EDINBURGH JOURNAL OF BOTANY 68 (1): 111–138 (2011)

doi:10.1017/S0960428610000302

REVISION OF THE LIMITS OF *PEDICULARIS* SERIES *MEGALANTHAE* (PRAIN) BONATI (OROBANCHACEAE)

R. R. Mill

The limits of *Pedicularis* L. ser. *Megalanthae* (Prain) Bonati (Orobanchaceae) are revised. The series, typified by *Pedicularis megalantha* D.Don, is restricted to seven species chiefly inhabiting the eastern Sino-Himalayan region. Authorship of the name *Megalanthae* at series rank is ascribed to Bonati (Mém. Soc. Bot. France 18: 13, 1910) because the groups recognised by Prain in 1890, that have been traditionally regarded as series, are in fact rankless. Two species of the NW Himalayan region, *Pedicularis bicornuta* Klotzsch and *P. elephantoides* Benth., are removed from *P.* ser. *Megalanthae* as they differ significantly from the eastern species in their floral morphology. These species are considered sufficiently distinct to warrant recognition as the new series *Pedicularis* ser. *Bicornutae* R.R.Mill. This new series is provisionally assigned to *Pedicularis* sect. *Phanerantha* H.L.Li. *Pedicularis bicornuta*, whose holotype is destroyed, and *P. eximia* G.Watt are lectotypified. The recently published *Pedicularis bicornuta* var. *adenocalyx* R.R.Mill includes the lectotype and much, but not all, material previously assigned to *P. eximia*.

Keywords. Epitype, Kashmir, lectotype, new series, new variety, NW India, Pakistan, *Pedicularis bicornuta*, *Pedicularis elephantoides*, *Pedicularis* sect. *Phanerantha*, *Pedicularis* sect. *Saccochilus*, *Pedicularis* ser. *Megalanthae*, Sino-Himalayan region.

Introduction and Taxonomic History

While revising the genus *Pedicularis* L. for *Flora of Pakistan*, in which it will be placed in Scrophulariaceae (for discussion concerning alternative placements in Scrophulariaceae or Orobanchaceae see Mill, 2011), it became necessary to consider the infrageneric classification of two NW Himalayan species, *Pedicularis bicornuta* Klotzsch and *P. elephantoides* Benth., whose taxonomic placements have not been critically evaluated for over a century.

Pedicularis elephantoides was described by Bentham (1835), who in his *Scrophularineae indicae* grouped it and *P. megalantha* D.Don as the last two (nos. 13 and 12 respectively) of four species that comprised his *P.* sect. *Siphonanthae* Benth., the other two being *P. siphonantha* D.Don and *P. hookeriana* Wall. ex Benth. In *Scrophularineae indicae*, Bentham (1835) only recognised one infrageneric rank – section – and *Pedicularis* sect. *Siphonanthae* was the third of five sections recognised by him in that work to encompass the 18 *Pedicularis* species he treated. Under Art.

Royal Botanic Garden Edinburgh, 20A Inverleith Row, Edinburgh EH3 5LR, Scotland, UK. E-mail: r.mill@rbge.ac.uk

22.6 of the *International Code of Botanical Nomenclature* (McNeill *et al.*, 2006) *Pedicularis* sect. *Siphonanthae* is typified by *P. siphonantha* D.Don. Thus, *Pedicularis* sect. *Siphonanthae* Benth. has priority over *P.* sect. *Schizocalyx* H.L.Li (Li, 1949: 148), which also includes *P. siphonantha* within its circumscription.

In his account of *Pedicularis* for De Candolle's *Prodromus*, Bentham (1846) grouped *P. elephantoides* in *P.* series II *Siphonanthae* Benth. sect. *Longirostres* Benth. In Bentham's 1846 classification, the ranks of series and section are misplaced and consequently the sectional name *Longirostres* is invalid under Arts. 4.2, 5.1 and 33.9 of the *ICBN* (McNeill *et al.*, 2006). Moreover, Bentham used the sectional names *Longirostres*, *Brevirostres* and *Erostres* (all of them misplaced and not validly published) within more than one of his series (e.g. *Longirostres* is used as a subdivision within *Pedicularis* ser. *Verticillatae*, *P.* ser. *Siphonanthae* and *P.* ser. *Faucidentes*) and therefore, if they had been validly published, they would all have been simultaneously published homonyms of each other (Art. 53.4). In Bentham's later work (Bentham, 1846), 'series *Siphonanthae*' [rank misplaced] had 10 species, arranged in two 'sections' [rank misplaced]. 'Sect. *Longirostres*' comprised nine species: *Pedicularis elephantoides*, *P. elephas* Boiss., *P. hookeriana*, *P. labellata* Jacquem., *P. megalantha*, *P. punctata* Decne., *P. rhinanthoides* Schrenk, *P. siphonantha* and *P. tubiflora* Fisch. Four of these (*Pedicularis elephas*, *P. labellata*, *P. punctata* and *P. rhinanthoides*) were described after publication of the *Scrophularineae indicae* (Bentham, 1835). A second 'section' of 'series *Siphonanthae*' was described in the *Prodromus* (Bentham, 1846); this was named 'sect. 2 *Erostris*' and was monospecific (*Pedicularis perrottetii* Benth. from south India). Limpricht (1924) classified *Pedicularis perrottetii* (which has white corollas lacking a beak: Maximowicz, 1877) in his unranked group equating to series *Muscicolae* Maxim. but Hurusawa (1949) made it the type of the new monospecific series *Pseudoerostres* Hurus., a classification that was followed by Tsoong & Chang (1965a, 1965b).

Between the publication of Bentham's two works, Bunge (1841) assigned *Pedicularis elephantoides*, *P. hookeriana*, *P. megalantha*, *P. siphonantha* and *P. tubiflora* to 'sect. *Tubiflorae* Bunge'. This was also not validly published, because no description for it was provided under Art. 41.2(a) of the *ICBN* (McNeill *et al.*, 2006). This 'section' corresponded largely to Bentham's 'sect. *Longirostres*' and it was renamed 'sect. *Siphonantha* Bunge' in Bunge's second classification (Bunge, 1843), again not validly published. The first validation of the name sect. *Siphonantha* with that spelling (rather than Bentham's 1835 orthography *Siphonanthae*) was by Bunge (1849: 276), three years after Bentham's account in the *Prodromus*. The earliest name for this group of species is sect. *Siphonanthae* Benth. (Bentham, 1835: 53); although an adjectival epithet rather than the more preferable substantive form '*Siphonantha*', Bentham's name *Siphonanthae* is not correctable to '*Siphonantha*' as the formation of names of sections and series is governed only by Recommendations (Recs. 21B.1, 2) rather than an Article in the *ICBN* (McNeill *et al.*, 2006). In his protologue of *Pedicularis* sect. *Siphonantha*, Bunge (1849: 276–277) gave formal treatments of two Russian species (*P. longiflora* Rudolph and *P. rhinanthoides*) and

mentioned several other species from various parts of Asia (*P. elephas*, *P. punctata*, *P. labellata*, *P. megalantha*, *P. siphonantha*, *P. hookeriana* and lastly *P. elephantoides*). The last four of these constitute Bentham's original, 1835, circumscription of the section.

Pedicularis bicornuta (Fig. 1) was described and illustrated by Klotzsch (in Klotzsch & Garcke, 1862), who did not assign it to any infrageneric category. The first person to do so seems to have been Maximowicz (1877), who treated both it and *Pedicularis elephantoides* as members of *P.* ser. *Siphonanthae*, which was one of two series subordinate to a higher rank wrongly named 'tribe I. *Longirostres*' (Art. 5 of the *ICBN* [McNeill *et al.*, 2006] applies). Besides eight of Bentham's 10 species (*Pedicularis punctata* and *P. tubiflora* were removed), Maximowicz added seven others to *P.* ser. *Siphonanthae* in his 1877 paper. One of these was *Pedicularis macrantha* Klotzsch (nom. illegit., non Spreng.); this is now correctly named *P. klotzschii* Hurus. (Hurusawa, 1948). Another was *Pedicularis longiflora*, which Bentham (1846: 565) synonymised with *P. tubiflora*. The remaining five were all new species first described from Gansu (China): *Pedicularis armata* Maxim., *P. chinensis* Maxim., *P. cranolopha* Maxim., *P. muscicola* Maxim. and *P. przewalskii* Maxim. Further species were added to ser. *Siphonanthae* by Maximowicz (1888a; reprinted as Maximowicz, 1888b), who treated 23 species in '*Siphonanthae typicae*' with *Pedicularis muscicola* being removed to *P.* ser. *Muscicolae* Maxim. Northwest Himalayan additions to ser. *Siphonanthae* in Maximowicz's 1888 treatment were *Pedicularis scullyana* Prain ex Maxim. and *P. eximia* G.Watt. The latter species, originally described and illustrated by Watt (1881), was later synonymised with *Pedicularis bicornuta* by Hooker (1884), Prain (1890) and Limpricht (1924). Prain (1890) considered that it was 'simply the ordinary eastern form of the species described by Klotzsch' [i.e. *Pedicularis bicornuta*].

In his monograph of the Indian species of *Pedicularis*, Prain (1890) made substantial changes to previous classifications. Although there is internal evidence on pp. 22, 58, 155 and 158 of Prain (1890) that Prain regarded his lowest hierarchical rank as series, as did Maximowicz (1888a, 1888b), there is no formal indication that this is so and all Prain's 'series' names should therefore be considered rankless; for a more detailed note see Husain *et al.* (2006). Attribution of authorship at series rank is here ascribed to the next most recent author definitely using the name at series rank that has been traced in the literature. Prain divided *Pedicularis* sect. *Siphonanthae*, which had grown quite large by the addition of more and more species, into three large subordinate groups that have been incorrectly regarded as subsections by some previous authors. Each of these was further subdivided into smaller groups that have been frequently but incorrectly regarded as series by later authors. These groups were:

- *Pedicularis* A. *Eusiphonanthae* Prain containing five groups:
  - group 1. *Rhinanthoides* Prain [= *Pedicularis* ser. *Rhinanthoides* (Prain) Bonati, 1910: 11]

- group 2. *Longiflorae* Prain [= *Pedicularis* ser. *Longiflorae* (Prain) Bonati, 1910: 12]
- group 3. *Megalanthae* Prain [= *Pedicularis* ser. *Megalanthae* (Prain) Bonati, 1910: 13]
- group 4. *Muscicolae* Prain [= *Pedicularis* ser. *Muscicolae* Maxim., 1888a, 1888b]
- group 5. *Pumiliones* Prain [= *Pedicularis* ser. *Pumiliones* (Prain) Bonati, 1910: 14]

- *Pedicularis* B. *Brevitubae* Prain containing two groups:
  - group 6. *Robustae* Prain [= *Pedicularis* ser. *Robustae* (Prain) Hurus., 1948: 184]
  - group 7. *Macranthae* Prain [= *Pedicularis* ser. *Macranthae* (Prain) Bonati, 1921: 110], and
- *Pedicularis* C. *Oppositifoliae* Prain with three groups:
  - group 8. *Integrifoliae* Prain ('Integrifolia') [= *Pedicularis* ser. *Integrifoliae* (Prain) H.L.Li, 1948: 258 & 351; *P.* ser. *Integrifolia* (Prain) Hurus., 1949 (Feb.): 112]
  - group 9. *Gyrorrhynchae* Prain ('Gyrorrhyncha') [= *Pedicularis* ser. *Gyrorrhynchae* (Prain) H.L.Li, 1948: 256 & 291; *P.* ser. *Gyrrorhyncha* (Prain) Hurus., 1949 (Feb.): 112]
  - group 10. *Franchetianae* Prain ('Franchetiana') [= *Pedicularis* ser. *Franchetiana* (Prain) Hurus., 1949 (Feb.): 112; *P.* ser. *Franchetianae* (Prain) H.L.Li, 1949 (Dec.): 148].

