Australian Journal of Taxonomy
Open-access, online, rapid taxonomy
https://doi.org/10.54102/ajt

Boea cavernarum Zich & B.Gray (Gesneriaceae), a remarkable new species from north Queensland, Australia

F.A. Zich [1,2*] & B. Gray [1]

[1] Australian Tropical Herbarium, James Cook University Nguma Bada Campus, McGregor Road, Smithfield, Queensland 4878, Australia
[2] National Research Collections Australia, Commonwealth Industrial and Scientific Research Organisation (CSIRO), GPO Box 1700, Canberra, ACT 2601, Australia

*Corresponding author: frank.zich@csiro.au
Frank Zich https://orcid.org/0000-0001-9984-8551

Abstract

Boea cavernarum, restricted to near limestone crevices and caves in NE Queensland, is described. Images of whole plants, flowers, fruit and leaf indumentum, a distribution map, and a key to all species of *Boea* in Australia are provided. Thirteen species are now recognised in *Boea*.

Cite this paper as: Zich FA & Gray B (2024). *Boea cavernarum* Zich & B.Gray (Gesneriaceae), a remarkable new species from north Queensland, Australia. *Australian Journal of Taxonomy* 62: 1–8. doi: https://doi.org/10.54102/ajt.fxy40

Introduction

Boea Comm. ex Lam. belongs to the subtribe Loxocarpinae, tribe Trichosporeae, subfamily Didymocarpoideae, family Gesneriaceae (Weber *et al.* 2020). At present, *Boea* comprises 12 species of caulescent or rosulate herbs distributed in Indonesia, Papua New Guinea, Solomon Islands and Australia (Puglisi & Middleton 2018; Zich & Gray 2021). Australia has three species of *Boea,* all of which are endemic to Queensland: *Boea hygroscopica* F.Muell. from south of Cooktown to near Rockhampton; *Boea kinnearii* (F.Muell.) B.L.Burtt from high altitude mountains in the Wet Tropics, and *Boea resupinata* Zich & B.Gray from northern Cape York Peninsula.

Soon after the naming of *Boea resupinata* (Zich & Gray 2021), another new and previously uncollected species was discovered in north Queensland by Tim Hawkes while exploring a remote limestone formation near Palmerville, north Queensland.

The limestone formation known as the Mitchell-Palmer Karst is located c. 180 km NW of Cairns, to the north-west of Chillagoe, between the Palmer River and Mitchell River on three pastoral stations, Palmerville, Mount Mulgrave and Bellevue. It consists of a series of exposed limestone ridges which are part of the Chillagoe Formation, extending north-south over 100 km in length and in a band up to approximately 10 km wide (Moylan 1980; Kavanagh 1999; Lourandos *et al.* 2012). The limestone outcrops are in a series of approximately 150 parallel towers, many of which exceed 1 km in length and 500 m in width, jutting up to 150 m above the surrounding landscape. The caves within the towers tend not to develop much below plain level (Kavanagh 1999). Lourandos *et al.* (2012: 52) discuss evidence from snail shells to "*...indicate an unbroken association with*

This paper was submitted on 6 March 2024 and published on 30 April 2024 (2024-04-29T21:16:33.993Z). It was reviewed by Wendy Cooper and Andrew Ford, and edited by Kevin Thiele. Australian Journal of Taxonomy. ISSN: 2653-4649 (Online).

vine thicket." and that "*While the karst formations may have acted as refugia for such relatively humid forest vegetation, low quantities of rainforest/wet forest vertebrate taxa at the site suggest that humid forest or vine thicket itself was never expansive across the region during the past 30,000 years*".

The Australian Heritage Council (AHC) has determined that the Chillagoe Karst Region, including parts of the Mitchell-Palmer Karst Belt, meets the National Heritage criteria for its outstanding karst limestone bluffs, towers and cave development (Australian Government 2023a), and contains "*...the best examples of tropical limestone bluffs and towers in Australia, and is potentially significant at a global level with the closest comparisons being in Cuba and Madagascar. The cave systems include over 1,000 recorded and mapped caves, the largest extent of cave development in Australia"* (Australian Government 2023b: 1).

