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The Kiandra leek orchid is the previously presumed extinct mignonette leek orchid (Orchidaceae; Orchidoideae): evidence from morphological comparisons

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Abstract

Prasophyllum morganii (Orchidaceae), the mignonette leek orchid, was first collected from a single population in the subalps of Victoria, Australia, in 1929 but has not been collected since 1933. A morphologically similar leek orchid, *P. retroflexum*, was described in 2000 from Kosciuszko National Park, New South Wales, Australia. We measured 51 morphological traits on 14 field collected and 13 herbarium specimens of *P. retroflexum*, and six historical herbarium collections of *P. morganii*. In addition, we conducted a comparison of the types of both species with the field and herbarium specimens. Multivariate analyses were undertaken using 35 characters, and an ordination performed on range-standardised data. Results show no morphological differences between specimens identified as *P. morganii* and *P. retroflexum*, and we conclude they are conspecific.

Keywords: multivariate analysis, *Prasophyllum morganii*, *Prasophyllum retroflexum*, threatened orchids

Introduction

Prasophyllum Brown (1810; 317) (Prasophyllinae: Diurideae) is a genus of orchids endemic to Australia and New Zealand (VicFlora 2021) commonly referred to as leek orchids. There are an estimated 207 species of *Prasophyllum*, with many of these yet to be formally described (Backhouse *et al*. 2019). *Prasophyllum* occur across southern and eastern Australia, with the highest diversity of species in southeastern Australia (ALA 2021). Many *Prasophyllum* species have highly restricted distributions, and 39 are listed nationally as either critically endangered, endangered, or vulnerable under Australia's *Environment Protection and Biodiversity Conservation Act 1999*.

Prasophyllum species have a pair of underground tubers and an annual dormant period, usually over the summer months at low elevations, although often delayed to late summer-early autumn in high-elevation environments. They occur primarily in temperate regions and are found from coastal lowlands to montane and alpine areas, typically in grasslands or shrub-dominated habitats (Jones 2000). *Prasophyllum* species are characterised by a single tubular leaf and a spike of small non-resupinate white, green or reddish flowers (Brown 1810) with most species flowering in spring and/or summer.

Taxonomic treatment of *Prasophyllum* has been a source of recent debate. Clements & Jones (2019: 30) proposed *Paraprasophyllum* for part of *Prasophyllum* sect. *Integra* George Don in Loudon (1830: 269), but this proposed generic change has not been widely accepted. We retain here the use of *Prasophyllum* sect. *Integra*, which includes *P. morganii* Nicholls (1930: 179) and *P. retroflexum* Jones (2000: 167).

Prasophyllum morganii, the mignonette leek orchid, was described by Nicholls (1930) as a small terrestrial herb that produces a single leaf 120–200 mm in length and a single green to reddish flowering stem 200–250 mm high with 50–80 densely crowded non-resupinate flowers. Flowers are compressed in appearance, 8–9 mm in width, 7–8 mm in

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length, and were described by Nicholls (1930) as green with "prune or purple markings". The labellum is reflexed and has irregular crinkling along the edges, and flowers are described as having a sweet citrus smell (Nicholls 1930). The only recorded population of *P. morganii* was discovered in 1929 on private land near Cobungra, Victoria, and consisted of fewer than 15 plants (Coates 2003). No plants have been seen since 1933, despite extensive surveys by orchid enthusiasts. The site where the species was thought to grow is now improved pasture (Coates 2003), and NR in 2020 observed it to comprise mostly of introduced pasture grasses. Eight specimens were lodged at herbaria in Melbourne and Adelaide between 1929 and 1933 (AVH 2021). To the best of our knowledge, there are no surviving photos of *P. morganii* aside from those of pressed herbarium specimens. *Prasophyllum morganii* is considered extinct under the state of Victoria's *Flora and Fauna Guarantee Act 1988* and the Threatened Species Scientific Committee Advice (Department of the Environment and Energy 2016).

