# A TAXONOMIC REVISION OF *GAULTHERIA* SERIES *TRICHOPHYLLAE* (ERICACEAE)

Peter W. Fritsch

*Botanical Research Institute of Texas*
*1700 University Drive*
*Fort Worth, Texas 76107-3400, U.S.A.*

Lu Lu

*School of Pharmaceutical Sciences and*
*Yunnan Key Laboratory of Pharmacology for Natural Products*
*Kunming Medical University*
*CN-650500 Kunming, Yunnan, P.R. CHINA*
*lulukmu@163.com (author for correspondence)*

ABSTRACT

The last taxonomic revision of *Gaultheria* series *Trichophyllae* (Ericaceae), a clade of high-elevation species endemic to the Himalaya-Hengduan Shan region of east-central Asia, was published in 1941. Since then, a number of new species have been described and other taxonomic changes have occurred in the group, prompting the need for a comprehensive revision. The present treatment of the series comprises 21 species, including **Gaultheria ×biluoensis**, a newly described hybrid between *G. crassifolia* and *G. major*. A key to species and species descriptions is provided, and lectotypes are newly designated for *G. cardiosepala*, *G. gonggashanensis*, *G. marronina*, and *G. stenophylla*.

**摘要**

杜鹃花科白珠树属刺毛叶系（小叶类群）是一个特有单系群，分布于东亚至中亚的喜马拉雅-横断山脉的高海拔地区，其最近的分类学修订发表于1941年。在此之后，学者们在该类群中相继发现了若干新物种，并进行了一些物种的分类学处理，亟待进行更全面的分类学修订。本文确定了该系包括21个种，其中一个新描述的杂交种碧罗白珠（**Gaultheria ×biluoensis**），是厚叶白珠和大叶华白珠的杂交产物。本文也提供了物种水平上的分类检索表及物种描述，并为苍山白珠、贡嘎山白珠、绛蒴白珠、狭叶白珠指定了模式标本。

KEY WORDS: *Gaultheria*, Ericaceae, Hengduan Shan, Himalaya, taxonomy

## INTRODUCTION

*Gaultheria* Kalm ex L. ser. *Trichophyllae* Airy Shaw (Ericaceae: Vaccinioideae: Gaultherieae) is a clade of diminutive evergreen shrubs endemic to the Himalaya-Hengduan Mountains of east-central Asia (Lu et al. 2010; Fritsch et al. 2011; Zhang et al. 2017). The most recent global classification of *Gaultheria* based on morphology places the group in *Gaultheria* sect. *Chiogenopsis* D.J. Middleton (Middleton 1991a). Molecular phylogenetic studies place it as most closely related to members of Middleton's *Gaultheria* ser. *Leucothoides* (Airy Shaw) D.J. Middleton p.p., as part of a "core East Asian" clade thought to be of allopolyploid origin (Lu et al. 2019). As in most members of *Gaultheria*, the species of *Gaultheria* ser. *Trichophyllae* possess a capsule surrounded by an expanded and fleshy calyx, and most or all express a wintergreen odor (methyl salicylate) produced on crushing the plant organs and detectable as a sweet odor or taste upon damage to various organs, typically rhizomes, stems, leaves, or fruits. The group is characterized within *Gaultheria* by the combination of plants < 30 cm tall, leaves generally < 15 mm long, solitary axillary flowers, paired apical bracteoles, and five calyx and corolla lobes. It also consistently has leaves with pinnate venation and (typically) serrulate margins (rarely entire), flowers with glabrous corollas, anther filaments, and gynoecia, anthers without disintegration tissue and with two awns per anther theca (often reduced to one or none), and a fruiting calyx with a blue to violet (occasionally white) outer wall.

The most recent global taxonomic treatment of *Gaultheria* ser. *Trichophyllae* (Airy Shaw 1941) recognized seven species and several vaguely defined varieties. Subsequent taxonomic progress was made through the discovery of new species and other additions, as well as the publication of treatments focusing on regional floras (e.g., Xu 1981; Rae 1991; Fang & Stevens 2005; Fritsch et al. 2008). Beginning in ca. 2006, we began a series of intensive field and laboratory studies with collaborators and students on the systematics and evolution of *Gaultheria*, particularly *Gaultheria* ser. *Trichophyllae*. Numerous collections, field observations, and photographs were made from these expeditions, resulting in new species discoveries, the elevation of several

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varieties to species, and the recircumscription of poorly defined species (Fritsch et al. 2015a,b, 2016, 2017; Zhang et al. 2017). Here we provide a culminating publication that integrates the results of these studies with prior taxonomic knowledge to create a revised species classification of the series. The treatment includes a species key, descriptions and synonymy of all 21 species recognized, including one new putative natural hybrid, illustrations and in situ photographs of species for which there has been no prior published documentation, lectotypifications of several names, and lists of specimens examined. We also note particular taxonomic problems for which additional data and further study will be required for resolution.

## MORPHOLOGY AND TAXONOMIC CHARACTERS

### Habit, Rhizomes, and Stems

The plants are diminutive shrubs, generally < 30 cm long or tall and prostrate to ascending-erect. They are often mat-forming, commonly growing among mosses and other alpine plants of low stature and in soils with high organic content such as humus or loam. The rhizomes creep in the soil among mosses and/or small vascular plants, and can either continue above the vegetation and thus constitute aerial stems that hold the leaves and reproductive parts, or produce more upright stems from the rhizomes. The rhizomes are white when young and brown or black at maturity; young aerial stems are green but often flushed red; older stems are brown to black.

Stem pubescence may consist of short, stiff, white or translucent unicellular trichomes, or coarse multicellular setose trichomes (setae), or both. In most species the setae on stems are hooked at a sharp more or less right angle near their bases (uncinate); in some species, the hook is weak or absent. Above this hook the setae may be appressed to erect relative to the stem surface, and can be straight, curved, or undulate. Like all other setae on the plants, the stem setae are reddish, reddish brown, or light brown when young, and often turn reddish black, gray, or black when older. In *Gaultheria trichophylla*, at least a few of the setae are clustered directly below the petiole and are often nearly appressed. This can help distinguish the species from others in which the setae are generally not clustered, do not occur near the base of the petiole, and are more erect.

### Leaves

The leaves are always alternate, simple, and petiolate, and nearly always possess some marginal serrations (rarely entire). The petioles are marginate, and generally U-shaped in cross section. They may be glabrous or bear setae abaxially or marginally, and/or white or translucent, short, stiff trichomes adaxially. The leaf blades are typically ≤ 15 mm long (cited erroneously as leaves < 10 mm long in some publications, e.g., Fritsch et al. 2017) except in *Gaultheria jingdongensis*, *G. major*, and *G. stenophylla*, whose longest leaf blades can be 22, 18, and 17 mm long, respectively. The width of the leaf blades ranges from 1.0 to 7.2 mm except in *G. jingdongensis*, which can reach 11 mm. A character that appears to be correlated with phylogeny is the presence or absence of setae on, or both on and near, the midvein abaxially (Zhang et al. 2017). For species in which such setae are present, the setae can be found on at least some leaves of an individual, although they are often absent on many or even most of the leaves. In some species (i.e., *G. crassifolia*, *G. eciliata*, *G. sinensis*, and *G. trichophylla*), most individuals among all collections have at least some leaves with these abaxial setae, but in other individuals (and possibly in the populations from which they were collected) the leaves are entirely without setae. Specimens require careful examination for the presence or consistent absence of this character. At least some of the leaf blades in individuals have at least a few white or translucent short and stiff trichomes adaxially along the midvein proximally. As with the abaxial setae, these can be absent on many leaves in an individual. In *G. albiflora* and *G. gonggashanensis*, they are completely absent. The marginal serrations of the leaf blades are each terminated by a single seta and there is a sessile glandular region at the apex of the leaf blade that often forms a short, blunt mucro.

In some species, the setae of the leaf blade margin are distributed along the entire length and in these species setae can often be found on the margin of the petiole as well; the setae thus can be regularly distributed along the leaf edge from the margin of the petiole (at or near its base) to near the apex of the blade. In other

species, the margin of the petiole is entire (i.e., without setae) and yet the leaf blade can have setae throughout. In yet other species, the petiole can be entire and the leaf blade margin can be entire throughout or entire from the base up to a point (the distance to which varies by species) beyond which the margin is setose to near the apex.

**Inflorescence, Flower Buds, and Pedicels**

The inflorescence always consists of a single flower in a leaf axil and appears that way along the entirety of the stem, versus bearing the appearance of a "pseudoraceme" as in other species of *Gaultheria* (see, e.g., Middleton 1991a). The flower buds form in the middle to late summer and typically overwinter with the flowers opening in the early spring even when snow is still on the ground, although occasionally autumn flowering can be observed. In the overwintering stage, the pedicellate flower bud is enclosed by a pair of (opposite or nearly so) apical bracteoles that are unfused to partly fused at the base, with one of them larger than and partially covering the other. The bracteoles at this stage of development can be keeled to rounded. The pedicels can be white-puberulent and/or setose abaxially and remain nearly the same length between the overwintering phase and the flowering phase, but tend to elongate slightly between flowering and fruiting. The green to strongly flushed red bracteoles are persistent, generally ovate or subrotund, and cucullate.

**Flowers: Receptacle and Calyx**

Flowers range from ca. 2.5–8.0 mm long and are always pedicellate, without a floral bract but with one pair of apical bracteoles (see above). The ovary is superior, but with a somewhat thick receptacle that is about half the length of and continuous with the calyx. Because the calyx lobes hide the junction of the receptacle and corolla in pressed intact flowers, the calyx is here described and measured as including the receptacle and lobes (as was done by Sleumer 1966–1967). The calyx lobes and corolla begin at the same point along the floral axis, and so the calyx lobes overlap and partially cover the proximal portion of the corolla in pressed intact flowers. The number of calyx lobes is always five; the general shape of the calyx lobe apex is described separately from the very tip of the apex, which can be sharp or blunt. The calyx (i.e., including the receptacle) can be green to strongly flushed red, or occasionally bicolored with the base (receptacle) red and the upper portion of the calyx lobes green (e.g., *Gaultheria trichophylla*). The calyx is glabrous except occasionally along the margins of the lobes ("ciliolate") and on the adaxial surface toward the apex. Ciliolate calyces can be used to distinguish *G. ciliisepala*, *G. eciliata*, *G. hypochlora*, *G. jingdongensis*, and *G. stenophylla* from the remaining species. In specimens without flowers or fruits, but with well developed overwintering flower buds, the flower buds can be dissected to reveal the presence or absence of ciliolate calyx lobes. When eciliolate, the calyx lobes can appear either slightly erose or smooth.

**Flowers: Corolla**

Corolla color ranges from white to red or white flushed with red (often in axially oriented lines along the middle of the petals), or rarely greenish, turning brown post-anthesis; corolla shape ranges from strongly urceolate to broadly campanulate. The corolla lobes can be oblong or deltoid and comprise only a short length of the corolla to nearly half the corolla length. The corolla is always glabrous.

**Flowers: Androecium**

The stamens are free from the corolla, included within it, and distinct from each other. The usual number is 10, but can be fewer (8 to 10 in *Gaultheria eciliata*). The filaments are white and basally appressed against the ovary wall; they are dilated more or less medially, glabrous, and minutely and densely papillose. The anthers are always yellow and persistent, and turn brown post-anthesis. Anther disintegration tissue is absent. Anthers (described post-inversion during development; see Stevens et al. 2004) open by ventral-apical pores that narrow ventrally from the apex. We follow Sleumer (1966–1967) in considering the anther thecae to possess either one or two awns, and if 1-awned then the awns are bifid or not (see Hermann & Palser 2000). The awns project apically to laterally from the apex of each anther theca on the dorsal side; the anthers are otherwise smooth and without any other appendages. Usually the number of awns per theca is consistent within a species, but in some species (*G. albiflora*, *G.* ×*biluoensis*, *G. crassifolia*, *G. hypochlora*, and *G. stenophylla*) the

number can be either 1 or 2. In *G. trichophylla*, there is one awn per theca, but occasionally at least some of the awns within a flower are shortly bifurcated in the distal half.

