



## A new broad-leaved species of loquat from eastern Myanmar and its phylogenetic affinity in the genus *Eriobotrya* (Rosaceae)

DAE-HYUN KANG<sup>1,5+</sup>, HOMERVERGEL G. ONG<sup>1,6+</sup>, JUNG-HOON LEE<sup>1,7</sup>, EUI-KWON JUNG<sup>2,8</sup>, NAING-OO KYAW<sup>3,9</sup>, QIANG FAN<sup>4,10</sup> & YOUNG-DONG KIM<sup>1,2,11\*</sup>

<sup>1</sup> Multidisciplinary Genome Institute, Hallym University, Chuncheon 24252, Korea.

<sup>2</sup> Department of Life Science, Hallym University, Chuncheon 24252, Korea.

<sup>3</sup> PPCWS Office, Forest Department (MONREC/MoECA), Ywangan 06041, Shan State, Myanmar.

<sup>4</sup> State Key Laboratory of Biocontrol and Guangdong Provincial Key Laboratory of Plant Resources, Sun Yat-sen University, Guangzhou, 510275, China.

<sup>5</sup> ✉ [imp520@naver.com](mailto:imp520@naver.com); <http://orcid.org/0000-0001-9167-9343>

<sup>6</sup> ✉ [homervergelong@gmail.com](mailto:homervergelong@gmail.com); <http://orcid.org/0000-0002-2162-4651>

<sup>7</sup> ✉ [sky262a@hallym.ac.kr](mailto:sky262a@hallym.ac.kr); <http://orcid.org/0000-0001-6760-7913>

<sup>8</sup> ✉ [dmlrnsjdlk@naver.com](mailto:dmlrnsjdlk@naver.com); <http://orcid.org/0000-0002-4422-2591>

<sup>9</sup> ✉ [kknaingoo13@gmail.com](mailto:kknaingoo13@gmail.com); <https://orcid.org/0000-0002-3740-4311>

<sup>10</sup> ✉ [fanqiang@mail.sysu.edu.cn](mailto:fanqiang@mail.sysu.edu.cn); <https://orcid.org/0000-0003-4254-6936>

<sup>11</sup> ✉ [ydkim@hallym.ac.kr](mailto:ydkim@hallym.ac.kr); <http://orcid.org/0000-0001-5904-4727>

<sup>+</sup>These authors contributed equally to this work.

\*Corresponding author: Young-Dong Kim; ✉ [ydkim@hallym.ac.kr](mailto:ydkim@hallym.ac.kr)

### Abstract

*Eriobotrya shanense*, a new species from the karst region of Shan State, eastern Myanmar, is described and illustrated. This evergreen tree is similar to the autumn and winter-flowering, large-leaved species *E. malipoensis* and *E. japonica* by having tomentose hairs on the abaxial leaf surface, but can be distinguished by its obovate, widely obelliptic or oval blade shape, leaf length-width ratio of 2:1 (vs. 3:1), and rounded or obtuse apex (vs. acute). The species also resembles less-known, undercollected Myanmar broad-leaved species *E. wardii* and *E. platyphylla* in leaf shape and length-width ratio, but can be easily differentiated by the presence of tomentose hairs on the leaves, and inflorescence. Phylogenetic analysis based on nrDNA ITS region supported its close affinity with *E. malipoensis* and *E. japonica*. Molecular data also generally grouped the 17 congeneric taxa accessions in congruence to their leaf morphology, with the entire *Eriobotrya* clade strongly supported to be monophyletic and separate from *Rhaphiolepis*.

**Keywords:** ITS, limestone karst, Panlaung Pyadalin Cave Wildlife Sanctuary, phylogeny, Shan State

### Introduction

*Eriobotrya* Lindley (1821: 96, 102) is a small genus of the economically valuable flowering plant family Rosaceae. The name is derived from the Greek *erio* (wool) and *botrys* (cluster), referring to its tomentose paniculate inflorescence (Huxley 1992). It is composed of ca. 25 taxa, including the widely cultivated and commercially important fruit tree loquat (*E. japonica* (Thunb.) Lindley (1821: 102)). Members of this genus naturally occur in many floristic regions of Asia: Malesia (Indonesia, Malaysia), Indochina (Vietnam, Laos, Cambodia, Thailand, and Myanmar), the Himalayas (Bhutan, Nepal, and northeast India), and East Asia, with southwestern China being considered as the center of diversity (Yang *et al.* 2005, Li *et al.* 2011). Taxonomically, *Eriobotrya* belongs to the apple tribe Maleae in the subfamily Amygdaloideae (Xiang *et al.* 2017). Most molecular phylogenetic studies established the position of the genus as sister to *Rhaphiolepis* Lindley (1820: 468) (Li *et al.* 2009, Lo & Donoghue 2012, Yang *et al.* 2012, Xiang *et al.* 2017), while some circumscribed the genus to *Pyrus* Linnaeus (1753: 479, 480) (Christenhusz *et al.* 2018), and more recently to *Rhaphiolepis* (Liu *et al.* 2020a).

Within *Eriobotrya*, members are traditionally classified according to leaf morphology, alongside characterizing the flowering period, especially for species found in temperate and subtropical areas (Zhang *et al.* 1990, Zhang *et al.*

al. 2017). Over the past decade, numerous studies have attempted to elucidate the (phylo)genetic relationships of members of *Eriobotrya* based on nrDNA ITS (Li *et al.* 2009, Yang *et al.* 2011, Zhao *et al.* 2011, Idrees *et al.* 2020), Adh gene (Yang *et al.* 2012), ISSR (Xie *et al.* 2007, Wang *et al.* 2010), AFLP (Yang *et al.* 2009), SSR (Wu *et al.* 2015), and even SNP markers (Yang *et al.* 2017), but mostly with incongruent results.

In this study, we report a putative new species discovered during our floristic work in Myanmar, and attempt to determine its phylogenetic position in the genus. We first came across several flowering individuals in January 2017 in Ywangan Township, southern Shan State, near the border of the Panlaung Pyadalin Cave Wildlife Sanctuary, a protected limestone area well-known for its cave and rock formations. The tree did not appear similar to its congeneric taxon *E. bengalensis* var. *angustifolia* Cardot (1918: 371), which occurs in the same locality (Kang *et al.* 2018). Its features rather resembled those of the karst-loving large-leaved species occurring in the adjacent Yunnan Province of southwestern China, in particular *E. malipoensis* Kuan in Yü & Kuan (1963: 231), as well as those of another autumn-winter flowering tree *E. japonica*. The species also appeared similar to broad-leaved loquat species known only from specimens last collected from northern Myanmar more than half a century ago, specifically *E. wardii* Fischer (1929: 205) and *E. platyphylla* Merrill (1941: 80).

After subsequent collections of fruiting specimens, detailed morphological examination, and comparison with herbarium specimens gathered from the region, we report this remarkable tree as a new species, adding to the growing number of loquat species occurring in karst topographies (Chen *et al.* 2020). Here, we formally describe the new species following the widely accepted taxonomic treatment for the genus (i.e. *Eriobotrya*), as in the most recently published loquat species (Chen *et al.* 2020), while noting the controversial transfer of the genus to *Rhaphiolepis* (Liu *et al.* 2020a). To support our nomenclatural decision, and to determine the taxonomic position of the new species within the genus, we carried out phylogenetic analyses using the ITS region as molecular marker.