This remarkable new *Boea* species is distinct from all other species in the genus in possessing a densely matted, interwoven indumentum of long, fine, multicellular, branched eglandular hairs on both leaf surfaces, resembling those recorded for *Paraboea* (C.B.Clarke) Ridl. and *Middletonia* C.Puglisi (Xu *et al.* 2008; Puglisi *et al.* 2016; Puglisi & Middleton 2017). Using Weber *et al.* (2020) this new species keys to *Paraboea* and *Middletonia* due to the densely matted hairs, however it closely resembles *Boea* in having the following combination of character states: flat-faced corolla, lips of corolla about equal in size, ovary with glands, unequally bifid stigma, and twisted capsule. Molecular phylogenetic research aimed at testing generic limits in *Boea* and allied genera is underway (D. Middleton *pers. comm.*) and tissue samples of this and other Australian species of the genus have been supplied to this project. Despite the unique indumentum, this new species is named here in the genus *Boea* pending the results of these phylogenetic studies.

Methods

This study is based on the examination of herbarium material at CNS combined with observations of plants in the field and cultivation. Measurements of the leaves, floral parts and fruits are based on wild and cultivated material, both living and preserved in 70% ethanol.

For Scanning Electron Microscopy (SEM) fresh leaf pieces were harvested into 3% glutaraldehyde in 0.1M cacodylate buffer and washed 3 times with fresh buffer. After post fixation with osmium tetroxide (1hr at room temperature), the samples were washed 3 times with DI water. Samples were then dehydrated in an ethanol series from 30–100% concentration for 15 minutes each (3x 100%) and dried (E3000 Series Critical Point Dryer, Quorum Technologies Ltd, Laughton, UK). Samples were then mounted on stubs, gold-coated (SPI Module, SPI Supplies, West Chester, PA, USA) and imaged in a SU5000 FEG scanning electron microscope (Hitachi Hi-Tech Corp., Tokyo, Japan).

Taxonomy

Key to Australian species of *Boea*

1a. Leaves with multicellular branched hairs **B. cavernarum**

1b. Leaves with multicellular uniseriate (unbranched) hairs **2**

2a. Petals with multicellular hairs on outside; filaments strongly bent **B. resupinata**

2b. Petals glabrous; filaments twisted, not strongly bent **3**

3a. Abaxial leaf surface with multicellular eglandular hairs only; flowers white; fruit 0.8–1 cm long, straight or slightly twisted **B. kinnearii**

3b. Abaxial leaf surface with mixture of gland-tipped and eglandular hairs; flowers purple to blue; fruit 1.5–3.5 cm long, twisted **B. hygroscopica**

Boea cavernarum Zich & B.Gray, *sp. nov.*

Queensland. Cook District: Palmerville limestone, 16 Aug 2021, *B. Gray 10003* (holo: BRI; iso: CNS [CNS152589], CANB, L, E).

Differing from all *Boea* by the presence of densely matted white multicellular, branched eglandular hairs (versus multicellular unbranched hairs). With affinity to *Boea resupinata* but differing in twisted filaments (versus strongly bent).

Woody, caulescent herb, appearing rosulate when young; stem to at least 30 cm long, 2.0–8.7 mm diameter, soft and spongy when young, sometimes branched; stems covered with persistent petiole bases which have a densely matted white multicellular branched eglandular hairs, becoming sparse and glabrous on old stems; persistent peduncles also sometimes present in axils of petioles; old stems longitudinally grooved when dry, extending down from the petiole base; glandular hairs absent; petiole base broad and partly sheathing stem when young; abaxial surface with densely matted white multicellular branched eglandular hairs; petiole c. 10–-30 mm long, slightly longitudinally grooved adaxially; abaxial surface with densely matted white multicellular branched eglandular hairs, sparser adaxially. Leaves alternate; blade elliptic, ovate to somewhat obovate, 62–110 mm long × 27–53 mm wide, c. 2 times as long as wide, apex rounded to obtuse, base cuneate, margin crenate in upper 2/3 to smooth in lower 1/3; lateral veins 5–6 pairs; adaxial surface pale–mid green, with white multicellular branched eglandular hairs, leaf surface visible through hairs, and with sparse yellow glands; abaxial surface covered with densely matted white multicellular branched eglandular hairs, denser on veins; yellow glands present; abaxial leaf surface