Prain's new group 7. *Macranthae* contained *Pedicularis klotzschii* (called by him *P. macrantha*), *P. scullyana* and *P. elwesii* Hook.f., the former two being previously in Maximowicz's large concept of ser. *Siphonanthae*. Unfortunately, the name *Pedicularis* [unranked] 7. *Macranthae* Prain is a later homonym of a long-overlooked unranked name in Bunge's treatment of *Pedicularis* for Ledebour's *Flora Rossica* (Bunge, 1849). On p. 301 of vol. 3(2) of that work Bunge recognised *Pedicularis* [unranked] *Macranthae* Bunge with the description 'corolla magna, galea obtusa edentula falcata'. This group contained only two species: *Pedicularis capitata* Adams and *P. tristis* L. By application of Art. 22.6 of the *ICBN* (McNeill *et al.*, 2006), the former is the type of *Pedicularis* [unranked] *Capitatae* Prain (Prain, 1890: 92) and the latter is the type of *P.* ser. *Tristes* Benth. (Bentham, 1846: 579). Neither of these species are at all closely related to the species of group *Macranthae* Prain; *Pedicularis* [unranked] *Capitatae* belongs to *P.* sect. *Anodon* Bunge and *P.* ser. *Tristes* to sect. *Lasioglossa* H.L.Li. Fortunately Bunge did not assign rank to his group *Macranthae* and therefore it does not displace either of these names (*ICBN* Art. 35.3: McNeill *et al.*, 2006). However, the same Article (35.3) of the *ICBN* states that names of unranked taxa are to be included in considerations of homonymy, and Prain's group *Macranthae* is clearly a later homonym of Bunge's group *Macranthae*. Consequently Prain's group *Macranthae* [= *Pedicularis* ser. *Macranthae* Bonati] was recently renamed as *P.* ser. *Klotzschianae* R.R.Mill (Mill, 2010). The type of Prain's group *Macranthae* was *Pedicularis macrantha* Klotzsch, itself an illegitimate later homonym of *P. macrantha* Spreng. and to which Hurusawa (1948) gave the new

FIG. 1. *Pedicularis bicornuta* var. *bicornuta*. Photograph of lectotype, the illustration in Klotzsch & Garcke, *Die botanischen Ergebnisse der Reise seiner königl. Hoheit des Prinzen Waldemar von Preussen in den Jahren 1845 und 1846* t. 61 (1862).

name *P. klotzschii* Hurus. A later synonym of *Pedicularis macrantha* Klotzsch, *P. ochroleuca* Duthie ex Maxim. (Maximowicz, 1888a: 530), also cannot be used as it is a homonym of *P. ochroleuca* J.C.Schloss. from Croatia. The replacement name, *Klotzschianae*, chosen by Mill (2010) for group *Macranthae*, reflects this past nomenclatural and taxonomic history. It is formed by analogy with *Pedicularis*

ser. *Ikomanae* Hurus. (type, *P. ikomai* Sasaki), *P.* ser. *Keiskeanae* T.Yamaz. (type, *P. keiskei* Franch. & Savat.) and *P.* ser. *Semenowianae* L.I.Ivanina & T.N.Popova (type, *P. semenowii* Regel).

Hooker (1884) used no formal infrageneric classification; instead he divided the genus *Pedicularis* as represented in 'British India' into two large unnamed series defined on phyllotaxy. In his numerical sequence he placed *Pedicularis megalantha* and *P. bicornuta* immediately after *P. elwesii* and immediately preceding *P. bella* Hook.f. and *P. siphonantha*. Inexplicably, he treated *Pedicularis elephantoides* as a synonym of *P. rhinanthoides*, despite major differences in leaf size (basal ones of *P. elephantoides* 80–115 × 20–35 mm, of *P. rhinanthoides* 10–60 × 5–10 mm), form of inflorescence (*P. elephantoides* a long raceme opening from top down, *P. rhinanthoides* short and capitate, the lower flowers opening first), corolla colour (*P. elephantoides* bicoloured yellow and purple, *P. rhinanthoides* wholly rose or magenta), galea beak (in *P. elephantoides* c.20 mm long and turned upwards, in *P. rhinanthoides* c.6 mm long and curved downwards and inwards) as well as other differences. His account of *Pedicularis rhinanthoides*, however, gave only features of that species.

Prain (1890: 68) classified both *Pedicularis bicornuta* and *P. elephantoides* within *Pedicularis* [unranked] 3. *Megalanthae* Prain. Apart from these two species, the only other species he included in that group was *Pedicularis megalantha*, which, under Art. 22.6 of the *ICBN* (McNeill *et al.*, 2006), must be taken as type of the group. Prain diagnosed group *Megalanthae* on the basis of a suite of characters of habit, indumentum, leaf and leaf-segment morphology, calyx morphology and glabrous corolla lip with oblong middle lobe. None of these characters was uniquely diagnostic for the group, even when originally characterised. Prain, however, significantly keyed out *Pedicularis megalantha* as distinct from both *P. bicornuta* and *P. elephantoides* on the basis of its hairy anterior filaments (all four filaments being glabrous in the other two species), and the basal part of the galea (upper corolla lip) being somewhat reflexed (as opposed to erect in the other two). In addition, *Pedicularis elephantoides* and *P. bicornuta* were said to have the filament margins crenulate or undulate (Prain used 'crenulate' in his key, but 'undulate' in the respective species accounts); this character was not commented on for *P. megalantha* which is therefore assumed here to have been regarded by Prain as having non-crenulate filaments. The beaks of the galeas in the three species all differed: *Pedicularis megalantha* was described as having a circinnate beak shortly 2-lobed at the apex with the lobes obtuse; *P. bicornuta*, a galea twisted at the throat with its beak decurved and deeply 2-partite at the apex, with the segments acute; and *P. elephantoides*, a galea not twisted at the throat with its beak rather straight and very long, with a resupinate, entire apex. Clearly, *Pedicularis* [unranked] 3. *Megalanthae* as originally conceived by Prain was a group of three very disparate species that presumably did not 'fit' elsewhere in his system. Despite this, the circumscription of the group has remained more or less unchanged since then, other than the addition of extra species as they have been discovered. Tsoong (1956a)

followed Prain (1890) in regarding *Pedicularis megalantha*, *P. bicornuta* and *P. elephantoides* as belonging to one series *Megalanthae* although in a later part of his paper (Tsoong, 1956b) he did acknowledge that *P. bicornuta* and *P. elephantoides* did not match *P. megalantha* in corolla structure. The earliest author to have definitely assigned series rank to the group appears to have been Bonati (1910: 13) who recognised five species (see below).

Since Prain's original description of *Pedicularis* 3. *Megalanthae*, several taxa have been added to it. Species known to have been added are: *Pedicularis hoffmeisteri* Klotzsch (NW Himalaya: Klotzsch & Garcke, 1862; classified by Prain, 1890 as a synonym of *P. megalantha* D.Don but regarded either as a distinct species – by Yamazaki, 1988 and other authors – or as a variety of *P. megalantha*, e.g. by Sealy, 1939); *P. fastigiata* Franch. (China: Franchet, 1900; Bonati, 1910)*, *P. kialensis* Franch. (China: Bonati, 1910)*; *P. pauciflora* (Prain ex Maxim.) Pennell (E Nepal, Sikkim, Chumbi: Pennell, 1943); *P. megalochila* H.L.Li (China, Burma and E Himalaya: Li, 1948, with several infraspecific taxa described later by Tsoong, 1955a, 1955b, and Yamazaki, 1980); *P. cornigera* T.Yamaz. (E Nepal: Yamazaki, 1980); *P. zhongdianensis* H.B.Yang (China: Yang, 1994); and, most recently, *P. woodii* R.R. Mill (Bhutan: Mill, 2001a, 2001b). The two asterisked species have since been removed from the series. *Pedicularis fastigiata* was transferred first to *Pedicularis* [unranked] *Robustae* Prain (by Limpricht, 1924) and then to ser. *Longiflorae* (Prain) Bonati (e.g. Yang *et al.*, 1998 who wrongly attributed series authorship to Prain). *Pedicularis kialensis*, which Bonati (1910: 13) had included 'à l'extrême limite' of *P.* ser. *Megalanthae* because of similarities he perceived between it and *P. elephantoides*, was removed first to *Pedicularis* [unranked] *Oxycarpae* Prain (by Limpricht, 1924) and finally to the monotypic *P.* ser. *Kialenses* H.L.Li (Li, 1949; Yang *et al.*, 1998). All the others are still currently regarded as members of *Pedicularis* ser. *Megalanthae*. Except for the transfers of *Pedicularis fastigiata* and *P. kialensis* as detailed above, no revision of the limits of this series appears to have been undertaken since Limpricht (1924), who restricted it to *P. bicornuta*, *P. elephantoides*, *P. megalantha* and *P. megalantha* var. *pauciflora* Prain ex Maxim. (now regarded as the species *P. pauciflora*; see above). Limpricht regarded *Pedicularis hoffmeisteri* as a mere synonym of *P. megalantha* and some authors (notably Macior & Sood, 1991) have followed that view while others (e.g. Pennell, 1943; Yamazaki, 1982, 1988) have retained the two as separate species.

