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MORPHOLOGICAL AND MORPHOMETRIC ANALYSIS OF GENUS *ERIOBOTRYA* LINDL. (ROSACEAE)

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ABSTRACT

Morphometric analysis based on 40 morphological (quantitative and qualitative) characters were used to evaluate the patterns of morphological variations and to better understand the taxonomic relationship of the whole genus of *Eriobotrya*. Cluster analysis, principal component analysis and principal coordinate analysis were performed for both quantitative and qualitative morphological characters. Result of factor analysis revealed that leaf blade length and width, bract shape, bract length and width, sepal length, petal length and width, petal state, style number, fruit length and width were highly positive significant, whereas pedicel length and style state were highly negative significant. Cluster analysis revealed that all the taxa of the genus grouped into 4 clusters. Cluster 1 included 18 taxa (*E. bengalensis*, *E. bengalensis* var. *angustifolia*, *E. bengalensis* var. *intermedia*, *E. stipularis*, *E. dubia*, *E. serrata*, *E. obovata*, *E. poilanei*, *E. elliptica* var. *petelotii*, *E. longifolia*, *E. angustifolia*, *E. petiolata*, *E. deflexa*, *E. deflexa* var. *buisanensis*, *E. kwangsiensis*, *E. fulvicoma*, *E. cavaleriei* and *E. glabrescens*). Cluster II included 16 taxa (*E. henryi*, *E. seguinii*, *E. hookeriana*, *E. japonica*, *E.* × *daduheensis, E. malipoensis*, *E. elliptica*, *E. grandiflora*, *E. fragrans*, *E. fragrans* var. *furfuracea*, *E. prinoides, E. prinoides* var. *laotica*, *E. salwinensis*, *E. tengyuehensis*, *E. latifolia* and *E. glabrescens* var. *victoriensis*). Two species (*E. wardii* and *E. platyphylla*) formed a distinct cluster and considered to be doubtful to the genus. The quantitative and qualitative characters studies will be particularly useful for further identification and systematic of the genus *Eriobotrya*.

Keywords: Cluster analysis, *Eriobotrya,* morphometric analysis, species, systematic, taxonomy.

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INTRODUCTION

Morphological characterization has been widely used for taxonomic studies as well as plant classifications (Sokal and Sneath 1973). The method of cluster analysis (CA) based on similarity matrixes which produce hierarchical classification of taxa. Principal component analysis (PCA) used for reducing the dimensions of the original data and Principal coordianate analysis (PCoA) indicate the position of point relative to each other's, both are commonly used for screening the accession collections, taxonomic relationships and botanical systematic (Badenes *et al.* 2000). However, such morphometric studies have been conducted in the genera of *Potamogeton* (Kaplan and Marhold 2012), *Clerodendrum* L. (Deshmukh *et al.* 2012), *Hedera* L. (Ackerfield and Wen 2002).

Eriobotrya Lindl. (1821), is a genus belongs to the family Rosaceae (Potter *et al.* 2007), comprises about more than 30 taxa, and are widely distributed in China and southeast Asia (Vidal 1965, Yang *et al.* 2005). Taxon relationships, delimitations and classification within this genus are controversial and unclear. Several early treatments for the classification of *Eriobotrya* were based on leaf morphology (Yang 2005). Yu (1974) classified (13 taxa of the genus) them into 2 groups, based on leaf blade tomentose and without tomentose. Zhang *et al.* (1990) classified (15 taxa of the genus) them into 2 groups, based on autumn and winter flowering group. Gu and Spongberg (2003) described 14 species of *Eriobotrya* and classified them in China. Yang *et al*. (2007) proposed a new classification system and divided (15 taxa of the genus) into 3 groups, based on style number, stamens and leaf blade size. All of these studies were based on *Eriobotrya* species which is mostly recorded in China, whereas the species found in Southeast Asia were not studies and investigated. Recently, Yang *et al.* (2017) classified (22 taxa of the genus) them into 3 groups, based on leaf length (small, medium, and large size). Zhang *et al.* (2017) classified (25 taxa of the genus) them into 5 group based on 53 morphological characters. These studies were included some of the taxa from Southeast Asia, but the completed classification and species relationships of the whole genus are still unclear.

The aims of the present study are to use a standard statistical method of multivariate analysis: 1) to clarify morphological patterns of variations within the whole genus of *Eriobotrya*; 2) to reveal the most informative characters for the determination of taxa, and to assess their taxonomic relationship.

MATERIALS AND METHODS

The present study was based on 36 taxa of *Eriobotrya* (Table 1), with more than 300 specimens were analyzed. The examined number of specimens for each taxon ranged from 2 to 20, depending upon availability and a suitable structure of both vegetative and reproductive characters were included to decrease missing data for analysis. Although in each taxa, the type specimens were examined. These specimens deposited in the relevant herbaria (A, B, BM, CDBI, CANT, HITBC, HENU, HUH, HGAS, IBK, IBSC, K, KATH, KUN, K, L, LINN, M, N, NAS, NYBG, P, PE, SYS, TAIF, U, US, UPS, WU, WUK, YU).

A total of 40 quantitative and qualitative morphological characters were recorded and included in the numerical analysis (Table 2). Each specimen characters were measured 4-8 time and means were recorded. Measurements were performed on each specimen, using ImageJ software or a ruler. The macro-morphological and micro-morphological observations were analyzed and examined under optical microscope (Stemi DV4 and LEICA S8 AP0).

Cluster analysis and scatter plot analysis were performed using PAST software (Hammer *et al.* 2001). A principal coordinate analysis was conducted on the basis of all morphological characters by using the methodology of Nobis *et al.* (2016). A principal component analysis was performed on the basis of correlation matrix (Sokal and Sneath 1963). Each accession was marked with the symbol on the scatter plot. Factors with eigenvalues >1 were chosen according to the Kaiser criterions (Kaiser 1960). Quantitative data were analyzed to determined mean analysis, analysis of variance, standard variation and coefficient of variation using SPSS software.

Table 1. List of investigated taxa and their type specimens, herbarium and collection site.