## Materials and methods

Plant habit and macro-morphological features were recorded and photographed in the field. Morphological characters were measured by examining fresh plant materials and dried herbarium specimens. The characters and measurements were compared with those of its sister species naturally occurring in China (i.e. *E. malipoensis* and *E. japonica*) as described in the Flora of China (Gu & Spongberg 2003a), and its close relatives reported in Myanmar (i.e. *E. wardii* and *E. platyphylla*) as found in related taxonomic literature (Fischer 1929, Merrill 1941, Vidal 1965). Major flora containing descriptions of other *Eriobotrya* taxa were also consulted (Kurz 1877, Hooker 1879, Vidal 1968, Vidal 1970, Kalkman 1993, Pendry & King 2012). Voucher specimens were deposited at the Hallym University (HHU) and the National Institute of Biological Resources (KB) herbaria in South Korea, and at the Forest Department Herbarium (RAF) in Myanmar.

The total DNA of the new species was extracted from fresh and/or silica gel-dried leaves using DNeasy plant mini kit according to manufacturer protocol (Qiagen, Germany). We selected the nrDNA ITS region (ITS1, 5.8S, and ITS2) as marker in order to maximize the use of available GenBank accessions that can represent a significant number of *Eriobotrya* taxa for our analyses. The ITS region was amplified using ITS5 and ITS4 primers (White *et al.* 1990). Polymerase chain reactions (PCR) were performed in a total reaction volume of 25 µL, containing 2.5 µL of 10× Ex Taq buffer (TaKaRa Bio Inc., Japan), 2 µL of 2.5 mM dNTPs, 0.01 µM each of a forward and reverse primer, 0.1 µL of TaKaRa Ex Taq DNA polymerase (5 units/µL) (TaKaRa Bio Inc., Japan), 5–10 ng of template DNA, and distilled water to the final volume. Conditions for amplification consisted of initial denaturation (95°C for 5 min), followed by 35 denaturation cycles (95°C for 1 min), annealing (59°C for 1 min), extension (72°C for 1 min), and final extension (72°C for 10 min). All PCRs were performed in a GeneAmp PCR System 9700 thermocycler (Applied Biosystems, USA). PCR products were purified with a QIAquick PCR purification kit according to manufacturer protocol (Qiagen, Germany). Purified double-stranded PCR products were determined using 3730xl DNA analyzer (Automatic Biosystems), and automatically sequenced using ABI PRISM 3730XL (PE Applied Biosystems).

A total of three ITS sequences of the new species were generated and deposited at the NCBI GenBank. For phylogenetic analysis, 30 nrDNA sequence accessions were retrieved from the same database, including and prioritizing all accessions of *Eriobotrya* and *Rhaphiolepis* used in the phylogenomic study by Liu *et al.* (2020a). Our final data set was composed of 33 accessions sampled from 17 (ca. 60%) taxa of *Eriobotrya* and 7 (ca. 70%) of *Rhaphiolepis* (POWO 2019), representing more than half the total species diversity of each genus. The outgroup represented taxa from *Pyrus*, *Malus* Miller (1754: unpagged), and *Photinia* Lindley (1820: 491), with a single accession for each retrieved.

Phylogenetic analyses were carried out using Bayesian Inference (BI) and Maximum Likelihood (ML) methods. The best-fit model was determined using jModelTest v.2.1.3 (Guindon & Gascuel 2003, Darriba *et al.* 2012). For all partitions, the GTR + I + G model was selected under the Akaike information criterion (Akaike 1974). BI analysis was performed with MrBayes v.3.2.7 (Ronquist *et al.* 2012) and was run with the Markov Chain Monte Carlo (MCMC) analyses for 1,200,000 generations. Stationarity was considered to be reached when the average standard deviation of split frequencies was less than 0.01. Trees were sampled every 200 generations, with the first 25% of samples discarded as burn-in. The remaining trees were utilized to build a 50% majority-rule consensus tree. ML analysis was performed using RAxML (Stamatakis 2014) implemented in Geneious Prime (Kearse *et al.* 2012), with gaps treated as missing data and set using the bootstrap option with 1,000 replicates. All sequence alignment and tree visualization were performed using Geneious Prime (Kearse *et al.* 2012).

## Results

### Taxonomic treatment

*Eriobotrya shanense* D.H. Kang, H.G. Ong & Y.D. Kim, *sp. nov.* (Figs. 1 & 2)

**Type:**—MYANMAR. Southern Shan State, Ywangan Township, N21° 14' 59.9" E96° 25' 43.7", elev. 1,422 m, 01 Jan. 2017, Kim *et al.* MM-6026 (holotype HHU barcode 880000016009; isotypes HHU barcode 880000016016, KB barcode 880000016023, RAF barcode 880000016030).

**Diagnosis:**—Leaf morphology of *Eriobotrya shanense* is similar to that of *E. malipoensis* and *E. japonica* by having tomentose hairs on the abaxial surface of its blade but can be differentiated by its obovate, widely obelliptic or oval blade shape, its length-width ratio of 2:1 (vs. 3:1), and rounded or obtuse apex (vs. acute). The species also resembles less-known, undercollected Myanmar broad-leaved species *E. wardii* and *E. platyphylla* in leaf shape and length-width ratio, but can be easily differentiated by the presence of tomentose hairs on the leaves and inflorescence. See Table 1 for a detailed comparison.

**Description:**—Trees to 8 m tall, evergreen, much-branched. Branchlets terete, stout, grayish to dark gray, roughened and marked by leaf scars, glabrous. Leaves simple, helically alternate, clustered at tips of branchlets; stipules paired, connate from base to below apex, adnate to petiole, triangular-hastate or subulate, 5–8 × 4–6 mm, apex shortly notched, margin incised-serrate or entire, rustic brown tomentose abaxially, caducous; petiole short, 3–5 mm long, brown tomentose, becoming glabrescent; leaf blades obovate, widely obelliptic or oval, 10–26 × 5–13 cm, dark green and leathery, base cuneate, margin remotely obtusely serrate, apex rounded or obtuse, midvein prominent, raised abaxially, lateral veins 14–20 pairs, usually branching before terminating at margin, abaxial surface grayish tomentose, brownish tomentose along veins, adaxial surface glabrescent to glabrous at maturity, lustrous. Inflorescence in terminal panicles, 30 to 80-flowered, ca. 16 × 12 cm; peduncle densely rustic brown tomentose; bracts lanceolate, 8–10 mm long, densely rustic brown tomentose abaxially; bracteoles narrowly lanceolate, 5–8 mm long, densely rustic brown tomentose abaxially; pedicels 2–8 mm long, brown tomentose, becoming gray and glabrescent at fruit. Flowers bisexual, actinomorphic, 1.5–2 cm in diam., fragrant; hypanthium shallowly cupular, ca. 2 mm long, slightly 5-ribbed, brown tomentose abaxially; sepals 5, connate and continuous with the hypanthium; sepal lobes ovate, 3–4 mm long, greenish, brown tomentose abaxially, spreading at anthesis, becoming strongly reflexed, persistent; petals 5, distinct, white, asymmetrically orbicular or obovate, 6–9 × 5–7 mm, base not clawed, apex obtuse or emarginate, glabrous; stamens 20, connate at base forming a ring, exserted; filaments ca. 4 mm long, white, glabrous; anthers dorsifixed, dithecal, ca. 1 mm long, light yellow with whitish connective, dehiscing longitudinally; pistil 1, syncarpous; ovary half-inferior, 3–5 locular, rhomboid, exposed portion less than 1 mm long, placentation axile, densely woolly apically; ovules 2 per locule; styles 3–5, connate at base, erect, 3–4 mm long, glabrous, densely woolly basally; stigma truncate. Fruit a pome, asymmetrically obovoid or ellipsoid, 1–2.5 × 1–2 cm, green and brown tomentose when young, becoming yellow and glabrescent at maturity, crowned with persistent sepals. Seeds 1–3(4) per fruit.