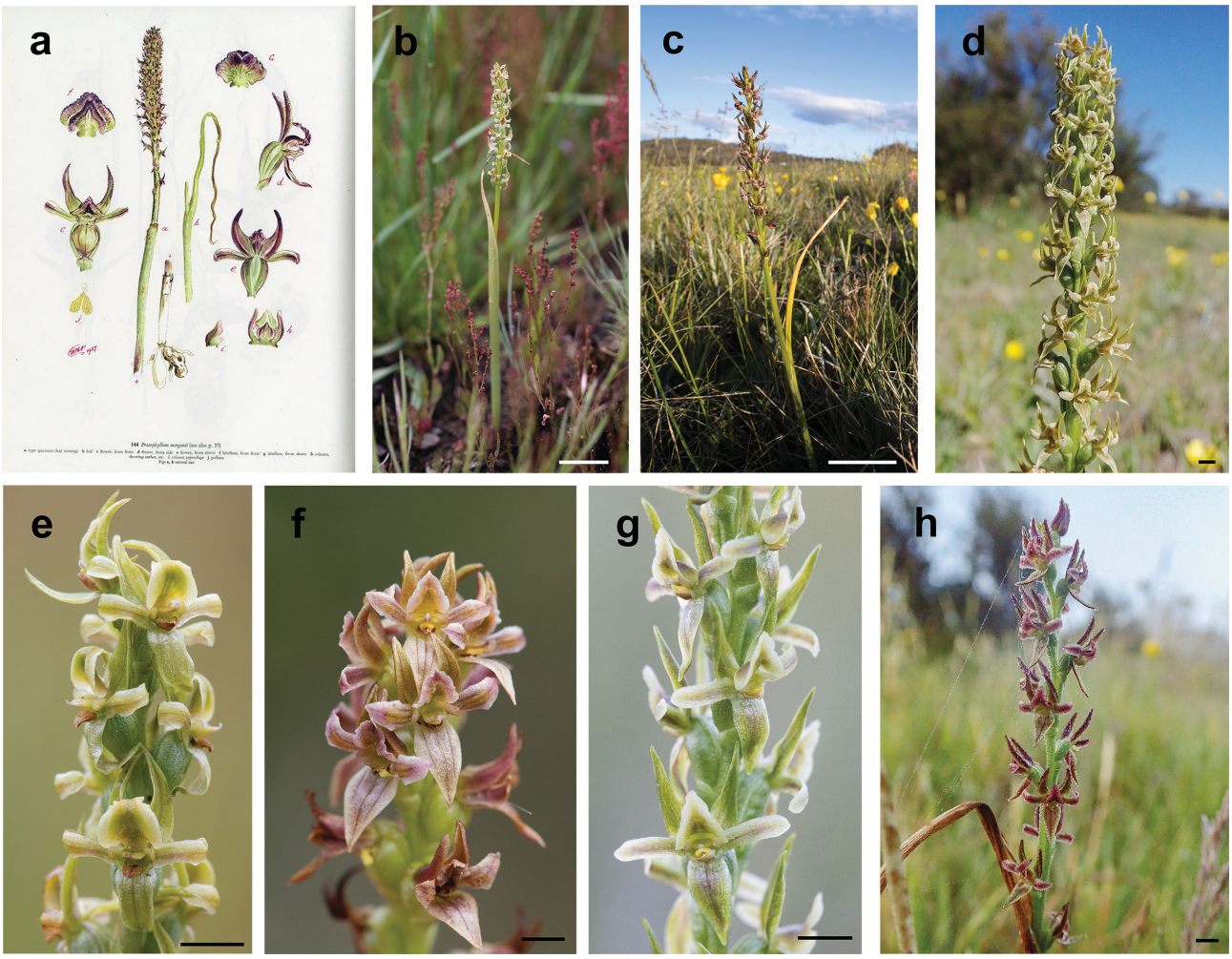

FIGURE 1. Variation in colour, number of flowers, and density of *Prasophyllum retroflexum* inflorescences, compared with an illustration of *P. morganii*. No photos of *P. morganii* are known to exist. A. *P. morganii* illustration from Nicholls (1969). B. *P. retroflexum* at Sawyers Hill, New South Wales (NSW). C. *P. retroflexum* at Nunniong Plain in Victoria. D. Dense-flowered inflorescence from Victoria. E–F. Close-up of inflorescences from NSW populations. G–H. Close-up of inflorescences from Victorian populations. Black scale bars = 2 mm and white scale bars = 20 mm. Photos by L. and M.J. Carrigan (d, h) and T. Hayashi.

Prasophyllum retroflexum Jones, the Kiandra leek orchid, was described (Jones 2000) from a population in Kosciuszko National Park, New South Wales (NSW), as a slender terrestrial herb, with leaves 200–400 mm long. Its inflorescences are described as having 10–40 green flowers with pink markings, sometimes slightly darker. Flowers are 6–8 mm across, and the petals are widely spread with strongly recurved tips. Lateral sepals are less than 6 mm long. The labellum is half recurved with slightly crenulate margins. Flowers have a lemon scent. Although originally only thought to occur in NSW, two populations have since been found in Victoria (VicFlora 2020). *Prasopyllum retroflexum* is considered vulnerable in NSW under the *Biodiversity Conservation Act 2016*.

Before *P. retroflexum* was named, populations in NSW and Victoria had been identified as the long-lost *P. morganii* (Backhouse *et al.* 2016). The key differences proposed by Jones (2000) between the two species were that *P. morganii*

had more flowers (50–80) compared to 10–40 in *P. retroflexum* in a denser inflorescence. *Prasophyllum retroflexum* is described as having a non-papillate labellum callus, whereas *P. morganii* is described as having a smaller, somewhat papillate labellum callus that extends almost to the apex of the labellum. According to Jones (2000), *P. morganii* flowers have purple markings, whereas *P. retroflexum* is described as having pink or dark pink markings (Jones 2000).

Prasophyllum morganii Nicholls was recognised by Walsh & Entwisle (1994) as a member of the *P. fitzgeraldii* 'group', but *P. retroflexum* had not been named at the time of that publication. Jones (2021) recognised both *P. morganii* and *P retroflexum* as part of the *P. alpinum*/*P. montanum* group, which he characterised as comprising plants from montane to alpine regions with small to large flowers, smooth labella with irregular margins and a variety of colours.

Both *P. morganii* and *P. retroflexum* have been the target of conservation programs (Threatened Species Scientific Committee 2016, Department of Planning, Industry and Environment 2014). The difficulty in reliably telling these two species apart based on their descriptions (Nichols 1930, Jones 2000, Coates 2003) has led us to question the distinction of *P. morganii* and *P. retroflexum*. Here, we compare morphological features of fresh, alcohol-stored and rehydrated dried herbarium specimens of *P. retroflexum* with rehydrated dried herbarium specimens of *P. morganii*. We aim to: (1) clarify the taxonomic status of *P. retroflexum*; (2) assign populations in NSW and Victoria to the correct species; and (3) revise the key to *Prasophyllum* as currently provided in VicFlora to accord with our findings.

Materials and methods

Field surveys and collections:—Four populations in Victoria and NSW were surveyed for *P. retroflexum*/*P. morganii* in November and December, 2020. Six plants were collected from Nunniong Plain and two from Timbarra North Plain, Victoria (Fig. 2). Two plants were sampled from northern Sawyers Hill and four from Kellys Plain, NSW. Samples were stored in 80 % ethanol and lodged as spirit collections at the Royal Botanic Gardens Victoria National Herbarium (RBGV). We recorded latitude and longitude for each specimen in this study and mapped the distribution of each population sampled using QGIS (2021).

FIGURE 2. A. *Prasophyllum morganii* isolectotype (AD E97708768). B. *Prasophyllum morganii* lectotype (MEL 54689). C. *Prasophyllum retroflexum* holotype and isotypes (CBG8914103.1).

Sampling:—We included in our statistical analysis 33 specimens: 11 spirit and two dried specimens of *P. retroflexum* from the RBGV and six dried specimens of *P. morganii*, along with the 14 specimens (cited above) collected in field surveys in 2020. For all dried specimens, an individual flower was removed from the middle of each inflorescence and rehydrated by placing it in a small vial of water with a drop of dishwashing detergent. The same characters measured on specimens stored in ethanol were then measured on these rehydrated flowers.

