland Asia (Thailand to Peninsular Malaysia); ▼= specimens from Sri Lanka; ∇ = specimens from Java.

DISCUSSION AND CONCLUSIONS

Delimitation of species

In the various PCA analyses, four groups of specimens formed particularly well-defined clusters, and a number of characters were found to distinguish reliably between the groups. The four groups can be characterized as follows:

1. The first group consists of all specimens tentatively identified as *P. andamanicum*, *P. linearifolium*, *P. maculosum*, *P. naevatum*, or *P. siamense* (Fig. 2). This group is characterized by the combination of tubular leaf sheaths (index = 1.0-1.8); longest leaf ca. 2.2 cm wide; dorsal sepal 3.4-5.5 mm long; petals 1.0-1.8 mm wide 1/4 from the base and 1.3-2.5 mm wide 1/4 from the apex; labellum mid-lobe acute, curved; apex of side lobes rounded; front wall of the spur 0.2-1.5 mm thick; junction between the back wall tongue and the spur wall 0.7-1.4 mm long (more than 1/3 the length of the tongue); ovary including pedicel 3.0-6.5 mm long.
2. The second group consists of all specimens tentatively identified as *P. koordersii* or *P. marsupiale* (Fig. 3). This group is characterized by the combination of usually semi-open leaf sheaths (index = 1.3-4.0); longest leaf 2.4-4.8 cm wide; dorsal sepal 5.5-7.8 mm long; petals 1.5-2.5 mm wide 1/4 from the base and 2.1-3.2 mm wide 1/4 from the apex; labellum mid-lobe acute, curved; apex of side lobes (sub)acute; front wall of the spur 0.8-1.6 mm thick; length of junction between the back wall tongue and the spur wall 0.5-1.5 mm (usually more than 1/3 the length of the tongue); ovary including pedicel 7.0-15.5 mm long.
3. The third group consists of all Philippine specimens tentatively identified as *P. latifolium* (Fig. 3). This group is characterized by the combination of usually semi-open leaf sheaths (index = 2.5-4.0); longest leaf 2.3-4.0 cm wide; dorsal sepal 4.0-5.2 mm long; petals 1.4-1.9 mm wide 1/4 from the base and 1.7-2.5 mm wide 1/4 from the apex; labellum mid-lobe acute, (sub)erect; apex of side lobes rounded to (sub)acute; front wall of the spur 1.0-1.3 mm thick; junction between the back wall tongue and the spur wall 1.0-1.4 mm long (more than 1/3 the length of the tongue); ovary including pedicel 5.0-8.6 mm long. According to published illustrations this entity has petals with purplish brown spots (Valmayor, 1984).
4. The fourth group consists of all non-Philippine specimens tentatively identified as *P. latifolium* (Fig. 3). This group is characterized by the combination of usually tubular leaf sheaths (index = 1.0-2.4); longest leaf 1.9-4.1 cm wide; dorsal sepal 3.1-4.5 mm long; petals 0.7-1.3 mm wide 1/4 from the base and 0.9-1.6 mm wide 1/4 from the apex; labellum mid-lobe acute, curved; apex of side lobes (sub)acute; front wall of the spur 0.2-0.7 mm thick; junction between the back wall tongue and the spur wall 0.3-0.5 mm long (less than 1/3 the length of the tongue; ovary including pedicel 3.0-3.5 mm long. According to published illustrations, this entity has unspotted petals with purplish brown margins (Seidenfaden, 1988; Comber, 1992).

Because of the clear distinction of these groups in the PCA analyses, and because several diagnostic characters exist for all of them (Table 2), it seems appropriate to recognize them as separate species. The oldest available names for groups 1 and 2 are *P. maculosum* (Lindl.) J. J. Sm. and *P. marsupiale* (Kraenzl.) J.J.Sm., respectively. The nomenclatural situation for groups 3 and 4, on the other hand, is more problematic and in need of closer scrutiny.