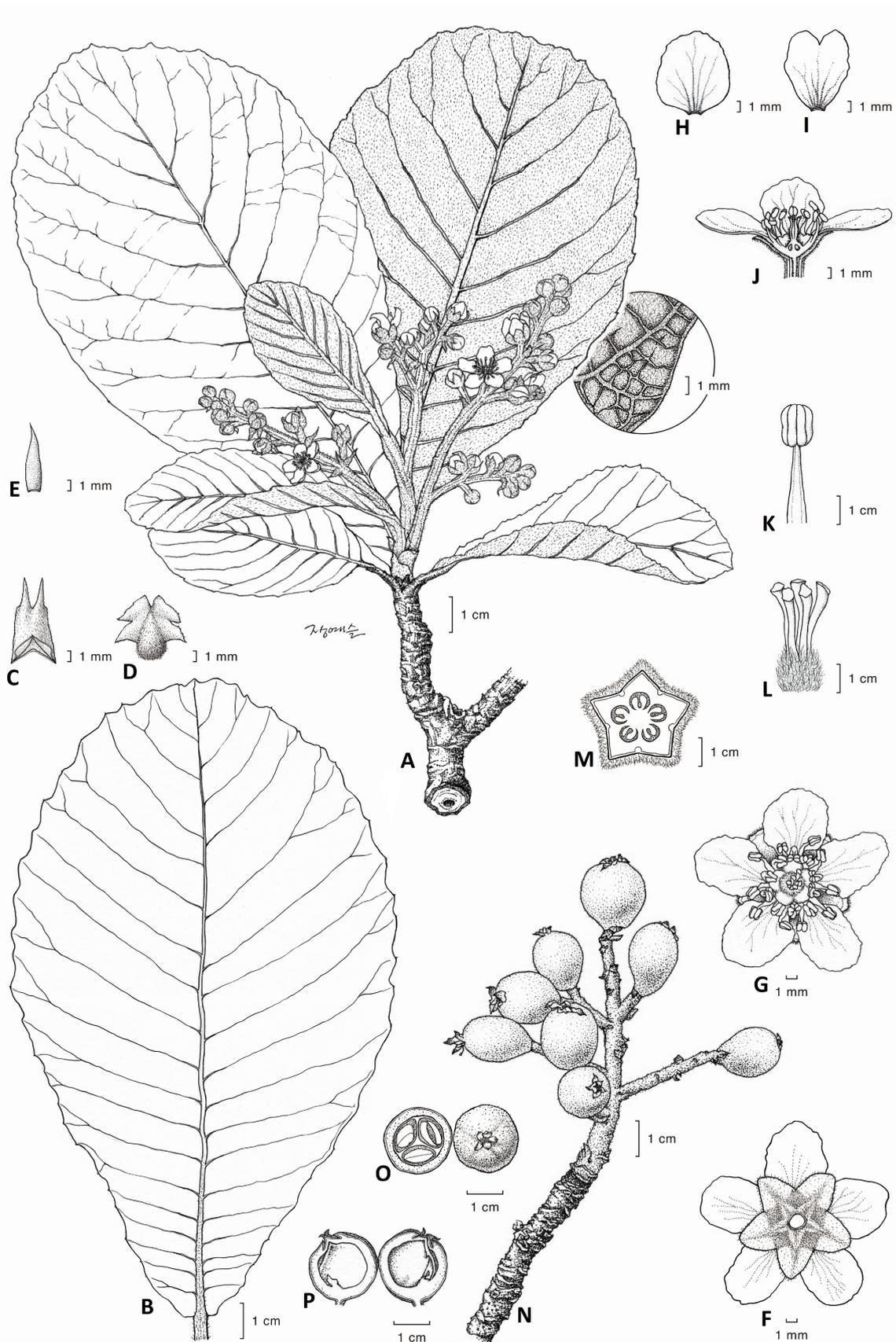
**Phenology:**—The species was observed to be flowering from December to February, and fruiting until May or June.

**Etymology:**—*Eriobotrya shanense* is named after its type locality, Shan State in eastern Myanmar.

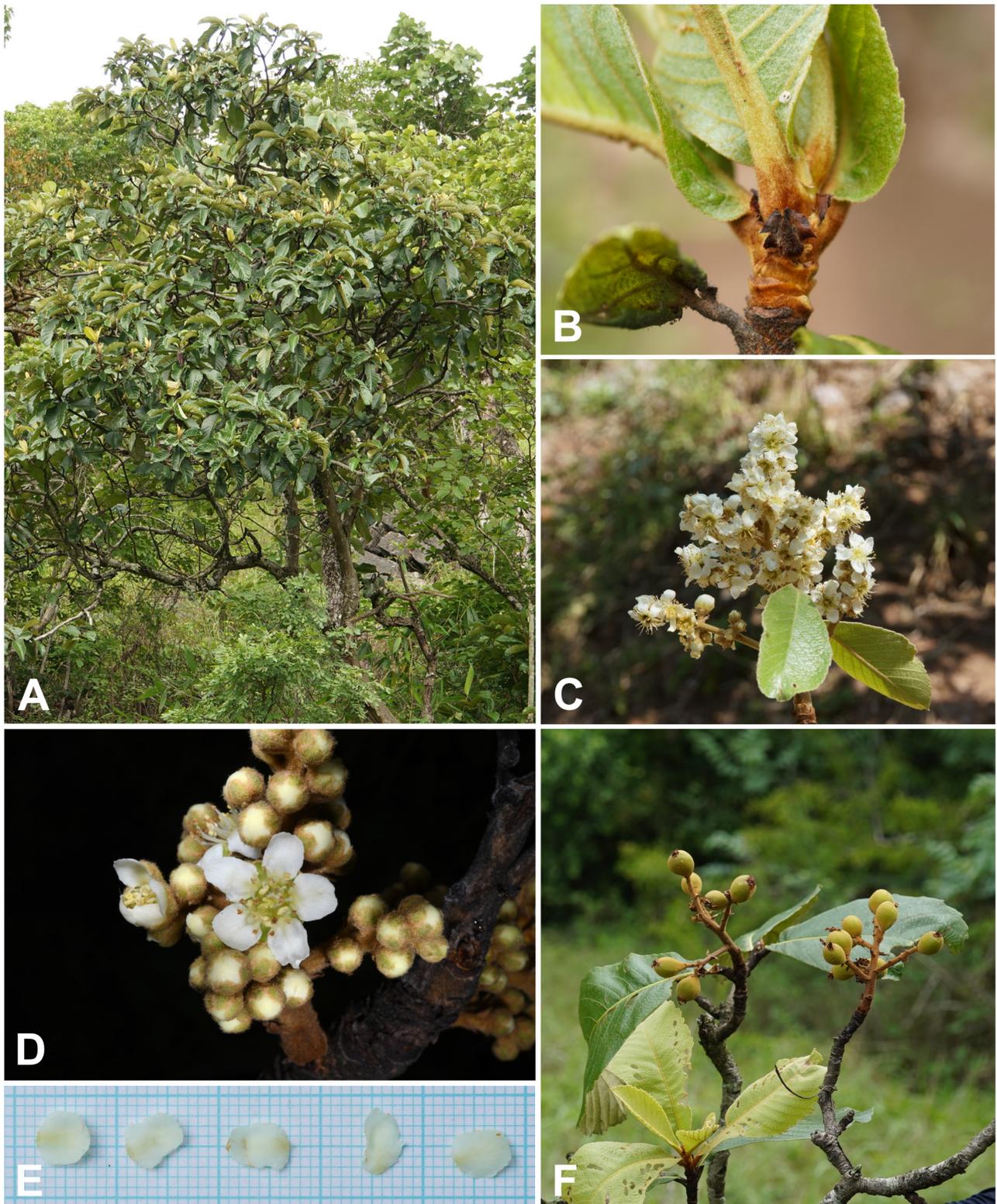
**TABLE 1.** Comparison of key morphological features.