Within the infrageneric taxonomy of *Pedicularis*, *P.* ser. *Megalanthae* was first grouped in *P.* sect. *Siphonanthae* (Prain, 1890; Limpricht, 1924). Hurusawa (1949), unaware of Bentham's earlier sectional name, placed the series in *Pedicularis* sect. *Siphonantha* Bunge subsect. *Rhinanthoides* Hurus., along with *P.* sers. *Rhinanthoides* (Prain) Bonati and *Longiflorae* (Prain) Bonati. *Pedicularis* ser. *Megalanthae* was not treated by Li in his revision of the Chinese species of *Pedicularis* (Li, 1948, 1949) although the name was mentioned a few times incidentally. In the very different treatment adopted in *Flora Reipublicae Popularis Sinicae* (Tsoong, 1963) and by Tsoong & Chang (1965) it was placed as one of 10 series within *Pedicularis* grex

Rhizophyllum subgrex *Rhizophyllum*. Yamazaki (1988) removed *Pedicularis* ser. *Megalanthae* from *P.* sect. *Siphonanthae* (which he called *P.* sect. *Schizocalyx* H.L. Li) and made it the only series within his new section *Saccochilus* T.Yamaz., although earlier (Yamazaki, 1980) he had regarded *P. megalochila* and his then newly described *P. cornigera* as members of *P.* ser. *Rhinanthoides*. Placement of *Pedicularis* ser. *Megalanthae* within *P.* sect. *Saccochilus* is the one accepted here, although very recently Garg (2009) has published a paper treating five Indian Himalayan members of *P.* sect. *Siphonanthae*, two of which (*P. megalantha* and *P. hoffmeisteri*) belong to ser. *Megalanthae*.

Li (1949: 10 & 143) described the new section *Pedicularis* sect. *Phanerantha* H.L.Li to accommodate the above-mentioned *P.* ser. *Klotzschianae* (called by him ser. *Macranthae*). He was aware of about four or five species within the section and series, of which three occurred within the geographical limits of his revision. Yamazaki (1988) expanded the section considerably, to include *Pedicularis* sers. *Robustae* and *Longiflorae* as well as what he called *P.* ser. *Macranthae* (i.e. *P.* ser. *Klotzschianae*). Mill (2001b) also included *Pedicularis* ser. *Robustae* and *Macranthae* within *P.* sect. *Phanerantha* which also contained the new series *P.* ser. *Garckeanae* R.R.Mill (Mill, 2001a; see below), but *P.* ser. *Longiflorae* was excluded following Yamazaki (1988) and placed in *P.* sect. *Schizocalyx* H.L.Li (for which the earlier name sect. *Siphonanthae* Benth. has since been traced; this paper).

Results and Discussion

In a recent study by Mill (2001a), *Pedicularis garckeana* Prain ex Maxim. was found to differ significantly from all the other members of *P.* ser. *Robustae* Prain, in which it had consistently been included for over a century. It was accordingly removed to the new monospecific series, *Pedicularis* ser. *Garckeanae* R.R.Mill (Mill, 2001a, 2001b). Similarly, it has become clear, as more species have been described, that the E Himalayan and Chinese members of the original *Pedicularis* ser. *Megalanthae*, including its type *P. megalantha*, form a natural group that has little or nothing in common with the NW Himalayan *P. bicornuta* and *P. elephantoides.* For these mostly eastern Sino-Himalayan species, Yamazaki (1988) described the new section *Pedicularis* sect. *Saccochilus* T.Yamaz., that had *P.* ser. *Megalanthae* as its only series. This section was diagnosed on the basis of its elongate corolla tube, 2–6 × longer than the calyx, the saccate lower corolla lip (hence the sectional name, *Saccochilus*) that covers the galea (see below), and the small, ligulate middle lobe of the lower lip. Yang *et al.* (1998) did not use a sectional classification, but they also diagnosed *Pedicularis* ser. *Megalanthae* by the very long corolla tube, large lower lip usually enveloping the galea, and curved, slender galea beak. In addition, they used the racemose, basipetal inflorescence, 5-lobed calyx, toothless galea, and other characters of less taxonomic significance.

In an extensive molecular phylogenetic study of Sino-Himalayan *Pedicularis* that included three species of *P.* ser. *Megalanthae*, Ree (2005) found that this series was

one of only seven strictly monophyletic groups within the genus. Although he included *Pedicularis cornigera*, *P. hoffmeisteri* and *P. megalantha* in his analysis, unfortunately he did not include *P. bicornuta* or *P. elephantoides*. Therefore, although his results support the morphological distinctiveness of *Pedicularis* ser. *Megalanthae* sensu stricto, they do not help in elucidating the degree of relationship, if any, between the species included in it and the two NW Himalayan ones, which have so far not been studied phylogenetically.

The two NW Himalayan species, *Pedicularis bicornuta* (Fig. 1) and *P. elephantoides*, do have some characters in common with the eastern group. These include the basipetal inflorescence and (at least in *Pedicularis bicornuta*) the fact that the lower lip envelops the galea. However, the inflorescence arrangement is not the same in the two groups. The inflorescence of *Pedicularis bicornuta* (particularly its western, trans-Indus, form, as distinguished by Prain, 1890) is dense, many-flowered and noticeably obovoid, and in its general arrangement closely resembles that of *P. scullyana*, which is now grouped in *P.* sect. *Phanerantha* H.L.Li ser. *Klotzschianae* R.R.Mill [= *Pedicularis* [unranked] 7. *Macranthae* Prain, nom. illegit.; *P.* ser. *Macranthae* (Prain) Bonati, nom. illegit.] along with *P. klotzschii* (= *P. macrantha* Klotzsch, non Spreng., type of ser. *Klotzschianae*) and *P. insignis* Bonati (Yamazaki, 1988; Yang *et al.*, 1998). *Pedicularis bicornuta* also inhabits similar habitats to *P. scullyana* (glacial debris, screes and alpine meadows) although it has been noted that it grows in very exposed habitats subjected to high rainfall and very strong winds, including during the flowering season (Husain & Garg, 2002; Garg & Husain, 2003). It might, but for its unique floral morphology and other differences, be considered a western replacement taxon for *Pedicularis scullyana*. *Pedicularis bicornuta* differs from *P. scullyana* not only in its unique corollas but also in having all filaments glabrous (in *P. scullyana*, and all other species of *P.* ser. *Klotzschianae*, all four filaments are hairy). The inflorescence of *Pedicularis elephantoides* is similar to that of *P. bicornuta* but often somewhat looser; *P. elephantoides* apparently grows in more wooded places at lower altitudes than either *P. scullyana* or the 'core group' of *P.* ser. *Megalanthae* (i.e. the type and its E Himalayan relatives), the species of which have similar habitat preferences to *P.* ser. *Klotzschianae* but perhaps prefer damper sites such as stream-sides.

Three characters set apart *Pedicularis megalantha* and its other Sino-Himalayan relatives (hereafter referred to as '*P.* ser. *Megalanthae* sensu stricto') from the two NW Himalayan species, *P. bicornuta* and *P. elephantoides*. These are (i) the very long corolla tube, (ii) the saccate 'lower' lip that is rotated in a very characteristic manner as described below, and (iii) the stamens with at least the anterior pair of filaments hirsute or villous (as first described for *Pedicularis megalantha* by Prain, 1890), a character not previously noted in diagnoses as being common to '*P.* ser. *Megalanthae* sensu stricto'. These three characters are discussed in more detail below.

In all the species of *Pedicularis* ser. *Megalanthae* sensu stricto, the galea and lower lip of the corolla are carried well above the top of the calyx on a very long, slender, more or less straight and cylindrical corolla tube. Because of the form of the inflorescence, these long, erecto-patent corolla tubes are very prominent, carrying the

lips of the corollas well above the top of the plant. Four of the species (*Pedicularis cornigera*, *P. hoffmeisteri*, *P. megalantha* and *P. pauciflora*) are illustrated side-by-side by Yamazaki (1988: fig. 21a–d). *Pedicularis hoffmeisteri* and *P. cornigera* (Yamazaki, 1988: fig. 21b & c) show the least tube extension but the tube is still at least twice the length of the calyx. *Pedicularis megalantha* (Yamazaki, 1988: fig. 21a) has a longer tube while that of *P. pauciflora* (Yamazaki, 1988: fig. 21d) is by far the longest. These four taxa, incidentally, all deserve separate species rank. *Pedicularis hoffmeisteri* has previously been sunk into *P. megalantha*, either as a variety (Sealy, 1939) or as a synonym (including, importantly, in the pollination paper by Macior & Sood, 1991; others taking this view have been Maximowicz, 1888a, 1888b and Prain, 1890). However, it differs from true *Pedicularis megalantha* in several correlated characters. One of these is corolla colour, which in *Pedicularis hoffmeisteri* is primarily pale yellow, with or without some purple streaking on the 'lateral' lobes of the 'lower' lip, and a galea that is either yellow or (in the forms with purple streaks on the labellum) purple. In *Pedicularis megalantha* the corolla is entirely magenta. Maximowicz (1888a, 1888b) commented that the illustration of '*Pedicularis megalantha*' in Regel, Gartenflora 27: 195, t. 943 (1878) was of a plant with yellow corollas, whereas Don (1825) had described the corollas of *P. megalantha* as having a purple galea and the labellum (with some doubt) as yellowish-red. Noting that according to Hooker (1884) collectors had described the corolla of '*Pedicularis megalantha*' as sometimes yellow, sometimes purple, Maximowicz wondered whether either colour variation or confusion between two different species was involved. Prain (1890) mentioned that forms from the NW Himalaya differed in their wholly golden-yellow corollas but these were included by Pennell (1943) in his concept of *Pedicularis hoffmeisteri*. Macior & Sood (1991) regarded *Pedicularis hoffmeisteri* and *P. megalantha* sensu stricto as colour morphs but their view is not accepted here because of the other correlated character differences. These include filament indumentum (both pairs of filaments villous in *Pedicularis hoffmeisteri*, only the anterior pair hairy in *P. megalantha*), and smaller anthers compared with *P. megalantha*. The two species are also disjunct, *Pedicularis hoffmeisteri* occurring in Himachal Pradesh and western Nepal, while *P. megalantha* is restricted to C and E Nepal, Sikkim, southernmost Tibet (Xizang: Chumbi) and Bhutan. The species with yellow corollas from the Himachal Himalaya whose pollination biology was studied by Macior & Sood (1991) was actually *Pedicularis hoffmeisteri*, not *P. megalantha* as stated by the paper's authors. *Pedicularis hoffmeisteri* and *P. megalantha* have also been regarded as distinct species by Aswal & Mehrotra (1994) and most recently by Garg (2009). The variation within *Pedicularis hoffmeisteri* itself is not yet properly understood and it is possible that the forms with purple streaking (as found in Nepal) and those with pure yellow corollas (as found further west) might deserve taxonomic separation at some rank.