**Gynoecium**

The gynoecium is glabrous. Ten more or less deltoid nectar glands surround the base of the ovary. The ovary is superior, green, depressed-globose, and five-locular with axile placentation. The style is white and is either included within the corolla or more or less flush with the apex. The stigma is truncate and slightly to strongly pink or occasionally whitish.

**Capsule and Fruiting Calyx**

The calyx plus receptacle (here "fruiting calyx") enlarges in fruit, becomes fleshy at maturity, and partly to completely surrounds the capsule; it can be open and thus expose the capsule within, or be completely closed. The color of the outer wall is generally blue or white, ranging from deep metallic blue to sky blue or to light purple; the inner wall is white. Species may consistently comprise plants with the same color fruiting calyx or exhibit polymorphisms among individuals, but in all cases fruiting calyces on the same individual are consistently the same color. Polymorphisms can be white and a shade of blue (*Gaultheria hypochlora*), white with a pale bluish tinge and blue (*G. ciliisepala*, *G. trichophylla*), or white and two shades of blue (*G. stenophylla*). Occasionally species with normally white fruiting calyces can be flushed pink (*G. albiflora*, *G. cardiosepala*, *G. thymifolia*). In *G. trichophylla*, the fruiting calyx can be deep blue, turquoise blue, sky blue, or rarely light purple or white tinged with blue. The shape of the fruiting calyx can generally be either oblate (shorter than wide) or prolate (longer than wide), can be e.g., subglobose, cupuliform, crateriform, or ellipsoid, and in outline can be curved or slightly truncate at the base. Capsules are usually green but in *G. bryoides* and *G. marronina* they are dark maroon. The calyx and capsule may remain on plants long into the autumn with the calyx color intact; if not taken by animals, the calyx shrivels, wrinkles, and turns brown and remains attached to plants along with the capsule. Occasionally fruits with mature seeds occur with a brown calyx that appears never to have expanded (is not wrinkled), but it is unclear whether this is really so, or if it actually shriveled and remained on the plant over the winter without wrinkling. This may be worth further study in the context that other species of *Gaultheria* have a completely dry unexpanded brown calyx and dry capsule. The mature fruiting calyces and fruits of *G. gonggashanensis* and *G. jingdongensis* are yet to be documented.

**Gynodioecy**

Gynodioecy occurs in many species of *Gaultheria* (Middleton 1991b). In *Gaultheria* ser. *Trichophyllae* it is known only in *G. cardiosepala* and *G. thymifolia*. The remainder of the species in the series has been observed to be either exclusively bisexual with hermaphroditic flowers, or uncertain if only a few individuals with flowers are known (and documented as bisexual). In the two species of *Gaultheria* ser. *Trichophyllae* known to exhibit gynodioecy, anthers are completely aborted with just the 10 filaments present, as opposed to other gynodioecious species of *Gaultheria* in which anthers are present but reduced in size or malformed (Middleton 1991b).

**Methyl Salicylate Expression**

The presence of methyl salicylate is confirmed in *Gaultheria* by crushing a plant organ and detecting a wintergreen (sweet and fragrant, menthol-like) odor or taste. We did not sample for this character systematically, but in most populations that we sampled for this character methyl salicylate was detected in some part of the plant. Nonetheless, in some populations no odor was detected, even in the rhizomes. Presence or absence varied within and among populations of the same species, which at least in part may be a function of sampling time during the day or season. The most consistent wintergreen odor is expressed by crushing young rhizomes, which are often fragrant even when the rest of the plant is not.

## ECOLOGY AND CONSERVATION

**Distribution, Elevational Range, and Habitats**

The species of *Gaultheria* ser. *Trichophyllae* occur from northwestern Pakistan (autonomous territory Azad

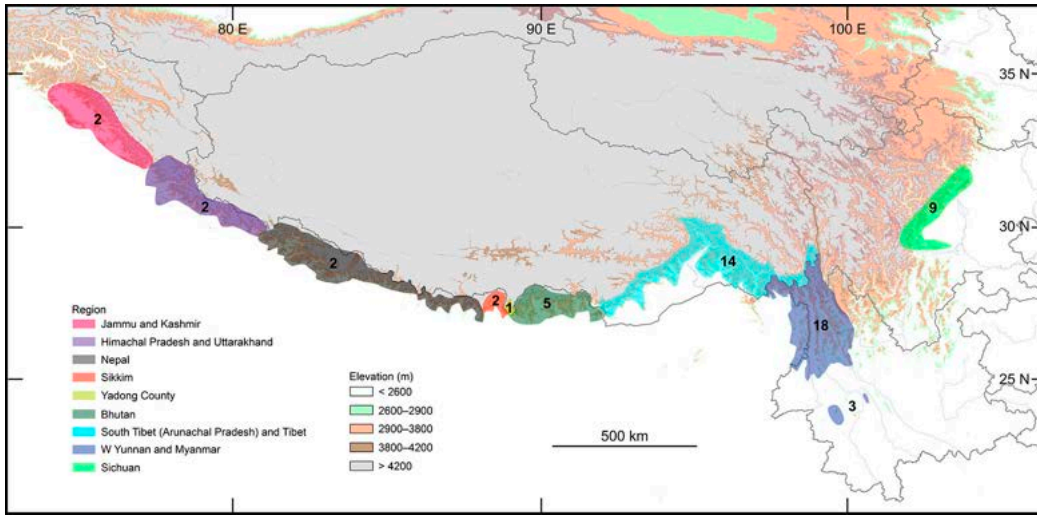


**Fig. 1. Generalized distribution of *Gaultheria* ser. *Trichophyllae*. Numerals indicate the number of species in each delimited area.**

Kashmir) along the southern edge of the Himalaya through India, Nepal and Bhutan, Xizang Province, China, Kachin State in northern Myanmar, to the southern and eastern edges of the Hengduan Shan in Yunnan Province and central Sichuan Province, China (Fig. 1). The ranges in the latter two areas are separated by a large discontinuity extending from northwestern Yunnan to south-central Sichuan. Two areas lie outside of this main range in Yunnan: the Wuliang Shan in Jingdong County, and the mountains of Yingjiang and Yongde counties. All 21 species have at least part of their range in China, with the greatest species concentration in Yunnan, followed by Xizang. Eight species are endemic to China, with three endemic to Sichuan and two to Yunnan. No other country contains endemic species in the series (Table 1).

Based on our examined herbarium material, the elevational range of the species in the series is from 2125 to 4724 m a.s.l. *Gaultheria cardiosepala*, *G. ciliisepala*, *G. dolichopoda*, *G. hypochlora*, *G. jingdongensis*, *G. marronina*, *G. sinensis*, *G. stenophylla*, *G. tetracme*, *G. thymifolia*, and *G. trichophylla* can be found below 3000 m; all the rest have only been found above 3000 m. *Gaultheria albiflora*, *G. cardiosepala*, *G. crassifolia*, *G. eciliata*, *G. hypochlora*, *G. major*, *G. minuta*, *G. obovata*, *G. sinensis*, *G. tetracme*, and *G. trichophylla* can be found above 4000 m. The highest elevation with definitive data recorded is attained by *G. minuta* in the Himalaya at 4724 m a.s.l., whereas the lowest is attained by *G. cardiosepala* in the Wuliang Shan in Yunnan at 2125 m a.s.l. The species with the broadest amplitudes of elevation are *G. cardiosepala*, *G. hypochlora*, and *G. trichophylla*.

The species of the series occur in the same general types of habitats. At the macro scale, habitats include alpine meadows, margins of bamboo thickets and subalpine scrub, coniferous forests at higher elevations, and deciduous and evergreen broadleaved forests at lower elevations. Local habitats include margins of swamps and lakes, banks of streams, wet seepages, and steep moist banks along roads. The species often grow among moss and/or humus; often this moss/humus is on or among rock faces. Less often they grow in rocky or stony soil or on scree slopes. They most typically grow in full sun or partial shade. The species can generally tolerate disturbance such as low-intensity livestock grazing and compaction, and to some extent appear to be pioneer species once sufficient moisture and protection (such as a moss and/or humus layer) is present.

**Species Abundance and Conservation Assessments**

The proposed conservation classification rendered in accordance with IUCN guidelines for the eight species of *Gaultheria* ser. *Trichophyllae* treated in Fritsch et al. (2015b) as Least Concern (LC) can extend to all species of the series except where noted below (IUCN Standards and Petitions Subcommittee 2019). This classification is

Table 1. Number of species and endemics of *Gaultheria* ser. *Trichophyllae* and endemic species by country and primary subdivision.

| Country/primary subdivision | Number of species | Number of endemics |
|---|---|---|
| Bhutan | 5 | 0 |
| China | 21 | 8 |
| Sichuan | 8 | 3 |
| Xizang | 14 | 0 |
| Yunnan | 18 | 2 |
| South Tibet [India, Arunachal Pradesh] | 4 | 0 |
| India | 5 | 0 |
| Himachal Pradesh | 2 | 0 |
| Jammu and Kashmir (union territory) | 2 | 0 |
| Sikkim | 2 | 0 |
| Uttarakhand | 1 | 0 |
| Myanmar (Kachin) | 10 | 0 |
| Nepal | 2 | 0 |
| Pakistan (Azad Kashmir) | 1 | 0 |

based on the relatively high number of individuals in populations, the tolerance of the plants for low to moderate levels of disturbance, and their occurrence in protected areas such as the Gaoligong Shan National Nature Reserve and other habitats that are relatively inaccessible to human activities or unaffected directly by them. The most common and widespread species are *G. cardiosepala*, *G. hypochlora*, *G. major*, *G. sinensis*, *G. stenophylla*, and *G. trichophylla*. Proposed large-scale mining in some areas of occurrence, such as in the largely unprotected Biluo Snow Mountains, could eventually warrant reassessment of this categorization for some of these species.

Several species are narrowly endemic or rarely collected but are under protection in various nature preserves and are relatively inaccessible to human disturbance. The most narrowly endemic species is *Gaultheria jingdongensis*, found only in the Wuliang Mountains; this species is protected within Wuliang Mountain Nature Preserve. *Gaultheria bryoides, G. dolichopoda*, and *G. nivea* are also narrowly endemic or rarely collected, but are protected by Gaoligong Shan Nature Preserve and other reserves. *Gaultheria minuta* is known from only a few collections, but has a widespread distribution from the western Himalaya to northwestern Yunnan. *Gaultheria ×biluoensis* is a nothospecies; it appears to be an $F_1$ hybrid. We classify it as Data Deficient because it is known from only one collection. All species should be monitored for any declines in populations and surveys should be conducted for more populations.

The three species with proposed protected status are all endemic to Sichuan Province, i.e., *Gaultheria gonggashanensis*, *G. marronina*, and *G. tetracme*. They are proposed as Critically Endangered, Endangered, and Endangered, respectively (Fritsch et al. 2015a, 2016, and 2017).

## MATERIALS AND METHODS

Because the leaves of most species can vary substantially in size within current-year innovations, we considered that the best comparisons of leaf measurements for species identification are from the larger examples on individuals, and thus only these are reported except where noted. Setae measurements on stems and leaves are also those of the longer setae, for the same reason. Average leaf internode length was measured with leaves within the current-year innovation. Characters involving color in the descriptions are based on observations in situ unless otherwise indicated. Care was taken to only measure intact setae because these are often broken, especially on older specimens. They are possibly sometimes caducous near the base as well. Habit is taken from in situ observations as supplemented by descriptions on specimen labels. Stems were measured from their point of divergence from the rhizome to the apical meristem.