Character selection and analysis:—Measurements of 51 floral characters (Appendix 1) were collected using cellSens standard imaging software (Olympus). Images were taken with a DP74 Olympus colour camera attached to an Olympus dissecting microscope. Fourteen morphological characters were excluded from further analysis as there was no difference between any samples in the 33 specimens. The characters excluded were: 1) flat dorsal sepal edges, 2) obtuse petal tips, 3) retroflexed petals, 4) flat petal edges, 5) acute labellum tip, 6) absent lateral sepal bidentate tips, 7) lateral appendage shape, 8) acute callus tip, 9) smooth ovary surface, 10) absent bract, 11) lateral sepals bulbous at base, 12), labellum papillate present, 13) channelled callus and 14) presence of crinkled labellum.

Multivariate analyses were performed using PATN (Belbin 1987). An ordination was performed on range-standardised data. Each species was assigned to its own *a priori* group. Distance matrices were calculated using the Gower metric (GM), whereas the variation between *a priori* groups for each characteristic is represented by Kruskal Wallis values. Ordinations were performed in three dimensions using multidimensional scaling (MDS), with 50 random starts and 1,000 iterations. A Kruskal-Wallis rank sum test was performed to test for any significant differences between the numerical characters of each species (R Development Core Team 2020). Following this, a comparison was conducted for the specimens examined above and measurements of the images of the type specimens (Fig. 2) and descriptions of *P. retroflexum* (Jones 2000) and *P. morganii* (Nicholls 1930). Measurements on images of the type specimens were conducted in ImageJ (Rueden *et al.* 2017).

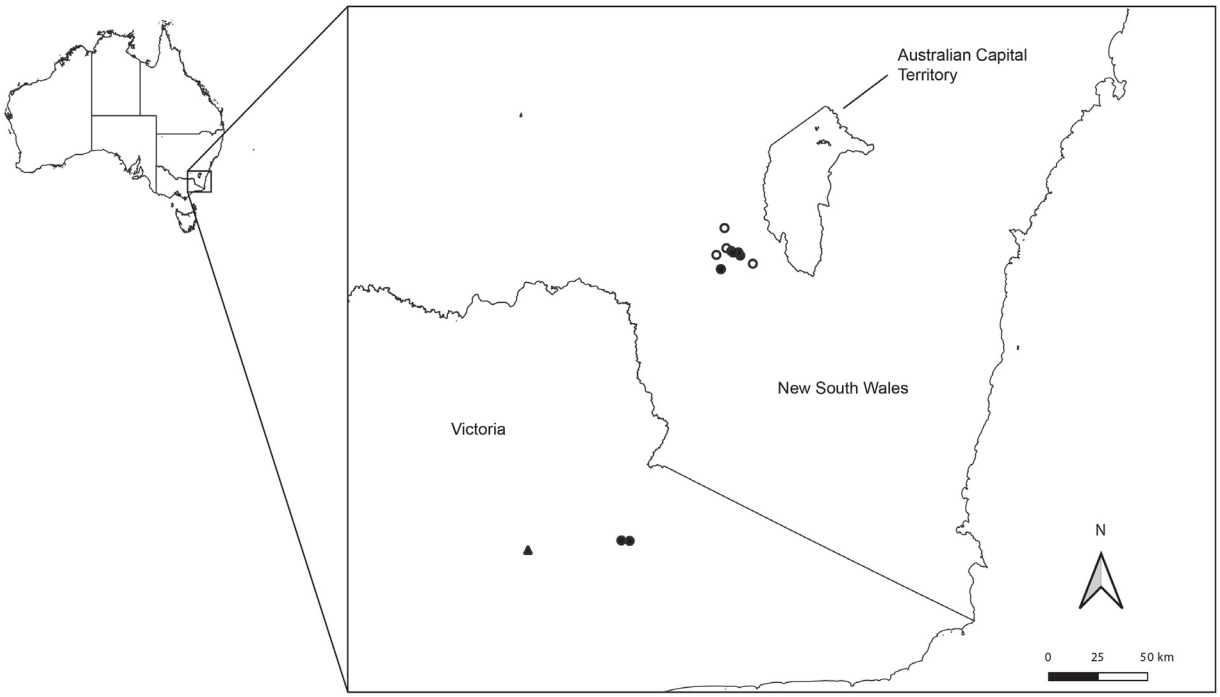

FIGURE 3. Populations of *Prasophyllum retroflexum* and *P. morganii*. Black triangle = location of extinct population of *P. morganii* and specimens examined, circle = known populations of *P. retroflexum*, and filled circles = populations with specimens examined in this study.

Results

There were no significant differences between the two entities for any of the numerical characters (Table 1). The ordination shows no groupings between species or between the spirit specimen or rehydrated specimen (Fig. 4). Kruskal Wallis values generated for each variable were all low, with the majority falling under 1.0 (Table 1). MDS stress values were within acceptable limits (0.1797).

FIGURE 4. Video ordination of specimens. Ordinations were performed in three dimensions using multidimensional scaling (MDS), with 50 random starts and 1,000 iterations. MDS stress values were acceptable (0.1797). Green = *Prasophyllum retroflexum* specimens stored in spirit, yellow= *P. retroflexum* rehydrated flowers, blue = *P. morganii* rehydrated flowers.
Available at: https://youtu.be/ODej5NyzqvU

All flowers examined had a papillate callus (Fig. 3). There was no clear difference in the average density of flowering spikes between *P. morganii* and *P. retroflexum* specimens or number of flowers per spike (Fig. 6). There is large variation in flower colour across NSW and Victoria (Fig. 1), including green flowers with white, pink or dark purple markings. The full variety of colour forms can occur within a single population.

TABLE 1. Minimum, maximum and average values for each of 32 numerical characters measured on *Prasophyllum morganii* and *P. retroflexum* specimens, ordered by largest to smallest Kruskal-Wallis value.