The Philippine specimens tentatively identified as *P. latifolium* (i.e., group 3) seem to match the

type of *P. fuscum* (Lindl.) J. J. Sm. (unknown geographic origin, deposited at K-Lindl). However, while the labellum mild-lobe was found to be subtruncate in all specimens of Philippine "*P. latifolium*" included in the analysis, the type of *P. fuscum* has flowers with an acute labellum mid-lobe as well as flowers with a subtruncate labellum mid-lobe. To test the importance of the character in question (no. 24 in Table 1), a new PCA of the *P. latifolium* subcomplex was run without inclusion of this character. Since the result of the new analysis (Fig. 8) was almost identical to the first (Fig. 3), it can be concluded that variation in the apex morphology of the labellum mid-lobe should be allowed and, consequently, that the name *P. fuscum* (Lindl.) J. J. Sm. can be adopted as the oldest available species name for the Philippine taxon previously referred to *P. latifolium*.

The specimens from southern Thailand, Peninsular Malaysia, Sumatra, Java, and Borneo tentatively identified as *P. latifolium* (i.e., group 4) indeed match the type of *P. latifolium* (Lindl.) J. J. Sm. – a name that was widely accepted for many years. However, when van Steenis-Kruseman & Veldkamp (1991) discovered a second copy of "Genera et Species Orchidearum fasc. IV" (Breda, 1830), thus demonstrating effective publication of *P. diffusum* Breda, the name *P. latifolium* had to be replaced by the latter.

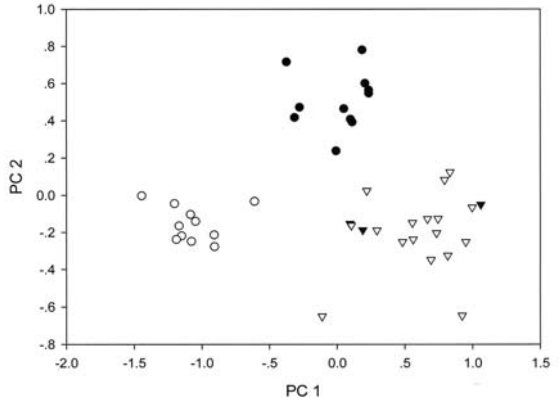

Fig. 8. Plot from the first two principal components from the PCA conducted on all examined specimens of the *P. latifolium* subcomplex. The variation was 56.2 % along PC axis 1 and 12.5 % along PC axis 2. The analysis was based on characters 1-2, 5-23, 25-29, 31-38, 40, 42 (cf. Table 1.). ● = *P. latifolium* (Philippines); ○ = *P. latifolium* (non Philippines); ▼ = *P. koordersii*; ▽ = *P. marsupiale*.

Delimitation of taxa below species level

The variation patterns within *P. marsupiale* (group 2), *P. diffusum* (group 3), and *P. fuscum* (group 4), clearly does not support any recognition of infraspecific taxa (cf. Figs. 3-4). On the other hand, *P. maculosum* (group 1) shows some interesting internal variation patterns that deserve special attention.

In Fig. 5 (displaying variation within *P. maculosum* as circumscribed above), the tentatively recognized *P. linearifolium*, *P. andamanicum*, *P. siamense* and *P. naevatum* form discrete (but immediately adjoining) groups, while a small overlap is seen between the tentatively recognized *P. naevatum* and *P. maculosum*. Seidenfaden (1988) used the shape and apex of the back wall tongue to distinguish between *P. naevatum*, *P. andamanicum*, *P. siamense*, and *P. linearifolium*. However, according to my own measurements of the back-wall tongue (including its total length, width 1/4 from the base, width at the middle, width 1/4 from the apex, and the depth of its apical sinus) from all available specimens, none of these characters distinguish reliably between the taxa concerned (cf. their relatively small contributions to variation along the PC axes 1 and 2 in the PCA plot in Fig. 5).

Seidenfaden (1988) furthermore used the swollen tissue below the stigmatic cavity to separate *P. andamanicum* and *P. linearifolium* from the other taxa of this group. According to my observations, however, the expression of this character is affected by drying. Additionally, most of the taxa within this group are very sparsely sampled and must be expected to be more variable than evident from Fig. 5. Consequently, it must be concluded that the traditional application of taxonomic boundaries within the group of taxa now united under *P. maculosum* is unreliable and should be rejected.