Flowers are here defined from the base of the calyx to the tip of the corolla lobes. Calyx and corolla lengths and widths are from either in situ observations, dried specimens, or both. For convenience, the receptacle is included as part of the calyx measurements (see above), and thus the calyx is measured from the base

of the receptacle to the tips of the calyx lobes. The anther thecae technically include the awns (Hermann & Palser 2000); here two anther thecae measurements are reported: the length of the "body" of the theca is measured from the base of the anther to the top of the pore, and the length of the awns is measured from their bases (at the top of the pore) to their apices. Fruiting calyx shapes are based on in situ observations. Shrinkage in floral and fruiting organs appears to be negligible upon drying when plants are pressed firmly.

A number of mixed species collections have been made, likely because the species superficially resemble one another and two or more species may grow intermingled in the same apparent "colony." To collectors unfamiliar with the characters that distinguish the species of the group, it is easy to conclude (as we sometimes did when we first began to study these plants) that plants in the same "colony" are all the same species. If a collection is mixed, we cite it in each of the relevant species entries and denote which species are mixed with it and which duplicates have the mixture.

Numbers following herbarium acronyms are specimen barcodes except when preceded by "No.," in which case they are specimen accession numbers. When we have not seen a specimen, we use "n.v." after the herbarium acronym; when we have not seen a specimen physically but have seen a digital image of the specimen, we use "n.v. (online image!)" after the herbarium acronym and/or barcode. All other specimens, including types, have been examined by us. In the lists of additional specimens examined sections, the specimens are ordered by country, then second- and third-level administrative units, then by the last (family) name of the collector (or first collector listed). First- (country), second- (e.g., province), third- (e.g., county) and fourth- (e.g., township) order localities are those that are currently in use and have been either taken directly from the label or inferred from the label information. English is used for all administrative ranks. Chinese characters on labels have been transliterated into Pinyin or translated into English. For simplicity, Chinese third-order administrative levels are referred to as county or city, and fourth-order levels as township, respectively, even though the technical names of the levels can differ (e.g., "autonomous county"). An area where collections of *Gaultheria* ser. *Trichophyllae* specimens have been made has been the subject of a border dispute between China and India. For the purposes of this work, we list these collections as occurring in South Tibet, China and cross-reference them as occurring in Arunachal Pradesh, India.

## TAXONOMIC TREATMENT

**Gaultheria** ser. **Trichophyllae** Airy Shaw, Bull. Misc. Inform. Kew 1940:308. 1941. TYPE: *Gaultheria trichophylla* Royle.

Plants 3–30 cm tall; branchlets with minute unicellular trichomes or coarse multicellular trichomes or both; leaf blades ≤ 15(≤ 22) mm long, secondary veins arising along midvein (sometimes obscure), margins usually serrulate or rarely entire. Inflorescences axillary, 1-flowered, not in a pseudoraceme; perules absent; bract absent; bracteoles 2, paired, positioned apically on pedicel; corolla urceolate or campanulate, 5-lobed, glabrous; stamens usually 10, rarely 8; filaments glabrous, papillose; anther thecae 1- or 2-awned, without disintegration tissue; ovary glabrous; calyx in fruit accrescent, fleshy and white, blue, light lavender, or light purple; fruit capsular, green or maroon.

20 species and 1 nothospecies (described herein), montane regions of the Himalaya-Hengduan Shan: Bhutan, China, India, Myanmar, Nepal, Pakistan; 2125 to 4724 m a.s.l.

### KEY TO THE SPECIES OF *GAULTHERIA* SER. *TRICHOPHYLLAE*

1. Calyx and often bracteoles ciliolate at apex (cilia often visible on fruiting calyx lobes as well).
   2. Stem setae 1.2–2.0 mm long; leaf blades 16–22 mm long, marginal teeth 19 to 25 per side _____ **G. jingdongensis**
   2. Stem setae 0.15–0.80 mm long; leaf blades 3.5–14.0(–17.0) mm long, marginal teeth 3 to 17 per side.
      3. Stem setae 0.15–0.24 mm long; leaf blades 3.5–6.5 × 1.5–2.4 mm, leaf blade marginal setae 3 to 8 per side _____ **G. eciliata**
      3. Stem setae 0.28–0.80 mm long; leaf blades 6.0–17.0 × 2.4–7.2 mm; leaf blade marginal setae 8 to 17 per side.
         4. Longer leaf blades 2.0–3.4 times as long as wide, narrowly elliptic to slightly obovate; fruiting calyx usually ellipsoid or long-cupuliform, occasionally cupuliform _____ **G. stenophylla**
         4. Longer leaf blades 1.7–2.4 times as long as wide, elliptic to obovate; fruiting calyx crateriform, broadly cupuliform, or broadly turbinate.

5. Longer leaf blades elliptic to slightly obovate, 3.1–5.7 mm wide, abaxial setae 1 to ca. 23 situated along or near midvein, midvein thickened abaxially immediately below apical gland; calyx red or green flushed red; fruiting calyx crateriform to broadly cupuliform ____ **G. ciliisepala**
5. Longer leaf blades obovate to broadly obovate, 4.5–7.2 mm wide, abaxial setae 4 to ca. 100 situated along midvein and usually spread across surface often to near margin, midvein usually not thickened or occasionally thickened abaxially immediately below apical gland; calyx green; fruiting calyx broadly turbinate or rarely broadly cupuliform ____ **G. hypochlora**

1. Calyx and bracteoles ciliolate.
6. Fruiting calyx white.
7. Leaf blades 2.0–6.2 mm long; overwintering flower bud pedicels 0.1–0.8 mm long; capsule maroon.
8. Branchlet setae 0.20–0.26 mm long; leaf blades 2.0–3.0 × 1.0–1.6 mm, margin entire or teeth (setae) 1 to 3 per side; fruiting calyx closed ____ **G. bryoides**
8. Branchlet setae 0.34–0.50 mm long; leaf blades 5.1–6.2 × 2.1–3.1 mm, marginal teeth (setae) 3 to 6 per side; fruiting calyx open ____ **G. marronina**
7. Leaf blades 5.5–14.2 mm long; overwintering flower bud pedicels 0.9–2.4 mm long; capsule green (color unknown in *G. thymifolia*).
9. At least some stems with dense white puberulence (usually in addition to setae); leaf blades elliptic; calyx 2.1–3.0 mm long ____ **G. nivea**
9. Stems without puberulence or with sparse white puberulence (in addition to setae); leaf blades oblanceolate, oblong-oblanceolate, or linear-oblanceolate; calyx 3.0–4.0 mm long.
10. Corolla urceolate, lobes 0.5–0.9 × 0.4–0.9 mm; anther body 0.8–1.0 mm long, awns 0.5–0.6 mm long; style 2.5–3.0 mm long; fruiting calyx 8.0–10.5 × 6.5–7.5 mm ____ **G. cardiosepala**
10. Corolla campanulate, lobes 1.0–2.0(–2.5) × 1.1–2.0 mm; anther body 0.4–0.7 mm long, awns 0.2–0.3 mm long; style ca. 1.5 mm long; fruiting calyx 6–8 × 8.0–10.5 mm ____ **G. thymifolia**
6. Fruiting calyx blue.
11. Fruiting calyx closed.
12. Fruiting pedicels 9.2–17 mm long ____ **G. dolichopoda**
12. Fruiting pedicels 0.8–5.0 mm long.
13. Corolla urceolate.
14. Leaf blades oblanceolate, 8.9–12.0 × 4.0–5.7 mm; anther awns 1 per theca; fruiting calyx subglobose, 6–9 × 6–9 mm ____ **G. crassifolia**
14. Leaf blades oblanceolate-elliptic to obovate-elliptic, 10.9–14.3 × 5.0–6.9 mm; anther awns 1 or 2 per theca; fruiting calyx turbinate to broadly cupuliform, 7–14 × 7–12 mm ____ **G. ×biluoensis**
13. Corolla campanulate.
15. Leaf blades 5.0–7.3 mm wide; overwintering flower bud pedicels 2.0–3.0 mm long; fruiting pedicels 2.5–5.0 mm long ____ **G. tetracme**
15. Leaf blades 2.5–4.8 mm wide; overwintering flower bud pedicels 0.6–1.8 mm long; fruiting pedicels 0.8–2.5 mm long ____ **G. trichophylla**[1]
11. Fruiting calyx open.
16. Leaf blade marginal setae 0.08–0.4 mm long.
17. Leaf blades 1.5–2.8 mm wide, adaxially glabrous; overwintering flower buds 1.1–1.9 × 1.1–1.6 mm ____ **G. albiflora**
17. Leaf blades 2.5–6.9 mm wide, adaxially with white puberulence on midvein proximally; overwintering flower buds 1.7–4.1 × 1.5–3.0 mm.
18. Current-year branchlets pale green not flushed red; leaf blade base narrowly cuneate, adaxially glabrous; anther body 0.3–0.6 mm long ____ **G. gonggashanensis**
18. Current-year branchlets pale green strongly flushed red; leaf blade base cuneate to subrounded, with white puberulence on midvein proximally; anther body 0.6–0.8 mm long.
19. Branchlet setae 0.46–0.96 mm long; leaf blades 7.5–18.0 × 2.8–6.9 mm, marginal teeth (setae) 8 to 15 per side, tip with planar apical gland ____ **G. major**[1]
19. Branchlet setae 0.26–0.48 mm long; leaf blades 4.5–10.7 × 2.9–4.9 mm, marginal teeth (setae) 6 to 12 per side, tip of at least some leaves with slightly abaxially directed apical gland ____ **G. sinensis**
16. Leaf blade marginal setae 0.5–1.4 mm long.
20. Awns 1 per anther theca (occasionally bifurcate at some point along distal half) ____ **G. trichophylla**[1]
20. Awns 2 per anther theca.
21. Leaf blades always glabrous abaxially, marginal teeth (setae) 3 to 8 per side; overwintering flower bud pedicels 1.1–1.5 mm long ____ **G. minuta**
21. At least some leaf blades abaxially with one or more setae along midvein, marginal teeth (setae) 8 to 15 per side; overwintering flower bud pedicels 1.7–4.1 mm long.
22. Branchlet setae basally uncinate; leaf blades elliptic or narrowly so to slightly oblanceolate, marginal teeth (setae) 0.34–0.84 mm long; calyx lobes 2.0–2.2 × 2.0–2.6 mm; corolla 5.0–5.2 × ca. 7.0 mm ____ **G. major**[1]
22. Branchlet setae basally ± straight; leaf blades broadly elliptic to slightly obovate, marginal teeth (setae) 0.7–1.3 mm long; calyx lobes 1.2–2.0 × 1.4–2.1 mm; corolla 3.0–4.0 × 3.0–5.3 mm ____ **G. obovata**

**1. Gaultheria albiflora** (T.Z. Hsu) P.W. Fritsch & Lu Lu, Phytotaxa 201(1):2. 2015. Basionym: *Chiogenes suborbicularis* (W.W. Sm.) Ching ex T.Z. Hsu var. *albiflorus* T.Z. Hsu, Acta Bot. Yunnan. 6:41. 1984. Type: CHINA. Yunnan. Gongshan County: Mekong-Salwin divide, Sila, 4000 m, 16 Aug 1938, *T.T. Yü 22351* (holotype: KUN0482916; isotypes: A00115068 n.v. (online image!), E00231175, KUN0482917).