No	Taxa	Type specimens	Herbaria with barcode	Collection site
1	*E. angustissima* Hook.f.	*J.D. Hooker & T. Thomson s.n.*	K000758406	India, Khasia
2	*E. bengalensis* (Roxb.) Hook.f.	*Wallich 668/2*	K001111550	India
3	*E. bengalensis (Roxb.)* Hook.f. var. *angustifolia* (Card.) J.E. Vidal	*F. Ducloux 4719*	P02143257	China, Yunnan
4	*E. bengalensis (Roxb.)*Hook.f. var. *intermedia* J.E. Vidal	*G. Forrest 17845*	E00072977	Myanmar
5	*E. cavaleriei* (H.Lév.) Rehder	*J. Cavalerie 3220*	E00011330	China, Guizhou
6	*E.* × *daduheensis* H.Z. Zhang ex W.B. Liao, Q. Fan & M.Y. Ding	*Q. Fan, 9292*	SYS00168451	China, Sichuan
7	*E. deflexa (Hemsl.)* Nakai	*A. Henry 498*	K000758389	Taiwan, Formosa
8	*E. deflexa* (Hemsley) Nakai var. *buisanensis* (Hayata) Hayata	*S. Sasak s.n.*	TAI!	Taiwan, Buizan
9	*E. dubia* (Lindl.) Decne.	*Wallich 668/1*	K001111549	Nepal
10	*E. elliptica* Lindl.	*F. Buchanan-Hamilton s.n.*	BM000521994	Nepal, Narainhetty
11	*E. elliptica* Lindl. var. *petelotii* J.E. Vidal	*Petelot s.n.*	P02143261	Vietnam, Kao Lay
12	*E. fragrans* Champ. ex Benth.	*J.G. Champion s.n.*	K000758384	China, Hong Kong
13	*E. fragrans* Champ. ex Benth. var. *furfuracea* J.E. Vidal	*A. Chevalier 38893*	P02143263	Vietnam, Nha Trang
14	*E. fulvicoma* W. Y. Chun ex W.B. Liao, F.F. Li & D.F. Cui	*Z. Huang 32257*	WUK0109531	China, Guangdong
15	*E. grandiflora* Rehder & E.H. Wilson	*Veitch Exped. 3506*	A00026472	China, Sichuan
16	*E. glabrescens* J.E. Vidal	*F. Kingdon-Ward 20616*	BM000602189	Myanmar, Burma
17	*E. glabrescens* J.E. Vidal var. *victoriensis* J.E. Vidal	*F. Kingdon-Ward 21915*	BM000602190	Myanmar, KachinState
18	*E. henryi* Nakai	*A. Henry 13018*	A00026474	China, Yunnan
19	*E. hookeriana* Decne.	*M.D. Anderson 490*	P02143268	India, Sikkim
20	*E. japonica* (Thunb.) Lindl.	*Thunberg s.n.*	UPS-THUNB11908	Japan
21	*E. kwangsiensis* Chun	*Z. Huang 39423*	IBK00061038	China, Guangxi
22	*E. latifolia* Hook.f.	*T. Lobb s.n.*	K000758400	Myanmar,

23	*E. longifolia* (Decne.) Hook.f.	*Griffith 2093*	P02143220	Moalmayne Bangladesh, Mishmi Hills
24	*E. malipoensis* K.C. Kuan	*C.W. Wang & Y. Liu 86318*	PE00004573	China, Yunnan
25	*E. obovata* W.W. Sm.	*E.E. Maire 2450*	E00011331	China, Yunnan
26	*E. petiolata* Hook.f.	*J.D. Hooker s.n.*	K000758394	India, Sikkim
27	*E. platyphylla* Merr.	*F. Kingdon-Ward 10205*	A00026485	Myanmar, Upper Burma
28	*E. poilanei* J.E. Vidal	*E. Poilanei 22591*	P02143226	Vietnam, Haut Donnai
29	*E. prinoides* Rehder & E.H. Wilson	*A. Henry 9878*	A00026476	China, Yunnan
30	*E. prinoides* Rehder & E.H. Wilson var. *laotica* J.E. Vidal	*E. Poliane 2243*	P02143229	Laos, Xieng Khouang
31	*E. salwinensis* Hand.-Mazz.	*H.R.E. von Handel-Mazzetti 9573*	WU0059392	China, Yunnan
32	*E. seguinii* (H.Lév.) Cardot ex Guillaumin	*J. Séguin & R.P. Bodinier 2617*	E00011359	China, Guizhou
33	*E. serrata* J.E. Vidal	*E. Poilane 2345*	P02143235	Laos, Xièng Khouang
34	*E. stipularis* Craib	*A.F.G. Kerr 14125*	K000758408	Thailand, Siam
35	*E. tengyuehensis* W.W. Sm.	*G. Forrest 9857*	E00011333	China, Yunnan
36	*E. wardii* C.E.C. Fisher	*F. Kingdon-Ward 7618*	K000758392	Myanmar, Namkia Moutains

Table 2. Morphological characters, taxonomic code, mean/average, standard deviation and variance measure in the genus *Eriobotrya.*

No	Character	Unit	Taxonomic Code	Min.	Max.	Mean	st. deviation	Variance
1	Leaf blade length	Cm		4.43	29.83	15.2384	5.85	34.2
2	Leaf blade width	Cm		1.58	15.36	5.66	3.01	9.12
3	Petiole length	Cm		entire or .5	4.49	2.2676	1.114	1.24
4	Lateral vein	Count	<10 (0); 10-20 (1); >20 (2)					
5	Leaf serration	Count	<15 (0); 15-30 (1); >30 (2)					
6	Blade length/Blade width	Ratio						
7	Petiole Length/Blade width	Ratio						
8	Leaf blade abaxially tomentose	Code	Glabrous (0); Tomentose (1)					
9	Petiole state	Code	Glabrous (0); Tomentose (1)					
10	Inflorescence size	Cm		2.42	16.77	8.06	3.46	12.03
11	Inflorescence type	Code	Contracted (0); Spreading (1)					
12	Bract shape	Code	Linear or lanceolate (0); Ovate (1), Other (2)					
13	Bract length	Cm		0.2	0.61	0.3532	0.117	0.014
14	Bract width	Cm		0.04	0.33	0.1548	0.079	0.006
15	Pedicel length	Cm		sessile or 0	0.66	0.2239	0.1666	0.028
16	Pedicel state	Code	Glabrous (0); Tomentose (1)					
17	Calyx (glabrous or tomentose)	Code	Glabrous (0); Tomentose (1)					
18	Sepal shape	Code	Triangular or trangular ovate (0); Ovate or rounded (1)					
19	Sepal length	Cm		0.13	0.35	0.2216	0.0617	0.004
20	Sepal width	Cm		0.09	0.65	0.1873	0.094	0.009