	Prasophyllum morganii			***Prasophyllum retroflexum***			**Kruskal-Wallis value**	**P-value**
Character	**Min**	**Mean**	**Max**	**Min**	**Mean**	**Max**		
Length from base of stem to bottom of flower (mm)	48	92.23	158	75	176.21	287	10.47	0.41
Leaf height (mm)	47	104.80	178	140	229.25	322	9.77	0.44
Specimen total height (mm)	116	145.14	187	43	239.89	418	9.23	0.42
Dorsal sepal width (front view) (mm)	1.2	1.51	2	1	2.07	3.1	4.75	0.34
Lateral appendage length (mm)	0.4	0.57	1	0.4	0.87	1.5	4.3	0.44
Pedicel length (mm)	0.5	0.93	1.5	0.5	1.36	3.3	3.34	0.55
Ovary length (mm)	2.7	3.59	4.5	1.6	3.08	4.4	2.31	0.49
Plate length (mm)	0.5	1.02	1.9	0.3	1.19	2	2.11	0.53
Flower height (side view) (mm)	3.9	6.87	10.2	5	8.35	11.6	1.92	0.67
Petals width (side view) (mm)	0.5	1.03	1.3	0.1	0.87	1.6	1.86	0.48
Distance between end of callus and end of labellum (mm)	1.2	1.89	4.5	0.9	2.23	4	1.75	0.80
Labellum total length (mm)	1.3	2.60	4.8	1.3	3.02	5.2	1.12	0.56
Density of inflorescence	0.12	0.24	0.52	0.08	0.31	0.51	1.12	0.42
Callus width at widest point (mm)	0.7	1.29	2.1	0.6	1.5	2.3	1.03	0.77
Specimen width at base (mm)	2	4.14	7	1	3.75	8	0.86	0.40
Angle of dorsal sepal from ovary (degrees)	20.3	59.66	86	4.5	60.12	294	0.86	0.47
Labellum length (side view) (mm)	1.5	2.96	4.3	1.6	3.33	4.9	0.86	0.68
Labellum width at widest point (mm)	1	1.70	2.7	0.8	2.06	3.6	0.81	0.11
Lateral appendage width (front view) (mm)	0.1	0.23	0.4	0.1	0.27	0.5	0.57	0.90
Petal length (mm)	1.9	2.59	4	0.7	2.64	4.5	0.53	0.19
Ovary width (side view) (mm)	1.2	1.80	2.1	0.9	1.79	3.1	0.44	0.73
Lateral sepal length (mm)	3.2	4.57	6.1	2.1	4.76	6.9	0.26	0.54
Number flowers and buds	20	26.29	35	13	25.85	59	0.21	0.74
Angle of bend in labellum (degrees)	60	125.16	176	11.2	118.43	207.2	0.14	0.51
Flower depth (side view) (mm)	2.1	3.26	6.1	0.8	3.01	6.1	0.1	0.80
Angle of ovary from stem (degrees)	5.6	19.43	45	1.9	17.21	33.8	0.06	0.51
Petal width (front view) (mm)	0.8	0.93	1.2	0.5	0.94	1.4	0.03	0.21
Labellum height (side view) (mm)	1.2	1.66	2.2	0.9	1.68	2.6	0.02	0.38
Lateral sepal width (front view) (mm)	0.6	0.89	1.3	0.4	0.9	1.6	0.02	0.92
Dorsal sepal length (mm)	2.4	3.79	6	1.3	3.71	5.5	0.01	0.84
Callus thickness (mm)	0.1	0.19	0.3	0.1	0.18	0.3	0.01	0.54
Angle of lateral sepal from ovary (degrees)	30	103.31	162	17.6	111.25	230	0.00	0.42

Discussion

The description of *P. morganii* in Nicholls (1930) generally matches the measurements we recorded from the isolectotype specimen (AD97708768) but not the lectotype (MEL54689): number of flowers (isolectotype = 52, lectotype = 36, description = 50–80); specimen total height (isolectotype = 256 mm, lectotype = 284 mm, description = 200–250 mm); dorsal sepal width (isolectotype = 2.4 mm, lectotype = 1.6 mm, description = 2.5 mm) and the density of flowers (isolectotype = 0.63 flowers/mm, lectotype = 0.46 flowers/mm, illustration with description = 0.63–1.14 flowers/mm). Exceptions to the description aligning with the type specimens include petal length (isolectotype = 2.3 mm, lectotype = 2.2 mm, description = 4.5 mm); and dorsal sepal length (isolectotype = 2.2 mm, lectotype = 3.2 mm, description = 4.5 mm).

The description in Nicolls (1930) also differed from the traits ranges we measured in *P. morganii* herbarium specimens. The number of flowers (50–80) and height (20–25 mm) fell outside our measured range of *P. morganii* specimens, despite all plants originating from the only known population.

The description of *P. retroflexum* in Jones (2000) falls within the range of most features measured for the three type specimens, including: number of flowers (types, mean and range = 20.33, 17–25, description = 10–40); specimen total height (types = 267.20, 250.31–341.47 mm, description = 200–400 mm); stem width at base (types = 3.07, 2.30–4.11 mm, description = 2–3 mm); ovary length (types = 3.46, 3.37–3.99 mm, description = 3–4 mm); and petal width (types = 0.92, 0.98–0.86 mm, description = 0.8–1.0 mm). Exceptions to this are the dorsal sepal length (types = 3.68, 3.54–3.86 mm, description = 5–6 mm) and dorsal sepal width (types = 1.26, 0.83–1.34 mm, description = 2.5–3 mm), ovary width (types = 1.22, 1.53–1.25 mm, description = 2 mm) and petal length (types = 2.53, 2.39–3.00 mm, description = 5–6 mm). Measurements of several morphological characters of the isolectotype of *P. morganii* (AD97708768) do not fall within the range of measurements from the other, non-type collections of the species, although this is not the case with the lectotype (MEL 54689).

For several characters, the isolectotype specimen and lectotype of *P. morganii* fall within the range of non-type specimens we measured for *P. retroflexum*: number of flowers (*P. morganii* isolectotype = 52, *P. morganii* lectotype = 36, *P. morganii* range = 20–35, *P. retroflexum* range = 13–59); specimen total height (*P. morganii* isolectotype = 256 mm, lectotype = 256 mm, *P. morganii* range = 116–187 mm, *P. retroflexum* range = 43–418 mm); specimen stem width at base (*P. morganii* isolectotype = 7.5 mm, lectrotype = 6.16 mm, *P. morganii* range = 2–7 mm, *P. retroflexum* range = 1–8 mm); dorsal sepal width (*P. morganii* isolectotype = 2.4 mm, lectotype = 1.6 mm, *P. morganii* range = 1.2–2 mm, *P. retroflexum* range = 1–3.1 mm). The density of flowers is higher in the isolectotype than any other plants measured (isolectotype = 0.63 flowers/mm, lectotype= 0.46 flowers/mm, *P. morganii* range = 0.12–0.52 flowers/ mm, *P. retroflexum* range = 0.08–0.51 flowers/mm).