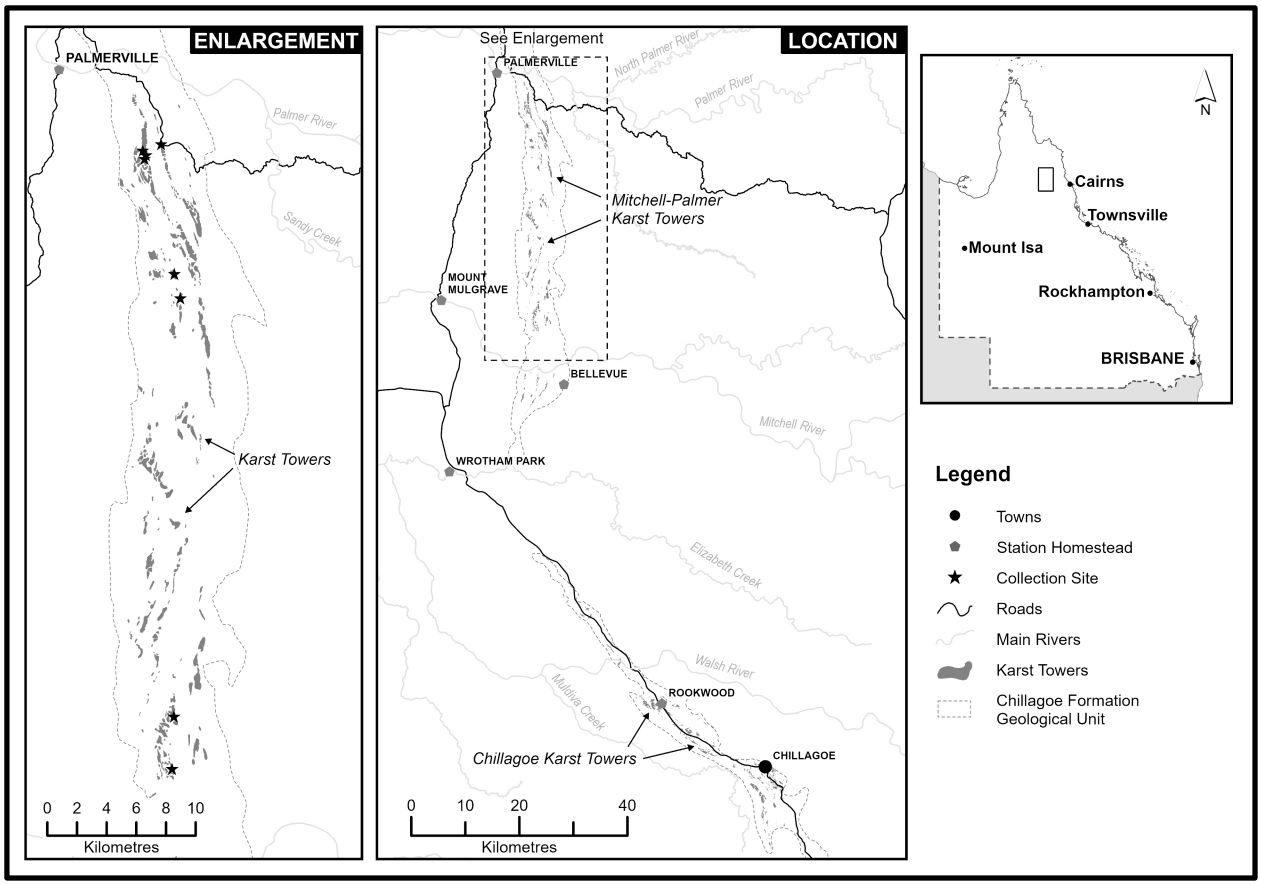

Figure 1. Distribution map of *Boea cavernarum* based on specimens at CNS. The limestone formation known as the Mitchell-Palmer Karst is shaded grey in the englargement (Pearson 1988).