**Stems** prostrate to 5 cm long. Current-year branchlets pale green, strongly flushed red above, to 1.8 cm long, without puberulence, with basally uncinate and more distally appressed to ascending straight or slightly curved setae 0.14–0.30 mm long, setae in cross section above base ± narrowly flattened tangentially to rounded. Internodes averaging ca. 1.0 mm long. **Leaves:** petioles 0.2–0.6 mm long, glabrous, margin entire; blades elliptic or ovate-elliptic, 2.5–5.2 × 1.5–2.8 mm, 1.5–2.4 times as long as wide, subcoriaceous, planar or often cupped, abaxially dull light green except glossy green or occasionally maroon near margin, glabrous, adaxially glossy green, glabrous, midvein abaxially raised, planar, or impressed, not thickened immediately below apical gland, adaxially impressed, secondary veins abaxially obscure, adaxially obscure or 1 to 3 faintly evident on each side of midvein, base cuneate to subrounded, margin serrulate throughout or entire anywhere up to first ca. 30% of length then serrulate distally, planar, apex acute to obtuse, tip with planar apical gland, marginal teeth (setae) 4 to 9 per side, often incurved and lying atop or adjacent to upper leaf surface or occasionally all off surface, 0.08–0.18 mm long. Overwintering flower bud pedicels 0.8–2.5 mm long, glabrous; overwintering flower buds subglobose, 1.1–1.9 × 1.1–1.6 mm, 1.0–1.4 times as long as wide, glabrous, bracteoles rounded, margin eciliolate. **Flowers** 2.5–4.8 mm long. Calyx green or green flushed red proximally with lobes maroon or purple, paler toward apex, 1.5–3.0 mm long; lobes deltoid or ovate-deltoid, 1.2–1.8 × 1.3–2.2 mm, adaxially glabrous, apex acute or obtuse, eciliolate, slightly erose, the very tip blunt. Corolla white, campanulate, 2.4–4.5 × 3.0–4.2 mm; lobes 0.8–1.6 × 1.4–1.9 mm. Stamens 10; filaments 1.0–1.5 mm long; anther body 0.4–0.5 mm long, awns 1 or 2 per theca, 0.12–0.30 mm long. Style 1.0–1.7 mm long; stigma deep pink. Fruiting pedicel 2.2–3.5 mm long. **Fruit:** calyx oblate, crateriform, widely open, 6–8 × 8–11 mm, outer wall sky blue, inner wall white or white flushed with pink; lobes incurved, broadly deltoid, 2.0–3.5 mm long, apex eciliolate. Capsule green, exceeded by calyx lobes. **Seeds** light brown.

***Chinese Name.—***白花白珠 bai hua bai zhu

***Images.—***Fritsch et al. 2008: fig. 14; Fritsch et al. 2015b: fig. 1(D–F).

***Illustrations.—***Fritsch et al. 2008: fig. 13(C–F); Fritsch et al. 2015b: fig. 2.

***Phenology.—***Flowering July–August; fruiting August–September.

***Distribution and Elevation Range.—***Bhutan, China (Sichuan, Xizang, Yunnan); 3500–4500 m.

***Discussion.—****Gaultheria albiflora* can be distinguished from all other species in the series by the combination of leaf blades without white trichomes on the midvein proximally and 2.5–5.2 mm long (versus longer). Only *G. bryoides*, *G. eciliata*, *G. minuta*, and *G. trichophylla* can have leaves that are of the same maximum length as *G. albiflora* or shorter, but these species all have at least a few white trichomes on the midvein of the adaxial leaf surface on at least some leaves. Furthermore, *G. bryoides* has a white mature calyx (versus sky blue), *G. eciliata* has ciliolate calyx margins (versus glabrous), and *G. minuta* and *G. trichophylla* have longer leaf blade marginal setae (0.5–1.4 mm long versus 0.08–0.18 mm long). See also discussion under *G. eciliata* and comments under *G. eciliata* in Fritsch et al. (2015b).

Additional specimens examined. **BHUTAN. Mongar:** Pung La, 3660 m, 9 Jul 1949, *F. Ludlow et al. 20904 p.p.* (BM mixed with the lectotype of *G. eciliata*, photograph of BM at E). **CHINA. Sichuan. Wenchuan County:** Tsao-puh, 14,000 ft, Aug 1942, *S.Y. Hu 2621* (A). **Xizang. Gongbujiangda County:** Nambu La, Kongbo, 14,800 ft, 24 Sep 1947, *F. Ludlow et al. 15775a* (BM). **Motuo County:** Duoxiongla, trail to Lage, 3700 m, 29°29'N, 94°55'E, 24 Jul 2007, *L. Lu LL-07149A* (CAS, KUN). **Zayü County:** Ridong Community, Qimalazha to Xizha, 4300 m, 26 Sep 1982, *Qinghai-Xizang Expedition 10719* (KUN, PE n.v. (online image!)); Chawalong, 17 Jul 2010, *South Tibet Expedition STET-0719* (CAS, KUN). **Yunnan. Deqin County:** Yanmen Township, Biluo Xue Shan, E slope just below Sila Pass, 3936 m, 28°00'8.5"N, 98°47'54.8"E, 24 Sep 2013, *L. Lu LL-2013-50* (CAS, KUN); Mekong-Salwin divide, Sila, 4200 m, *T.T. Yü 22292* (A, E, KUN, PE n.v. (online image!)). **Gongshan County:** Bingzhongluo Township, vicinity of Niwaidanbu, ca. 2.4 direct km SW of Gawagapu Mtn., ca. 1.3 direct km E of Chukuai Lake, and ca. 16.5 direct km WSW of Bingzhongluo, W side of Gaoligong Shan, 3900 m, 27°59'44.8"N, 98°27'43.1"E, 30 Aug 2006, *Gaoligong Shan Biodiversity Survey 31667* (CAS, KUN); Cikai Township, Yipsaka Lake, 2.4 direct km SE of Heipu Pass tunnel on new road from Gongshan to Dulongjiang Valley, E side of Gaoligong Shan, 3500 m, 27°45'14"N, 98°27'33"E, 12 Aug 2006, *Gaoligong Shan Biodiversity Survey 32019 p.p.* (CAS mixed with *G. eciliata*, KUN); Upper Kiukiang Valley, (Clulung) S of Lungtsahmuru, 3900 m, 10 Aug 1938, *T.T. Yü 19877* (A, E, KUN).

**2. Gaultheria ×biluoensis** P.W. Fritsch & Lu Lu, **sp. nov. (Figs. 2A–D, 3)**. TYPE: CHINA. Yunnan. Deqin County: Yanmen Township, Biluo Xue Shan, E slope just below Sila Pass, 3936 m, 28°00'8.5"N, 98°47'54.8"E, 24 Sep 2013, *L. Lu LL-2013-54* (HOLOTYPE: KUN1249228; ISOTYPES: CAS, E, GH, K, KUN1249227).

Haec species *Gaultheriae crassifoliae* (Airy Shaw) P.W. Fritsch & Lu Lu simillima, sed ab eo foliis grandioribus et plus ellipticis, setis in caulibus et foliis grandioribus differt.

**Stems** ascending-erect to 15 cm long. Current-year branchlets pale green, to 2.5 cm long, with sparse white puberulence, with basally uncinate and more distally ascending to nearly appressed straight or slightly curved setae 0.44–0.70 mm long, setae in cross section above base ± narrowly flattened tangentially to rounded. Internodes averaging ca. 1.0–1.4 mm long. **Leaves:** petioles 1.3–1.6 mm long, abaxially glabrous or occasionally with 1 or 2 setae, adaxially with sparse white puberulence, margin often entire but on at least some leaves 1- to 3-toothed (-setose) per side; blades oblanceolate-elliptic to obovate-elliptic, 10.9–14.3 × 5.0–6.9 mm, 2.0–2.4 times as long as wide, coriaceous, planar, abaxially dull whitish green except glossy near margin and at least some leaves with 1 to 10 appressed or ascending setae scattered on midvein (setae 0.34–0.50 mm long), adaxially glossy deep green, glabrous except with white puberulence on midvein proximally, midvein abaxially raised, not thickened immediately below apical gland, secondary veins 1 to 4 faintly evident on each side of midvein or occasionally obscure, adaxially obscure, base cuneate to subrounded, margin serrulate throughout, planar or slightly revolute or occasionally strongly revolute proximally, apex obtuse to rounded, tip with slightly to strongly abaxially directed apical gland, marginal teeth (setae) 10 to 15 per side, all oriented off leaf surface, 0.2–0.3 mm long. Overwintering flower bud pedicels 2.0–3.2 mm long, glabrous; overwintering flower buds slightly compressed laterally to subglobose, 2.5–3.1 × 1.2–1.9 mm, 1.3–2.0 times as long as wide, glabrous, bracteoles rounded to slightly keeled, margin eciliolate. **Flowers:** calyx (observed post-mature in sicco only) ca. 3.2 mm long; lobes deltoid, ca. 1.8 × 1.4 mm, adaxially glabrous, apex acute, eciliolate, the very tip sharp. Corolla (observed post-mature in sicco only) apparently urceolate. Stamens: filaments ca. 1.4 mm long; anther body ca. 0.5 mm long, awns 1 or 2 per theca, ca. 0.2 mm long. Style 1.6–2.5 mm long. Fruiting pedicel 2.5–3.3 mm long. **Fruit:** calyx prolate, turbinate to broadly cupuliform but often abruptly widening ca. 2–3 mm beyond base, closed, 7–14 × 7–12 mm, outer wall dark bluish purple, inner wall light blue; lobes incurved, long-deltoid, 4.0–5.5 mm long, apex eciliolate. Capsule green, exceeded by calyx lobes. **Seeds** deep chestnut brown.

***Chinese Name.—***碧罗白珠 bi luo bai zhu

***Images.—***Fig. 2(A–D).

***Illustration.—***Fig. 3.

***Phenology.—***Flowers at anthesis unknown; fruiting September.

***Etymology.—***The species is named for its only known locality, in the Biluo Xue Shan of western Yunnan Province, China.

***Distribution and Elevation Range.—***China (Yunnan); 3500–3936 m. In addition to the elevation at which the type of the hybrid was collected, we also observed the species growing along the same trail E of Sila Pass at around 3500 m.

***Discussion.—***This putative hybrid was found growing in the general vicinity of both *Gaultheria crassifolia* and *G. major*. The hybrid is similar to *G. crassifolia* in its toothed petiole margin, coriaceous leaf blades, 1 to 10 setae on the leaf blade midvein abaxially, 10 to 15 teeth (setae) on the leaf blade margin per side, anther awns one or two per theca, and a closed fruiting calyx with dark bluish purple outer walls and eciliolate lobes. It can be distinguished from *G. crassifolia* by longer stem setae (0.44–0.70 mm long versus 0.28–0.50 mm), larger leaf blades (10.9–14.3 × 5.0–6.9 mm versus 9.7–11.0 × 4–5 mm), longer leaf blade midvein setae (0.34–0.5 mm long versus 0.26–0.34 mm), longer overwintering flower bud pedicels (2.0–3.2 mm long versus 1.7–2.3 mm), and a turbinate to broadly cupuliform fruiting calyx that often widens ca. 2–3 mm beyond the base (versus a subglobose fruiting calyx without a widened base). The fruiting calyx is also generally larger (7.0–13.5 mm long) than that of *G. crassifolia* (6–9 mm long). The hybrid can easily be distinguished from *G. major* by its