Characters	<i>E. malipoensis</i> <sup>a</sup>	<i>E. japonica</i> <sup>a</sup>	<i>E. shanense</i>	<i>E. wardii</i> <sup>b</sup>	<i>E. platyphylla</i> <sup>c</sup>
Stipule shape, and length	lanceolate, 8–9 mm	subulate, 10–15 mm	triangular-hastate, subulate, 5–8 mm	not seen	not seen
Petiole length	5–10 mm	6–10 mm or absent	3–5 mm	absent	25–40 mm
Leaf shape	oblong, oblong-ovate	lanceolate, oblanceolate, obovate, elliptic-oblong	obovate, widely obelliptic, oval	obovate	widely obovate
Leaf size and length-width ratio	30–40 × 10–15 cm 3:1	12–30 × 3–9 cm 3:1	10–26 × 5–13 cm 2:1	16–30 × 8–15 cm 2:1	21–28 × 15–19 cm 3:2
Leaf apex	acute	acute	rounded or obtuse	obtuse	rounded
Lateral veins (pairs)	20–25	11–12	14–20	11–13	ca. 15
Leaf margin	remotely obtusely serrate	entire below remotely serrate above	remotely obtusely serrate	entire <sup>d</sup>	subundulate-serrate, coarsely dentate
Leaf surface	tomentose abaxially, glabrous adaxially	tomentose abaxially, glabrous adaxially	tomentose abaxially, glabrescent to glabrous adaxially	glabrous abaxially and adaxially	glabrous abaxially and adaxially
Bract shape, and length	lanceolate, 3–5 mm	subulate, 2–5 mm	lanceolate, 8–10 mm	lanceolate, 7–10 mm	not seen
Peduncle surface	tomentose	tomentose	tomentose	glabrous	glabrous or glabrescent <sup>d</sup>
Pedicele surface	tomentose	tomentose	tomentose	glabrous <sup>e</sup>	glabrescent <sup>e</sup>
Hypanthium surface	tomentose	tomentose	tomentose	glabrous <sup>d</sup>	glabrescent

Species characters and measurements are those described in <sup>a</sup>Gu & Spongberg 2003a, <sup>b</sup>Fischer 1929, and <sup>c</sup>Merrill 1941, unless otherwise specified in <sup>d</sup>Vidal 1965 or based on <sup>e</sup>examined specimens. Examined type specimens of *E. platyphylla* and *E. wardii* can be seen at Global Plants on JSTOR (JSTOR 2020), respectively below: <http://plants.jstor.org/stable/10.5555/al.ap.specimen.bm000602191> and <http://plants.jstor.org/stable/10.5555/al.ap.specimen.k000758392>. Additional *E. wardii* digital specimen images examined can be found in the Data Portal website of BM (Scott & Smith 2014): [barcode BM013717463], [barcode BM013717464], and [barcode BM013717465].



**FIGURE 1.** *Eriobotrya shanense* D.H. Kang, H.G. Ong & Y.D. Kim A. Flowering branch B. Leaf blade C–D. Stipules E. Bract F–G. Flower abaxial and adaxial view H–I. Petals J. Flower longitudinal section showing the androecium and gynoecium K. Stamen L. Styles and exposed ovary M. Ovary cross section N. Fruiting branch O–P. Fruit cross and longitudinal section. A–M. from Kim *et al.* MM-6026 (holotype HHU). Illustration by Ye-Seul Jang.



**FIGURE 2.** *Eriobotrya shanense* D.H. Kang, H.G. Ong & Y.D. Kim. **A.** Habitat **B.** Stipule and petiole **C.** Inflorescence **D.** Flower **E.** Petals (base not clawed) **F.** Fruiting branch.

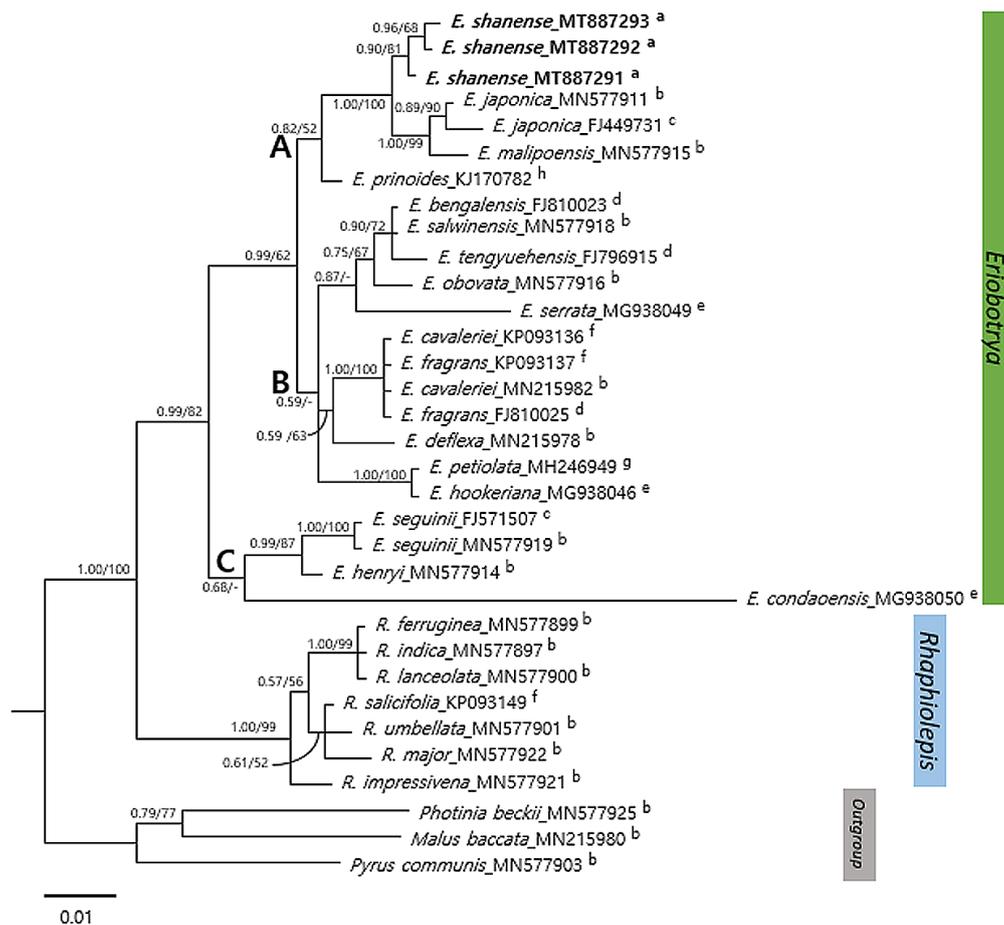
**Distribution and habitat:**—*Eriobotrya shanense* is known to be narrowly distributed in its type locality, Ywangan Township in southern Shan State. So far, two populations have been found, one consisting of not less than 10 full-grown trees, and the other of ca. 20 mature and juvenile individuals. The tree grows on slopes of irregularly rocky limestone karst hills, along with *Firmiana kerri* (Craib) Kostermans (1961: 389), *Sterculia villosa* Roxburgh (1832: 153, 154), *Wightia speciosissima* (D. Don) Merrill (1938: 67), *Bauhinia variegata* Linnaeus (1753: 375), *Ceratostigma asperinum* Stapf ex Prain (1906: 6, 7), and *Trichodesma calycosum* Collett & Hemsley (1890: 92, 93).