If the tentatively recognized taxa within *P. maculosum* as presently circumscribed (i.e., group 1 above) are disregarded, and the variation is observed from a geographic point of view, a more distinct pattern emerges (Figs. 6 & 7). Now, the two loose clusters separated along the first axis reflect the geographic origin of specimens. Thus, one cluster encompasses all specimens from the Andaman Islands and mainland Asia and the other one encompasses all specimens from Java and Sri Lanka. In the plot against the first and second axes, two Javanese specimens are somewhat separated from the rest of the latter group (Fig. 6). In the plot against the first and third axes, however, only one specimen is peripheral in the group (Fig. 7). Three morphological characters show discrete variation between the two geographic groups, viz. the length of the lateral sepals, the length of the petals, and the petal width 1/4 from the apex (Table 2: column C). However, it should be borne in mind that these three characters may not be completely independent, but rather be different expressions of a general difference in flower size. The phenomenon of two

rather highly variable taxa that are only reliably separated through a minor difference in flower size suggests that these taxa should be recognized as varieties or subspecies rather than species. Because of their different geographic ranges, the subspecific level appears more appropriate than the varietal level. Consequently, two subspecies should be recognized, viz. *P. maculosum* subsp. *Maculosum* and *P. maculosum* subsp. *andamanicum* (comb. et stat. nov., see below).

Identification key to accepted taxa

1a. Labellum mid-lobe (sub)erect, obovate, usually subtruncate to broadly emaginate ……...…….. *P. fuscum*

1b. Labellum mid-lobe more or less curved, triangular to triangular-ovate, acute to obtuse 2

2a. Ovary (including pedicel) 7.0-15.5 mm long. Dorsal sepal 5.5-7.8 mm long. Leaf sheaths usually semi-open..... ……...……. *P. marsupiale*

2b. Ovary (including pedicel) 3.0-6.5 mm long. Dorsal sepal 3.4-5.5 mm long. Leaf sheaths usually tubular …….…..... 3

3a. Junction between back wall tongue and spur wall 0.3-0.5 mm long, usually less than ⅓ the length of the tongue. Petals unspotted, but with purplish brown margins, usually obovate-oblong. Labellum sidelobes (sub)acute, hind edge of each side lobe usually producing a distinct sinus ……..... *P. diffusum*

3b. Junction between back-wall tongue and spur wall 0.7-1.4 mm long, usually 1/3 to 1/2 the length of the tongue. Petals with purplish brown spots, usually ovate. Labellum sidelobes rounded, hind edge of each side lobe not producing a distinct sinus (*P. maculosum*) ……..... 4

4a. Flowers large (lateral sepal 3.9-5.1 mm long; dorsal sepal 4.0-5.5 mm long; petals 3.4-4.5 x 1.9-2.5 mm) …. ...…….…..... *P. maculosum* subsp. *maculosum*

4b. Flowers small (lateral sepal 3.3-3.8 mm long; dorsal sepal 3.4-4.2 mm long; petals 2.8-3.1 x 1.3-1.8mm) …… ….…..... *P. maculosum* subsp. *andamanicum*

Taxonomic synopsis

1a. ***Pomatocalpa maculosum*** (Lindl.) J. J. Sm. subsp. ***maculosum*** Natuurw. Tijdschr. Ned.-Indië 72: 35, 1912. – *Cleisostoma maculosum* Lindl., Gen. Sp. Orch. Pl : 227, 1833. – Type: Sri Lanka, sine loc., *Macrae 39* (holotype K-Lindl.!).

Pomatocalpa naevatum J.J.Sm., Natuurw. Tijdschr. Ned.-Indië 72: 106, 1912. – Syntypes (Java): Loemadjan, sine anno, *E. Connell s.n.* (BO 70316!); Tegal, sine anno, *Raciborski s.n.* (not located).

Distribution: Sri Lanka, Java.