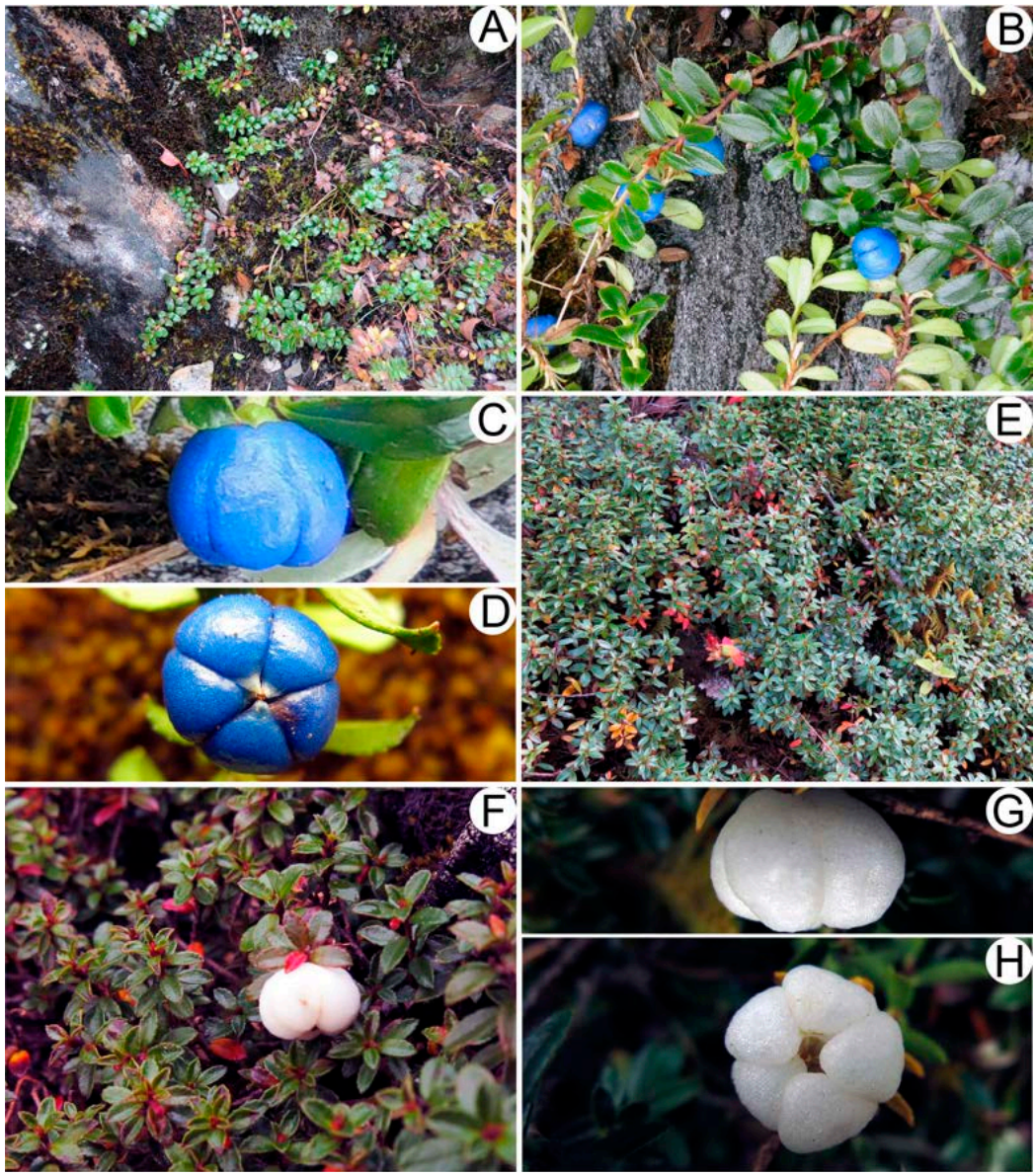


**Fig. 2.** ***Gaultheria* ×*biluoensis* and *G. nivea*. A–D, *G.* ×*biluoensis*. A. Habit. B. Fruiting branchlets arranged to show leaves in abaxial and adaxial view. C. Fruit, lateral view. D. Fruit, apical view. E–H, *G. nivea*. E. Habit. F. Branchlets, one fruiting. G. Fruit, lateral view. H. Fruit, apical view. [Photos, A, B, D by P.W.F; C, E–H by L.L.; A–D, *L. Lu LL-2013-54*; E–H, *L. Lu LL-2013-56*.]**

ascending-erect stems (versus prostrate or prostrate-ascending), anther awns one or two per theca (versus consistently two), and a closed fruiting calyx (versus open).

Phylogenetic analysis based on whole plastid genomes groups a sample of this hybrid with *Gaultheria crassifolia* with strong support, and the genomes of this sample and that of *G. crassifolia* used in the study are identical (Zhang et al. 2017). On this basis, along with intermediacy in morphology (e.g., habit and leaf length) and occurrence in the same area as the two putative parents, we designate *G.* ×*biluoensis* as a nothospecies,

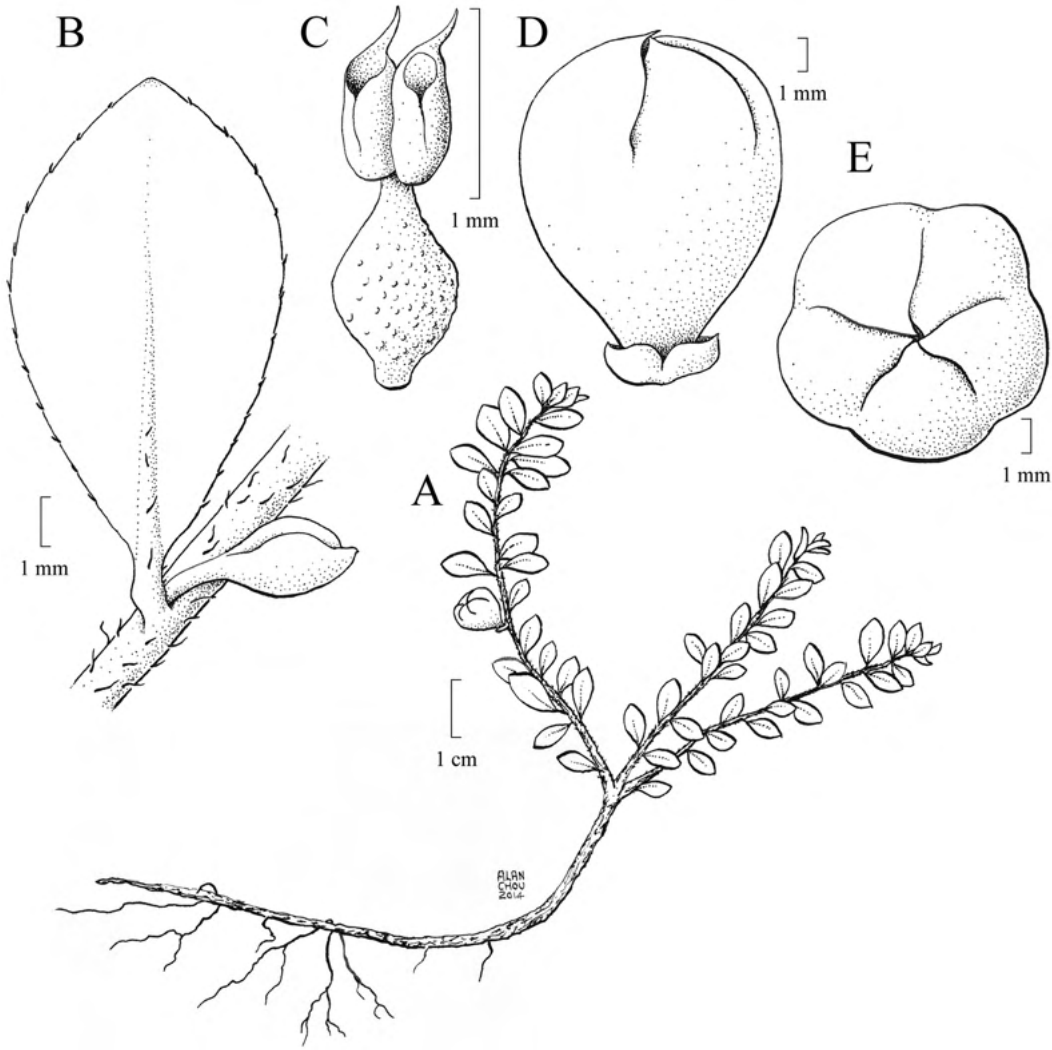


**Fig. 3. *Gaultheria ×biluoensis*. A. Fruiting plant. B. Section of branchlet with leaf in abaxial view, and flower bud. C. Stamen. D. Bracteoles and fruit, lateral view. E. Fruit, apical view. [A–C drawn from the holotype *L. Lu LL-2013-54* (CAS); D, E drawn from the holotype and images of the living plant.]**

with *G. crassifolia* as the putative maternal parent and *G. major* as the putative paternal parent. We name this hybrid with the caveat that hybridization is common in the genus but hybrids are mostly not named.

**3. Gaultheria bryoides** P.W. Fritsch & L.H. Zhou, Proc. Calif. Acad. Sci., ser. 4, 59:154. 2008. Type: MYANMAR. Kachin: [Putao District, Nogmung Township], Nam Tamai Valley [Gaoligong Shan], 1937–1939, *F. Kingdon-Ward 13216a* (holotype: BM).

**Stems** prostrate to 2 cm long. Current-year branchlets pale green, strongly flushed red above, to 0.8 cm long, with sparse to dense white puberulence, with basally uncinate and more distally ascending setae 0.20–0.26 mm long, setae in cross section above base ± narrowly flattened tangentially to rounded. Internodes averaging 0.6–1.0 mm long. **Leaves:** petioles 0.2–0.4 mm long, abaxially glabrous, adaxially glabrous or with very sparse white puberulence, margin entire; blades broadly elliptic, rhombic, or slightly obovate, 2.0–3.0 × 1.0–1.6 mm, 1.4–2.6 times as long as wide, thick-chartaceous to subcoriaceous, planar to cupped, abaxially dull pale green,

glabrous, adaxially glossy green, glabrous or with sparse white puberulence on midvein proximally, midvein abaxially planar or raised, not thickened immediately below apical gland, adaxially planar or impressed or obscure, secondary veins abaxially obscure or 1 to 3 faintly evident on each side of midvein, adaxially obscure, base cuneate to subrounded, margin entire throughout or serrulate anywhere beginning from a point ca. 50% from base to near apex and then entire proximally to base, planar, apex acute, tip with planar or adaxially directed apical gland, marginal teeth (setae) when present 1 to 3 per side, often incurved and lying atop or adjacent to upper leaf surface, 0.04–0.12 mm long. Overwintering flower bud pedicels 0.1–0.2 mm long, glabrous; overwintering flower buds slightly compressed laterally, 0.7–0.9 × 0.5–0.6 mm, 1.4–1.6 times as long as wide, glabrous, bracteoles rounded to slightly keeled, margin eciliolate. **Flowers** 2.5–3.3 mm long. Calyx green, 1.8–2.3 mm long; lobes narrowly deltoid, 1.5–2.0 × 0.8–1.1 mm, adaxially glabrous, apex sharply acute to acuminate, eciliolate, smooth, the very tip sharp. Corolla white, campanulate, 2.7–3.0 × 3.4–4.5 mm; lobes 1.0–1.2 × 1.2–1.5 mm. Stamens 10; filaments 0.7–0.9 mm long; anther body 0.3–0.4 mm long, awns 1 per theca, 0.1–0.2 mm long. Style ca. 1.0–1.5 mm long; stigma pale pink. Fruiting pedicel 0.6–1.2 mm long. **Fruit:** calyx ± globose, closed, 4–6 × 4–6 mm, outer and inner wall white; lobes incurved, narrowly deltoid, 2.5–4.2 mm long, apex eciliolate. Capsule maroon, exceeded by calyx lobes. **Seeds** light tawny brown.

***Chinese Name.—***拟苞藓白珠 ni tai xian bai zhu

***Images.—***Fig. 4.

***Illustration.—***Fritsch et al. 2008: fig. 1.

***Phenology.—***Flowering June; fruiting June, September.

***Distribution and Elevation Range.—***China (Yunnan), Myanmar (Kachin); 3142–3357 m.

***Discussion.—****Gaultheria bryoides* is easily distinguished from all other species of *Gaultheria* ser. *Trichophyllae* by its leaves, being only 2.0–3.0 × 1.0–1.6 mm in size. From phylogenetic analysis based on whole plastid genomes, its closest relative is *G. marronina* (Zhang et al. 2017), with which it shares a white fruiting calyx and maroon capsule. It is distinguished from this species by the characters in the key as well as a geographic range in Yunnan and northern Myanmar, well away from *G. marronina*, which is found only in Sichuan. *Gaultheria bryoides* is known only from a few collections but could well be more widespread when one considers that it is likely overlooked by collectors because of its small size, as well as the relative inaccessibility of the area in which it grows. Prior to 2014, the species was only known from the type and another collection from a mat of plants ca. 0.5 m in diameter along the road from Gongshan town to the Dulongjiang Valley. In 2014, an extensive colony of the species was discovered growing on and among boulders on the road bank along the same road but at lower elevation.