In all these species [and in the two not illustrated by Yamazaki (1988), i.e. *Pedicularis woodii* and *P. zhongdianensis*], the 'lower' lip of the corolla exhibits an unusual modification. Instead of being outspread and topographically below the topographical upper lip or galea as in most species of *Pedicularis* (e.g. *P. longiflora*,

P. oederi Vahl and *P. pyramidata* Royle), it is rotated through about 90° so that one of the two lateral lobes is at the base and the other one is at the top of the corolla, where it forms an overhanging cowl-like hood that hides the galea; the middle lobe of the 'lower' lip projects downwards at an oblique angle to partly cover the front of the flower. This is clearly illustrated in the colour plate of *Pedicularis hoffmeisteri* in Yamazaki (1988: col. pl. 6d). This type of corolla rotation may be unique to *Pedicularis* sect. *Saccochilus* and is possibly an adaptation to shelter pollinators from cold and/or wet alpine conditions (Ree, 2005). Macior & Sood (1991) maintained that this type of corolla rotation was also shared by *Pedicularis elwesii* (of uncertain position: best regarded as a member of *P.* ser. *Klotzschianae* R.R.Mill [= (unranked) 7. *Macranthae* Prain], though recently transferred to *P.* ser. *Robustae* by Husain & Agnihotri, 2007) and *P. fletcheri* P.C.Tsoong (*P.* ser. *Pseudomacranthae* P.C.Tsoong ex H.B.Yang) but it is clear from the photograph of *P. elwesii* in Yamazaki (1988: col. pl. 6a) that the end result, in that species at least, is different: the corolla in *P. elwesii* is much more open and less strongly hooded than in any species of ser. *Megalanthae*. Other Himalayan species exhibit different types of rotation, the most extreme so far discovered being in an as yet undescribed Nepalese species where the whole corolla is rotated on its axis by 180° to face inwards, and the lower lip is also rotated through 180° so that the middle lobe (not one of the laterals as in *Pedicularis hoffmeisteri*, *P. megalantha*, etc.) covers the top of the galea. The combination of long tube and the orientation of the galea and its beak in the members of sect. *Saccochilus* are adaptations to sternotribic pollination, as demonstrated for *Pedicularis hoffmeisteri* by Macior & Sood (1991, under the name *P. megalantha*) and by Macior *et al.* (2001) for several unrelated species also having long-tubed corollas such as *P. longiflora*.

At least the anterior pair of anthers is hirsute or villous in all the species of 'ser. *Megalanthae* sensu stricto', while the posterior pair is also hairy in *Pedicularis cornigera*, *P. hoffmeisteri*, *P. pauciflora* and some forms of *P. megalochila*. By contrast, both pairs of filaments are glabrous in both *Pedicularis bicornuta* and *P. elephantoides*.

Thus, neither *Pedicularis bicornuta* nor *P. elephantoides* share any of these characters that are diagnostic for *P.* ser. *Megalanthae* sensu stricto. They also possess a suite of inflorescence and floral characters that unite them and are not shared by the species of *Pedicularis* ser. *Megalanthae* sensu stricto. These include:

- The corolla tubes in *Pedicularis bicornuta* and *P. elephantoides* are both about twice as long as the calyx. This is shorter than most members of *Pedicularis* ser. *Megalanthae* sensu stricto but both *P. hoffmeisteri* and *P. cornigera* have tubes of about the same relative proportionate length. However, in both *Pedicularis bicornuta* and *P. elephantoides* the tube is broader than in the members of *P.* ser. *Megalanthae* sensu stricto, being 2–3 mm wide. This, combined with the longer inflorescences with many more flowers, compared with those of *Pedicularis* ser. *Megalanthae* sensu stricto, means that the tubes of the two NW Himalayan

species look relatively shorter; nor do they carry the corolla lips above the rest of the plant, as in all the species of *P.* ser. *Megalanthae* sensu stricto.

- The galea in both *Pedicularis bicornuta* and *P. elephantoides* is twisted at the base – a tight corkscrew in *P. bicornuta*, somewhat less pronounced in *P. elephantoides*. The anther case in both species is resupinate so that it points upwards rather than downwards as is usual in the genus.
- Both these species have a long slender galea beak which has a deeply bifid tip. In *Pedicularis bicornuta* the two lobes of the tip spread outwards like horns, hence the specific epithet. Although *Pedicularis elephantoides* also has a deeply bifid beak apex, the two lobes remain close together, so that its bifid nature is much less obvious than in *P. bicornuta*.

Pedicularis bicornuta and *P. elephantoides* thus both have a unique corolla morphology, neither being exactly similar to any member of *P.* ser. *Megalanthae* sensu stricto. The floral structure of *Pedicularis bicornuta* was first correctly described and illustrated by Wendelbo (1965: 131–133, fig. 4A–D). As in *Pedicularis hoffmeisteri*, the galea is enclosed by the lower lip. However, the method of enclosure is totally different. Instead of the two lateral lobes being more or less parallel to each other at the topographical top and bottom of the flower, the left-lateral lobe is orientated almost vertically on the anterior side of the flower, while the right-lateral lobe is spread out horizontally at right-angles to the left-lateral lobe to form a porrect, canopy-like structure (described as 'pale yellow balloons' by Taylor & Taylor, 1998; also see Husain & Garg, 2002; Garg & Husain, 2003). Below this, the broadly obovate middle lobe hangs downwards. The base of the galea beak is twisted like a corkscrew and the anthers are contained just below this corkscrew. Above the corkscrew, the galea is produced into a long, decurved, shallowly sinuous S-shaped beak. This projects downwards below the 'canopy' towards the middle lobe, which probably acts as a landing platform for pollinators. The whole flower is adapted for nototribic pollination, not sternotribic as in *Pedicularis* ser. *Megalanthae* sensu stricto, in which the pollination mechanism was described for *P. hoffmeisteri* by Macior & Sood (1991, under the name *P. megalantha*). In life, the galea (including the beak) of *Pedicularis bicornuta* is totally enclosed within the structure formed by the lobes of the lower lip, which, because of their orientation, do not gape like open jaws as do the two lateral lobes of *P. hoffmeisteri* and the other species of ser. *Megalanthae* sensu stricto. In *Pedicularis bicornuta*, the apex of the beak is deeply bifid with the two lobes tending (at least in herbarium material) to splay outwards, so that the bifid nature of the beak is immediately obvious even to the unaided eye.

Wendelbo (1965) rightly pointed out that, in many instances (including *Pedicularis bicornuta*), it is impossible to determine the true, living appearance of the corolla of *Pedicularis* species by boiling flowers taken from herbarium material and then opening them out, which is how Prain (1890) and others (including, I suspect, Watt, 1881 and Yamazaki, 1988) prepared their drawings. This resulted in the drawings of the flowers of *Pedicularis bicornuta* in Prain's monograph (Prain, 1890: t. 3A & 3B)

being grossly inaccurate, with the three lobes of the labellum (lower lip) being conventionally shown as spreading, rather than enveloping the galea, which is wrongly shown as projecting beyond them. Watt (1881) depicted the flowers of his *Pedicularis eximia* in a similar manner; the flowers in his drawing are strikingly similar to fig. 4A of Wendelbo (1965) which shows an opened-out corolla, but bear no relation to the situation *in vivo* as illustrated by Wendelbo (1965: fig. 4B–D).

Unlike *Pedicularis bicornuta*, there have been no studies of the corollas of *P. elephantoides* from living material. Prain's illustration of *Pedicularis elephantoides* (Prain, 1890: t. 3C) shows the three lobes of the corolla labellum orientated in exactly the same way as for *P. bicornuta* (op. cit., t. 3A), namely outspread. Therefore, there is no guarantee that this illustration is any more accurate (or, less inaccurate) in its depiction of the lateral lobes as they appear *in vivo*. Careful study of boiled herbarium material indicates that the labellum in *Pedicularis elephantoides* is in fact enfolded round the galea in a similar manner to *P. bicornuta* and that the galea is resupinate. Prain himself (1890: 117, and in key p. 68) described the galea *apex* as being resupinate but the resupination appears to affect the whole galea and its relation to the lower lip, which appears in herbarium material to be located behind and above the galea, as in *Pedicularis bicornuta*, rather than in front of and below it as would be the case if orientation were conventional. Thus the corolla structure of *Pedicularis elephantoides* is analogous to that of *P. bicornuta* and very different from the species of ser. *Megalanthae* sensu stricto. As in *Pedicularis bicornuta*, the beak of the galea is shallowly S-shaped. However, instead of the beak being enclosed within the rest of the corolla as in *Pedicularis bicornuta*, the longest part of the 'S' is turned upwards so that its tip, which abruptly becomes more horizontal, is carried well above, and forward from, the rest of the corolla. In shape, the whole beak and its relation to the rest of the galea resembles an elephant's trunk when the animal is 'trumpeting' (hence the specific epithet). The labellum of *Pedicularis elephantoides* is noticeably smaller than in *P. bicornuta* and consequently does not form a balloon-like enclosure as in that species. Nevertheless, the balloon-like structure of *Pedicularis bicornuta* would appear to have evolved from the less highly developed form of the corolla morphology found in *P. elephantoides*, no doubt in response to the environmental conditions of its habitat.

Chromosome counts of W Himalayan *Pedicularis* are relatively few. However, it is noteworthy that *Pedicularis megalantha* agrees with the vast majority of species that have been counted worldwide in having $2n = 16$ (Vaseduvan, 1975, reported as haploid $n = 8$). Two other, Nepalese, species of *Pedicularis* ser. *Megalanthae*, *P. hoffmeisteri* and *P. pauciflora*, have recently been cytologically examined; both also had $2n = 16$, with tetraploid counts of $2n = 32$ also recorded for both species (Amano, 1999; Saggoo & Srivastava, 2009). This suggests that 16 is the diploid number typical for ser. *Megalanthae*. However, *Pedicularis bicornuta* differs from these three species in having $2n = 14$ (Vaseduvan, 1975, reported as haploid $n = 7$). Very few other *Pedicularis* species are so far known to have a base number of 7; indeed, Fischer (2004) does not give 7 as a base number within *Pedicularis* at all. This

is incorrect; apart from *Pedicularis bicornuta*, species with $x = 7$ include *P. ludwigii* Regel of ser. *Abrotanifoliae* Limpr. (Zakharjeva, 1993), *P. siphonantha* D.Don var. *delavayi* (Franch.) P.C.Tsoong of ser. *Longiflorae* (Wang *et al.*, 2004), *P. longiflora* Rudolph var. *tubiformis* (Klotzsch) Pennell of ser. *Longiflorae* (Amano, 1999, Nepal; but Wang *et al.*, 2004, have found $x = 8$ in Chinese material) and *P. integrifolia* Hook.f. subsp. *integerrima* (Pennell & H.L.Li) P.C.Tsoong of *Pedicularis* [unranked] *Integrifoliae* Prain [= *P.* ser. *Integrifoliae* (Prain) Hurus., 1949: 112], all of which are diploid ($2n = 14$) (Wang *et al.*, 2004), as well as *P. anserantha* T.Yamaz. var. *elevatogaleata* (T.Yamaz.) T.Yamaz of ser. *Craspedotrichae* Maxim., which is tetraploid ($2n = 28$; Amano, 1999). This unusual base number in *Pedicularis bicornuta* lends further support for its separation from the remainder of *P.* ser. *Megalanthae*. Unfortunately, no chromosome count is yet known for *Pedicularis elephantoides*.