1b. *Pomatocalpa maculosum* (Lindl.) J. J. Sm. subsp. *andamanicum* (Hook.f.) S. Watthana, comb. et stat. nov. *Cleisostoma andamanicum* Hook.f., Fl. Brit. Ind. 6: 71, 1896; *Pomatocalpa andamanica* (Hook.f.) J. J. Sm., Natuurw. Tijdschr. Ned.-Indië 72: 103, 1912. – Type: South Andaman Islands, 23 September 1867, *Kurz s.n.* (holotype CAL; isotypes K! P!).

Pomatocalpa linearifolium Seidenf., Opera Bot. 95: 98, 1988.–Type: Thailand, Krabi, Ao Luk, 14 Apr. 1969, *Chermsirivatana & Kasem 1335* (holotype BK!)

Cleisostoma siamense Rolfe ex Downie, Kew Bull. 1925: 406, 1925; *Pomatocalpa siamense* (Rolfe ex Downie) Summerh., Orchid Rev. 69: 372, 1961. – Type: Thailand, Lampang, Mae Tan, 360 m, 8 May 1912, *Kerr 301* (holotype K!).

Distribution: Laos, Thailand, Andaman Islands, Peninsular Malaysia.

2. ***Pomatocalpa marsupiale*** (Kraenzl.) J. J. Sm. Natuurw. Tijdschr. Ned.-Indië 72: 105, 1912. – *Cleisostoma marsupiale* Kraenzl. in K. Schum. & Hollr., Fl. Kai. Wilh. Land: 34-35, 1889. – Type: New Guinea, the area in front of the "II Augusta-station", September 1886, *Hollrung 743* (holotype probably destroyed at B).

Cleisostoma koordersii Rolfe, Kew Bull. 1899: 31, 1899; *Pomatocalpa koordersii* (Rolfe) J. J. Sm., Natuurw. Tijdschr. Ned.-Indië 72: 104, 1912. – Syntypes (Sulawesi, Minahassa): near Amoerang, sine anno, *Koorders 29500* (BO-76355! BO-76354! K!); Ratatok, sine anno, *Koorders 29501* (BO-76352! BO-76353! K!).

Distribution: Sulawesi, Maluku, New Guinea, North Australia, Solomon Islands, Vanuatu.

3. ***Pomatocalpa fuscum*** (Lindl.) J. J. Sm. Natuurw. Tijdschr. Ned.-Indië 72: 104, 1912. – *Cleisostoma fuscum* Lindl., J. Hort. Soc. V: 80, 1850. – Type: *sine loco et coll*., received from the East India Company in 1846 (holotype K-Lindl.!).

Distribution: The Philippines.

4. ***Pomatocalpa diffusum*** Breda. Gen. Sp. Orchid. Asclep., fasc. IV: t.16, 1830. – Type: icon in Gen. Sp. Orchid. Asclep. fasc. IV: Pl. 16, 1830 (lectotype, designated here); Java, Tjilangkahan and Tjoerock Dinding, *Kuhl & van Hasselt s.n.* (not located).

Cleisostoma latifolium Lindl., Edward's Bot. Reg. 26: 60, 1840; *Pomatocalpa latifolium* (Lindl.) J.J.Sm., Natuurw. Tijdschr. Ned.-Indië 72: 105, 1912. – Type: Singapore, sine loco et anno, *Loddiges s. n.* (K-Lindl.!).

Distribution: Peninsular Malaysia, Sumatra, Java, Borneo.

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Appendix 1: List of material studied

The list is arranged alphabetically after the tentatively recognized names (with their current status indicated in brackets). For those tentative taxa that were eventually split in the present study, a geographic disctinction of the material is incorporated.

Pomatocalpa andamanicum (synonym of *P. maculosum* subsp. *andamanicum*): Kurz *s. n.* (K, holotype), Prain *s. n.* (AMES), Ridley 15223 (K).