All measured features of the three specimens of *P. retroflexum* on the holotype (CBG 8914103.1) fall within the range of specimens currently classified as *P. retroflexum* and *P. morganii* (Table 1). Jones' description (2000) of *P. retroflexum* overlaps with the range of measurements of both *P. morganii* and *P. retroflexum* specimens, including number and density of flowers, specimen height, specimen width, dorsal sepal length and width, ovary length and width, flower height and depth, petal width and length, dorsal sepal length and lateral sepal length (Table 1).

There are no significant differences between the measurements taken from *P. morganii* specimens and those from *P. retroflexum* (Table 1), indicating that these two species are better regarded as being conspecific. In Jones (2000), the key differences listed between *P. retroflexum* and *P. morganii* are: 1) density of inflorescences, with *P. morganii* bearing 50–80 flowers, and *P. retroflexum* 10–40 flowers; 2) colour markings, with *P. morganii* marked with dark purple and *P. retroflexum* pink or dark pink; 3) lateral sepal curvature, with *P. morganii* having strongly falcate lateral sepals 'curving upwards and inwards over the labellum' and *P. retroflexum* 'falcate, erect or recurved' lateral sepals; 4) 'spreading petals with retroflexed tips vs 'widely spreading, tips strongly recurved'; and 5) *P. morganii* having a papillate labellum callus, whereas *P. retroflexum* is smooth extending nearly to the labellum apex. Here, we show that the density and number of flowers on both species overlap (Table 1), with *P. morganii* averaging 0.24 ± 0.07 (SE) flowers per mm and *P. retroflexum* 0.31 ± 0.02 (SE) flowers per mm (p = 0.42). Although *P. morganii* is described as having 50–80 flowers, the average across herbarium specimens was 25.85 ± 2.3 (lower than the isolectotype and lectotype), and no specimens came close to the number of flowers depicted in Nichols' drawing (Fig. 1A), compared to 26.29 ± 1.9 in *P. retroflexum* (Fig. 6A). Although we are unaware of any surviving photographs of *P. morganii* to gauge the range of colour forms in that species, there is significant variation in the colour of *P. retroflexum* within populations, and some flowers have purple, pink or otherwise cream-green flowers with no markings (Fig. 1). All *P. retroflexum* lateral sepals curved upwards over the labellum, and petal tips curved inwards (Fig. 1). All flowers examined had a papillate callus (Fig. 5).

FIGURE 5. Photo of a *Prasophyllum retroflexum* flower that has been stored in 80% ethanol.

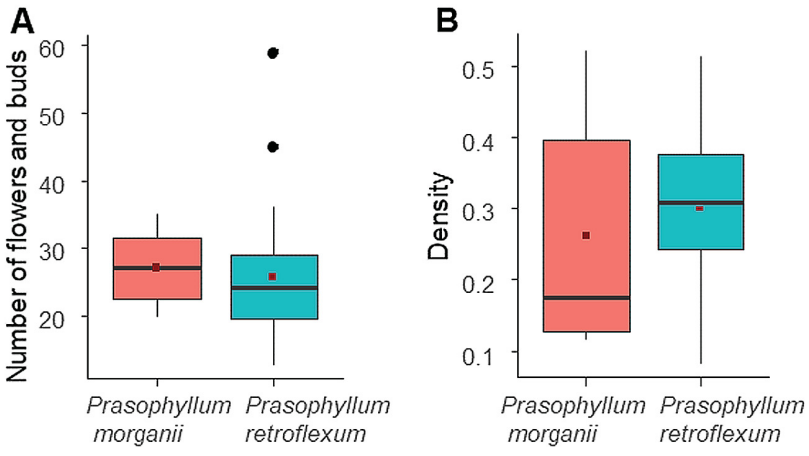

FIGURE 6. Boxplot. A. Number of flowers. B. Density of flowering heads (flowers per mm) of *Prasophyllum morganii* and *P. retroflexum*. Solid black lines indicate median, red square the mean, black dots outliers. The box represents the upper quartile, median and lower quartile respectively, whiskers indicate 1.5 × IQR (Interquartile range).

Based on the lack of differences between the two named species across all characters measured, we conclude that *P. retroflexum* and *P. morganii* are conspecific. An updated key to Victorian *Prasophyllum* (VicFlora, 2021), without *P. retroflexum*, is provided (Appendix 2).

Taxonomy

Prasophyllum morganii Nicholls (1930)

Type:—AUSTRALIA. Victoria: Cobungra [37.1°S, 147.433°E], 26 Nov 1929, *Morgan, H., s.n.;* comm. *Nicholls* (lectotype: MEL54689!, here designated; isolectotype: AD97708768!)

Heterotypic synonym: *Prasophyllum retroflexum* Jones (2000). Type—AUSTRALIA. New South Wales: Southern Tablelands ca 3 km along Tantangara Dam Road from turnoff, 16 Dec 1989, *Jones 5573* (holotype: CBG8914103.1!)

Flowering stem 11–42 cm tall. Leaf-blade usually senescent at flowering time, 14–33 cm long, 1–8 mm diam. at base, apex lax. Flowers 13–59, green or green suffused with pink or purple markings, in a dense narrow-cylindric spike 4–10 cm long, perianth expanding widely; ovary ovoid, turgid, 1.6–4.0 mm long, 0.9–3.1 mm wide, erect, 1.9–45.0 degrees from stem; lateral sepals 0.6-1.6 mm long, curving upwards over the labellum; dorsal sepal 2.4–6.0 mm long ovate-lanceolate, lateral sepals free, narrow, divergent; petals 0.7–4.5 mm long, 0.8 – 1.4 mm wide, recurved, apex sub-acute to obtuse. Labellum cordate to ovate-lanceolate, 1.3–5.2 mm long, 0.8–3.6 mm wide, recurved at 11–208 degrees from base, lamina flat, green, purplish or pink, margins crenate or undulate; callus plate 0.1–0.3 mm thick, deep purplish or green, triangular, papillate, with a prominent v-shaped ridge extending nearly to labellum apex. Column appendages ovate, 1.5–1.8 mm high, obtuse. Flowering October–December.