The main palynological study of *Pedicularis* to date has been the extensive light-microscopical survey by Tsoong & Chang (1965a, 1965b). They examined, but did not illustrate, two species of *Pedicularis* ser. *Megalanthae* sensu stricto, namely *P. megalochila* and *P. megalantha*. These had prolate, 2-syncolpate pollen, that of *Pedicularis megalantha* being about 50% larger than that of *P. megalochila*. Neither *Pedicularis bicornuta* nor *P. elephantoides* was included in that study and neither has been palynologically studied in detail since. Although both were included in a recent light-microscopy (LM) survey of Scrophulariaceae pollen (Aman *et al.*, 2002), this paper did not give detailed palynological descriptions for each species, and, of the two species, only *Pedicularis elephantoides* was included in the poorly reproduced set of LM micrographs which show little detail and are without indications of scale or magnification. From the data available in the papers by Tsoong & Chang (1965a, 1965b) and Aman *et al.* (2002), it is not possible to establish either whether *Pedicularis bicornuta* and *P. elephantoides* show any significant palynological differences from each other, or whether either or both of them differ from *P.* ser. *Megalanthae* sensu stricto. A more detailed examination of the pollen of *Pedicularis bicornuta* and *P. elephantoides* was deemed to be beyond the scope of this paper as these species should be studied as part of a more extensive survey of pollen of Himalayan *Pedicularis* in order that the palynological affinities between the various groups of species in the Himalaya can be properly understood.

On account of the distinctiveness of *Pedicularis bicornuta* and *P. elephantoides* from *P.* ser. *Megalanthae* sensu stricto, they are here assigned to *P.* ser. *Bicornutae* R.R.Mill, recently described but without discussion in Mill (2010). This series is assigned to *Pedicularis* sect. *Phanerantha* H.L.Li. For *Pedicularis bicornuta* this placement is not problematic since the superficial similarities between *P. bicornuta* and *P. scullyana* of *P.* ser. *Klotzschianae* of that section have been mentioned above. *Pedicularis elephantoides* also shares with the members of *P.* sect. *Phanerantha* the character of centrifugal inflorescence and thus keys out to that section using the key in *Flora of Bhutan* (Mill, 2001b). It is clearly closely allied to *Pedicularis bicornuta*, of

which it can be considered a less derived progenitor, and does not warrant series recognition of its own. With the addition of this recently described series *Pedicularis* sect. *Phanerantha* comprises the following four series: *P.* ser. *Bicornutae* R.R.Mill (this paper), *P.* ser. *Garckeanae* R.R.Mill (Mill, 2001a), *P.* ser. *Klotzschianae* R.R.Mill (Mill, 2010 and this paper) and *P.* ser. *Robustae* (Prain) Hurus., plus a fifth as yet undescribed series. *Pedicularis* ser. *Longiflorae* (Prain) Bonati, which has frequently also been included in *P.* sect. *Phanerantha*, differs from the other five series in numerous respects, including calyx lobes reduced in nearly all species to two or three. It seems better placed in *Pedicularis* sect. *Siphonanthae* Benth. (= *Schizocalyx* H.L.Li) following the placements of Li (1948) and Mill (2001b) with necessary nomenclatural amendment.

DESCRIPTION OF *PEDICULARIS* SERIES *BICORNUTAE*

Pedicularis L. series **Bicornutae** R.R.Mill, Edinburgh J. Bot. 67: 185 (2010) (Sect. *Phanerantha* H.L.Li). – Type: *Pedicularis bicornuta* Klotzsch. For typification of this name see species account below.

Cauline leaves alternate, all petiolate or the uppermost ones subsessile. *Inflorescence* a long raceme opening from the top down, dense to lax, often interrupted at base, flowers spirally arranged. *Calyx* tubular, ± inflated, 10-ribbed, slightly narrowed and ± constricted at top of tube, deeply split anteriorly. *Corolla* tube hairy or glabrous, not more than twice as long as calyx. *Lower lip* of corolla with two large semicircular lateral lobes, rotated and with one of the lateral lobes wholly or partly hiding the galea; lower lip margin densely but minutely ciliate, or glabrous. *Galea* twisted at the base (like a corkscrew in *Pedicularis bicornuta* but less tightly in *P. elephantoides*), with resupinate anther case and shallowly sigmoid beak; distal part of beak deeply bifid, the two halves spreading outwards like horns or remaining close together. *Stamens* inserted at top of corolla tube; all filaments glabrous. *Capsule* obliquely lanceolate-ovoid to ovoid, the adaxial side curved distally or convex, the apex apiculate or abruptly acuminate. – Two species: *Pedicularis elephantoides* Benth. and *P. bicornuta* Klotzsch.

Distribution. E and NE Afghanistan (including Badakhshan), Pakistan (Gilgit-Baltistan, Khyber Pakhtunkhwa, Federally Administered Tribal Areas (FATA), Azad Kashmir), Kashmir, NW India (Himachal Pradesh and Uttarakhand). Absent from Nepal and further east; I have seen no material to substantiate the conjecture that *Pedicularis bicornuta* might occur in C Nepal, as stated in Appendix 1 to Press *et al.* (2002: 334).

Pedicularis ser. *Bicornutae* differs from *P.* ser. *Megalanthae* (Prain) Bonati by the thicker corolla tube, the labellum neither saccate nor gaping, with the middle lobe pendent, the laterals rotated in a different manner (one at the top and the other covering the side of the flower).

Pedicularis elephantoides is more or less constant in its characters but *P. bicornuta* is a variable taxon. Prain (1890) commented that, on the basis of the material he examined, there existed within it two forms, an eastern one from Garhwal and the Punjab Himalaya with 'elongated looser racemes, with a longer corolla tube and with smaller calyx teeth', which he considered typical, and a western, trans-Indus one with 'more condensed racemes, a shorter corolla tube, larger calyx teeth and a more densely leafy stem'. However, he did not formally name these, stating that 'the peculiarly contorted corolla throat which characterises this species and makes its confusion with any other Indian species impossible is the same in both districts, so that the forms are not separable even as varieties. Extreme conditions of the Eastern form (*Duthie* 237) from Rudaghera in Garhwal have very lax racemes and closely resemble *P. megalantha*'. Some aspects of Prain's comments are difficult to understand, on the basis of the material examined. Many of the plants from Kashmir and northern Pakistan, which would presumably have been considered western or trans-Indus by Prain, have far longer corolla tubes and/or more extended inflorescences than many of the plants seen from the east of the range. The example seen of *Duthie* 237, which he specifically mentioned as having a particularly lax raceme, is a small plant with a condensed inflorescence! Nevertheless, I have come to the same conclusion as Prain: although some plants have larger and/or laxer inflorescences, longer corolla tubes, and larger more swollen calyces than others, there is too much intergradation for them to be divided into infraspecific taxa on the basis of those features.

Watt (1881) described *Pedicularis eximia* which appears to be a variant of *P. bicornuta* with a relatively long, dense inflorescence whose flowers all open more or less simultaneously, as claimed in an annotation on one of the original collections by Watt. The name was based on several syntypes, at least two of which (*Watt* 49A and 97B) have glandular calyces and are therefore referable to *Pedicularis bicornuta* var. *adenocalyx* (see below).

Among the material examined during the present study, several specimens could be easily distinguished from the others by their calyces covered with dense short glandular hairs. Prain (1890) apparently failed to notice this variant. This material has been distinguished as *Pedicularis bicornuta* var. *adenocalyx* R.R.Mill (Mill, 2010). This is the only constant infraspecific variation that in my opinion deserves taxonomic recognition, and that only at varietal rank. The remainder of the material has calyces that are more or less long-pilose along the veins but otherwise glabrous. The degree of eglandular pilosity is very variable, with a continuum from nearly glabrous calyces, as in *Bowes Lyon* 1027 from Chitral, to densely pilose ones, as in *Siddiqi et al.* 4235 from Baltistan.

Key to species

1a. Corolla tube glabrous; labellum relatively small, not enclosing the galea, its margin glabrous; anther-bearing part of galea not corkscrew-like at base; beak of galea strongly turned upwards, red and contrasting with rest of corolla, the

two halves of the bifid tip remaining close together; upper cauline leaves sessile _____ **P. elephantoides**

1b. Corolla tube pilose; labellum large, ± enclosing galea like a balloon, its margin ciliate; anther-bearing part of galea tightly twisted at base like a corkscrew; beak of galea not turned upwards, yellow and same colour as rest of corolla, the two halves of the bifid tip spreading apart like horns; all cauline leaves petiolate _____ 2

2a. Calyx ± eglandular-pilose but lacking glands or glandular hairs _____ _____ **P. bicornuta** var. **bicornuta**

2b. Calyx tube and teeth covered with ± dense short glandular hairs as well as longer eglandular-pilose indumentum _____ **P. bicornuta** var. **adenocalyx**

Pedicularis bicornuta Klotzsch in Klotzsch & Garcke, Bot. Ergebn. Reise Waldemar 109, t. 61 (1862). –Type: Holotype of *Pedicularis bicornuta* collected in the Himalayas, probably between Kedarnath and upper Kunawar, collected by Hoffmeister in 1846: B, destroyed; no isotypes traced at C (database search, 26 Jan. 2001) or elsewhere. Lectotype: The illustration of *Pedicularis bicornuta* in Klotzsch & Garcke, op. cit., t. 61 (1862; fig. 1A), designated by Mill (2010: 186). **Fig. 1.**

Pedicularis bicornuta Klotzsch var. **bicornuta**

Pedicularis eximia G.Watt, J. Linn. Soc., Bot. 18: 381, t. 13, figs 1–6 (1881) p.p. excl. lectotype.

Calyx ± eglandular-pilose but lacking glands or glandular hairs.

A full account of this variety, with specimen citations, will appear in the Scrophulariaceae fascicle of *Flora of Pakistan*.