curling upwards when dried and enclosing the adaxial surface. Inflorescence as long as or longer than leaves, 2–9 or more-flowered, with densely matted white multicellular branched eglandular hairs up to and including the adaxial surface of the calyx. Peduncles 65–97 mm long; bracts 4.5–7 mm long × 1 mm wide at base, narrowly lanceolate to linear; abaxial surface with densely matted white multicellular branched eglandular hairs, sparser adaxially. Pedicels 7–14 mm long, with densely matted white multicellular branched eglandular hairs. Calyx free or almost free to base, lobes 5–7 × 1–1.5 mm, linear-lanceolate, apex acute to obtuse, appressed to petals; abaxial surface covered with densely matted white multicellular branched eglandular hairs, adaxial surface glabrous; glands sparse. Corolla bilabiate, violet with purple lines on 3-lobed lip, throat yellow, glabrous; tube c. 11.5 mm long, shortly-campanulate; 2-lobed lip c. 14 mm long, lobes equal, rounded, lobes c. 9 mm long × 9 mm wide, overlapping; 3-lobed lip 12–14 mm long, lobes ovate to rounded, central lobe smaller than lateral lobes and sometimes slightly spathulate, lobes c. 8 × 8 mm, overlapping, longer than half the length of the lip. Stamens 2, bright yellow, glabrous, c. 5 mm long; filaments arising c. 0.5 mm above the corolla base, broader and flattened in the middle; anthers coherent, c. 3 mm long × 1 mm wide, dehiscing longitudinally; staminodes 3, outer staminodes c. 1 mm, central staminode c. 0.4 mm long. Gynoecium c. 11 mm long; ovary c. 4 mm long, glands present; style c. 6 mm long, glabrous; stigma c. 1 mm long, bifid with unequal hirsute lobes. Capsule brown, 14–27 mm long, c. 2 mm diameter prior to dehiscence, glabrous, 2-valved, twisted, dehiscing longitudinally along valves. Seeds elliptic, c. 0.6 mm long × 0.3 mm wide. Figs. 2–5.

Additional specimens examined: Queensland. Cook District: Palmerville Limestone, Limestone Creek Road, 7 April 2021, *B.Gray 10000 & Simpson* (BRI, CNS); Palmerville Limestone, 7 April 2021, *B.Gray 10001 & Simpson* (BRI, CANB, CNS); Wilsons Cave, Limestone Creek road, Palmerville, Qld, 17 August 2021, *B.Gray 10004* (BRI, CNS, CANB); Small cave 20 m N of Smeargile Drift Cave, Mt Mulgrave Station, 20 September 2021, *B.Gray 10006* (BRI, CNS); At mouth of cave NP145, Mt Mulgrave Station, 20 September 2021, *B.Gray 10007* (BRI, CNS, E); At mouth of cave NP 211, Limestone Creek Road, Palmerville, 5 December 2021, *B.Gray 10009* (CNS); Palmerville Limestone, 29 April 2022, *B.Gray* 10054 (CNS). CULTIVATED: Hastie Road, Atherton, 31 January 2022, *B.Gray 10011* [flowering] (BRI, CNS) (Wild origin: *B.Gray 10009*).

Figure 2. *B. cavernarum*. (a) hydrated habit and habitat; (b) desiccated habit and habitat. Vouchers: (a) Palmerville limestone, Qld, *B.Gray 10054*, CNS 152597; (b) Palmerville, Qld, *B.Gray 10004*, CNS 152590 (b). Images: B.Gray.

Figure 3. *B. cavernarum*. (a) flower; (b) calyx. Voucher: *B.Gray 10011*, CNS 152595. Images: B. Gray.

Distribution and habitat: *Boea cavernarum* is known from caves and cracks in a series of limestone towers in the karst of the Mitchell-Palmer River region as mapped by Pearson (1988) (Fig. 1), c. 180 km NW of Cairns, north Queensland. It grows as a lithophyte in bare areas of limestone and skeletal leaf debris in the mouth of limestone caves, in areas of deciduous microphyll vine thicket on limestone outcrops, at an elevation of c. 300–400 m above sea level. The geology of the limestone outcrops and the region is described in Moylan (1980), Kavanagh (1999) and Lourandos *et al.* (2012).

Phenology: Flowering plants have been collected in the wild in April. Plants cultivated at Atherton, north Queensland, have flowered from December to April. It is likely that the flowering season commences at the beginning of, and lasts for the duration of, the wet season. Previous season's fruits are still present in a fully dehisced state in December.

Figure 4. *B. cavernarum*. (a) bifid stigma; (b) green fruit partly enclosed by sepals; (c) dehisced fruit. Voucher: *B.Gray 10011*, CNS 152595. Images: B. Gray.