**Conservation status:**—The species can be seen thriving along a trail up a Buddhist pagoda/stupa and can (still) be observed growing near a hillside village and farm area, despite having no apparent economic value, except maybe as firewood. It may, therefore, be categorized as Vulnerable (VU) according to the IUCN category (IUCN 2019).

**Additional specimens examined (paratypes):**—MYANMAR, Southern Shan State, Ywangan Township, N21° 15' 13.5" E96° 25' 50.8", elev. 1,517 m, 02 Feb. 2018, *Kim et al. MM-6665* (4 sheets, HHU); N21° 15' 14.7" E96° 25' 49.9" 1,530 m, 02 Feb. 2018, *Kim et al. MM-6671* (4 sheets, HHU); N21° 15' 12.8" E96° 25' 51.7" 1,513 m, 26 Jun. 2019, *Kim et al. MM-7165* (2 sheets, HHU); N21° 15' 12.8" E96° 25' 51.7" 1,513 m, 26 Jun. 2019, *Kim et al. MM-7170* (7 sheets, HHU); N21° 14' 28.5" E96° 26' 11.8" 1,469 m, 01 Jul. 2019, *Kim et al. MM-7352* (2 sheets, HHU); N21° 14' 28.5" E96° 26' 11.8" 1,469 m, 01 Jul. 2019, *Kim et al. MM-7353* (3 sheets, HHU); N21° 14' 28.5" E96° 26' 11.8" 1,469 m, 01 Jul. 2019, *Kim et al. MM-7365* (1 sheet, HHU); N21° 14' 28.5" E96° 26' 11.8" 1,469 m, 01 Jul. 2019, *Kim et al. MM-7366* (1 sheet, HHU); N21° 14' 27.1" E96° 26' 15.6" 1,493 m, 02 Jul. 2019, *Kim et al. MM-7385* (1 sheet, HHU)

### Phylogenetic analysis

The concatenated ITS region generated an aligned matrix of 602 bp in length. Phylogenetic analyses resulted in identical BI and ML tree topology (Fig. 3), showing a well-supported *Eriobotrya* that is divided into three clades. The new species *E. shanense* was placed in a strongly supported group with accessions of *E. malipoensis* and *E. japonica*, two large-leaved congeners with a very close affinity (Xie *et al.* 2007, Li *et al.* 2009, Yang *et al.* 2009, Yang *et al.* 2017, Zhang *et al.* 2017, Chen *et al.* 2020). The three species finally formed a moderately robust Clade A (PP = 0.82, BS = 52) with *E. prinoides* Rehder & Wilson (1913: 194, 195), another autumn-winter flowering species shown to putatively hybridize with *E. japonica* (Tang 1997, Yang *et al.* 2007, Ding *et al.* 2015).



**FIGURE 3.** Phylogenetic tree based on ITS sequences showing the position of the new species (bold) in the genus *Eriobotrya*. Numbers above/below branches are BI posterior probabilities (PP) and ML bootstrap value (BS). PP and BS with less than 0.5 and 50, respectively, are not reported (-). Branch lengths are scaled to the number of nucleotide substitutions per site. Accessions are those used in <sup>a</sup>This study, <sup>b</sup>Liu *et al.* 2020a, <sup>c</sup>Zhao *et al.* 2011, <sup>d</sup>Li *et al.* 2012, <sup>e</sup>Idrees *et al.* 2018, <sup>f</sup>Liu *et al.* 2015, <sup>g</sup>Idrees *et al.* 2020, <sup>h</sup>Unpublished study.

Clade B on the other hand resulted in a rather weakly supported, if not unresolved group (PP = 0.59). This clade comprised the most number of taxa that clustered into three polytomous subclades but can be generally classified as a group with medium-sized leaves (Yang *et al.* 2017). Previous studies revealed that members of this clade clustered inconsistently, often depending on the molecular marker of choice (Xie *et al.* 2007, Li *et al.* 2009, Yang *et al.* 2009, Yang *et al.* 2011, Yang *et al.* 2012, Yang *et al.* 2017), except for *E. cavaleriei* (H. Lév.) Rehder (1932: 307, 308) and *E. fragrans* Champion ex Bentham (1852: 80), two taxa with very close interspecies or even infraspecies relation (Yang 2005, Li 2009). Further analyses based on molecular and morphological data would hopefully resolve the phylogenetic placements of species in this group.

Clade C was also shown to be less robust (PP = 0.68), forming the basal group for *Eriobotrya* and comprising accessions of *E. henryi* Nakai (1924: 70), *E. seguinii* (H. Lév.) Cardot ex Guillaumin (1924: 287) and *E. condaoensis* Gao, Idrees & Do in Idrees *et al.* (2018: 290). The first two small-leaved species were previously shown to consistently group based on molecular data (Xie *et al.* 2007, Li *et al.* 2009, Yang *et al.* 2009, Yang *et al.* 2017, Idrees *et al.* 2020). It was, however, the first time for the recently described species *E. condaoensis* to group with other loquats, a result not observed in previous work by its authors (Idrees *et al.* 2018, Idrees *et al.* 2020), and could aid in understanding the evolution of *Eriobotrya* and its relationship with *Rhaphiolepis*. For instance, a shared morphological character of the members of Clade C could be their camptodromous venation (Idrees *et al.* 2018: Fig. 2 & 3, Liu *et al.* 2020a: Fig. 6B & 6C), a leaf character not found among taxa in Clade A, nor in Clade B (except *E. tengyuehensis*). More interestingly, the camptodromous venation of this basal *Eriobotrya* clade is its synapomorphy with *Rhaphiolepis* (Robertson *et al.* 1991, Gu & Spongberg 2003b).

Overall, the identical BI and ML tree (Fig. 3) showed a very robust monophyly of *Eriobotrya* (PP = 0.99, BS = 82), separate and distinct from *Rhaphiolepis* (PP = 1.00, BS = 99), which were results not found to agree with those of Liu *et al.* (2020a) in their proposal to reduce *Eriobotrya* to synonymy under *Rhaphiolepis*. In the same paper, the authors argued the lack of stability of two distinguishing morphological characters of *Eriobotrya* versus *Rhaphiolepis*: (1) the camptodromous leaf venation in some loquat species, as in *E. henryi* and *E. seguinii* (Liu *et al.* 2020a: Fig. 6B & 6C), and (2) the (im)persistent calyx in fruit in *E. henryi* (Liu *et al.* 2020a: Fig. 6A). Taxonomic studies, however, were clear that both the camptodromous and craspedodromous venation can be observed in *Eriobotrya* (Robertson *et al.* 1991, Gu & Spongberg 2003a). Also, although the impersistence of the fragile fruit calyx in *E. henryi* (Liu *et al.* 2020a: Fig. 6A) can be debated (see Biotracks website <http://www.biotracks.cn/search/list/f/3/t/1/id/68659> (Kunming Institute of Botany, Chinese Academy of Sciences 2020) for the same image, and other photos of *E. henryi* fruits with calyx intact), the (circular) annular ring mark after early fruit sepal senescence can only be observed in *Rhaphiolepis* (Robertson *et al.* 1991, Gu & Spongberg 2003b).

