



NOTE

Supplementary descriptions of inflorescence and achene of two species of *Elatostema* (Urticaceae) from China

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ABSTRACT: We demonstrate the high value of the inflorescence and achene for taxon delimitation in *Elatostema*. Over half of the descriptions of the ca 280 species described from China, however, lack information on inflorescence and/or achene morphology and this hampers the progress of species discovery and infrageneric classification. In this paper we supplement the descriptions, illustrations and photos of infructescence and achene of *Elatostema binatum* and staminate inflorescence of *E. fengshanense* in order to support future taxonomic revisions of this species-rich genus. In addition, we assessed the extinction threat of these species.

KEY WORDS: *Elatostema binatum*, *E. fengshanense*, Conservation assessment, Guangxi, Infructescence, Limestone cave.

INTRODUCTION

Elatostema J.R. Forst. & G. Forst. (Urticaceae) comprises several hundred species of herbs and subshrubs that grow in deep shade of forests, gorges, stream sides and caves (Wang, 2014; Fu *et al.*, 2017). *Elatostema* is distributed throughout tropical and subtropical Africa, Madagascar, Asia, Australasia and Oceania. China is a center of diversity for *Elatostema* as at least 280 species occur there (Wang, 2014), especially on karst (Fu *et al.*, 2019).

Recent phylogenetic studies have reassessed the circumscription of *Elatostema s.l.* and its generic and subgeneric classification based on morphological and molecular evidence (Tseng *et al.*, 2019). The newly defined *Elatostema sensu auct.* comprises four clades: core *Elatostema*, *Pellionia*, *Weddellia*, and African *Elatostema* and does not support the classification of Wang (1980, 2014). The core *Elatostema* clade comprises the majority of *Elatostema* and occurs mainly in China, Southeast Asia and Oceania. Because of unclear relationships amongst the species within this clade, however, their classification within the clade has never been achieved. *Elatostema* species are difficult to distinguish from each other due to their tiny flowers congested into receptacle-like involucre, variation in staminate tepal number and the reduced nature of the pistillate tepals (Fu *et al.*, 2014a). The inflorescence and achene include more informative characters useful for determining the systematic position and infrageneric relationships in this genus (Wang, 2010; Tseng *et al.*, 2019). However, information is lacking on pistillate inflorescence (21%), staminate inflorescence (29%) and achene (44%) of Chinese species (Wang, 2014). Despite

extensive supplementary research and fieldwork to decrease these proportions (Wu *et al.*, 2012a, 2012b; Fu *et al.*, 2014b; Chen *et al.*, 2017), the documentation of these characters remains a high priority for future study.

During our investigations of limestone karst in Guangxi, China, in 2018, *Elatostema binatum* and *E. fengshanense* were collected with infructescences and staminate inflorescences respectively. After a thorough review of the literature we confirmed that the infructescence (including achene) and staminate inflorescence of these species had not hitherto been described (Lin *et al.*, 2003; Wu *et al.*, 2012a, 2012b; Fu *et al.*, 2014b; Wang, 2014; Chen *et al.*, 2017). Thus we supplement the existing species descriptions to support the identification, description of new species and classification of these species and facilitate their subsequent conservation.

MATERIALS AND METHODS

Specimens of *Elatostema binatum* and *E. fengshanense* were collected in their natural habitat in Yangzi cave, Fengshan County, Guangxi, China and deposited at the herbarium of the Guangxi Institute of Botany (IBK). The infructescences of *E. binatum* including mature achenes, and the staminate inflorescences of *E. fengshanense* were carefully detached from the herbarium specimens and examined under an Olympus SZX16 binocular microscope and Plan Apo lens at $\times 10$ and $\times 90$ magnifications (Japan). Photos were taken using the Olympus DP72 digital imaging system (Japan) and line drawings prepared from the dissecting microscope images.