Conservation status:—Endangered, *P. morganii* meets the IUCN criteria (IUCN, 2012) EN B1abii for endangered, being known to exist at no more than five locations with a predicted decline in the area, extent, and quality of habitat. In *P. morganii*, one population appears to be extinct and the remaining populations are being variously impacted by weeds, cattle grazing, feral horses and climate change.

Habitat:—Herb-rich subalpine grasslands, dominated by *Poa* species. Common co-occurring species include *Poa sieberiana* Spreng., *Poa clivicola* Vickery, *Hakea microcarpa* R.Br., *Plantago euryphylla* B.G.Briggs and the introduced grass *Anthoxanthum odoratum* L.

Taxonomic notes:—In the protologue for *P. morganii*, Nicholls (1930: 179) referred to two specimens but did not indicate which of these should be considered the holotype. However, Nicholls stated that "a specimen has been forwarded to the National Herbarium, Melbourne". Clements (1989: 114) designated the MEL specimen as the holotype of *P. morganii*, despite a note by him on the Melbourne specimen in 1986 indicating it as the isotype (Fig. 2). However, the 'holotype' selection of Clements can be considered a first step lectotypification. Because there has been some confusion over the correct typification of this species with two available original specimens (MEL54689 and AD97708768), we here formally designate the MEL54689 specimen as the lectotype, rendering AD97708768 the isolectotype. We refer to these specimens as such throughout this paper.

Specimens examined:—AUSTRALIA. Victoria: Cobungra, Oct 1931, *Morgan s.n* (MEL56532A); Oct 1931, *Morgan s.n* (MEL56532B); Nov 1930, *Morgan s.n* (MEL1601696); 11 Dec 1930, *Morgan s.n* (MEL56351A); 11 Dec 1930, *Morgan s.n* (MEL56351B); Nov 1933, *Braine s.n.* (MEL573889); Nunniong Plain, 21 Dec 2005, *Rouse, s.n* (MEL2296314); 4 Dec 2011, *Saxon 1192* (MEL2358608A, MEL2358608B); 26 Nov 2015, *Jeanes 3106* (MEL2394764); Nunniong Plateau, Timbarra North Plain, 24 Oct 2019, *Turner 2175* (MEL2474232A, MEL2474232B, MEL2474232C, MEL2474232D); Nunniong Plain, 25 Nov 2020, *Ayre 1* (MEL2501485); *Ayre 2* (MEL2501486)*; Ayre 3* (MEL2501487); *Ayre 4* (MEL2501488); *Ayre 5* (MEL2501489); *Ayre 6 (*MEL2501490); Nunnet Road, 27 Nov 2020, *Ayre 7* (MEL2501491); *Ayre 8* (MEL2501492). New South Wales: Tantangara Dam Road, 3 km from turnoff, 16 Dec 1989, *Jones s.n.* (MEL259037); Nungar Plain, Kosciusko National Park, 11 Dec 2001, *Walsh s.n.* (MEL2123144); Beside Snowy Mountains Highway near the Eucumbene River, c. 5 km by road SE of Kiandra, 28 Dec 1994, *Jeanes 134* (MEL2024475); 28 Dec 1994, *Jeanes 133* (MEL2024476); 5 km SE of Kiandra near the Eucumbene River, 28 Dec 1994, *Jeanes 469* (MEL2068199); 28 Dec 1994, *Jeanes 493* (MEL2068327); Northern Sawyers Hill, 12 Dec 2020, *Ayre 9* (MEL2501493); *Ayre 10* (MEL2501494); Kellys Plain, 12 Dec 2020, *Ayre 11* (MEL2501495); *Ayre 12* (MEL2501496); *Ayre 13 (*MEL2501497*); Ayre 14* (MEL2501498).

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APPENDIX 1. All morphological characters measured across 33 *Prasophyllum morganii* and *P. retroflexum* specimens.

Character	Character state
Specimen total height	Continuous (mm)
Specimen width at base	Continuous (mm)
Leaf height	Continuous (mm)
Length from base of stem to bottom flower	Continuous (mm)
Number flowers and buds	Continuous (integer)
Angle of ovary from stem	Continuous (degrees)
Angle of lateral sepal from ovary	Continuous (degrees)
Angle of dorsal sepal from ovary	Continuous (degrees)
Angle of bend in labellum	Continuous (degrees)
Pedicel length	Continuous (mm)
Ovary length	Continuous (mm)
Ovary width (side view)	Continuous (mm)
Flower height (side view)	Continuous (mm)
Flower depth (side view)	Continuous (mm)
Labellum length (side view)	Continuous (mm)
Petal width (side view)	Continuous (mm)
Labellum height (side view)	Continuous (mm)
Lateral appendage length	Continuous (mm)
Plate length	Continuous (mm)
Petal length	Continuous (mm)
Dorsal sepal length	Continuous (mm)
Lateral appendage width (front view)	Continuous (mm)
Lateral sepal length	Continuous (mm)
Callus thickness	Continuous (mm)
Distance between end of callus and end of labellum	Continuous (mm)
Lateral sepal width (front view)	Continuous (mm)
Dorsal sepal width (front view)	Continuous (mm)
Labellum width at widest point	Continuous (mm)
Callus width at widest point	Continuous (mm)
Petal width (front view)	Continuous (mm)
Labellum total length (front view)	Continuous (mm)
Density of inflorescence	Continuous (flowers per mm)
Labellum tip position	Top (0), Middle (1) or Base (2) of lateral sepal
Dorsal sepal shape	Recurved (0), Straight (1)
Callus bidentate tip	Present (0), Absent (1)
Dorsal sepal edges	Curled (0), Flat (1)
Petal tip shape	Acute (0), Obtuse (1)
Retroflexed petals	Absent (0), Present (1)
Petal edges	Curled (0), Flat (1)
Labellum tip shape	Acute (0), Obtuse (1)
Callus tip shape	Acute (0), Obtuse (1)
Lateral sepal bidentate tip	Present (0), Absent (1)
Lateral appendage shape	Straight (0), Curved (1)
Callus channel	Present (0), Absent (1)
Ovary surface	Papillate (0), Smooth (1)
Bract present	Present (0), Absent (1)
Lateral sepals free	Not free (0), Free (1)
Lateral sepals bulbous at base	Not bulbous (0), Bulbous (1)
Lateral sepal edges	Incurve (0), Outcurve (1)
Labellum papillate (bumps)	Smooth (0), Papillate (1)
Labellum edge	Smooth (0), Crinkled (1)

APPENDIX 2. Proposed modified VicFlora Key to *Prasophyllum* identification.