With the above conflicting issues, we agree with the proposal to conserve the name *Eriobotrya* against *Rhaphiolepis* (Shaw 2020). In this proposition, Shaw (2020) stressed the importance of maintaining nomenclatural stability of *Eriobotrya* species with horticultural and agricultural value, in particular *E. japonica*, which just months after the publication by Liu *et al.* (2020a), received another name combination (i.e. *E. japonica* to *R. loquata* Liu & Wen in Liu *et al.* (2020a: 11) to *R. bibas* (Lour.) Galasso & Banfi in Galasso *et al.* (2020: 66), along with *E. latifolia* Hooker (1878: 370) that underwent another name change from the same original transfer proponents (i.e. *E. latifolia* to *R. herae* (M.F.Fay & Christenh.) Liu & Wen in Liu *et al.* (2020a: 11) to *R. latifolia* (Hook.f.) Liu & Wen in Liu *et al.* (2020b: 39). The phylogenetic evidence of the monophyly of the loquat genus, which more or less showed congruence with leaf morphological characters, as shown in this study, thus convinced us to formally describe the new species following *Eriobotrya*.

## Acknowledgments

This work was supported by the grants from the National Institute of Biological Resources (NIBR) of the Republic of Korea (NIBR202006203) and the Hallym University Research Fund (H20200719). Our gratitude extends to the Ministry of Natural Resources and Environmental Conservation (MONREC) of the Union of Myanmar, and the management and officers the Panlaung Pyadalin Cave Wildlife Sanctuary, especially to Ye Min Tun, who accompanied us during most of our fieldwork. Finally, we thank Dr. Jian Huang for the link to his plant images in Biotracks.

## References

- Akaike, H. (1974) A new look at the statistical model identification. *IEEE Transactions on Automatic Control* 19 (6): 716–723.  
<https://doi.org/10.1109/TAC.1974.1100705>
- Bentham, G. (1852) Florula Hongkongensis: an enumeration of the plants collected in the Island of Hong Kong. *Hooker's Journal of Botany and Kew Garden Miscellany* 4: 73–81.
- Cardot, J. (1918) Rosacees nouvelles d'extreme-orient. *Notulae Systematicae, Herbarium du Museum de Paris* 3: 371.
- Chen, S.F., Meng, K.K., Guo, X.B., Zhao, W.Y., Liao, W.B. & Fan, Q. (2020) A new species of *Eriobotrya* (Rosaceae) from Yunnan Province, China. *Phytokeys* 146: 61–69.  
<https://doi.org/10.3897/phytokeys.146.50728>
- Christenhusz, M.J.M., Fay, M.F. & Byng, J.W. (2018) *The Global Flora: A Practical Flora to Vascular Plant Species of the World*. Special Edition, GLOVAP Nomenclature Part 1. Plant Gateway Ltd. 4, Bradford.
- Collett, H. & Hemsley, W.B. (1890) On a collection of plants from Upper Burma and the Shan States. *Journal of the Linnean Society, Botany* 28: 1–150.  
<https://doi.org/10.1111/j.1095-8339.1890.tb01452.x>
- Darriba, D., Taboada, G.L., Doallo, R. & Posada, D. (2012) jModelTest 2: more models, new heuristics and parallel computing. *Nature Methods* 9 (8): 772.  
<https://doi.org/10.1038/nmeth.2109>
- Ding, M., Fan, Q., Guo, W., Shi, S. & Liao, W. (2015) Valid publication of the name *Eriobotrya* × *daduheensis* (Malinae, Rosaceae). *Phytotaxa* 212 (1): 95–98.  
<https://doi.org/10.11646/phytotaxa.212.1.5>
- Fischer, C.E.C. (1929) Contributions to the Flora of Burma: VII. *Bulletin of Miscellaneous Information (Royal Botanic Gardens, Kew)* 1929 (6): 204–207.  
<https://doi.org/10.2307/4115393>
- Galasso, G., Domina, G., Adorni, M., Angiolini, C., Apruzzese, M., Ardenghi, N.M.G., Assini, S., Aversa, M., Bachetta, G., Banfi, E., Giuseppina, B., Bartolucci, F., Bernardo, L., Bertolli, A., Bonali, F., Bonari, G., Bonini, I., Bracco, F., Brundu, G., Buccomino, G., Buono, S., Calvia, G., Cambria, S., Castagnini, S.C., Ceschin, S., Dagnino, D., Di Gristina, E., Di Turi, A., Fascetti, S., Ferretti, G., Fois, M., Gentili, R., Gheza, G., Gebellini, L., Hofmann, N., Iamónico, D., Ilari, A., Király, A., Király, G., Laface, V.L.A., Lallai, A., Lazzaro, L., Lonati, M., Longo, D., Lozano, V., Lupoletti, J., Magrini, S., Mainetti, A., Manca, M., Marchetti, D., Mariani, F., Mariotti, M.G., Masin, R.R., Mei, G., Menini, F., Merli, M., Milani, A., Minuto, L., Mugnai, M., Musarella, C.M., Olivieri, N., Onnis, L., Passalacqua, N.G., Peccenini, S., Peruzzi, L., Pica, A., Pinzani, L., Pittarello, M., Podda, L., Prosser, F., Ravetto Enri, S., Roma-Marzio, F., Rosati, L., Sarigu, M., Scafidi, F., Sciandrello, S., Selvaggi, A., Spampinato, G., Stinca, A., Tavilla, G., Toffolo, C., Tomasi, G., Turcato, C., Villano, C. & Nepi, C. (2020) Notulae to the Italian alien vascular flora: 9. *Italian Botanist* 9: 47–70.  
<https://doi.org/10.3897/italianbotanist.9.53401>
- Gu, C.Z. & Spongberg, S.A. (2003a) *Eriobotrya* Lindley. In: Wu, Z.Y., Raven, P.H. & Hong, D.Y. (Eds.) *Flora of China*. Vol. 9 (Pittosporaceae through Connaraceae). Science Press, Beijing and Missouri Botanical Garden Press, St. Louis, pp. 138–141.
- Gu, C.Z. & Spongberg, S.A. (2003b) *Rhaphiolepis* Lindley. In: Wu, Z.Y., Raven, P.H. & Hong, D.Y. (Eds.) *Flora of China*. Vol. 9 (Pittosporaceae through Connaraceae). Science Press, Beijing and Missouri Botanical Garden Press, St. Louis, pp. 141–144.
- Guillaumin, A. (1924) Observations sur les Symplocos d'Extreme-Orient, particulièrement d'Indo-Chine. *Bulletin de la Société Botanique de France* 71: 273–288.  
<https://doi.org/10.1080/00378941.1924.10836934>
- Guindon, S. & Gascuel, O. (2003) A simple, fast, and accurate algorithm to estimate large phylogenies by maximum likelihood. *Systematic Biology* 52 (5): 696–704.  
<https://doi.org/10.1080/10635150390235520>
- Hooker, J.D. (1879) *Eriobotrya* Lindl. In: Hooker, J.D. (Ed.) *The Flora of British India*. Vol. 2 (Sabiaceae to Cornaceae). L. Reeve & Co., London, pp. 370–372.
- Huxley, A. (1992) *The New Royal Horticultural Society Dictionary of Gardening*. Vol. 2. Macmillan Press, London, pp. 196.
- Idrees, M., Tariq, A., Pathak, M.L., Gao, X.F., Sadia, S., Zhang, Z.Y. & Zeng, F.J. (2020) Phylogenetic relationships of genus *Eriobotrya* Lindl. (Rosaceae), based on nuclear ribosomal DNA (ITS) sequence. *Pakistan Journal of Botany* 52: 5.  
[https://doi.org/10.30848/PJB2020-5\(11\)](https://doi.org/10.30848/PJB2020-5(11))
- Idrees, M., Van Do, T. & Gao, X.F. (2018) A new species of *Eriobotrya* (Rosaceae) from Con Dao National Park, southern Vietnam. *Phytotaxa* 365 (3): 288–294.  
<https://doi.org/10.11646/phytotaxa.365.3.6>