21	Sepal inside surface	Code	Glabrous (0); Tomentose (1)					
22	Sepal outside surface	Code	Glabrous (0); Tomentose (1)					
23	Petal shape	Code	Obovate (0); Ovate (1); other (2)					
24	Petal at base	Code	Glabrous (0); slightly pilose or woolly (1); Villous (2)					
25	Petal Length	Cm		0.27	0.94	0.562	0.188	0.036
26	Petal width	Cm		0.2	0.64	0.3835	0.132	0.018
27	Petal length/Petal width	Ratio						
28	Indulendum of Ovary	Code	Glabrous (0); Villous (1)					
29	Style number	Code	Consistently 2 (0); 2-4 (1); upto 5 (2), consistently 5 (3)					
30	Style state	Code	Free (0); Connate/fused (1)					
31	Style at base	Code	Glabrous (0); Villous (1)					
32	Fruit length	Cm		1.25	2.01	1.522	0.204	0.042
33	Fruit width	Cm		0.53	2.29	1.277	0.4529	0.205
34	Fruit length/Fruit width	Ratio						
35	Tree habit	M	<5 (0); 5-10 (1); >10 (2)					
36	Stamens	Code	10-15 (0); 15-20 (1); >20 (2)					
37	Stipule state	Code	Cuducous (0); Persistent (1)					
38	Stipule shape	Code	Linear or lanceolate (0); elliptic (1), Other (2)					
39	Stipule length	Cm		0.33	2.05	0.989	0.4117	0.17
40	Stipule width	Cm		0.25	1.24	0.695	0.3188	0.102

RESULTS

Cluster analysis: Cluster analysis was performed on 40 quantitative and qualitative characters resulted, the separation of 36 taxa of the genus grouped into 4 clusters. The first main cluster was further divided into 4 subgroups; Subgroup I consist of *E. bengalensis*, *E. bengalensis* var. *angustifolia*, *E. bengalensis* var. *intermedia*, *E. stipularis* and *E. dubia* (Plate 1).

Subgroup II consists of *E. serrata*, *E. obovata*, *E. poilanei*, and *E. elliptica* var. *petelotii* (Plate 2). Subgroup III consists of *E. longifolia*, *E. angustifolia*, and *E. petiolata* (Plate 3). Subgroup IV consists of *E. deflexa, E. deflexa* var. *buisanensis, E. cavaleriei, E. fulvicoma, E. glabrescens,* and *E. kwangsiensis* (Plate 4). In cluster analysis, the taxa were clearly separated on the basis of first or second component or both (Figure 1). Both PCA and PCoA analysis were strongly support the cluster analysis (Figure 2 and 3).

The second main cluster was also further divided into 4 subgroups; Subgroup V consists of *E. japonica*, *E. × daduheensis* and *E. malipoensis* (Plate 5). Subgroup VI consists of *E. henryi, E. seguinii, E. prinoides*, *E. prinoides* var. *laotica* and *E. hookeriana* (Plate 6 and 7). Subgroup VII consists of *E. fragrans*, *E. fragrans* var. *furfuracea*, *E. elliptica, E. grandiflora*, and *E. salwinensis* (Plate 8). Subgroup VIII consists of *E. tengyuehensis*, *E. latifolia* and *E. glabrescens* var. *victoriensis* (Plate 9). *E. wardii* and *E. platyphylla* formed a distinct cluster (Cluster III and IV) (Plate 8).

Principal component analysis (PCA) and Principal coordinate analysis (PCoA): Fourty quantitative and qualitative characters with taxonomic code, mean, standard deviation, and variance are illustrated in (Table 3). In principal component analysis, the first 12 principal component accounted for 84.8329 % of total variances, whereas the first 2 main principal components account for 17.1 % and 12.186 % respectively. The loading of the first to four principal's components are presented in Table 2. The factor loading of > 0.6 was considered as significant. Ten characters showed highest correlation with the first axis, while two characters showed highest correlation with the second axis. Twelve characters showed that the positive factor loading > 0.6 on the first and second axis and included leaf length & width, bract shape, bract length and width, sepal length, petals length and width, petal state, style number, fruit length and width, whereas two characters showed negative factor loadings that > -0.6 on the second axis and included pedicel length and style state (free or connate). In addition, six characters showed that the positive factor loading > 0.6 on the third and fourth axis and these included pedicel state (glabrous or tomentose), calyx state (glabrous or tomentose), sepals outer surface, leaves abaxially tomentose or glabrous, petioles state (tomentose or glabrous), fruit length/fruit width, while there is no such characters that found to be listed in the negative factor loading that >-0.6 on the third and fourth axis.

Principal coordinate analysis (PCoA) was clearly separated the taxa on the basis of position on both side of the axis (PCoA eigenvalues and cumulative varianceare illustrated in Suppl. S2). PCoA scatter plot analysis supports the results of PCA analysis (Figure 1 and 2).