Additional specimens examined. **CHINA. Yunnan. Gongshan County:** Dulongjiang Township, Gaoligong Shan, vicinity of the tunnel at Heipu Pass along road from Gongshan to Dulongjiang, 3357 m, 27°46'30.0"N, 98°26'49.1"E, 15 Sep 2013, *L. Lu LL-2013-19* (CAS, KUN); ibid., 26 Jun 2014, *L. Lu LL-2014-6* (CAS, KUN); ibid., 3142 m, 27°47'32.7"N, 98°27'11.4"E, 29 Jun 2014, *L. Lu LL-2014-24* (CAS, KUN).

**4. Gaultheria cardiosepala** Hand.-Mazz., Anz. Akad. Wiss. Wien, Math.-Naturwiss. Kl. 60:185. 1923. TYPE: CHINA. Yunnan. Dali City: Montis Dji-schan ad bor.-occ. urbis Dali (Talifu), 3350 m, 21 May 1915, *H.F. v. Handel-Mazzetti 6416* (LECTOTYPE, here designated: WU0043084 n.v. (online image!); ISOLECTOTYPES: E00231106, K000227991).

**Stems** decumbent to erect, to 30 cm long. Current-year branchlets green, without or occasionally with sparse white puberulence, with basally uncinate and more distally ascending straight or curved setae 0.24–0.60 mm long, setae in cross section above base ± narrowly flattened tangentially to rounded. Internodes averaging ca. 0.5–2.0 mm long. **Leaves:** petioles 0.4–1.2 mm long, abaxially glabrous, adaxially with white puberulence, margin entire; blades oblanceolate, oblong-oblanceolate, or linear-oblanceolate, 8.2–14.2 × 1.9–3.5 mm, 3–6 times as long as wide, coriaceous, planar, abaxially dull light green to light brown except glossy near margin, glabrous, adaxially ± glossy green to brown, glabrous except with white puberulence on midvein proximally, midvein abaxially raised, not thickened immediately below apical gland, adaxially impressed, secondary veins abaxially obscure or 1 to 3 faintly evident on each side of midvein, adaxially obscure, base cuneate, margin serrulate throughout or entire anywhere up to first 25% of length (rarely to ca. 50%) then serrulate distally, planar or revolute, apex acute to obtuse, tip with planar or slightly abaxially directed apical gland, marginal

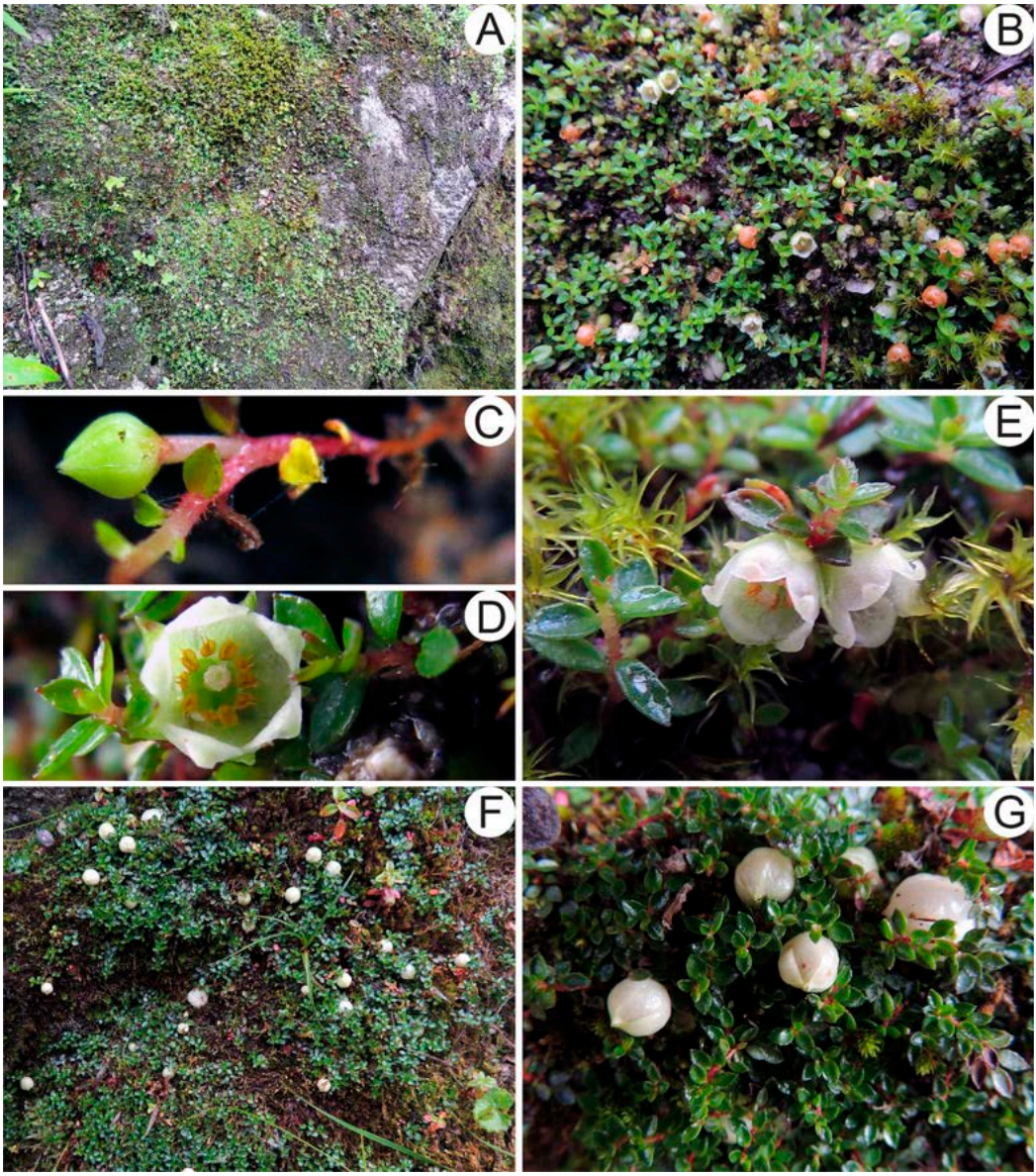


Fig. 4. *Gaultheria bryoides*. **A.** Habit, growing on steep face of boulder. **B.** Flowering plants. **C.** Young branchlet and flower bud. **D.** Flowering branchlet with flower in apical view. **E.** Flowering branchlet in moss. **F, G.** Fruiting plants. [Photos A, B, E–G by P.W.F.; C, D by L.L.; A–E, *L. Lu LL-2014-24*; F, G, *L. Lu LL-2013-19*.]

teeth (setae) (4 to) 6 to 15 per side, all oriented off leaf surface, 0.12–0.30 mm long. Overwintering flower bud pedicels 0.9–2.4 mm long, glabrous; overwintering flower buds compressed laterally, 1.1–2.1 × 0.7–1.4 mm, 1.1–1.9 times as long as wide, glabrous, bracteoles keeled, margin eciliolate. **Flowers** 4.5–5.0 mm long. Calyx white or lobes flushed pale pink to red, 3.0–3.5 mm long; lobes ovate-deltoid to lanceolate-deltoid, 2.5–3.0 × 1.1–2.0 mm, adaxially glabrous, apex acuminate, eciliolate, smooth, the very tip sharp. Corolla white, greenish white, pinkish white, white flushed with pink, or pink, urceolate, 3.5–5.0 × 2.0–4.0 mm; lobes 0.5–0.9 ×

0.4–0.9 mm. Stamens 10; filaments 1.0–1.2 mm long; anther body 0.8–1.0 mm long, awns 2 per theca, 0.4–0.6 mm long or occasionally inner two shorter. Style 2.5–3.0 mm long; stigma green. Fruiting pedicel 2–4 mm long. **Fruit:** calyx slightly prolate, subglobose (slightly truncate at base in outline), closed, 8.0–10.5 × 6.5–7.5 mm, outer wall white or pinkish white, inner wall white; lobes incurved to erect, deltoid, 2.5–5.5 mm long, apex eciliolate. Capsule green, exceeded by calyx lobes. **Seeds** light brown.

***Chinese Name.—***苍山白珠 cang shan bai zhu

***Images.—***Fritsch et al. 2008: fig. 3; Fig. 5.

***Illustrations.—***Xu 1986a: fig. 171(4–8); Fig. 6.

***Phenology.—***Flowering March–June, August; fruiting July–October.

***Distribution and Elevation Range.—***China (Yunnan), Myanmar (Kachin); 2125–4000 m.

***Discussion.—****Gaultheria cardiosepala* is widely distributed in Yunnan and also occurs in Myanmar. It is typically found growing as extensive mats, with the fruits held within the foliage and thus somewhat hidden from view. The species is one of only three with consistently urceolate corollas, along with *G. crassifolia* and *G. dolichopoda*, from which it can easily be distinguished by, e.g., a white fruiting calyx (versus blue or purple). From phylogenetic analysis based on whole plastid genomes, its closest relatives are *G. thymifolia* and *G. nivea* (Zhang et al. 2017), both of which share a white fruiting calyx with *G. cardiosepala* but which have a campanulate corolla.

In addition to the characters in the key, *Gaultheria cardiosepala* can also usually be distinguished from *G. thymifolia* by larger leaf blades (8.2–14.2 × 1.9–3.5 mm versus 6.2–9.4 × 1.3–2.2(–2.5) mm) and the leaf margins serrulate (setose) either throughout or entire anywhere up to the first 25% of length (rarely to ca. 50%) then serrulate distally (versus the margin entire anywhere between the first ca. 30–60% of length then serrulate distally). In *G. Forrest 8931* from Tengchong County, Yunnan, the marginal teeth begin at ca. 50% above the leaf blade base yet the corolla is urceolate, which is diagnostic for *G. cardiosepala*. A sterile specimen from Luyobenzhou Township, *Gaoligong Shan Biodiversity Survey 25749*, also shows this feature but the leaf blade size (up to 11.5 × 2.8 mm) falls within the range for *G. cardiosepala* and outside of the range for *G. thymifolia*.

Two collections were cited in the protologue of *Gaultheria cardiosepala*. We have lectotypified on *H.F. v. Handel-Mazzetti 6416* because the other collection cited, *H.F. v. Handel-Mazzetti 9441*, is *G. thymifolia* (Fritsch et al. 2008). We have lectotypified on the WU specimen of *H.F. v. Handel-Mazzetti 6416* because we have located this specimen on the JStor Global Plants website, and a label with "lectotype" is affixed to that specimen. It is likely that Handel-Mazzetti used this specimen in the description of the species, and specimens from his main herbarium, W, are not known by us to exist.