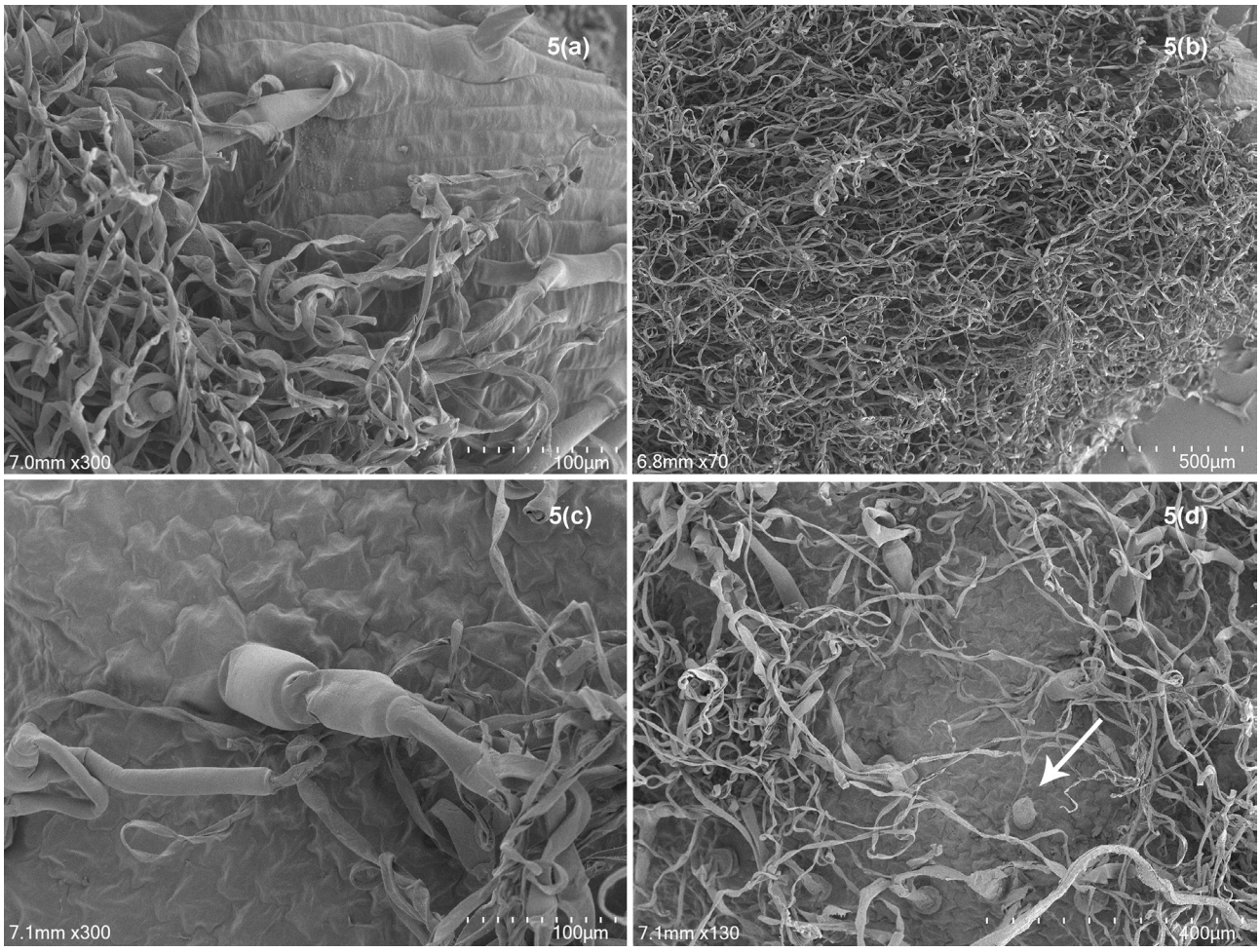

Figure 5. *B. cavernarum*. (a) SEM image of lower leaf surface showing multicellular branched eglandular hairs, with bare surface near base of leaf; (b) SEM image of lower leaf surface showing multicellular branched eglandular hairs near midzone of leaf blade; (c) SEM image of upper leaf surface showing multicellular branched eglandular hairs and cells with sinuate margins; (d) SEM image of upper leaf surface showing multicellular branched eglandular hairs, a single gland (arrow), and cells with sinuate margins. Voucher: *B.Gray 10011*, CNS 152595. Images: J. Whan.