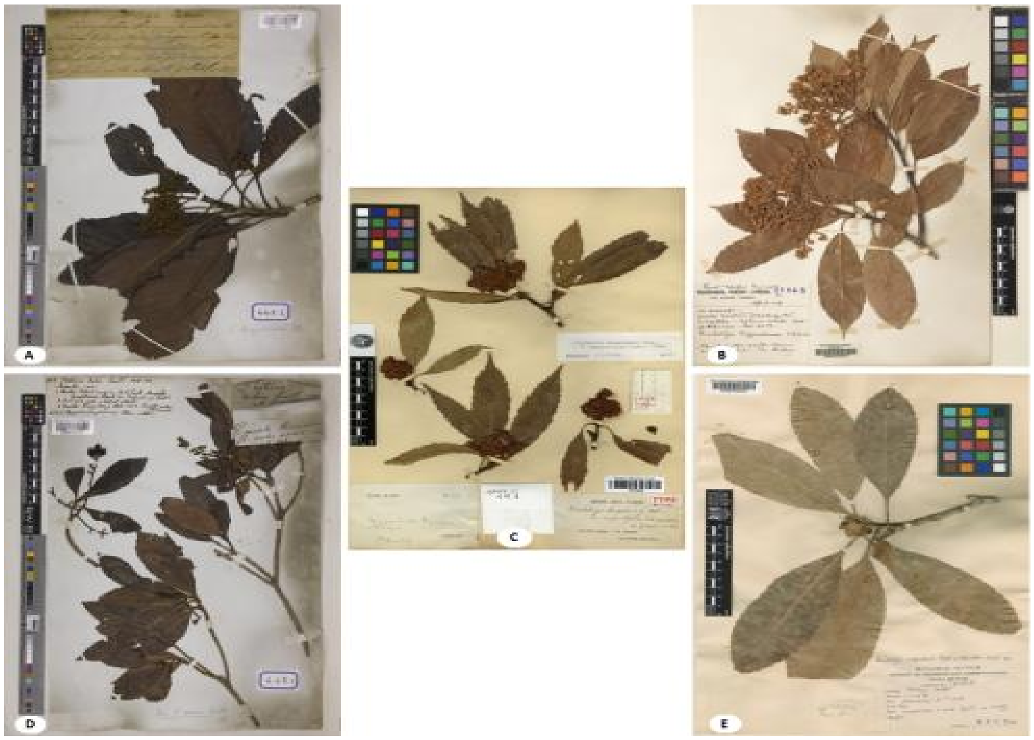

Plate 1. Morphological relationships among closely related species A). *E. bengalensis*, B). *E. bengalensis* var. *intermedia,* C). *E. bengalensis* var. *angustifolia*, D). *E. dubia* and E). *E. stipularis.* See Table 1 for details of the type specimens.

Plate 2. Morphological relationships among closely related species A). *E. serrata*, B). *E. elliptica* var. *petelotii,* C). *E. poilanei*, D). ~~*E. dubia,* E)~~ *E. obovata.* See Table 1 for details of the Type specimens.

Plate 3. Morphological relationships among closely related species A). *E. angustifolia*, and B). *E. longifolia.* See Table 1 for details of the type specimens.

Plate 4. Morphological relationships among closely related species A). *E. deflexa*, B). *E. deflexa* var. *buisanensis,* C). *E. glabrescens*, D). *E. cavaleriei,* E). *E. kwangsiensis,* andF). *E. fulvicoma.* See Table 1 for details of the type specimens.

Plate 5. Morphological relationships among closely related species A). *E. japonica*, B). *E. malipoensis,* and C). *E.* × *daduheensis.* See Table 1 for details of the type specimens.

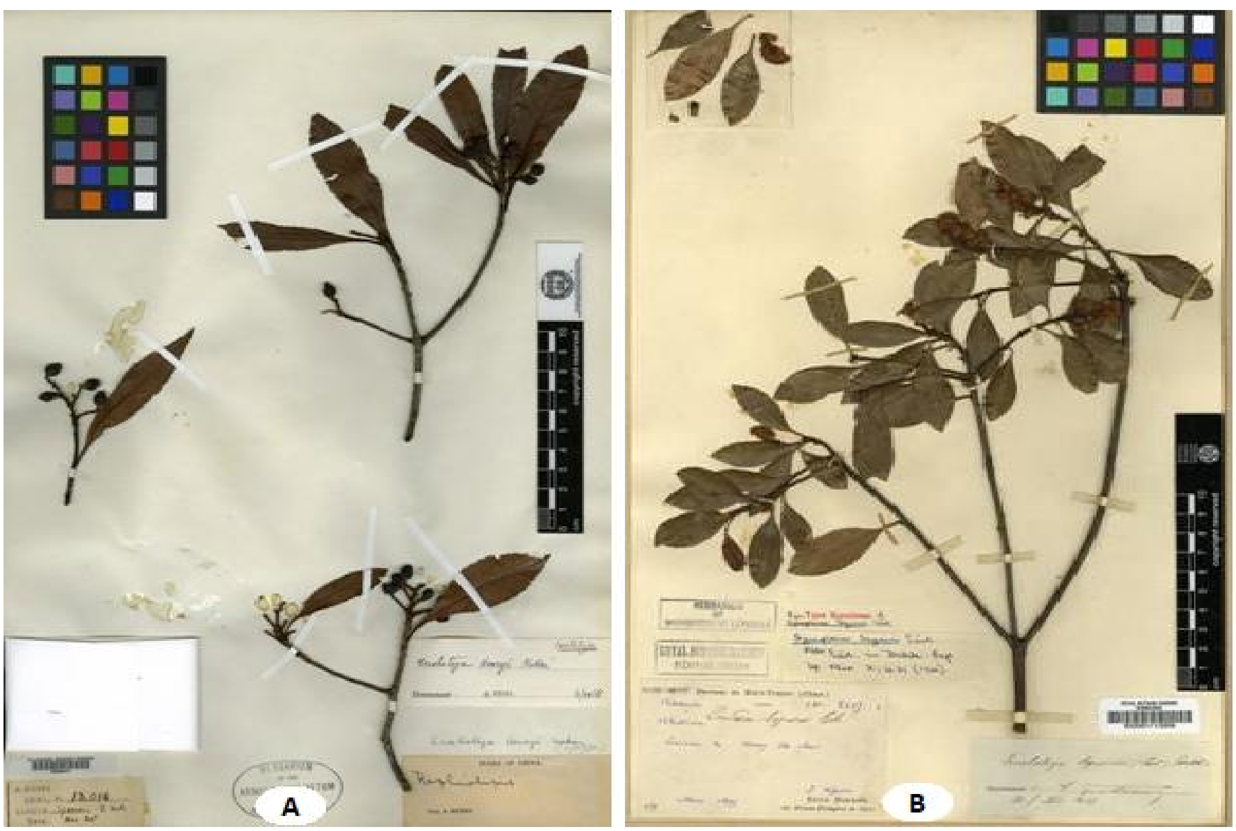

Plate 6. Morphological relationships among closely related species A). *E. henryi*, and B). *E. seguinii.* See Table 1 for details of the type specimens.