Pedicularis bicornuta Klotzsch var. **adenocalyx** R.R.Mill, Edinburgh J. Bot. 67: 186 (2010). – Type: Pakistan, B-8 Kashmir, Sonamarg, 34°20′N, 75°20′E, 10,500 ft, at edge of stream, flowers yellow, 5 viii 1965, *Stainton* 5031 (holo BM). **Fig. 2.**

Pedicularis eximia G.Watt, J. Linn. Soc., Bot. 18: 381 (1881) p.p. incl. lectotype. – Type: India, Himachal Pradesh, Pangi, Chumba State, Chenab River, southerly aspect, 8500–9000 ft, 25 vii 1878, *J. Ellis snr.* s.n. (hb. *G. Watt* 97B) (lecto E, designated by Mill, 2010: 186; see discussion below).

Differs from *Pedicularis bicornuta* var. *bicornuta* by the calyx tube and teeth covered with ± dense short glandular hairs as well as longer eglandular-pilose indumentum. *Stems* 12–42(–70) cm. *Calyx* 11–17 mm, ± densely glandular-pubescent, sometimes with dark blotches or spots on tube; tube 8–14.5 mm; teeth 1–4.5 mm. *Corolla* 15–35 (–53) mm overall; tube 18.5–27(–42) mm; beak of galea 12–16 mm. Flowering from early June to mid-July; fruiting August onwards.

FIG. 2. *Pedicularis bicornuta* var. *adenocalyx*. Illustration from Watt (1881), forming part of the protologue of *Pedicularis eximia* G.Watt.

Distribution. Afghanistan, Pakistan (Khyber Pakhtunkhwa and Federally Administered Tribal Areas (FATA)), Kashmir.

Habitat and ecology. Wet meadows and marshes, 2600–3600 m.

Proposed IUCN conservation assessment. Least Concern (LC).

Additional specimens examined. AFGHANISTAN. **Parvan**: Panjshir valley, between Shanez and Chimar, seen on both sides of the Anjuman Pass, 2600–3000 m, 22 vii 1962, *I. Hedge & P. Wendelbo* W. 5356 (E). **Badakhshan**: Oberes Anjuman, Umgebung des Ortes Anjuman, 3100 m, 15 viii 1965, *D. Podlech* 12389 (E, M n.v.). **Baghlan**: Oberstes Andarab-Tal, Darrah-i-Til südlich Doab-i-Til, 2800 m, 7 vi 1965, *D. Podlech* 11165 (E, M n.v.). Safrd Koh, 11,000 ft, vii 1879, *Major H. Collett* 114 (K). PAKISTAN. **Khyber Pakhtunkhwa**: d. Chitral, Chitral, *Maj. S.M. Toppin* 552 (K, 2 sheets). Hazara region, Sarul, Kagan, 13 viii 1897, *Inayat* 22043 (E). **FATA**: Kurram Agency, Kuriam and Hariab districts, 10,500–11,000 ft, 24 & 25 vi 1880, *Aitchison* 220 (K); Kurrum Valley, Shend Toi Hills, 10,000–11,000 ft, 9 vii 1879, *Aitchison* 779 (BM, K). KASHMIR. Erin Valley, near Bandapur, 11,000 ft, 24 vii 1940, *Ludlow & Sherriff* 7817 (BM); above Gulmarg, 10–11,000 ft, 2 vi 1892, *Duthie* 11336 (BM, E); Tsurlat Pass (Salnai Sar), 13,500 ft, summer 1969, *O. Polunin* 9634 (BM); Gulmarg, 9000 ft, 9 viii 1933, *J. Venning* K 46 (K); Alibad, 11,000 ft, 6 vii 1876, *C.B. Clarke* 28985 (BM); Srinagar, Lashpathri, 10,000 ft, 3 vii 1978, *C.R. Lancaster* 34 (BM); Gangabal Lake, near Mt. Haramukh, 11,700 ft, 14 viii 1940, *P.M. Pinfold* 280 (BM; corolla much longer, and calyx less glandular, than typical for the variety); Upper Chenab, 10,000 ft, *B.H. Baden-Powell* 269 (K).

As mentioned above, the syntypes cited by Watt (1881) under his new species *Pedicularis eximia* are a mixture of *P. bicornuta* var. *bicornuta* and *P. bicornuta* var. *adenocalyx* as here defined. I have decided to lectotypify the name *Pedicularis eximia* G.Watt by one of the glandular specimens, so that Watt's name can be revived if any later worker wishes to regard *P. bicornuta* var. *adenocalyx* as a full species. There are three Watt herbarium sheets in the type folder at E, where Watt's original collection is now conserved, having been presented to the Royal Botanic Garden Edinburgh around 1900 (Vegter, 1988). Two of these are cited in the protologue (49A and 97B) and are *Pedicularis bicornuta* var. *adenocalyx*. The third sheet, collected at Pangi at 13,000 ft, is unnumbered; it is eglandular and consequently falls within *Pedicularis bicornuta* var. *bicornuta*. Pinned to this unnumbered sheet is the original drawing that formed the basis of the lithograph (plate 13; reproduced here as Fig. 2) that accompanied Watt's paper and thus forms part of the protologue. However, the drawing shows numerous buds at the base of the inflorescence, which are absent on this sheet. Therefore it is concluded that either a different herbarium sheet must have been used by the artist, or that the drawing is a composite relying on information from more than one sheet.

Pedicularis elephantoides Benth., Scroph. Ind. 23 (1835). – Type: 'Hab. ad Pyr Panjal, *Royle*' (K).

A full account of this species will appear in the Scrophulariaceae fascicle of *Flora of Pakistan*.

Emendation of series *Megalanthae*

Pedicularis L. series **Megalanthae** (Prain) Bonati, Mém. Soc. Bot. France 18: 13 (1910), emend. R.R.Mill hoc loco (Sect. *Saccochilus* T.Yamaz.). – *Pedicularis* [unranked] 3. *Megalanthae* Prain, Ann. Roy. Bot. Gard. (Calcutta) 3: 68 (1890). – Type: *Pedicularis megalantha* D.Don (Art. 22.6 of the *ICBN*: McNeill *et al.*, 2006).

Leaves mainly clustered near base, alternate, petiolate. *Inflorescence* basipetal, racemose. *Calyx* split to least 1/3, lobes 5. *Corolla* usually uniformly pink to purple (in *Pedicularis hoffmeisteri* lemon yellow, with or without purple streaks on the top lateral lobe of the labellum), with a long tube (usually at least twice as long as calyx) and large, saccate lower lip (which usually envelops the upper lip or galea), whose middle lobe is much smaller than the two laterals; the corolla rotated above the tube through c.90° so that the two larger lobes of the lower lip gape outwards like an open jaw, the upper of the two situated at the top of the flower and forming a hood over the galea and the lower, basal one a landing platform. *Galea* erect in centre of (and protected by) lower lip, its erect part very reduced or absent, not toothed, its anther-bearing part thus ± sessile on the lower lip, strongly twisted into a ring or arc and with a slender, coiled beak that is emarginate at the apex. *Stamens* with at least the anterior pair of filaments hirsute or villous. *Capsule* ovoid to lanceolate, apiculate. – Seven species: *Pedicularis cornigera* T.Yamaz., *P. hoffmeisteri* Klotzsch, *P. megalantha* D.Don, *P. megalochila* H.L.Li with three varieties, *P. pauciflora* (Prain ex Maxim.) Pennell, *P. woodii* R.R.Mill, *P. zhongdianensis* H.B.Yang. Excluded species: *Pedicularis bicornuta* Klotzsch (incl. *P. eximia* G.Watt; to ser. *Bicornutae* – Mill, 2010 and this paper), *P. elephantoides* Benth. (to ser. *Bicornutae* – Mill, 2010 and this paper), *P. fastigiata* Franch. (to ser. *Longiflorae* – Yang *et al.*, 1998) and *P. kialensis* Franch. (to ser. *Kialenses* – Li, 1949).

Distribution. NW India (Uttarakhand, Himachal Pradesh), Nepal, Sikkim, Bhutan, China (SW, S and SE Xizang, NW Yunnan), N Burma. Perhaps also in NE India (Arunachal Pradesh); this region is poorly known botanically but given the known distribution of *Pedicularis megalochila* and some of the others, it is likely that the series will be represented there although no species belonging to it was recorded in *Flora of Assam* (Kanjilal *et al.*, 1939).

Key to species of Pedicularis *series* Megalanthae

1a. Corolla yellow, with the galea yellow, reddish, magenta or purple _____ 2
1b. Corolla wholly magenta _____ 6

2a. Whole corolla including galea yellow; calyx split to halfway on anterior side _____ 3
2b. Galea of corolla not yellow; calyx split *either* to 1/4–1/3 *or* to more than halfway on anterior side _____ 4

3a. Beak of galea c.15 mm; dorsal part of galea with a horn-like appendage; corolla tube 30–50 mm ____ **P. cornigera**
3b. Beak of galea 5–6 mm; dorsal part of galea lacking a horn-like appendage; corolla tube 50–65 mm ____ **P. zhongdianensis**

4a. Calyx split to 1/4–1/3 on anterior side (Nepal) ____ **P. hoffmeisteri**
4b. Calyx split to 2/3 on anterior side (China: *P. megalochila*) ____ 5

5a. Anterior pair of filaments villous, posterior pair glabrous; middle lobe of corolla labellum ligulate; corolla tube relatively short, c.15 mm ____ **P. megalochila** var. **ligulata**
5b. All filaments pubescent; middle lobe of corolla labellum obcordate; corolla tube longer, up to 38 mm ____ **P. megalochila** var. **megalochila** f. **megalochila**

6a. Corolla 27–31 mm with tube 14–20 mm; beak of galea with entire, truncate apex ____ **P. megalochila** var. **megalochila** f. **rhodantha**
6b. Corolla 35–90 mm with tube 25–75 mm; beak of galea with emarginate apex ____ 7

7a. Galea and throat white, rest of corolla reddish-purple; leaf petioles usually completely glabrous (sometimes sparsely pilose only at base); pedicels glabrous ____ **P. megalantha**
7b. Galea and throat purple, like rest of corolla; leaf petioles and pedicels sparsely pubescent or pilose ____ 8

8a. Corolla tube 35–75 mm, 4.5–6 × as long as tube; lobes of lower corolla lip pilose ____ **P. pauciflora**
8b. Corolla tube 25–30 mm, c.2 × as long as tube; lobes of lower corolla lip glabrous or at most very sparsely pilosulous ____ **P. woodii**

Pedicularis cornigera T.Yamaz., J. Jap. Bot. 55(10): 293 (1980). – Type: E Nepal, Lamni Nama, 4200–4900 m, 15 viii 1977, *Ohashi, Kanai, Ohba & Tateishi* 772407 (holo TI n.v.).

A full account of this species is given by Yamazaki (1988: 157, pl. 26c, fig. 21c). It was said (Yamazaki, 1980) to be allied to *Pedicularis megalochila* var. *ligulata* P.C. Tsoong from which it differed by the longer galea with a horn-like projection, and by the filaments all densely villous.