- IUCN (2019) Guidelines for Using the IUCN Red List Categories and Criteria. Version 14. Prepared by the Standards and Petitions Subcommittee of the IUCN Species Survival Commission. Available from: <http://cmsdocs.s3.amazonaws.com/RedListGuidelines.pdf> (accessed 10 June 2020)
- JSTOR (2017) Global Plants on JSTOR. Available from: <http://plants.jstor.org/> (accessed 16 December 2020)
- Kalkman, C. (1993) Rosaceae In: Kalkman, C., Geerinck, D.J.L., Buijsen, J.R.M., Duyfjes, B.E.E. (Eds.) *Flora Malesiana Ser. I – Spermatophyta: Flowering Plants*. Vol. 11 (2), Flora Malesiana Foundation, Leiden, 227–351.
- Kang, D.H., Kyaw, N.O., Jung, E.K., Shin, J.S., Kim, Y.D. & Ong, H.G. (2018) New records of flowering plants for the flora of Myanmar collected from southern Shan State. *Korean Journal of Plant Taxonomy* 48 (3): 218–229.  
<https://doi.org/10.11110/kjpt.2018.48.3.218>
- Kearse, M., Moir, R., Wilson, A., Stones-Havas, S., Cheung, M., Sturrock, S., Buxton, S., Cooper, A., Markowitz, S., Duran, C., Thierer, T., Ashton, B., Meintjes, P. & Drummond, A. (2012) Geneious Basic: an integrated and extendable desktop software platform for the organization and analyses of sequence data. *Bioinformatics* 28: 1647–1649.  
<https://doi.org/10.1093/bioinformatics/bts199>
- Kostermans, A.J.G.H. (1961) Miscellaneous botanical notes 2. *Reinwardtia* 5 (4): 375–411.
- Kunming Institute of Botany, Chinese Academy of Sciences (2020) Biotracks (v4.0.2) [Mobile application software]. Available from: <http://www.biotracks.cn/search/list/f/3/t/1/id/68659> (accessed 16 December 2020)
- Kurz, S. (1877) *Forest Flora of British Burma*. Vol. 1 (Ranunculaceae to Cornaceae). Office of the Superintendent of Government Printing, Calcutta, 442–443.  
<https://doi.org/10.5962/bhl.title.52413>
- Li, G.F., Zhang, Z.K. & Lin, S.Q. (2011) Origin and evolution of *Eriobotrya*. *Acta Horticulturae* 887: 33–38.  
<https://doi.org/10.17660/ActaHortic.2011.887.2>
- Li, P., Lin, S., Yang, X.H., Hu, G.B. & Jiang, Y.M. (2009) Molecular phylogeny of *Eriobotrya* Lindl. (Loquat) inferred from internal transcribed spacer sequences of nuclear ribosome. *Pakistan Journal of Botany* 41 (1): 185–93.
- Li, Q.Y., Guo, W., Liao, W.B., Macklin, J.A. & Li, J.H. (2012) Generic limits of Pyrinae: insights from nuclear ribosomal DNA sequences. *Botanical Studies* 53: 151–164.
- Lindley, J. (1820) *The Botanical Register: Consisting of Coloured Figures of Exotic Plants Cultivated in British Gardens with their History and Mode of Treatment*. Vol. 6. James Ridgway, London. pp. (plates) 436–520.
- Lindley, J. (1821) Observations on the natural group of plants called Pomaceae. *Transactions of the Linnean Society of London* 13: 88–106.  
<https://doi.org/10.1111/j.1095-8339.1821.tb00058.x>
- Linnaeus, C.V. (1753) *Species Plantarum* 1, pp. 560.
- Liu, B.B., Liu, G.N., Hong, D.Y. & Wen, J. (2020a) *Eriobotrya* belongs to *Raphiolepis* (Maleae, Rosaceae): evidence from chloroplast genome and nuclear ribosomal DNA data. *Frontiers in Plant Science* 10 (1731): 1–14.  
<https://doi.org/10.3389/fpls.2019.01731>
- Liu, B.B., Wang, Y.B., Hong, D.Y. & Wen, J. (2020b) A synopsis of the expanded *Raphiolepis* (Maleae, Rosaceae). *Phytokeys* 154: 19–55.  
<https://doi.org/10.3897/phytokeys.154.52790>
- Liu, J., Yan, H.F., Newmaster, S.G., Pei, N., Ragupathy, S. & Ge, X.J. (2015) The use of DNA barcoding as a tool for the conservation biogeography of subtropical forests in China. *Diversity and Distributions* 21 (2): 188–199.  
<https://doi.org/10.1111/ddi.12276>
- Lo, E.Y. & Donoghue, M.J. (2012) Expanded phylogenetic and dating analyses of the apples and their relatives (Pyreae, Rosaceae). *Molecular Phylogenetics and Evolution* 63 (2): 230–243.  
<https://doi.org/10.1016/j.ympev.2011.10.005>
- Merrill, E.D. (1938) New or noteworthy Indo-Chinese plants. *Journal of the Arnold Arboretum* 19 (1): 21–70.
- Merrill, E.D. (1941) The upper Burma plants collected by Captain F. Kingdon Ward on the vernay-cutting expedition, 1938–39. *Brittonia* 4 (1): 20–188.
- Miller, P. (1754) *The Gardeners Dictionary: containing the methods of cultivating and improving all sorts of trees, plants, and pleasure gardens... Abridged...* Vol. 2, Fourth Edition. Bible and Crown, London.
- Nakai, T. (1924) *Raphiolepidis et Eriobotryae species Sino-Japonicae*. *Journal of the Arnold Arboretum* 5 (2): 61–72.
- Pendry, C.A. & King, C. (2012) Rosaceae: Webedition 2 (2012). In: Watson, M.F., Akiyama, S., Ikeda, H., Pendry, C.A., Rajbhandari, K.R., Shrestha, K.K. (Eds.) *Flora of Nepal*. Royal Botanic Garden Edinburgh, UK. Available from: <http://www.floraofnepal.org/accountlibrary?name=Eriobotrya&rank=Genus> (accessed 16 December 2020)
- POWO (2019) Plants of the World Online. Facilitated by the Royal Botanic Gardens, Kew. Available from: <http://www.plantsoftheworldonline.org/> (accessed 22 December 2020)