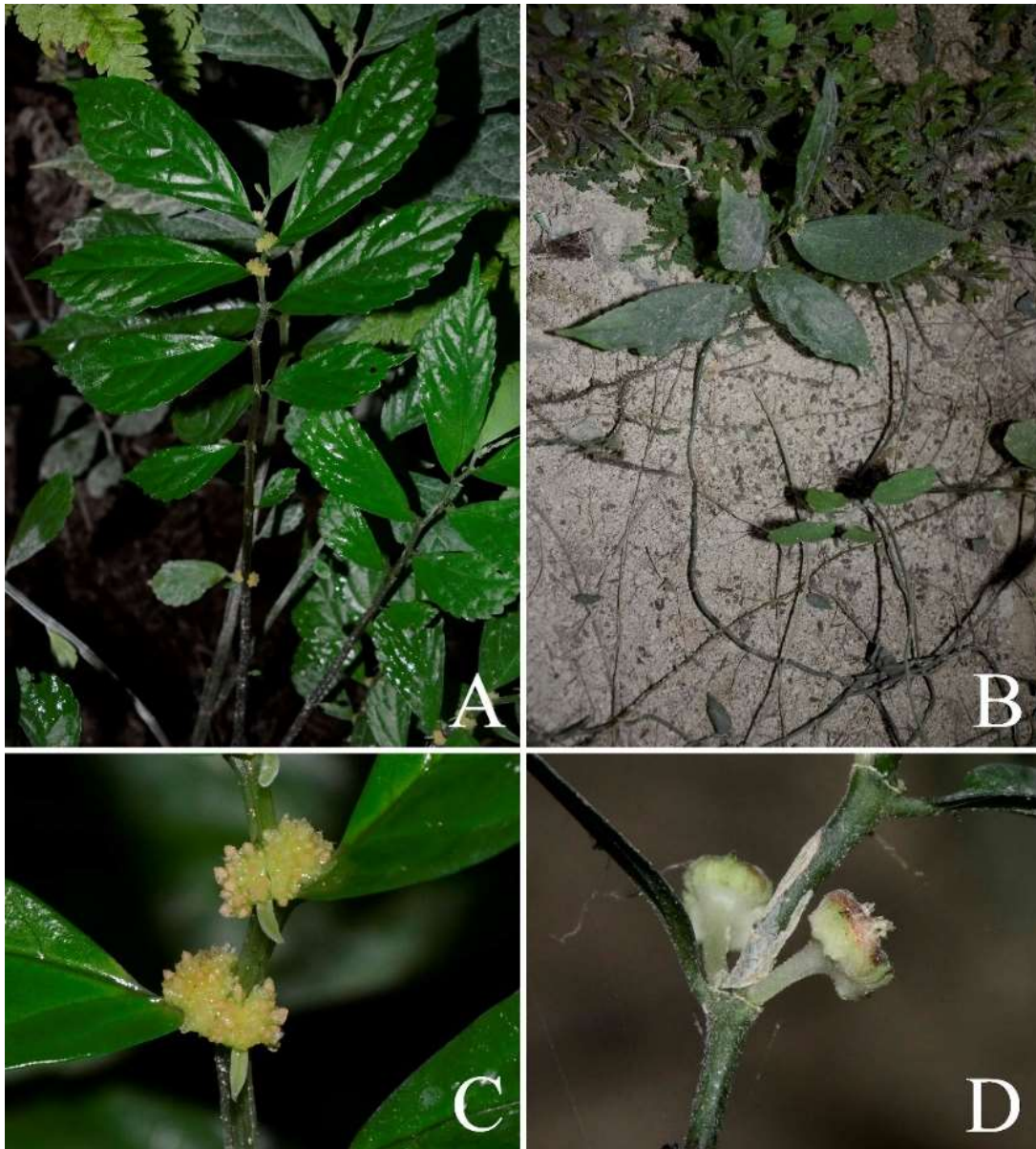


Fig. 1. Photographs of two *Elatostema* species. *E. binatum* W.T. Wang. **A:** Habit, **C:** Paired pistillate infructescences with mature achenes; *E. fengshanense* W.T. Wang & Y.G. Wei. **B:** Habit, **D:** Paired staminate inflorescences. (Photograph by L.F. Fu)

TAXONOMIC DISCUSSION

Elatostema binatum W.T. Wang in *Guihaia* 27(6): 813. 2007. **Fig. 1: A, C; Fig. 2: A–C**

Type: CHINA. Guangxi: Fengshan County, Lindong, in cave on a limestone hill, 23 April 2007, *Y.G. Wei 0779* (holotype: PE!; isotype: IBK!)