Pedicularis zhongdianensis H.P.Yang, Acta Bot. Yunnan. 6(3): 277, t. 1, figs 1–3 (1984). – Type: China, Yunnan, Zhongdian, 3300 m, 19 viii 1981, *Zhao Kui-yi* 762 (holo PE n.v.).

An account of this species is given by Yang *et al.* (1998: 208).

Pedicularis hoffmeisteri Klotzsch in Klotzsch & Garcke, Bot. Ergeb. Reise Waldemar 108, t. 60 (1862). – *Pedicularis megalantha* var. *typica* Prain 'forma *hoffmeisteri*'

(Klotzsch) Prain, Ann. Bot. Gard. Calcutta 3(1): 119 (1890, perhaps not validly published [Art. 34.1(a) of the *ICBN* (McNeill *et al.*, 2006) would seem to apply; see below]). – *Pedicularis megalantha* var. *hoffmeisteri* (Klotzsch) Sealy, Bot. Mag. 162: t. 9570 (1939). – Type: No type was designated beyond 'Dr Hoffmeister fand diese Art im Himalaya' and the original material collected (seemingly from Kunawar, *fide* Prain, 1890: 118 who apparently saw it and cited it under *Pedicularis megalantha* var. *typica*), formerly at B, is now lost. Lectotype: The illustration in Klotzsch & Garcke, Bot. Ergeb. Reise Waldemar t. 60 (1862; illustrated here as Fig. 3, designated here). As this is a line illustration and Klotzsch did not describe the yellow corolla colour, which is diagnostic from *Pedicularis megalantha* (corollas purple), in either his Latin diagnosis or his fuller German description, I also simultaneously here designate the following epitype: India, Bashahr State, Kanaki, 7500 ft, lower lip very large, bright yellow, 4 vii 1890, *J.H. Lace* 350 (epi E; isoepi E with no field notes). Both epitype and isoepitype have preserved the yellow corolla colour well. **Fig. 3.**

An account of this species as it occurs in Nepal is given by Yamazaki (1988: 156, col. pl. 6d, pl. 26a & fig. 21b). Garg (2009: 127 ff., fig. 7) has published a treatment of *Pedicularis hoffmeisteri* in NW India, with distribution map and illustration. Neither of these accounts, nor that of Sealy (1939), discussed typification.

Prain (1890: 119), in a figure legend in his account of *Pedicularis megalantha*, wrote:

A—Specimen of VAR. typica ('vera') from Chumbi.
B— " " " " (forma 'Hoffmeisteri') from Kamaon.

When Prain (1890) recognised forms within other species, such as *Pedicularis brevifolia* D.Don (pp. 134–135) and *P. gracilis* (p. 140), he gave them Greek letters, provided short diagnostic descriptions and indicated at least one specimen. He did none of these things when mentioning the two forms of *Pedicularis megalantha* var. *typica* and I therefore conclude that Art. 34.1(a) of the *ICBN* (McNeill *et al.*, 2006) can be applied to the mention of forma 'hoffmeisteri' to deem the name not validly published in the figure legend. His only comment about *Pedicularis hoffmeisteri* occurs in the final sentence of his account of *P. megalantha*, which reads: 'Dr. Garcke of Berlin has very kindly sent to Calcutta authentic specimens of *P. Hoffmeisteri* Klotzsch, which is reduced in the Flora of British India to *P. siphonantha*; they show, as Mr. Maximowicz had already suggested (*Mel. Biol.* x, 82, *footnote* 8), that Klotzsch's species is a form of *P. megalantha* VAR. *typica*.'

Pedicularis megalantha D.Don, Prodr. Fl. Nepal. 94 (1825). – Type: Hab. in Gosaingthan Nepaliae, *Wallich* 411/1 (lecto K, designated by Mill, 2001a: 91).

Accounts of this species have been published by Yamazaki (1988: 157, col. pl. 6c, pl. 26b & fig. 21a) for Nepal, Mill (2001b: 1231–1232) for the area treated by *Flora of*

FIG. 3. *Pedicularis hoffmeisteri*. Photograph of lectotype, the illustration in Klotzsch & Garcke, *Die botanischen Ergebnisse der Reise seiner königl. Hoheit des Prinzen Waldemar von Preussen in den Jahren 1845 und 1846* t. 60 (1862).

Bhutan and by Garg (2009: 126–127) for NW India (only specimens from Sikkim are cited).

Pedicularis megalochila H.L.Li, Taiwania 1: 91 (1948); **P. megalochila** var. **megalochila** f. **megalochila**. – Type: Burma, Adung Valley, 6000–7000 ft, 11 vii 1931, *F. Kingdon-Ward* 9220 (holo F, photo seen).

P. megalochila var. **megalochila** f. **rhodantha** P.C.Tsoong, Acta Phytotax. Sin. 3: 279 (Jan. 1955); Bull. Brit. Mus. (Nat. Hist.), Bot. 2: 8 (Nov. 1955). – Type: Bhutan, Me La, 14,000 ft, 6 viii 1933, *Ludlow & Sherriff* 425 (lecto BM, designated by Mill, 2001a: 92; isolecto E).

P. megalochila var. **ligulata** P.C.Tsoong, Acta Phytotax. Sin. 3: 279 (Jan. 1955). – Type: China, SE Xizang, Singo Samba, Lo La Chu near Molo, 28 vi 1936, *Ludlow & Sherriff* 1874 (holo BM; iso E).

A treatment of *Pedicularis megalochila* and all its subsidiary taxa appears in Yang *et al.* (1998: 208). Mill (2001b: 1232–1233) treated *Pedicularis megalochila* f. *rhodantha* for *Flora of Bhutan*.

Pedicularis pauciflora (Prain) Pennell, Monogr. Acad. Nat. Sci. Philadelphia 5: 149 (1943). – *Pedicularis megalantha* D.Don var. *pauciflora* Prain ex Maxim., Bull. Acad. Sci. Saint-Pétersbourg 32: col. 532 (1888). – Type: India, Sikkim, Bhoktan near Jongri, vii 1887, *King's collector* s.n. [lecto CAL 327668, designated here, n.v. but colour illustration in Garg, Taiwania 54: 131, fig. 7 (2009), seen].

Pedicularis megalochila subsp. *longituba* T.Yamaz., J. Jap. Bot. 55: 294 (1980). – Type: Nepal, Thudam–Lamni Nama, 3500–4000 m, 14 viii 1977, *Ohashi, Kanai, Ohba & Tateishi* 770760 (holo TI n.v. but illustrated in Yamazaki, Revis. Pedic. Nepal pl. 26d, 1988).

A full account of this species was published by Yamazaki (1988: 158, pl. 26d & fig. 21d) for Nepal, synonymising his earlier *Pedicularis megalochila* subsp. *longituba*. Mill (2001b: 1233–1234) treated the species for the *Flora of Bhutan* area.

Pedicularis woodii R.R.Mill, Edinburgh J. Bot. 58: 82 (2001). – Type: Bhutan, Thimphu District, Dongshola, 4400 m, 19 viii 1990, *J.R.I. Wood* 7316 (holo E).

As well as the protologue cited above a treatment of this species appeared in Mill (2001b: 1234).

Acknowledgements

I am grateful to M. Amano for sending me a copy of his 1999 cytology paper and to T. Husain for sending copies of two papers on *Pedicularis bicornuta*. Wang Hong (Kunming Institute of Botany) greatly increased my knowledge of Chinese *Pedicularis* while she was on an extended study visit to the Royal Botanic Garden

Edinburgh in 2001/02 and which resulted in two publications. I am grateful to Patrick Kuss and an anonymous reviewer for their constructive reviews that have helped to improve the paper. Patrick Kuss (Bern) and Rick Ree (Harvard University) are also warmly thanked for making available their unpublished draft large phylogenetic trees of *Pedicularis*. The Royal Botanic Garden Edinburgh is supported by the Scottish Government's Rural and Environment Research and Analysis Directorate.

REFERENCES

AMAN, N., NAQSHI, A. R. & DAR, G. H. (2002). Pollen morphology of some species of *Scrophulariaceae*. *J. Indian Bot. Soc.* 81: 217–225.

AMANO, M. (1999). Cytotaxonomical study of *Pedicularis* (Spermatophyta; Scrophulariaceae) in Annapurna Himal, Nepal. *Natural History Research (Chiba)* 5(2): 73–78.

ASWAL, B. S. & MEHROTRA, B. N. (1994). *Pedicularis*. In: *Flora of Lahaul-Spiti (A cold desert in North West Himalaya)*, pp. 473–484. Dehra Dun: Bishen Singh Mahendra Pal Singh.

BENTHAM, G. (1835). *Scrophularineae indicae. A synopsis of the East Indian Scrophularineae contained in the collections presented by the East India Company to the Linnean Society of London, and in those of Mr. Royle and others; with some general observations on the affinities and sub-divisions of the order*. London: James Ridgway & Sons.

BENTHAM, G. (1846). *Pedicularis* L. In: DE CANDOLLE, A., *Prodromus Systematis Naturalis Regni Vegetabilis*, vol. 10, pp. 560–582. Paris: Treuttel & Wurtz.

BONATI, G. (1910). Contribution à l'étude du genre *Pedicularis*. *Mém. Soc. Bot. France* 18: 1–35.

BONATI, G. (1921). New species of the genera *Phtheirospermum* and *Pedicularis*. *Notes Roy. Bot. Gard. Edinburgh* 13: 103–141.

BUNGE, A. VON (1841). Ueber eine neue Art der Gattung *Pedicularis*. *Bull. Sci. Acad. Imp. Sci. Saint-Pétersbourg* 8(184): 241–253.

BUNGE, A. VON (1843). Ueber *Pedicularis comosa* L. und die mit ihr verwandten Arten. *Bull. Cl. Phys.-Math. Acad. Imp. Sci. Saint-Pétersbourg* 1: 369–384.

BUNGE, A. VON (1849). *Pedicularis*. In: LEDEBOUR, C. F., *Flora Rossica, sive Enumeratio plantarum in totius imperii rossici provinciis europaeis, asiaticis et americanis hucusque observatarum*, vol. 3, pp. 268–303. Stuttgart: E. Schweizerbart.

DON, D. (1825). *Prodromus Florae Nepalensis*. Londini: J. Gale.

FISCHER, E. (2004). *Scrophulariaceae*. In: KUBITZKI, K. (ed.) *The Families and Genera of Vascular Plants*, vol. VII: *Flowering Plants – Dicotyledons, Lamiales (except Acanthaceae including Avicenniaceae)* (ed. J. W. KADEREIT), pp. 333–432. Berlin, Heidelberg & New York: Springer-Verlag.