- Prain, D. (1906) The genus *Ceratostigma*. *Journal of Botany, British and Foreign* 44: 6–8.
- Rehder, A. & Wilson, E.H. (1913) Rosaceae: *Cotoneaster*, *Pyracantha*, *Crataegus*, *Osteomeles*, *Photinia*, *Stranvesia*, *Eriobotrya*, *Amelanchier*, *Prunus*. In: Sargent, C.S. (Ed.) An enumeration of the woody plants collected in Western China for the Arnold Arboretum of Harvard University during the years 1907, 1908 and 1910 by E.H. Wilson. *Plantae Wilsonianae* 1 (2): 154–282.
- Rehder, A. (1932) Notes on the ligneous plants described by L veill  from Eastern Asia. *Journal of the Arnold Arboretum* 13 (3): 299–332.  
<https://doi.org/10.5962/bhl.part.10810>
- Robertson, K.R., Phipps, J.B., Rohrer, J.R. & Smith, P.G. (1991) A synopsis of genera in Maloideae (Rosaceae). *Systematic Botany* 16: 376–394.  
<https://doi.org/10.2307/2419287>
- Ronquist, F., Teslenko, M., van der Mark, P., Ayres, D.L., Darling, A., Hohna, S., Larget, B., Liu, L., Suchard, M.A., Huelsenbeck, J.P. (2012) MrBayes 3.2: efficient Bayesian phylogenetic inference and model choice across a large model space. *Systematic Biology* 61 (3): 539–542.  
<https://doi.org/10.1093/sysbio/sys029>
- Roxburgh, W. (1832) *Flora Indica; or, Descriptions of Indian Plants* 3. W. Thacker & Co., Calcutta and Parbury, Allen & Co., London, pp. 875.  
<https://doi.org/10.5962/bhl.title.590>
- Scott, B. & Smith, V. (2014) Natural History Museum Data Portal. Available from: <https://doi.org/10.5072/1https://data.nhm.ac.uk/> (accessed 16 December 2020)
- Shaw, J.M.H. (2020) Proposal to conserve the name *Eriobotrya* against *Rhaphiolepis* (Rosaceae). *Taxon* 69 (3): 620.  
<https://doi.org/10.1002/tax.12272>
- Stamatakis, A. (2014) RAxML version 8: a tool for phylogenetic analysis and post-analysis of large phylogenies. *Bioinformatics* 30 (9): 1312–1313.  
<https://doi.org/10.1093/bioinformatics/btu033>
- Tang, B. (1997) A study of the sibship among *Eriobotrya japonica* Lindl., *E. prinoides* Rehd. & Wils. var. *daduheensis* H. Z. Zhang and *E. prinoides* Rehd. & Wils. J. *Chongqing Teachers College* 14: 18–25.
- Vidal, J.E. (1965) Notes sur quelques Rosac es asiatiques (III). R vision du genre *Eriobotrya* (Pomoideae). *Adansonia* 5: 537–580.
- Vidal, J.E. (1968) *Flore du Cambodge du Laos et du Vietnam* (Supplement a la Flore generale de l'Indochine de H. Lecomte). Vol. 6. Museum National D'Histoire Naturelle, Paris, 60–82.
- Vidal, J.E. (1970) *Eriobotrya*. In: Larsen, K. (Ed.) *Flora of Thailand*. Vol. 2. Forest Herbarium, Royal Forest Department, Bangkok, 42–44.
- Wang, Y.Q., Fu, Y., Yang, Q., Deng, Q.X., Lu, X.L., Luo, N. & Yan, J. (2010) Analysis of a germplasm collection of loquat using ISSR markers. *The Journal of Horticultural Science and Biotechnology* 85 (2): 113–118.  
<https://doi.org/10.1080/14620316.2010.11512640>
- White, T.J., Bruns, T., Lee, S. & Taylor, J. (1990) Amplification and direct sequencing of fungal ribosomal RNA genes for phylogenetics. In: Innis, M.A., Gelfand, D.H., Sninsky, J.J. & White, T.J. (Eds.) *PCR Protocols: A Guide to Methods and Application*. Academic Press, San Diego, California, pp. 315–322.  
<https://doi.org/10.1016/B978-0-12-372180-8.50042-1>
- Wu, D., Fan, W.G., He, Q., Guo, Q.G., Spano, A.J., Wang, Y., Timko, M.P. & Liang, G.L. (2015) Genetic diversity of loquat [*Eriobotrya japonica* (Thunb.) Lindl.] native to Guizhou Province (China) and its potential in the genetic improvement of domesticated cultivars. *Plant Molecular Biology Reporter* 33 (4): 952–961.  
<https://doi.org/10.1007/s11105-014-0809-y>
- Xiang, Y., Huang, C.H., Hu, Y., Wen, J., Li, S., Yi, T., Chen, H., Xiang, J. & Ma, H. (2017) Evolution of Rosaceae fruit types based on nuclear phylogeny in the context of geological times and genome duplication. *Molecular Biology and Evolution* 34 (2): 262–281.
- Xie, J.H., Yang, X.H. & Lin, S.Q. (2007) Analysis of genetic relationships among *Eriobotrya* germplasm in China using ISSR markers. *Acta Horticulturae* 750: 203–208.  
<https://doi.org/10.17660/ActaHortic.2007.750.31>
- Yang, X.H., Glakpe, K., Lin, S.Q., Hu, Y.L., He, Y.H., Nguyen, T.C.N., Liu, Y.X., Hu, G.B. & Liu, C.M. (2005) Taxa of genus *Eriobotrya* plants around the world and native to Southeastern Asia. *Journal of Fruit Science* 22: 55–59.
- Yang, X.H., Najafabadi, S.K., Shahid, M.Q., Zhang, Z.K., Jing, Y., Wei, W.L., Wu, J.C. & Lin, S.Q. (2017) Genetic relationships among *Eriobotrya* species revealed by genome-wide RAD sequence data. *Ecology and Evolution* 7 (8): 2861–2867.  
<https://doi.org/10.1002/ece3.2902>
- Yang, X.H., Li, P., Lin, S.Q., Hu, G.B. & He, X.L. (2012) A preliminarily phylogeny study of the *Eriobotrya* based on the nrDNA Adh sequences. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca* 40 (2): 233–237.

<https://doi.org/10.15835/nbha4027997>

- Yang, X.H., Liu, C.M. & Lin, S.L. (2009) Genetic relationships in *Eriobotrya* species as revealed by amplified fragment length polymorphism (AFLP) markers. *Scientia Horticulturae* 122 (2): 264–268.  
<https://doi.org/10.1016/j.scienta.2009.04.012>
- Yang, X.H., Liu, C.M. & Lin, S.Q. (2007) The genetic relationship among common loquat, Daduhe loquat and Oakleaf loquat, according to RAPD and AFLP analysis. *Subtropical Plant Science* 36 (2): 9–12.
- Yang, X.H., Lin, S.Q., Hu, G.B., Li, P., & Xu, S.J. (2011) Preliminary study on ITS sequencing and characterization of *Eriobotrya*. *Acta Horticulturae* 887: 85–88.  
<https://doi.org/10.17660/ActaHortic.2011.887.12>
- Yü, T.T. & Kuan, K.C. (1963) Taxa nova *Rosacearum sinicarum* (I). *Acta Phytotaxonomica Sinica* 8 (3): 202–234.
- Zhang, H.Z., Peng, S.A., Cai, L.H. & Fang, D.Q. (1990) The germplasm resources of the genus *Eriobotrya* with special reference on the origin of *E. japonica* Lindl. *Acta Horticulturae Sinica* 17 (1): 5–12. [In Chinese with English abstract]
- Zhang, Z.K., Li, G.F., Yang, X.H. & Lin, S.Q. (2017) Taxonomic studies using multivariate analysis of *Eriobotrya* based on morphological traits. *Phytotaxa* 302 (2): 122–132.  
<https://doi.org/10.11646/phytotaxa.302.2.2>
- Zhao, G.J., Yang, Z.Q., Chen, X.P. & Guo, Y.H. (2011) Genetic relationships among loquat cultivars and some wild species of the genus *Eriobotrya* based on the internal transcribed spacer (ITS) sequences. *Scientia Horticulturae* 130 (4): 913–918.  
<https://doi.org/10.1016/j.scienta.2011.09.007>