Affinities: *Boea cavernarum*, while possessing features typical of the genus *Boea* (herbaceous, caulescent or rosulate habit, flat-faced corolla, lips of corolla about equal in size, ovary with glands, unequally bifid stigma and twisted capsule) does not have obvious affinities with any other *Boea* species based on the indumentum of matted, interwoven, white, multicellular, branched, eglandular hairs. This hair type is not recorded for *Boea* (Puglisi *et al.* 2016; Puglisi & Middleton 2018; Weber *et al.* 2020) and its presence is used to distinguish *Boea* from its close relatives *Paraboea* and *Middletonia* by Puglisi *et al.* 2016 and Weber *et al.* (2020). Despite these differences in hairs, and pending further investigation including molecular studies, a pragmatic decision to name the species in *Boea* has been made here.

Notes: Scanning electron micrographs (SEM) of the abaxial (lower) leaf surface (Fig. 5a, b) did not reveal any stomata, though these can be seen elsewhere under stereo microscope magnification, and the epidermal cells appear rectangular. SEM of the adaxial (upper) leaf surface (Fig. 5c, d) reveal sinuate epidermal cells. Both leaf surfaces have an indumentum of fine, multicellular, branched, eglandular hairs.

The hairs of *B. cavernarum* closely resemble the arachnoid hairs of Burtt (1984) and the matted hairs of Zu *et al.* (2008). Burtt (1984: 402) describes a hair type called arachnoid which is "*…closely interwoven hairs that are … usually branched at least near the base*" and resurrected *Paraboea* for species carrying these hairs. Zu *et al.* (2008:166-167) redefines this hair type in *Paraboea* as matted indumentum "*…matted cashmere-wool-like hair. The hair, while very densely appressed, is very thin, curled, and interwoven. Under the scanning electron microscope we can seldom identify a hair from its base to its end and the hairs often branch throughout their length. A hair is generally multicellular.*". Additionally, Zu *et al.* (2008: 168) say of *Paraboea* that "*Plants that possess a matted indumentum are found almost exclusively from limestone substrates, and those with a long (unbranched) pubescent indumentum seem to have no preference for substrate. It is possible that the existence of a matted indumentum on the lower leaf surface provides a mechanism to survive in a dry environment because this dense layer of hairs covers the stomata on the lower leaf surface and reduces water loss by transpiration*."

Boea cavernarum demonstrates desiccation tolerance similar to that observed in *Boea resupinata* and *B. hygroscopica* (Bianchi *et al.* 1991; Proctor & Zoltán 2002; Zich & Gray 2021), in that extreme air-dry plants may rehydrate, thereby enabling them to withstand prolonged dry periods. As such *B. cavernarum* can also be regarded as a 'resurrection plant'. The dense, white hairs on leaf surfaces results in a striking silvery appearance to the leaves when plants are desiccated (Fig. 2b) and, as in *B. resupinata,* is possibly an adaptation to reflect solar radiation, reduce heat absorption and reduce transpiration (Pereira-Dias & Santos 2015; Zu *et al.* 2008).

In cultivation some flowers of *Boea cavernarum* can demonstrate morphological plasticity in some features, in particular, the staminodes. In some flowers of *Gray 10011* the two lateral staminodes developed much larger. In one flower the two lateral staminodes appeared to be functional, and in that same flower the three calyx lobes were fused almost entirely.

Conservation status: *Boea cavernarum* is known from very few collections from a few locations in the one general locality, the caves of the Mitchell-Palmer Karst limestone towers. The species has not been found in similar habitat occurring in the Chillagoe-Mungana karst formations c. 50 km SE. The small geographic extent of the Mitchell-Palmer Karst limestone towers is discussed above, and one author (B. Gray) searched suitable habitat along the extent of the formation in 2021-2022 for sub-populations of *B. cavernarum*. Plants were found at caves in many of the limestone towers searched. All plants found are restricted to the mouths of limestone caves, presumably due to a unique combination of environmental variables including light, substrate, humidity, seasonal moisture and protection from fire.