Plate 7. Morphological relationships among closely related species A). *E. prinoides*, B). *E. prinoides* var. *laotica*, and C). *E. hookeriana.* See Table 1 for details of the type specimens.

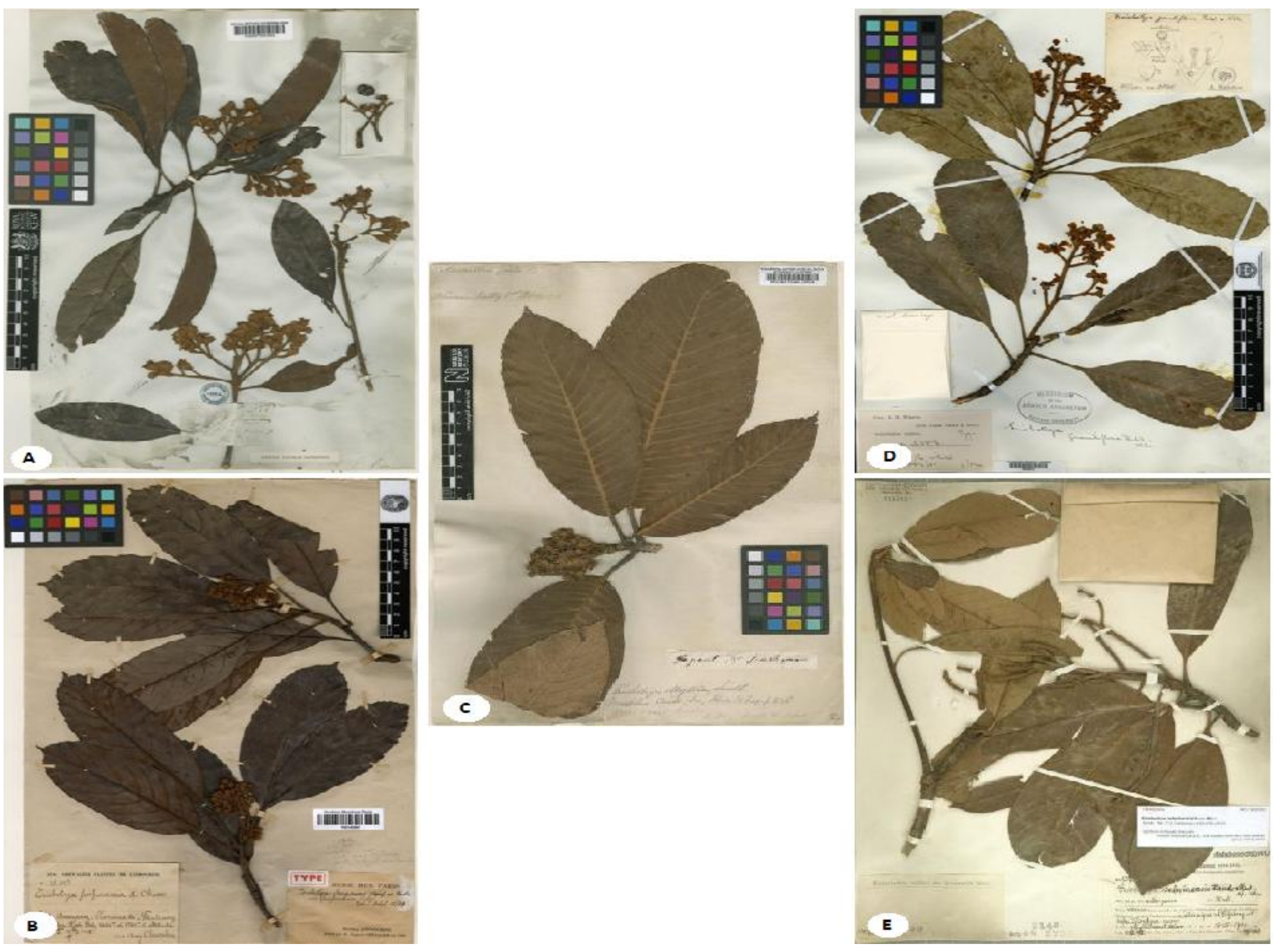

Plate 8. Morphological relationships among closely related species A). *E. fragrans*, B). *E. fragrans* var. *furfuracea*, C). *E. elliptica*, D). *E. grandiflora,* and E). *E. salwinensis.* See Table 1 for details of the type specimens.

Plate 9. Morphological relationships among closely related species A). *E. tengyuehensis*, B). *E. glabrescens* var. *victoriensis,* and C). *E. latifolia.* See Table 1 for details of the type specimens.

Plate 10. Morphological distinct and doubtful species A). *E. wardii*, and B). *E. platyphylla.* See Table 1 for details of the type specimens.