Additional specimens examined. **CHINA. Yunnan. Precise locality uncertain:** without label *22593* (KUN); no locality, 28 Aug 1938, *Lian Da Expedition 11526 p.p.* (KUN [2] mixed with *G. sinensis*); no locality, *P.Y. Mao 1033* (KUN); no locality, *P.Y. Mao 05696* (KUN [2]); no locality, Yunnan Expedition, *H.T. Tsai 57715* (A, KUN). **Dali City:** E side of Diancang Shan, vicinity of Yinglofeng, ca. 3000 m, 25°42'N, 100°07'E, 8 and 11 Jul 1984, *1984 Sino-Amer. Bot. Exped. 846* (CAS, E, GH, KUN [2]); Tsang (Cang) Shan, Xi Shan ridge W of Huadianba, 3270 m, 18 Oct 1990, *Chungtien-Lijiang-Dali Expedition CLD-90* (E); Tsang Chan, 4 Jun 1883, *J.F. Delavay 301* (MO, P); ibid., 3500 m, 10 Jun 1885, *J.M. Delavay s.n.* (*or 183 or No. 1877*) *p.p.* (A [2], K, P [2], all variously mixed with *G. major* and *G. trichophylla*); ibid., 30 Apr 1889, *J.M. Delavay 4736* (P [2]); ibid., 4 Jul 1882, *E. Drake 301* (P); ibid., Zhonghe Peak, 3450 m, 13 May 1997, *R.C. Fang & Lü Zhengwei s.n.* (KUN0001429 (same collection but different sheet, KUN0002735, is *G. trichophylla*)); E slope of Cang Shan, Yinqiao, Heilongtan, 3400–3600 m, 19 Oct 1980, *K.M. Feng 80-22* (KUN [2], PE n.v. (online image!)); E flank of the Tali Range, 25°40'N, 11,000–12,000 ft, Aug–Sep 1906, *G. Forrest 4188* (A, E); ibid., 12,000 ft, Aug–Sep 1906, *G. Forrest 4190A* (E [2], P); ibid., 10,000–12,000 ft, Jul 1910, *G. Forrest 6784* (E, K); Tali Range, Sep 1929, *G. Forrest 28077* (E, PE n.v. (online image!)); Dsang-schan supra urbem Dali (Talifu), 2850–3600 m, 15 May 1916, *H.F. v. Handel-Mazzetti 8722* (A); Zhonghe Peak of Mt. Cang Shan, 3000–3600 m, 3 Jul 2005, *L. Lu 05-16* (CAS, KUN); E slope of Cang Shan, road to Zhong-He Peak, 25.68407°N, 100.11043°E, 3200 m, 19 Sep 2014, *L. Lu LL-2014-44* (KUN); ibid., 25.69454°N, 100.11095°E, 957 m, 6 Sep 2011, *L. Lu & P.W. Fritsch LL-2011-7* (CAS); ibid., 3200 m, 25.68407°N, 100.11043°E, 6 Sep 2011, *L. Lu & P.W. Fritsch LL-2011-9* (KUN); Zhonghe Peak of Mt. Cang Shan, 3000–3600 m, 10 Jun 2006, *L. Lu & R.-F. Lu 06-0017* (CAS [2]); Cangshan, just above ca. 3200 m, 25°40.799'N, 100°07.232'E, *S. Matuszak & A. Favre 072* (KUN); E side of Cang Shan, near Ximatan, 3 Jun 1929, *R.C. Qin 22863* (KUN, PE [2] n.v. (online images!)); Tsang prope Tali, 2500–3000 m, 16 Oct 1914, *C. Schneider 2797* (A); below Longquan Peak, above Dali, 3550 m, 13 May 1981, *Sino-British Expedition to Cangshan 0512* (A, K); W of Huadianba Farm [Hua Dian Ba, Shui Chang Qin], 2900 m (A specimen) or 3050 m (KUN specimen), 19 May 1981, *Sino-British Expedition to Cangshan 0824* (A, E, K, KUN); Xiaohuadian Ba, 2600 m, 14 May 1984, *Sino-German Exp. 1984, No. 0056* (KUN [2]); Xiaohuadian, 3300 m, 18 May 1984, *Sino-German Exp. 1984, No. 0377* (KUN); Chang Shan, 3200 m, 8 May 1995, *H. Sun*

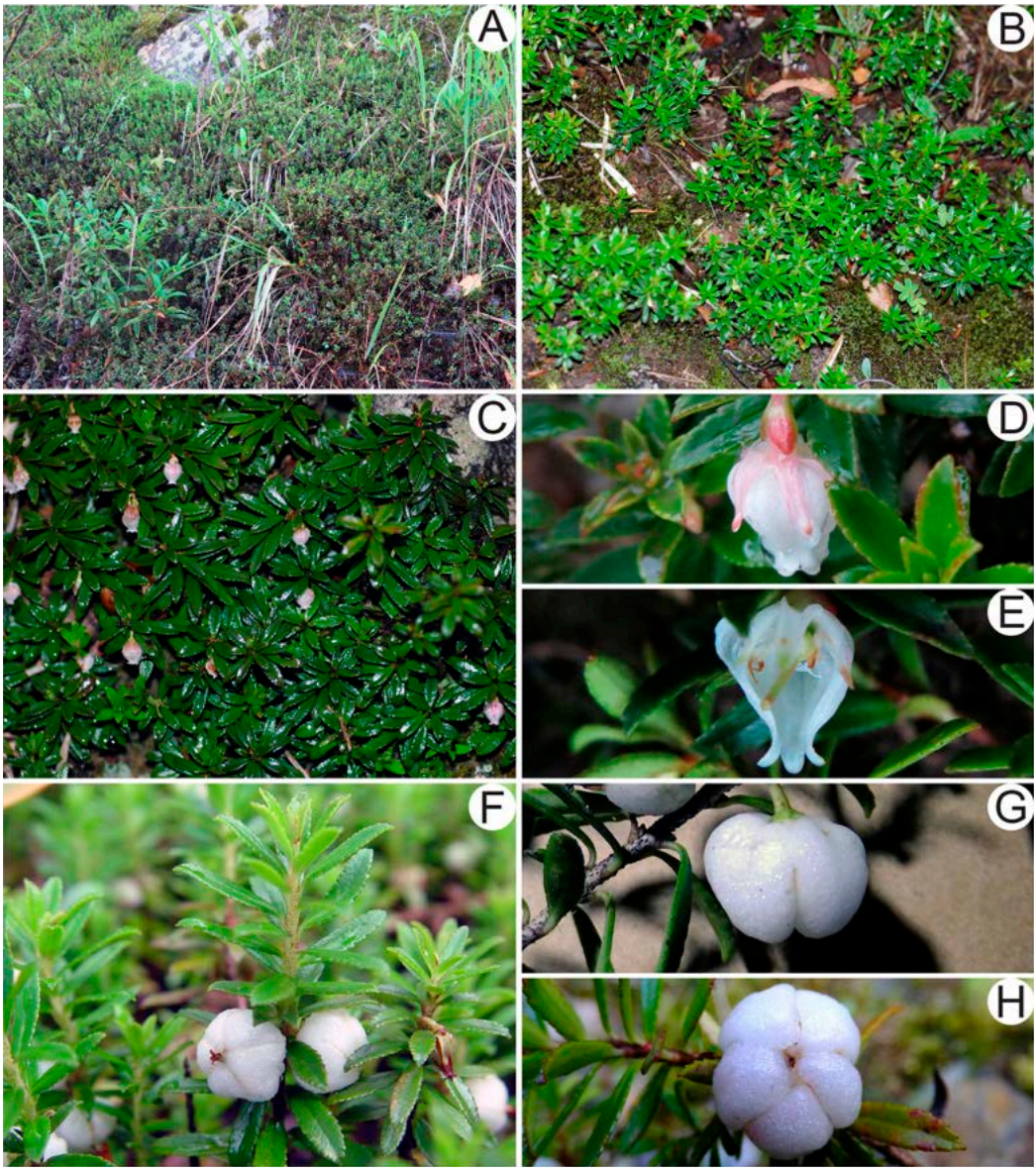


Fig. 5. *Gaultheria cardiosepala*. **A, B.** Habit. **C.** Flowering branchlets. **D.** Bracteoles and flower. **E.** Female plant with corolla cut longitudinally to show filaments without anthers. **F.** Fruiting branchlet. **G.** Fruit, lateral view. **H.** Fruit, apical view. [Photos by L.L.; A, *L. Lu LL-2014-38*; B, F, *L. Lu 05-16*; C, *L. Lu 06-0019*; D, E, *L. Lu LL-2014-44*; G, H, *L. Lu & P.W. Fritsch LL-2011-7*.]

*8015* (KUN); 2800 m, May 1935, *C.W. Wang 63219* (A, PE n.v. (online image!) mixed with *G. trichophylla*); ibid., *C.W. Wang 63235* (A, KUN); from Dali town to television tower, E side of Cang Shan, 2300–3000 m, 14 Apr 2009, *Z.J. Yin & H.J. Dong 0401* (KUN); ibid., 3300 m, 15 Jul 2009, *Z.J. Yin et al. 1357* (PE n.v. (online image!)); W side of Huadianba, E side of Cang Shan, 3050 m, 22 Jul 2009, *Z.J. Yin et al. 1638* (KUN); Cangshan, 3100 m, 9 May 1981, *S.W. Yü* 129 (KUN); ibid., Zhonghe Peak, 3000 m, 2 Aug 1963, *Zhongdian Expedition 63-3811* (KUN [3]). **Fugong County:** Che-tse-lo, 4000 m, 26 Aug 1934, *H.T. Tsai 58197* (A, E, KUN [2], PE n.v. (online image!)). **Jianchuan County:** Chien-chuan-Mekong divide, 26°30'N, 99°40'E, 12,000–13,000 ft, Sep 1922, *G. Forrest 22333* (E, K); Lotueshan, mountains of Labako, W of the Yangtze bend at Shiku, year 1923, *J.F.C. Rock 9517* (A, E). **Jingdong County:** Maotou Shan, 3306 m, Jun 1996, *H. Peng 2577* (KUN);

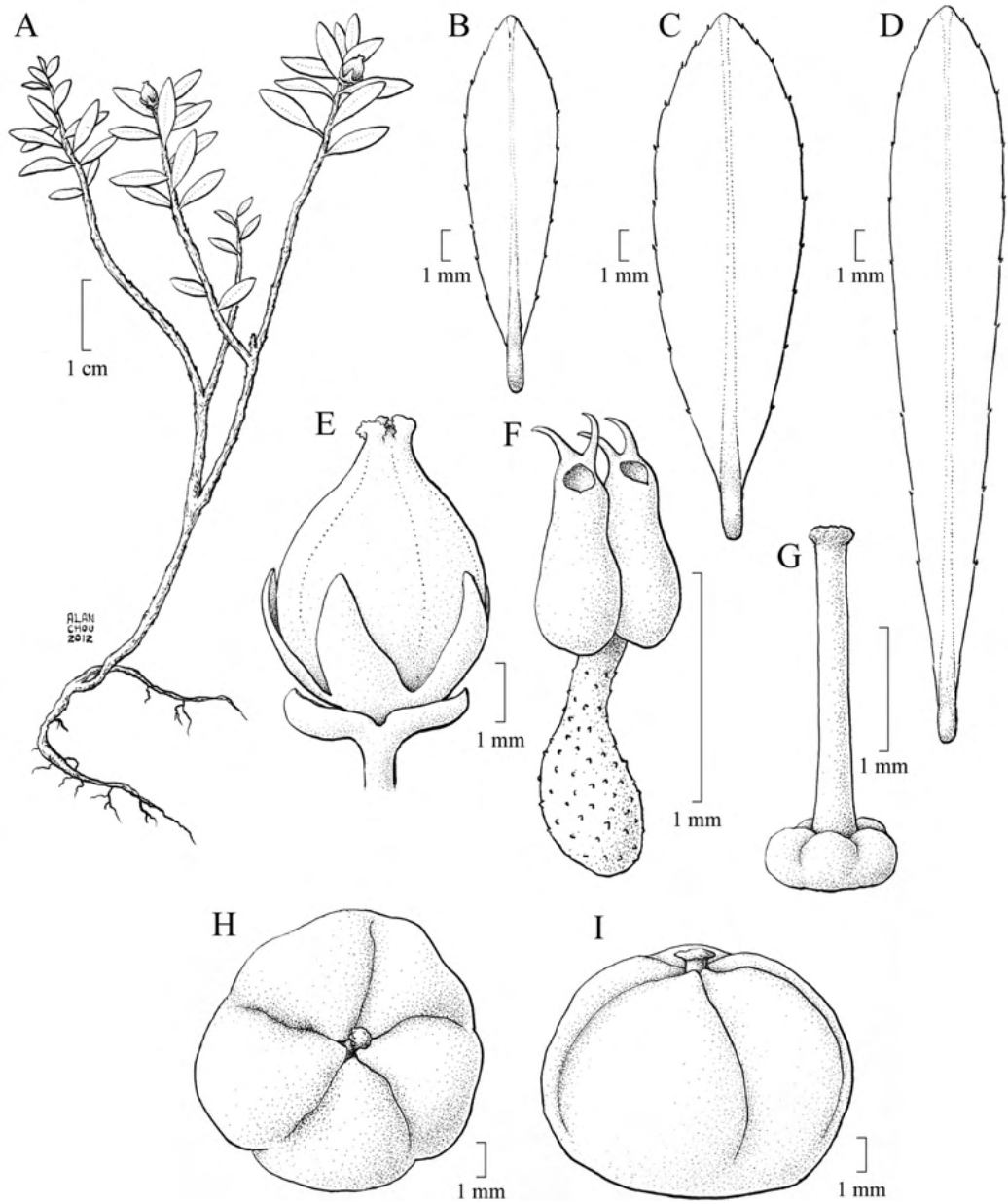


**Fig. 6.** ***Gaultheria cardiosepala*****. A.** Flowering plant. **B–D.** Leaves in abaxial view showing variation. **E.** Flower. **F.** Stamen. **G.** Gynoecium. **H.** Fruit, apical view. **I.** Fruit, lateral view. **[A, C, E–G drawn from** ***R. Farrer 895*** **(E); B drawn from** ***G. Forrest 4190A*** **(E); D drawn from** ***J.F.C. Rock 9517*** **(E); H–I, G drawn from images of the living plant (*L. Lu 05-16*).]**