Pistillate inflorescences axillary, paired, sessile, involucre receptaculate, bracteolate; receptaculate involucre 1.4–1.7 × 3–3.3 mm, rectangular, deeply divided into two lobes, each lobe further weakly divided into two lobes, glabrous, subtended by marginal bracts, bracts ca. 24, subequal, triangular, 0.4–0.6 × 0.2–0.3 mm; bracteoles 2

per flower, subequal, ca. 0.7 × 0.07 mm, lanceolate-linear, membranous, semitransparent; pistillate flower not seen. Achenes 10–15 per infructescence, 0.703–0.769 × 0.326–0.398 mm, length : width ratio 1.8–2.1, ellipsoid, with 6–7 narrow longitudinal ribs, pale brown.

Specimens examined: CHINA. Guangxi: Fengshan County, Yangzi cave, N 107°04'53" E 24°24'38", 740 m, *L.F. Fu & Z.B. Xin FLF180528-14* (IBK, TAD).

Notes: In a recent phylogenetic analysis *Elatostema binatum* was recovered in a moderately supported clade comprising it, *E. oblongifolium* and *E. tenuinerve* (Tseng *et al.*, 2019). Despite similarities in leaf shape among these three species, they have completely different staminate inflorescence morphology and so would not

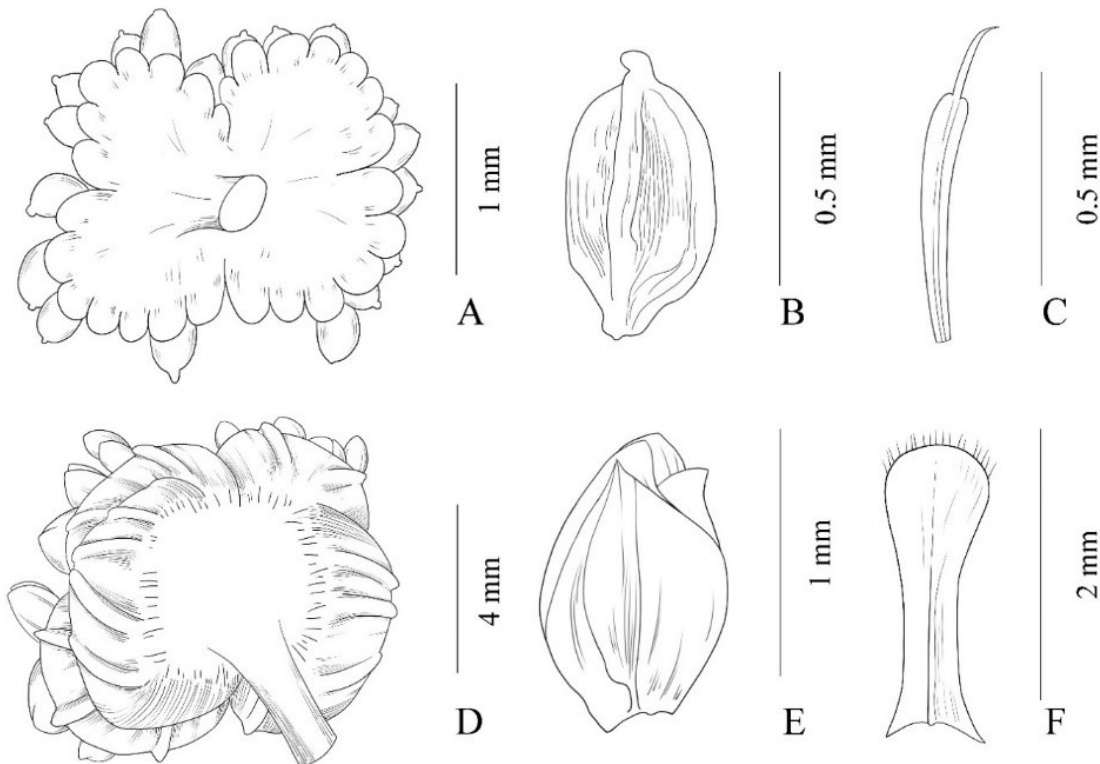


Fig. 2. Illustrations of two *Elatostema* species. *E. binatum* W.T. Wang. **A:** Pistillate inflorescence; **B:** achene; **C:** Pistillate bracteole; *E. fengshanense* W.T. Wang & Y.G. Wei. **D:** Staminate inflorescence; **E:** Immature staminate flower; **F:** staminate bracteole. (Illustration by Yi-Xuan Zhu)