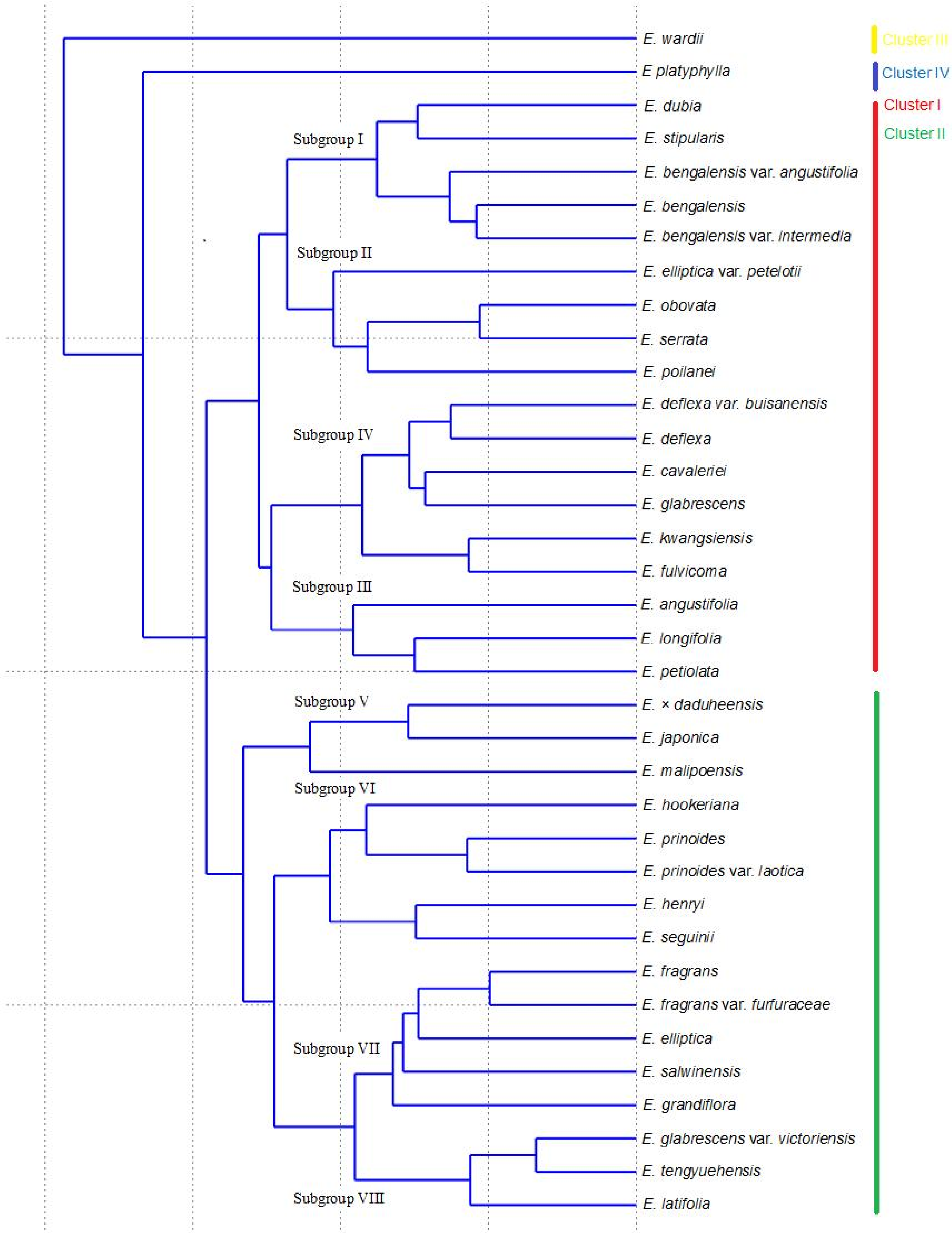

Figure 1. Cluster analysis on basis on both vegetative and floral characters using 36 taxa of *Eriobotrya*.

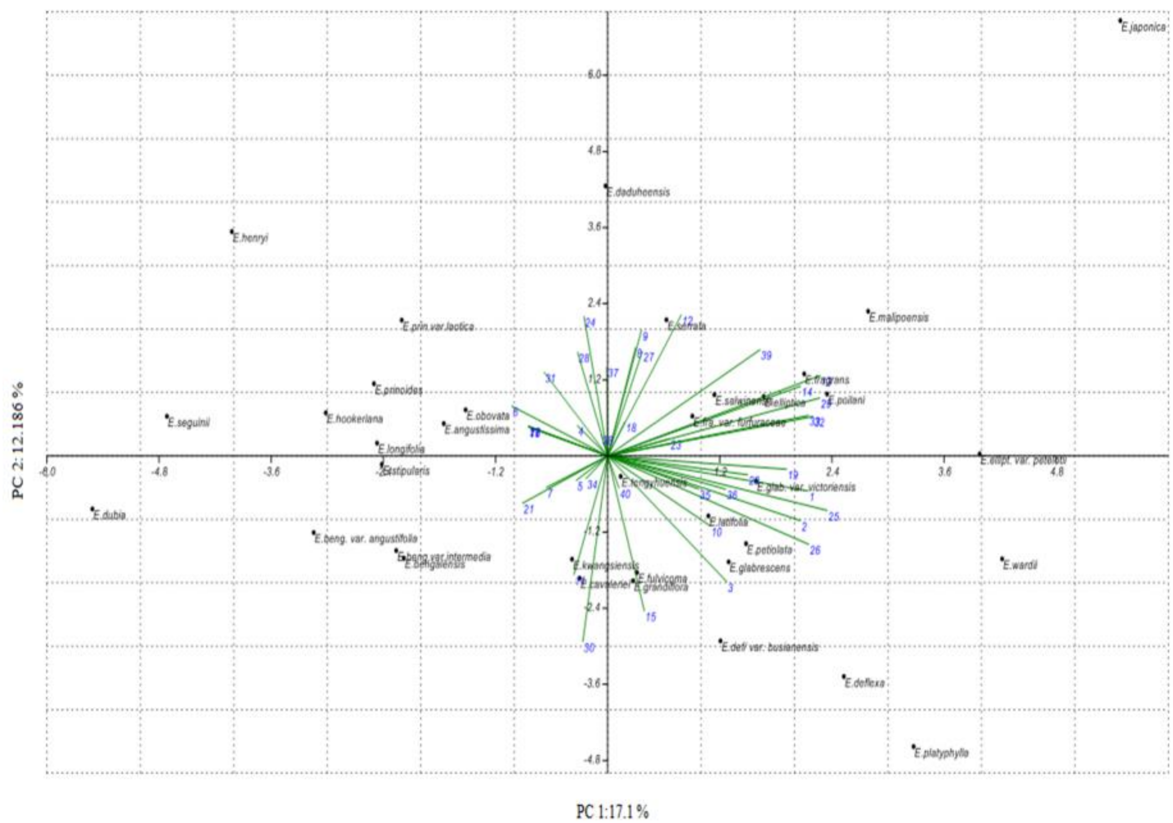

Figure 2. Principal components analysis according to the first 2 main factors performed on 40 morphological characters (PC1 x PC2).