FRANCHET, A. (1900). Les Scrofulariacées de la Chine, dans l'herbier du Muséum de Paris. *Bull. Soc. Bot. France* 47: 10–37.

GARG, A. (2009). Critical taxonomic appraisal of some taxa of *Pedicularis* from Indian Himalayas belonging to section *Siphonanthae*. *Taiwania* 54(2): 122–133.

GARG, A. & HUSAIN, T. (2003). Strategies adopted by the alpine genus *Pedicularis* L. (*Scrophulariaceae*) to overcome environmental stress. *Current Science* 85: 1413–1414.

HOOKER, J. D. (1884). *Pedicularis*. In: HOOKER, J. D., *Flora of British India*, vol. 4, pp. 306–317. London: L. Reeve & Co.
HURUSAWA, I. (1948). Genus *Pedicularis* Linnaeus (5). *J. Jap. Bot.* 22: 178–184.
HURUSAWA, I. (1949). Genus *Pedicularis* Linnaeus (7). *J. Jap. Bot.* 23: 106–113.
HUSAIN, T. & AGNIHOTRI, P. (2007). Taxonomic notes on *Pedicularis* L. series *Robustae* Prain (Scrophulariaceae). *J. Econ. Taxon. Bot.* 31: 696–700.
HUSAIN, T. & GARG, A. (2002). The sanctity of *Pedicularis bicornuta* Kl. ex Kl. & Garcke in the Indian cold deserts of Lahaul-Spiti. *Current Science* 83(8): 929–930.
HUSAIN, T., GARG, A., AGNIHOTRI, P. & MILL, R. R. (2006). A revision of *Pedicularis* series *Curvipes* (Prain) Hurus. (*Orobanchaceae*). *Edinburgh J. Bot.* 63: 49–65.
KANJILAL, U. N., DAS, A., KANJILAL, D. C. & DE, R. N. (1939). *Flora of Assam*, vol. 3. *Caprifoliaceae to Plantaginaceae*. [Shillong] Government of Assam (printed by Prabash Press, Calcutta).
KLOTZSCH, F. & GARCKE, A. (1862). *Die botanischen Ergebnisse der Reise seiner königl. Hoheit des Prinzen Waldemar von Preussen in den Jahren 1845 und 1846*. Berlin: R. Decker.
LI, H.-L. (1948). A revision of the genus *Pedicularis* in China. Part I. *Proc. Acad. Nat. Sci. Philadelphia* 100: 205–378 and pl. 15–23.
LI, H.-L. (1949). A revision of the genus *Pedicularis* in China. Part II. *Proc. Acad. Nat. Sci. Philadelphia* 101: 1–214 and pl. 1–16.
LIMPRICHT, W. (1924). Studien über die Gattung *Pedicularis*. *Repert. Spec. Nov. Regni Veg.* 20: 161–265.
MACIOR, L. W. & SOOD, S. K. (1991). Pollination ecology of *Pedicularis megalantha* D.Don (*Scrophulariaceae*) in the Himachal Himalaya. *Pl. Spec. Biol.* 6: 75–81.
MACIOR, L. W., YA, TANG & ZHANG, JIANCHEN (2001). Reproductive biology of *Pedicularis* (Scrophulariaceae) in the Sichuan Himalaya. *Pl. Spec. Biol.* 16: 83–89.
MAXIMOWICZ, C. J. (1877). Diagnoses plantarum novarum asiaticarum. II. *Mélanges Biol.* 10: 79–134 (= *Bull. Acad. Imp. Sci. Saint-Pétersbourg* 24: 26–88).
MAXIMOWICZ, C. J. (1888a). Diagnoses des plantes nouvelles asiatiques. VII. *Bull. Acad. Imp. Sci. Saint-Pétersbourg* 32: cols. 477–629. (*Pedicularis* L., Synopsis generis nova, cols. 516–620.) (Reprinted as Maximowicz, 1888b).
MAXIMOWICZ, C. J. (1888b). Diagnoses des plantes nouvelles asiatiques. VII. *Mél. Biol. Acad. Sci. Saint-Pétersbourg* 12: 713–934. (*Pedicularis* L., Synopsis generis nova, pp. 769–919, pl. 1–7). (Reprint of Maximowicz, 1888a.)
MCNEILL, J., BARRIE, F. R., BURDET, H. M., DEMOULIN, V., HAWKSWORTH, D. L., MARHOLD, K. *et al.* (eds) (2006). *International Code of Botanical Nomenclature (Vienna Code) adopted by the Seventeenth International Botanical Congress, Vienna, Austria, July 2005*. Ruggell: A. R. G. Gantner Verlag KG [Regnum Veg. vol. 146].
MILL, R. R. (2001a). Notes relating to the flora of Bhutan: XLIII. *Scrophulariaceae* (*Pedicularis*). *Edinburgh J. Bot.* 58: 57–98.
MILL, R. R. (2001b). *Pedicularis*. In: GRIERSON, A. J. C. & LONG, D. G. (eds) *Flora of Bhutan* 2(3): 1156–1234.
MILL, R. R. (2010). New taxa and lectotypifications of *Pedicularis* (Orobanchaceae) required for the *Flora of Pakistan*. *Edinburgh J. Bot.* 67: 185–187.
MILL, R. R. (2011). Revision of *Pedicularis* series *Tenuirostres* (Orobanchaceae). *Edinburgh J. Bot.* 68: 61–109.
PENNELL, F. W. (1943). *Scrophulariaceae* of the Western Himalayas. *Monogr. Acad. Nat. Sci. Philadelphia* 43. (*Pedicularis*, pp. 113–157.)
PRAIN, D. (1890). The species of *Pedicularis* of the Indian Empire and its frontiers. *Ann. Bot. Gard. Calcutta* 3: 1–196, t. 1–37.

PRESS, J. R., SHRESTHA, K. K. & SUTTON, D. A. (2002). *Annotated Checklist of the Flowering Plants of Nepal*. London: The Natural History Museum, and Kathmandu: Tribhuvan University.

REE, R. H. (2005). Phylogeny and the evolution of floral diversity in *Pedicularis* (*Orobanchaceae*). *Int. J. Pl. Sci.* 166: 595–613.

SAGGOO, M. I. S. & SRIVASTAVA, D. K. (2009). Meiotic studies in some species of *Pedicularis* L. from cold desert regions of Himachal Pradesh, India (North-West Himalaya). *Chromosome Bot.* 4: 83–86.

SEALY, J. R. (1939). *Pedicularis megalantha* var. *hoffmeisteri*. *Bot. Mag*. 162: t. 9570.

TAYLOR, M. & TAYLOR, H. (1998). New flowers in the N. W. Himalaya. *The Rock Garden* 25: 375–385.

TSOONG, P. C. (1955a ['1954']). Genus *Pedicularis* in Ludlow-Sherriff and Polunion [sic] collections. *Acta Phytotax. Sin.* 3: 273–333. (Published Jan. 1955; names take precedence over those in Tsoong, 1955b.)

TSOONG, P. C. (1955b). New Himalayan species of *Pedicularis* with special reference to those from the eastern Himalaya. *Bull. Brit. Mus. (Nat. Hist.), Bot.* 2(1): 3–34. (Published Nov. 1955.)

TSOONG, P. C. (1956a). A new system for the genus *Pedicularis*. *Acta Phytotax. Sin.* 5: 19–74.

TSOONG, P. C. (1956b). A new system for the genus *Pedicularis*. *Acta Phytotax. Sin.* 5: 205–278.

TSOONG, P. C. (1963). *Flora Reipublicae Popularis Sinicae. Tomus LXVIII. Angiospermae Dicotyledonae. Scrophulariaceae (Pars II)*. Beijing: Science Press. (*Pedicularis*, pp. 1–378.)

TSOONG, P. C. & CHANG, K. T. (1965a). Palynological study of *Pedicularis* and its relation with the taxonomic systems of the genus, I. *Acta Phytotax. Sin.* 10: 257–281.

TSOONG, P. C. & CHANG, K. T. (1965b). Palynological study of *Pedicularis* and its relation with the taxonomic systems of the genus, II. *Acta Phytotax. Sin.* 10: 357–374.

VASUDEVAN, K. N. (1975). Contribution to the cytotaxonomy and cytogeography of the flora of the western Himalayas (with an attempt to compare it with the flora of the Alps). Part II. *Ber. Schweiz. Bot. Ges.* 85: 210–252.

VEGTER, I. H. (1988). *Index Herbariorum. Part II(7). Collectors T t/m Z*. Utrecht & Antwerp: Bohn, Scheltema & Holkema; The Hague & Boston: W. Junk.

WANG, H., CAI, J., GU, Z-J. & MILL, R. R. (2004). Karyotype morphology of thirteen species of *Pedicularis* (*Scrophulariaceae*) from the Hengduan Mountains Region, NW Yunnan, China. *Caryologia* 57: 337–347.

WATT, G. (1881). Notes on the vegetation &c. of Chumba State and British Lahoul; with descriptions of new species. *J. Linn. Soc., Bot.* 18: 368–382 and pl. IX–XIV.

WENDELBO, P. (1965). The genus *Pedicularis* in Afghanistan with notes on the floral morphology of *P. bicornuta*. *Nytt. Mag. Bot.* 12: 123–134.

YAMAZAKI, T. (1980). Three new taxa of *Pedicularis* from Nepal and Tibet. *J. Jap. Bot.* 55: 289–294.

YAMAZAKI, T. (1982). *Pedicularis*. In: HARA, H., CHATER, A. O. & WILLIAMS, L. H. J., *An Enumeration of the Flowering Plants of Nepal*, vol. 3, pp. 119–126. London: Trustees of British Museum (Natural History).

YAMAZAKI, T. (1988). A revision of the genus *Pedicularis* in Nepal. In: OHBA, H. & MALLA, S. B. (eds) *The Himalayan Plants*, vol. 1, pp. 91–161. Tokyo: The University Museum, The University of Tokyo, Bulletin No. 31.

YANG, HAN-BI (1994). Two new species of *Pedicularis* L. from Yunnan. *Acta Bot. Yunnan.* 6: 277–279.

YANG, HAN-BI, HOLMGREN, N. H. & MILL, R. R. (1998). *Pedicularis*. In: WU, ZHENG-YI & RAVEN, P. H. (eds) *Flora of China*, vol. 18, pp. 97–209. Beijing: Science Press, and St Louis: Missouri Botanical Garden.
ZAKHARJEVA, O. I. (1993). In: TAKHTAJAN, A. (ed.) *Numeri chromosomatum Magnoliophytorum florae URSS, Moraceae–Zygophyllaceae*. Nauka, Petropoli.

Received 16 December 2009; accepted for publication 12 November 2010