Based on known localities, and using the AAO IUCN default cell width of 2 km, the Extent of Occurrence (EOO) of *Boea cavernarum* is estimated to be 50 km^2 with an Area of Occupancy (AOO) of 20km^2 (calculated with GeoCat; Bachman *et al*. 2011). Sufficient information is not available to make good estimates of population size, generation time or reproductive rates. The known localities are in remote areas outside of National Parks or other conservation areas. Recent 'megafires' on the Australian continent have demonstrated the risk to ecosystems, in particular mesic and fire-protected ecosystems, posed by the combination of changing climate and fire regimes (Jones & Ricketts 2023). Increasing drying has seen habitats previously considered not likely to be threatened by fire become susceptible to larger, more intense fires in certain seasons. Invasion by highly flammable grasses such as the environmental weed gamba grass (*Andropogon gayanus*) are also increasing the fire frequency and/or intensity in rangeland and savanna communities in northern Australia (Russell-Smith *et al.* 2019) of the kind adjacent to and surrounding the limestone karst formations. Given these factors, it is reasonable to infer a decline in habitat area, extent or quality into the future (Sub-criterion b(iii)). Given the most-likely preferred habitat for this species is at the entrance to caves in limestone karst formations, areas historically relatively protected from fires and with relatively stable humidity due to the microclimate of the cave systems (Lourdanos 2012), it is reasonable to infer a corresponding decline in the number of mature individuals at known locations (Sub-criterion b(v)). Given the potential horticultural value of this peculiar novelty, it is also reasonable to infer that collecting by plant enthusiasts in the future might damage populations. Consequently, *Boea cavernarum* satisfies

the requirements for listing as EN B1+2ab(i-v). under the IUCN criteria at the National/regional scales (IUCN 2012) and a formal nomination for the Queensland Nature Conservation Act is recommended.

Etymology: From the Latin *caverna*, cave, referring to the only known habitat of the species being at and around the entrance to limestone caves and crevices. The epithet is a noun in apposition as outlined under ICN Art. 23.5 (Shenzhen Code, Turland *et al.* 2018).

Disclosures

The authors have no conflicts of interest to declare.

Acknowledgments

We thank Tim Hawkes and his very keen eye for the discovery of the species, Jen Whan for assistance with microscopy, and Peter Bannink for the the distribution map. We thank the managers of Palmerville, Mount Mulgrave and Bellevue Stations for permission to visit and collect herbarium samples from their land.

References

Australian Government, Department of Climate Change, Energy, and Environment and Water (2023a) *Australia's National Heritage List, Chillagoe Karst Region proposed National Heritage Listing* (Canberra: Commonwealth of Australia, 2023) <https://www.dcceew.gov.au/parks-heritage/heritage/places/national-heritage-list/chillagoe-karst-region-proposed-national-heritage-listing> [Accessed 24 October 2023].

Australian Government, Department of Climate Change, Energy, and Environment and Water (2023b) *Chillagoe Karst Region National Heritage assessment* (Canberra: Commonwealth of Australia, 2023) < https://www.dcceew.gov.au/sites/default/files/env/consultations/788d0e24-b6a9-47bb-beda-13fab29632f9/files/chillagoe-karst-region-consultation-factsheet.pdf> [Accessed 24 October 2023].

Bachman, S., Moat, J., Hill, A.W., de la Torre, J., & Scott., B. (2011). Supporting Red List threat assessments with GeoCAT: geospatial conservation assessment tool. In V. Smith & L. Penev (eds.), *e-Infrastructures for data publishing in biodiversity science*. *ZooKeys* 150: 117–126. (Version BETA).

Bianchi, G., Murelli, C., Bochicchio, A. & Vazzana, C. (1991) Changes of low-molecular weight substances in *Boea hygroscopica* in response to desiccation and rehydration. *Phytochemistry* 30(2): 461-466.

Burtt, B. L. (1984). Studies in the Gesneriaceae of the Old World: XLVII – Revised generic concepts for Boea and its allies. *Notes from the Royal Botanic Garden, Edinburgh*41: 401–452.

IUCN (2012). International Union for the Conservation of Nature. IUCN Red List categories and Criteria: Version 3.1, 2nd edition. https://www.iucnredlist.org/resources/categories-and-criteria [Accessed 24 October 2024].

Jones, R.N. & Ricketts, J.H. Identifying and Attributing Regime Shifts in Australian Fire Climates. *Climate 2023*, 11, 121:1-54. https://doi.org/10.3390/cli11060121.