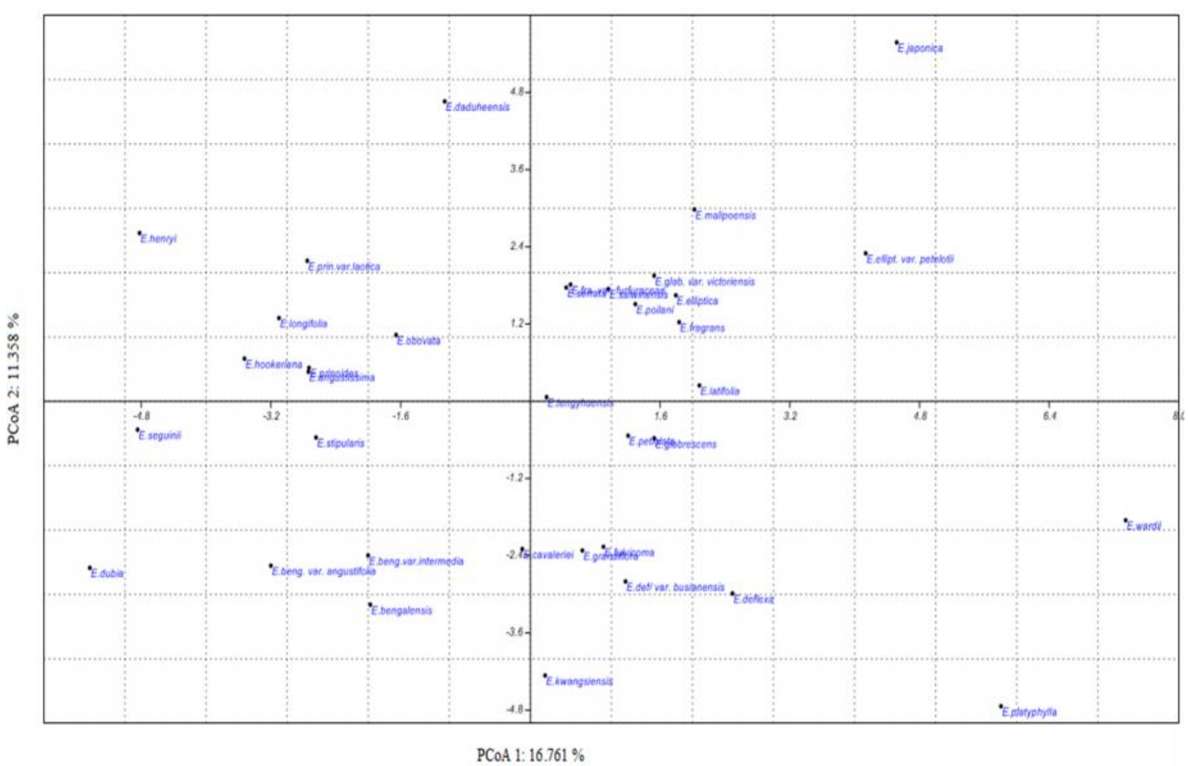

Figure 3. Principal coordinate analysis (PCoA) performed on 40 morphological characters

Table 3. Eigenvalues and cumulative variance for 4 major factors obtained from PCA analysis and 40 characters for each factor within all taxa of *Eriobotrya*.

PC	Eigenvalues	% variance
1	6.84006	17.1
2	4.87428	12.186
3	3.93641	9.841
4	3.17074	7.9268
5	2.63888	6.5972
6	2.04928	5.1232
7	1.98776	4.9694
8	1.70867	4.2717
9	1.60908	4.0227
10	1.39198	3.4799
11	1.29935	3.2484
No	**PC1**	**PC2**
1	0.7005	-0.1519
2	0.6738	-0.281
3	0.4164	-0.5474
4	-0.1061	0.1318
5	-0.1099	-0.1064
6	-0.3355	0.2166
7	-0.2146	-0.137
8	0.09734	0.4714
9	0.1179	0.546
10	0.3586	-0.3044
11	-0.1182	-0.5159
12	0.2567	0.613
13	0.7425	0.3492
14	0.6742	0.3034
15	0.1279	-0.6733
16	-0.2766	0.126
17	-0.2766	0.126
18	0.05974	0.1481
19	0.625	-0.0578
20	0.489	-0.08166
21	-0.2975	-0.2057
22	-0.276	0.1297
23	0.2161	0.07432
24	-0.08278	0.6056
25	0.7672	-0.2367
26	0.7024	-0.3841
27	0.1211	0.4546
28	-0.1051	0.4504
29	0.7408	0.2519
30	-0.08692	-0.8067
31	-0.2221	0.3634
32	0.7172	0.1713
33	0.701	0.1758
34	-0.07582	-0.09849
35	0.3179	-0.1436
36	0.4126	-0.1444
37	-0.00332	0.3861
38	-0.02257	0.09264
39	0.5322	0.4618
40	0.03905	-0.1388

[*] Number indicates 40 morphological characters.