P. koordersii (synonym of *P. marsupiale*): Koorders 29500 (K, syntype), Kaudern *s. n.* (AMES, L).

P. latifolium/Philippines (synonym of *P. fuscum*): Celastino *s. n.*/Bur. Sci. 12129 (AMES), Taylor 329 (AMES), Lyon 23/sheets 1-3 (AMES), Pope *s. n.* (AMES), Ramos & Edano *s. n.*/Bur. Sci. 44263 (AMES), Ramos & Edano *s. n.*/Bur. Sci. 44264 (AMES), Weber 08 (AMES), Weber 600/sheets 1-2 (AMES).

P. latifolium/Thailand to Borneo (synonym of *P. diffusum*): Alston 13227 (BM), Collenette 683 (K), Curtis 1834 (SING), Evans *s. n.* (K), Glodham *s. n.* (SING), Maxwell 87-475 (AMES), Put 755 (AMES, L), Wray 2052 (K), Zollinger H. 1A (L), sine coll. et no./cult. Hort. Bot. Bog. Borneo (L-489102).

P. linearifolium(synonym of *P. maculosum* subsp. *andamanicum*): Chermsirivatana & Kasem 1335 (BK, holotype).

P. maculosum (now recognized as *P. maculosum* subsp. *maculosum*): C.P. 2343 (BM), Hooker 1867 (K), Jayaweera 34(1)/sheets 1-2 (AMES), Kostermans 23309 (L), Kostermans 24713 (K, L), Kostermans *s. n.* (L-489093).

P. marsupiale (accepted): Schlechter 14092 (K), Gibbs 6296 (BM, K), Janously 542 (L), Meijer 10108 (L), Millar 23826 (L), van Royen NGF 16349 (L), Schlechter 18424 (AMES), Taxopus 19 (L), de Vogel 3227 (L), sine coll./cult. Hort. Bot. Bog. II M.b. 160 (L489134), sine coll. et no./cult. Hort. Bot. Bog. (Sulawesi, L-489125; Sulawesi, L-489126; Ambon, Maluku, L-489131; Kai, Maluku, L-489132; Halmaheira, Maluku, L-489136; New Guinea, L-489140).

P. naevatum/Thailand (synonym of *P. maculosum* subsp. *andamanicum*): Geesink 6636 (K, L), Maxwell 74-410 (AAU).

P. naevatum/Java (synonym of *P. maculosum* subsp. *maculosum*): Comber 1269 (K), Comber 1547 (K), Leschenautt *s. n.* (L), sine coll. et no./cult. Hort. Bot. Bog., Java (L-489149).

P. siamense (synonym of *P. maculosum* subsp. *andamanicum*): Kerr 301 (K, holotype), Kerr 455 (K).

多變方形態計量分析處理蘭科植物 *Pomatocalpa maculosum* 複合群

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摘　　要

用主群體分析方法(PCA)來檢視 63 份暫定為 *P. linearifolium* Seidenf., *P. maculosum* (Lindl.) J. J. Sm., *P. marsupiale* (Kraenzl.) J. J. Sm., *P. naevatum* J. J. Sm., or *P. siamense* (Rolfe ex Downie) Summerh.的臘葉標本。分析項目包括 37 個定量及 5 個二元的特徵。於主群體分析結果中，依觀測到的標本群團界定分類群並確認識別特徵。同時經由模式標本檢驗建立正確之學名。共認定有四個種，也就是 *P. diffusum* Breda (*P. latifolium* 為其同物異名)，*P. fuscum* (Lindl.) J. J. Sm. (*P. latifolium* 為其同物異名)，*P. marsupiale* (*P. koordersii* 為其同物異名) 及 *P. maculosum*。而最後一種可再分為兩亞種，也就是 *P. maculosum* (Lindl.) J. J. Sm. subsp. *maculosum* (*P. maculosum*, *P. naevatyum* p.p.為其同物異名)及 *P. maculosum* (Lindl.) J. J. Sm. subsp. *andamanicum* (Hook.f.) Watthana (*P. andamanicum*, *P. linearifolium*, *P. siamense*, *P. naevatum* p.p.為其同物異名)。本文並提供檢索表及分類綱要。

關鍵詞：蘭科、*Pomatocalpa*、分類學、主群體分析、東南亞植物誌。

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