Kavanagh, C. (1999) Mitchell-Palmer Karst Expeditions. In *Proceedings of the XXII Biennial Conference ¬ Taking caving in to the next Century with Fun, Unity and Fellowship*, 4-8 January 1999, Yeppoon, Queensland (pp. 98¬102). Australian Speleological Federation. http://st1.asflib.net/JNS/AUNat/ASF/ASF-ConfProc/ASF-ConfProcs22.html

Lourandos, H., David, B., Roche, N., Rowe, C., Holden, A., & Clarke, S. (2012). Hay Cave: A 30,000 year cultural sequence from the Mitchell-Palmer limestone zone, north Queensland (Australia). In S. G. Haberle, & B. David (Eds.), *Peopled Landscapes: Archaeological and Biogeographic Approaches to Landscapes* (pp. 27 - 63). ANU E Press.

Moylan, M. (1980) 'Limestone of the Mitchel-Palmer region, North Queensland. In P.J. Mackey (Ed.), A.S.F. Conference, P*roceedings of the XIII Biennial Conference Cave Convict, December 1980, Melbourne, Victoria* (pp. 61-63). Australian Speleological Federation.

Pearson L. (1988) Mitchell-Palmer Karst A Speleological Field Guide for the Towers and Caves of the Mitchell-Palmer Areas in Far North Queensland. Chillagoe Caving Club. ISBN 0 9592739 2 1.

Pereira-Dias, F. & Santos, M. (2015) Adaptive strategies against water stress: a study comparing leaf morphoanatomy of rupicolous and epiphytic species of Gesneriaceae. *Brazilian Journal of Botany* 38, 911–919. https://doi.org/10.1007/s40415-015-0180-8.

Proctor, M.C.F. & Zoltán, T. (2002) Tansley Review No. 141. Poikilohydry and homoihydry: antithesis or spectrum of possibilities? *The New Phytologist* 156(3): 327-349.

Puglisi, C., Yao, T.L., Milne, R., Moller, M. & Middleton, D.J. (2016) Generic recircumscription in the Loxocarpinae (Gesneriaceae), as inferred by phylogenetic and morphological data. *Taxon* 65(2): 277–292. https://doi.org/10.12705/652.5

Puglisi, C. & Middleton, D.J. (2017) A revision of *Middletonia* (Gesneriaceae) in Thailand. *Thai Forest Bull., Bot.* 45(1): 35-41. https://doi.org/10.20531/tfb.2017.45.1.07

Puglisi, C. & Middleton, D.J. (2018). A revision of *Boea* (Gesneriaceae). *Edinburgh Journal of Botany* 75(1): 19-49. https://doi.org/10.1017/S0960428617000336

Russell-Smith, J., Edwards, A.C., Sangha, K.K., Yates, C.P., & Gardener, M.R. (2019) Challenges for prescribed fire management in Australia's fire-prone rangelands-the example of the Northern Territory. *International Journal*

of Wildland Fire 29: 339–353. https://doi.org/10.1071/WF18127

Turland, N.J., Wiersema, J.H., Barrie, F.R., Greuter, W., Hawksworth, D.L., Herendeen, P.S., Knapp, S., Kusber, W.-H., Li, D.-Z., Marhold, K, May, T.W., McNeill, J., Monro, A.M., Prado, J., Price, M.J. and Smith, G.F. (2018) International Code of Nomenclature for algae, fungi, and plants (Shenzhen Code). *Regnum Vegetabile* 159. Glashütten: Koeltz Botanical Books. https://dx.doi.org/10.12705/Code.2018

Weber, A., Middleton, D.J., Clark, J.L. & Möller, M. (2020) Keys to the infrafamilial taxa and genera of Gesneriaceae. *Rheedea* 30(1): 5-47. https://dx.doi.org/10.22244/rheedea.2020.30.01.02

Xu, Z., Burtt, B.L., Skog, L.E. & Middleton, D.J. (2008). A revision of *Paraboea*. *Edinburgh Journal of Botany* 65(2): 161–347. https://doi.org/10.1017/S0960428608005106

Zich, F.A. & Gray, B. (2021) *Boea resupinata* Zich & B.Gray (Gesneriaceae), a new species from Cape York Peninsula, Queensland, Australia. *Austrobaileya* 11: 56-55.