1 Ovary attenuate, cylindric to narrow obovoid, appressed to rachis 2
- Ovary obovoid to pyriform, not appressed to rachis 4

2 Labellum bent at an angle greater than 90 deg., basal portion pouched, callus ending in two protruding knuckles ..... *Prasophyllum australe*
- Labellum bent at an angle less than 90 deg., basal portion not pouched, callus not ending in protruding knuckles 3

3 Leaf-blade more than 3 cm long; labellum margins voluminous, not incurved; tubers ovoid ..... *Prasophyllum elatum*
- Leaf-blade less than 3 cm long; labellum margins narrow, incurved; tubers rhizomatous ..... *Prasophyllum flavum*

4 Labellum lamina and/or callus papillate or pubescent 6
- Labellum lamina and callus not papillate or pubescent 10

5 Labellum with a sigmoid bend when viewed from the side ..... *Prasophyllum lindleyanum*
- Labellum bent once at about 90 deg. near the middle 6

6 Ovaries tumid, roundish at anthesis ..... *Prasophyllum occultans*
- Ovaries not tumid, narrow ellipsoidal at anthesis 7

7 Perianth segments usually not widely opening, at least petals remaining forwards-directed; labellum lamina pink (sometimes fading to white with age) with a green callus ..... *Prasophyllum roseum*
- Perianth segments spreading; labellum lamina whitish with a brownish callus, or labellum (and usually other segments) deep pink to purple and shining 8

8 Labellum lamina and usually other floral segments, deep pink to purplish, distinctly glossy; callus of similar colour but darker ..... *Prasophyllum nitidum*
- Labellum lamina pale green or whitish with a brownish callus, neither it nor other segments distinctly glossy 9

9 Lateral sepals more or less parallel, narrow and not flared at the base; labellum <3 mm wide, recurved near midde then the tip recurved beyond vertical; known only from Stawell area ..... *Prasophyllum stygium*
- Lateral sepals spreading, broad and flared widely at the base; labellum >3 mm wide, recurved near middle and the tip remaining about vertical; known only from Edenhope area ..... *Prasophyllum spadiceum*

10 Labellum callus hardly raised, lamina prominently crisped and undulate toward margin, usually white, translucent 11
- Labellum callus distinctly raised, lamina not prominently crisped, variously coloured, not translucent 18

11 Lateral sepals joined for at least part of their length 12
- Lateral sepals free to base 13

12 Labellum reflexed back on itself; not alpine ..... *Prasophyllum brevilabre*
- Labellum reflexed at about 90 deg; alpine ..... *Prasophyllum suttonii*

13 Flowering stem to 80 cm high; lowland heaths ..... *Prasophyllum spicatum*
- Flowering stem usually <50 cm tall; various habitats 14

14 Petals lavender; labellum pink; lateral sepals gibbous at base; Bayswater to Heathmont east of Melbourne where probably extinct ..... *Prasophyllum colemaniarum*
- Combination of flower features not as above; widespread and variable 15

15 Ovaries short, pyriform; labellum narrow, reflexed at more than right angles near middle; alps and subalps only ..... *Prasophyllum suttonii*
- Ovaries somewhat elongate, obovoid; if labellum ever reflexed beyond right-angles, habitat not alpine 16

16 Sepals to 10 mm long; labellum 6–10 mm long; widespread species from a range of habitats 17
- Sepals 10–12 mm long; labellum 12–15 mm long; known only from grassland in north-central Victoria and Callitris woodlands of the north-west ..... *Prasophyllum beatrix*

17 Lateral sepals diverging; habitat various but not from deep sands in north-western Victoria ..... *Prasophyllum odoratum*
- Lateral sepals parallel or nearly so; known with certainty only from deep sand mallee-heath in north-western Victoria ..... *Prasophyllum rousei*

18 Labellum callus most prominent near the labellum bend, not extending to labellum apex; perianth segments generally short and broad; lateral sepals usually free 19
- Labellum callus most prominent beyond the labellum bend, extending almost to labellum apex; perianth segments slender; lateral sepals often joined at least near base 28

19 Labellum with a tail-like caudiform apex ..... *Prasophyllum appendiculatum*
- Labellum with an apiculate to obtuse apex 20

20 Perianth mostly incurved; labellum callus ending in a highly raised verrucose horse-shoe shaped structure ..... *Prasophyllum frenchii*
- Perianth spreading widely; labellum callus not as above 21

21 Labellum callus extending to, or just beyond, bend; labellum lamina extending well beyond end of callus 22
- Labellum callus extending well beyond bend; labellum lamina not extending well beyond end of callus 24

22 Petals <7.0 mm long; lateral sepals <9.0 mm long; flowers December to January ..... *Prasophyllum uvidulum*
- Petals >7.5 mm long; lateral sepals >9.0 mm long; flowers October to November 23

23 Callus ovate-oblong, broad and open; petals very broad, whitish, similar in colour to labellum lamina ..... *Prasophyllum anticum*
- Callus lanceolate, channelled; petals narrow, greenish, similar in colour to the lateral sepals ..... *Prasophyllum sp. aff. diversiflorum 2*

24 Labellum margins crisped to undulate; petals broad, similar in colour to labellum lamina 25
- Labellum margins entire to slightly irregular; petals narrow, similar in colour to the lateral sepals 26

25 Labellum laterally compressed near bend; petals whitish; moist grassland near water-courses ..... *Prasophyllum diversiflorum*
- Labellum not laterally compressed; petals reddish; coastal heath and scrub on sand ..... *Prasophyllum litorale*

26 Lateral sepals partially connate; alpine herbfields; flowers mostly January ..... *Prasophyllum niphopedium*
- Lateral sepals free to base; low altitude grasslands; flowers October to December 27