have been considered closely-related based on Wang's classification which treated the structure of staminate inflorescence as key morphology at section level (Wang, 1980, 2014). The structure of the pistillate inflorescence and achene morphology, however, does supports this relationship with all three species possessing a receptaculate involucre divided into four lobes, numerous bracts, and ellipsoidal achenes with 6–7 narrow longitudinal ribs (Wang, 2014).

Conservation status: An assessment of extinction threat is presented here based on IUCN methodology (2012, version 3.1). *Elatostema binatum* is known from only three localities where there are ca. 150 mature individuals (<250 mature individuals, criteria D). Three localities are in limestone karst, associated with caves and close to agricultural land, which although deforested in the past, appears not to be actively disturbed. Using the IUCN methodology we assess *E. binatum* as Endangered (EN) based on criteria D: population size and number of locations combined with a plausible future threat that could drive this taxon to Extinct in a very short time. The most active threats include the use of caves in agriculture to store livestock or cultivate medicinal plants, the mining of the limestone hills for cement production, or tourism (Monro *et al.*, 2018).

Elatostema fengshanense W.T. Wang & Y.G. Wei in Guihaia 29(6): 714. 2009.

Fig. 1: B, D; Fig. 2: D–F

Type: CHINA. Guangxi: Fengshan County, in limestone hills, 22 April 2008, *Y.G. Wei 08018* (holotype: PE!; isotype: IBK!).

Staminate inflorescence axillary, paired, pedunculate, involucre receptaculate, bracteolate, bearing ca. 60 flowers; peduncle ca. 2 × 0.7 mm, glabrous; receptaculate involucre ca. 6 × 4 mm, rectangular or oblong, weakly divided into two lobes, glabrous, subtended by marginal bracts, bracts 6, unequal, glabrous, outer major bracts 2, inner minor bracts 4; major bracts ca. 1.4 × 4.0 mm, broadly ovate, with 3–5 longitudinal ribs, each rib extending apically as a corniculate protuberance; minor bracts, obovate, ca. 2 × 3 mm, abaxial surface with 1–2 longitudinal ribs, at least 1 rib extending apically as a corniculate protuberance. Staminate flowers (only immature ones seen) pedicellate; bracteoles 2 per flower, subequal, ca. 2.1 × 0.4 mm, spatulate-linear, membranous, semitransparent, apex sparsely ciliate.

Specimens examined: CHINA. Guangxi: Fengshan County, Yangzi cave, N107°04'53" E24°24'38", 740 m, *L.F. Fu & Z.B. Xin FLF180528-11* (IBK, TAI); same locality, *A.K. Monro & Y.G. Wei 6651* (BM, IBK).



Notes: In a recent phylogenetic analysis *Elatostema fengshanense* was recovered in a strongly supported clade comprising also *E. balansae*, *E. cyrtandrifolium* and *E. garrettii* (Tseng *et al.*, 2019). The description of the staminate inflorescence of *E. fengshanense* further supports this close relationship, all three species sharing the characters of receptaculate involucre weakly divided into two lobes and six bracts, of which the two outer bracts are major and the four inner are minor (Wang, 2014). The major bracts of *E. fengshanense* possess 3-5 longitudinal ribs, the minor bracts 1-2 longitudinal ribs. The major bracts of *E. cyrtandrifolium* have 7 short longitudinal ribs, the minor bracts 1-2 short longitudinal ribs. The major bracts of *E. balansae* have 3 inconspicuous longitudinal ribs and the minor bracts have no ribs. Unfortunately, no information about these characters is available for *E. garrettii*, a Thai endemic (Yahara, 1984). *E. retrohirtum* also possessing these characters (Fu *et al.*, 2014b) revealed its systematic position likely belongs to this clade although it has not yet included in the phylogenetic studies (Tseng *et al.*, 2019). Differences in these characters might indicate an evolutionary trend for the longitudinal ribbed number and corniculate protuberance of staminate bracts from less to more but this requires further research (Wang, 2010).