DISCUSSION

The present study focused on the morphological patterns of variations and interspecies relationships reported here for the first time among 36 taxa of the genus *Eriobotrya*. Factor analysis revealed that leaf length and leaf width, bract shape, bract length and width, petal length and width, petal state (glabrous or villous), style number, and style state (free or connate), fruit length and width were the most informative characters for determination and identification of *Eriobotrya* taxa. The first and second component analysis using 40 characters clearly separated this genus into 4 clusters with 2 main clusters. The first main cluster consists of 18 species and was further divided into 4 subgroups. *E. bengalensis*, *E. bengalensis* var. *angustifolia*, *E. bengalensis* var. *intermedia*, *E. stipularis*, *E. dubia* formed a subgroup I. The morphological relationships with each other based on leaf blade abaxially glabrous, leaf size, 10 pairs of lateral veins, bract shape lanceolate, sepal shape triangular ovate, petal shape obovate and slightly pilose or glabrous, style connate at base and style number 2. Our results support the former classification and are consistent with previous analysis by using ITS sequences (Idrees *et al.* 2018, Idrees *et al.* 2020), and also with morphometric analysis of Zhang *et al.* (2017) that showed *E. bengalensis*, *E. bengalensis* var. *angustifolia* formed subgroup 1 in the group 5. *E. bengalensis* and *E. stipularis* totally close resembles to each other, and there are no such characters which can distinguish both species from each other except for stipule persistent or caducious. In addition, one of the sheets (isotype) of *E. bengalensis* “Wallich 668/2” kept at P barcode 02143254, the stipule is persistent and can be seen clearly. Another subgroup formed by *E. obovata*, *E. serrata*, *E. poilanei*, and *E. elliptica* var. *petelotii*. The relationship among these species mostly based on leaf blade abaxially glabrous, leaf length 15–25 cm, leaf width 4.5–9.5 cm, 10–20 pairs of lateral veins, bract obovate or elliptic, sepal shape ovate or rounded, petal shape obovate or cochelate, style connate at base and style number 2–5, leaf serration of all these taxa almost same. *E. angustissima*, *E. longifolia* and *E. petiolata* formed a subgroup and the relationships among these species based on leaf blade abaxailly glabrous, leaf length 15–20 cm, bract shape lanceolate, petal obovate, style connate at base and style number 2–5. *E. deflexa*, *E. deflexa* var. *buisanensis*, *E.cavaleriei*, *E. kwangsiensis*, and *E. fulvicoma* formed subgroup and the relationship among these species based on leaf blade abaxailly glabrous, leaf margin serrated, petal glabrous, style connate at base and style number 2–5. These results are consistent with ITS sequences analysis in our present work (Idrees *et al.* 2020), and also agreement with previous studies (Li *et al.* 2009, Yang *et al.* 2012, Zhang *et al.* 2017).

The second major cluster consists of 16 taxa and was further divided into 4 subgroups. *E. japonica*, *E. malipoensis*, and *E.* × *daduheensis* formed a subgroup and morphological relationship among these species based on leaf blade abaxailly tomentose, leaf size 16–22 cm, leaf width 4–8 cm, 12–18 pairs of lateral veins, petiole sessile and tomentose, large inflorescence 7–10 cm and contracted, bract subulate, pedicel sessile, style free at base and style number 3–5. Our results confirmed their close relationship, and are consistent with molecular study based on ITS sequences analysis (Idrees *et al.* 2020)) and also agreement with Yang (2005); Li *et al.* (2009); Yang *et al.* (2012); Yang *et al.* (2017); Zhang *et al.* (2017). *E. henryi*, *E. seguinii*, *E. hookeriana*, *E. prinoides,* and *E. prinoides* var. *laotica* formed a subgroup. Li *et al.* (2017) suggested that *E. henryi* and *E. seguinii* might be the most primitive taxa in the genus *Eriobotrya*. While *E. hookeriana*, *E. prinoides* and *E. prinoides* var. *laotica* formed a clade and have close relationship with each other's. Our results confirmed their close relationship, and agreement with Yang *et al.* 2009, Li *et al.* 2009, Yang *et al.* 2017, and Idrees *et al.* 2020. *E. fragrans*, *E. fragrans* var. *furfuracea*, *E. salwinensis*, *E. grandiflora*, and *E.elliptica* formed a subgroup and morphological relationship among these species based on leaf blade axially tomentose, leaf length 12–16 cm, blade 3.5–6.5 cm, petiole >2 cm, 10–14 pairs of lateral veins, inflorescence size 4.5–9.5 cm, spreading, pedicel 0.2–6 mm, sepal ovate or rounded, petal obovate, petal length 7 × 5 cm, fruit length 1.2–1.3 × 0.9–1 cm. In addition, *E. grandiflora* was redescribed and confirmed to have a close relationship with *E. fragrans* (Idrees *et al.* 2020). Our results confirmed that *E. grandiflora* nested with *E. fragrans*, *E. fragrans* var. *furfuracea*, *E. salwinensis*, and *E. elliptica*. *E. tengyuehensis*, *E. latifolia* and *E. glabrescens* var. *victoriensis* formed a subgroups and relationship among these species based on leaf blade abaxailly tomentose, leaf width 5–7 cm, petal obovate and villous at base, petal length 4–5 × 3–4 mm, inflorescence size 7 cm. *E. wardii* and *E. platyphylla* formed a distinct cluster, however morphologically both species entirely different from the rest of the species. Both species can be identified on the basis of only type specimens and suggested here to be as doubtful species within this genus. Most of the species relationships were consistent with the phenetic analysis of morphological studies (Yang *et al.* 2017, Zhang *et al.* 2017), as well as molecular study (Li *et al.* 2009, Idrees *et al.* 2020).

Conclusions: We present here 40 morphological characters (quantitative and qualitative characters) using 36 taxa of the genus *Eriobotrya*. The morphometric analysis (cluster analysis, principal component analysis and principal coordinate analysis) distinguished well the whole taxa of the genus *Eriobotrya*. The most informative characters for determination and identification of taxa in the present study was leaf length and leaf width, bract shape, bract length and width, petal state (glabrous or villous), petal length and width, style number, and style state (free or connate), fruit length and width. Furthermore, *E. wardii* and *E. platyphylla* considered as the dubious species and it would be necessary to conduct molecular study to confirm its relationship with rest of the species. The quantitative and qualitative combinations of character studies will be particularly useful for further identification and systematic of the genus *Eriobotrya*.

Conflict-of-interest: All authors declared that there is no conflict of interest.

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