27 Lateral sepals more or less parallel; labellum lamina usually white, not constricted; grasslands south of Ballarat ..... *Prasophyllum fosteri*
- Lateral sepals diverging; labellum lamina usually pink, often constricted just beyond the bend; grasslands near Warrnambool ..... *Prasophyllum viretrum*

28 Flowers opening widely with petals and sepals reflexed; labellum erect almost from base 29
- Flowers not opening widely; labellum only erect from the bend 31

29 Petals retroflexed, not upswept; lateral sepal < **7**m long ..... *Prasophyllum morganii*
- Petals recurved, upswept; lateral sepals > 6 mm long 30

30 Inflorescence of up to 20 flowers in an open inflorescence; stigmatic plate much longer than column wings; grasslands near Bairnsdale ..... *Prasophyllum correctum*
- Inflorescence of up to 50 flowers in a crowded inflorescence; stigmatic plate of similar length to column wings; grasslands near Mortlake ..... *Prasophyllum sp. aff. correctum*

31 Labellum with a broad white lamina; petals with extensive white colouration at distal end; grasslands near Wangaratta ..... *Prasophyllum argillaceum*
- Labellum and petals not as above; widespread 32

32 Plants from higher altitude grasslands, herbfields and swampy heaths often on peaty soils 33
- Plants from lower altitude sites, or if in montane areas then in dry woodlands on shallow soils 34

33 Sepals to 6.5 mm long; labellum sessile ..... *Prasophyllum tadgellianum*
- Sepals > 6.5 mm long; labellum on a short stalk ..... *Prasophyllum sphacelatum*

34 Plants from well-drained shallow or dry sandy soils 35
- Plants from waterlogged or seasonally inundated heavy loams, silts, peats or peaty sand 45

35 Flowers <12 mm × 7 mm 36
- Flowers >12 mm × 7 mm 39

36 Labellum callus with a deep groove down centre for entire length; apex of lateral sepals often unequally bidentate ..... *Prasophyllum subbisectum*
- Labellum callus not deeply grooved for the greater part; apex of lateral sepals not or weakly bidentate 37

37 Lateral sepals connate at base; coastal heathlands east of French Island ..... *Prasophyllum parviflorum*
- Lateral sepals mostly free; woodlands and heathy woodlands of western Victoria 38

38 Plants usually >16 cm tall; flowers >10 per inflorescence; dry inland areas ..... *Prasophyllum sp. aff. occidentale C*

- Plants usually <16 cm tall; flowers <10 per inflorescence; mesic near coastal areas ..... *Prasophyllum aff. parviflorum*

39 Apex of lateral sepals usually strongly bidentate 40
- Apex of lateral sepals not or only weakly bidentate 41

40 Labellum margins entire or slightly irregular; lateral sepals >8 mm long ..... *Prasophyllum barnettii*
- Labellum margins irregularly wavy to crinkled-crenulate; lateral sepals 6–7.5 mm long ..... *Prasophyllum occidentale*

41 Distal margins of labellum irregularly crenulate ..... *Prasophyllum sp. aff. montanum*
- Distal margins of labellum entire or slightly irregular 42

42 Labellum callus wrinkled; perianth segments relatively broad, usually greenish brown; labellum lamina not pure white 43
- Labellum callus not wrinkled; perianth segments relatively narrow, usually light greenish; labellum lamina white 44

43 Flowers <20 mm long; labellum tapering gradually from below the middle to the apex, margins broad and often conspicuously veined; petals tapering from base to apex ..... *Prasophyllum pyriforme*
- Flowers often >20 mm long; labellum abruptly contracted near middle to a slender tail-like tip, margins not as above; petals not tapering from base to apex ..... *Prasophyllum maccannii*

44 Flowers to 15 mm; plants of near coastal forests ..... *Prasophyllum sylvestre*
- Flowers >15 mm; plants of inland open forests and woodlands ..... *Prasophyllum sp. aff. validum*

45 Distal labellum margins undulate to crenulate 46
- Distal labellum margins entire, more or less flat to slightly irregular 47

46 Flowers to 12 × 7 mm; distal labellum margins undulate to crenulate; known from Bulloke and Belah woodlands on wet loams and cracking clay; flowers September–October ..... *Prasophyllum occidentale*
- Distal labellum margins undulate-crispate, voluminous; flowers usually bright pink and white; found in grassy redgum woodlands on heavy clay loam soils; flowers November–December ..... *Prasophyllum hygrophilum*

47 Flowers to 12 × 6 mm 48
- Flowers >12 × 6 mm 51

48 Labellum length to width ratio >2; labellum lamina <0.3 mm wide 49
- Labellum length to width ratio <2; labellum lamina >0.4 mm wide 50

49 Lateral sepals 2–3 mm long; labellum protruding forward and strongly reflexed in distal third; southern Victorian basalt plains grassland; flowers October–November ..... *Prasophyllum suaveolens*
- Lateral sepals 5–7 mm long; labellum erect and only slightly reflexed in distal third; northern Victorian grasslands on winter-wet heavy clays; flowers August–September ..... *Prasophyllum aff. occidentale D*

50 Labellum reflexed at <90 deg. in distal half; lateral sepals not bidentate at apex; plants not clumping; River Red Gum woodlands on water-retentive clay; flowers October to November ..... *Prasophyllum erythrocommum*
- Labellum reflexed at >90 deg. in distal half; lateral sepals often bidentate at apex; plants often clumping; southern Victorian basalt plains grassland; flowers September to October ..... *Prasophyllum sp. aff. occidentale E*

51 Lateral sepals contracting abruptly; River Red Gum woodlands on water-retentive clay; northeast Victoria; flowers October–November ..... *Prasophyllum gilgai*
- Lateral sepals tapering evenly from base to apex; habitat not as above 52

52 Lateral sepals with acute to shortly acuminate, widely diverging apices; flowers to 9 mm across; petals to 8.5 mm long; swampy habitats; western Victoria; flowers December to January ..... *Prasophyllum readii*
- Lateral sepals with long-acuminate, not widely diverging apices; flowers 9 mm across or more; petals 9 mm long or more; dryer habitats; eastern Victoria; flowers October to November ..... *Prasophyllum chasmogamum*