Conservation status: An assessment of extinction threat is presented here based on IUCN methodology (2012, version 3.1). *Elatostema fengshanense* is known from more than five localities in Guangxi, China and Cao Bang, Vietnam (Fu *et al.*, 2019) and we estimate that the population of mature individuals is >1000. Given the distance separating the known localities for this species, it is also likely that there remain as yet undiscovered populations. For these reasons we assess *E. fengshanense* as Least Concern (LC).

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LITERATURE CITED

- Chen, X.-Q., L.-F. Fu, F. Wen, S. Li, Y. Liu and Y.-G. Wei. 2017. Supplementary description of achenes of *Elatostema* (Urticaceae). *Guihaia* **37**(7): 849-854.
- Fu, L.-F., V. T. Do, F. Wen and C.-X. He. 2014a. *Elatostema arcuatobracteatum* (Urticaceae), a new species from Vietnam. *Phytotaxa* **174**(2): 111-115.
- Fu, L.-F., S.-L. Huang, Y. Liu, V. T. Do, F. Wen and Y.-G. Wei. 2014b. A newly recorded species of *Elatostema* (Urticaceae) from Vietnam. *Taiwania* **59**(3): 281-286.
- Fu, L.-F., A. K. Monro, S.-L. Huang, F. Wen and Y.-G. Wei. 2017. *Elatostema tiechangense* (Urticaceae), a new cave-dwelling species from Yunnan, China. *Phytotaxa* **292**(1): 085-090.
- Fu, L.-F., A. Monro, V. T. Do, M. S. Nuraliev, L. V. Averyanov, F. Wen, Z.-B. Xin, T. V. Maisak, A. N. Kuznetsov, S. P. Kuznetsova, K. S. Nguyen and Y.-G. Wei. 2019. Checklist to the *Elatostema* (Urticaceae) of Vietnam including 19 new records, ten new combinations, two new names and four new synonyms. *PeerJ* **6**: e6188.
- IUCN 2012. IUCN Red List Categories and Criteria, ver. 3.1. ed. 2. IUCN Red List Unit, Gland.
- Lin, Q., I. Friis and M. C. Wilmot-Debar. 2003. *Elatostema*. In: Wu, Z. & Raven, P. H. [eds.], *Flora of China*, vol. 5: 76-189. Science Press, Beijing and Missouri Botanical Garden Press, St. Louis, Missouri.
- Monro, A. K., N. Bystrakova, L. Fu, F. Wen and Y. Wei. 2018. Discovery of a diverse cave flora in China. *Plos One* **13**(2): e0190801.
- Tseng, Y.-H., A. K. Monro, Y.-G. Wei and J.-M. Hu. 2019. Molecular phylogeny and morphology of *Elatostema s.l.* (Urticaceae): implications for inter- and infrageneric classifications. *Mol. Phylogenet. Evol.* **132**: 251-264.
- Wang, W.-T. 1980. *Classificatio specierum sinicarum Elatostematis* (Urticaceae). *Bull. Bot. Lab. N. E. Forest. Inst., Harbin* **7**: 1-96.
- Wang, W.-T. 2010. Morphology of the bracts of *Elatostema* (Urticaceae) and the evolutionary trends in them. *Guihaia* **30**(5): 571-583.
- Wang, W.-T. 2014. *Elatostema* (Urticaceae) in China. Qingdao: Qingdao Press.
- Wu, Z.-Y., H. Wang and D.-Z. Li. 2012a. Supplementary description of inflorescences of three species in *Elatostema* (Urticaceae). *Plant Diversity and Resour.* **34**(1): 13-16.
- Wu, Z.-Y., H. Wang, D.-Z. Li. 2012b. Supplementary description of achenes of seven species in *Elatostema* (Urticaceae). *Guihaia* **32**(5): 603-606.
- Yahara, T. 1984. *Pellionia* and *Elatostema* in Thailand. Taxonomic studies of Urticaceae II. *J. Fac. Sci. Univ. Tokyo, Bot.* **13**: 483-499.