Ching-Tung, Ta-Tun-Tzu Shan, 3200 m, 1 Nov 1939, *M.K. Li 1033* (KUN, PE n.v. (online image!)); Wuliang Shan, Luoshuidong Village, 3000 m, 17 May 1963, *Q.A. Wu 9235* (KUN); Wuliang Shan, Shui Mo Pang, 2125 m, 8 Apr 1959, *S.G. Xu 4514* (KUN [2]). **Lushui County:** Pianma Township, W slope of Pianma Yakou, Fengxue Yakou, 3000 m, 27 Jul 1978, *Bijiang Expedition 1351* (KUN); Pianma Township, Hpimaw Hill, 10,800 ft, 10 May 1919, *R.J. Farrer 895* (E); Pianma Township, vicinity of Km 58 on road from Lushui to Pianma, W side of Gaoligong Shan, 2810 m, 14 May 2005, *Gaoligong Shan Biodiversity Survey 22922* (BRIT, CAS, GH, KUN); Luyobenzhou Township, E'ga Cun, Km 25 on forest

road, E side of Gaoligong Shan, 2130 m, 8 Aug 2005, *Gaoligong Shan Biodiversity Survey 25749* (BRIT, CAS, GH, KUN); Pianma Township, Hpimaw, 10,000–11,000 ft, 20 Jun 1914, *F. Kingdon-Ward 1691* (E); Pianma Township, Pianma Pass, W side of Gaoligong Shan, 3122 m, 25°58'23.8"N, 98°40'48.2"E, 3 Jul 2014, *L. Lu LL-2014-38* (CAS); Pianma Township, Pianma Yakou, 3300 m, 8 Jun 2006, *L. Lu & R.-F. Lu 06-0022* (CAS, GH, KUN); ibid., 3150 m, 4 Aug 1978, *Nujiang Zhou Investigative Expedition 1853* (KUN); Pianma Township, Hpimaw Pass, above 11,000 ft, 8 Jun 1929, *Sukoe 10080* (K); Pianma Township, Pianma Yakou, Jia Gao Di, 3600 m, 15 Aug 1964, *S.K. Wu 8416* (KUN). **Shangri-La City:** Chungtien [= Zhongdian] area, *G. Forrest 30879* (E, PE n.v. (online image!)); **Tengchong County:** Shweli-Salween divide, 24°40'N, 7000–8000 ft, Mar 1906, *G. Forrest 5003* (A, E); W flank of Shweli-Salwin divide, 25°20'N, 10,000–11,000 ft, Aug 1912, *G. Forrest 8931* (A, E, K); Shweli-Salwin divide, 10,000 ft, Sep 1913, *G. Forrest 12021* (E, PE n.v. (online image!)); Ji Shan, 2900 m, 18 Sep 1929, *R.C. Qin 24716* KUN); Houqiao Township (Guyong Township), Ji Zhao Shan, 3500–3640 m, 25 May 1964, *S.K. Wu 6886* (KUN); Dan Za to Liang Ya Shan, 3700 m, 18 Apr 1980, *L.S. Xie 0886* (KUN). **Yangbi County:** W side of Diancang Shan, vicinity of Baiyunfeng Peak, above Malutang, ca. 3100–3500 m, 25°46'N, 100°01'E, *1984 Sino-Amer. Bot. Exped. 579* (A, CAS, KUN); Gongshe, mountains behind Xiao Ma Lu Tan, 3000–2400 m, 25 May 1963, *Jinsha River Expedition 4058* (KUN [2], PE n.v. (online image!)); mountains of the Yangpi River drainage basin, Aug 1922, *J.F.C. Rock 6272* (E); Dapingdi, above Yangbi, 3000 m, 3 May 1981, *Sino-British Expedition to Cangshan 0072* (A, E, K); Dashichang, above Yangbi, 3400 m, 5 May 1981, *Sino-British Expedition to Cangshan 0241* (A, K); Jiucaipo, above Yangbi, 3450 m, 8 May 1981, *Sino-British Expedition to Cangshan 0347* (A, E, K). **Yongde County:** Daxue Shan, 3450 m, 9 Jul 2002, *E. Liu 5016* (KUN). **MYANMAR. Kachin. Myitkyina District:** Chipwi Township, N'Maikha-Salwin divide, Jun 1931, *G. Forrest 29668* (E, PE n.v. (online image!)).

**5. Gaultheria ciliisepala** Airy Shaw ex P.W. Fritsch & Lu Lu, Phytotaxa 201(1):5. 2015. TYPE: CHINA. Yunnan. Gongshan County: Dulongjiang Township, Sandui, W side of Gaoligong Shan, along Gamolai He on trail from Xishaofang to Bapo, 2570 m, 27°43'00"N, 98°25'20"E, 17 Jul 2002, *H. Li 15033* (HOLOTYPE: KUN; ISOTYPE: CAS1030153).

**Stems** prostrate-ascending to 10 cm long. Current-year branchlets pale green, occasionally flushed red above, to 7(–11) cm long, with sparse to dense white puberulence, with basally uncinate and more distally ascending straight, curved, or often slightly undulate setae 0.40–0.80 mm long, setae in cross section above base ± narrowly flattened tangentially to rounded. Internodes averaging ca. 1.1–3.0 mm. **Leaves:** petioles 0.4–1.0 mm long, abaxially glabrous or with sparse ascending or appressed setae, adaxially with sparse white puberulence, margin often entire but on at least some leaves 1- to 3-toothed (-setose) per side; blades elliptic to slightly obovate, 6.0–11.3 × 3.1–5.7 mm, 1.7–2.4 times as long as wide, subcoriaceous to coriaceous, planar, abaxially dull whitish green except glossy deep green near margin, at least some leaves with 1 to ca. 23 ascending setae scattered on midvein or occasionally also on surface but near midvein (setae 0.26–0.70 mm long), adaxially glossy deep green, glabrous except with white puberulence on midvein proximally, midvein abaxially raised, thickened immediately below apical gland, adaxially impressed, secondary veins abaxially obscure or 2 to 5 on each side of midvein, adaxially obscure, base cuneate to rounded, margin serrulate throughout, revolute, apex obtuse to subrounded, tip with planar or usually abaxially directed apical gland, marginal teeth (setae) 9 to 14 per side, all oriented off leaf surface, 0.10–0.46 mm long. Overwintering flower bud pedicels 0.7–1.5(–2.0) mm long, glabrous or with white puberulence and/or minute setae; overwintering flower buds slightly to strongly compressed laterally, 1.6–2.8 × 1.3–2.1 mm, 1.0–1.8 times as long as wide, glabrous, bracteoles keeled, margin eciliolate or sparsely ciliolate at apex. **Flowers** 3.5–7.5 mm long. Calyx red or green flushed red, 2.3–4.5 mm long; lobes ovate-deltoid, 1.3–2.5 × 1.2–2.5 mm, adaxially with sparse puberulence, apex acute or slightly obtuse, ciliolate, smooth, the very tip blunt. Corolla white, white flushed pink, or pink, narrowly campanulate, 3.5–6.5 × 3.5–8.0 mm; lobes 1.5–3.0 × 1.4–2.7 mm. Stamens 10; filaments 0.8–1.5 mm long; anther body 0.50–0.74 mm long, awns 2 per theca, 0.3–0.7 mm long. Style 1.4–2.5 mm long; stigma pink. Fruiting pedicel 1.8–3.0 mm long. **Fruit:** calyx strongly oblate or occasionally subglobose or slightly prolate, crateriform to broadly cupuliform, widely open, 5–12 × 8–17 mm, outer wall sky blue to deeply so or occasionally white with pale bluish tinge, inner wall white; lobes erect to slightly incurved, broadly deltoid, 2–5 mm long, apex ciliolate. Capsule green, exceeded by calyx lobes. **Seeds** light brown or light tawny brown.

***Chinese Name.—***缘毛萼白珠 yuan mao e bai zhu

***Images.—***Fritsch et al. 2015b: fig. 1(G–K).

***Illustration.—***Fritsch et al. 2015b: fig. 3.

***Phenology.—***Flowering May, June; fruiting June–September.

***Distribution and Elevation Range.—***China (Xizang, Yunnan), Myanmar (Kachin); 2438–3800 m.

***Discussion.—****Gaultheria ciliisepala* is a common species in western Yunnan, and also occurs in Xizang

and Kachin. From phylogenetic analysis based on whole plastid genomes (Zhang et al. 2017), its closest relative is *G. jingdongensis*. The two species share ciliolate calyx margins but occur in allopatry, with *G. jingdongensis* found only in the Wuliang Shan in west-central Yunnan. The only other species of the series with ciliolate calyx lobe margins are *G. eciliata*, *G. hypochlora*, and *G. stenophylla* but these species group in clades away from the clade comprising *G. ciliisepala* and *G. jingdongensis* (Zhang et al. 2017). *Gaultheria ciliisepala* and *G. stenophylla* were confused with *G. hypochlora* and other species of the series until their recognition as new species (Fritsch et al. 2015b). These three species are often found growing together, and can be challenging to distinguish from one another. To supplement the key, we provide a list of the best characters for use in distinguishing these species (Table 2).

See also comments under this species in Fritsch et al. (2015b).

Additional specimens examined. **CHINA. Xizang. Motuo County:** Duoxiongla, trail to Lage, 3600–3800 m, 29°29'N, 94°55'E, 24 Jul 2007, *L. Lu LL-07151* (KUN). **Yunnan. Dali City:** Diancang Shan, vicinity of Huadianba Herbal Medicine Farm, 2900–3300 m, 25°53'N, 100°01'E, 18 Jul 1984, *1984 Sino-American Botanical Expedition No. 1129* (A, CAS, KUN); Cang Shan, Zhonghe Peak, 3000–3700 m, 17 Jul 2010, *L. Lu 06-15* (CAS); ibid., 3200 m, 25.68407°N, 100.11043°W, 6 Sep 2011, *L. Lu & P.W. Fritsch LL-2011-8* (CAS, GH); ibid., 3000–3700 m, 10 Jun 2006, *L. Lu & R.F. Lu 06-0018* (CAS [3]); ibid., 3000–3600 m, 23 May 1984, *Sino-German Expedition 1984 No. 0665* (KUN); from Dali Town to television tower, E side of Cang Shan, 3100 m, 20 Apr 2009, *Z.J. Yin & H.J. Dong 0602* (KUN); ibid., 3800 m, 15 Jul 2009, *Z.J. Yin et al. 1327* (KUN). **Fugong County:** Lishadi Township ["Yaping Township"], between Shibali Logging Station and Yaping Pass, ca. 4.1 km W of Shibali, road from Nujiang [River] to Yaping Pass, E side of Gaoligong Shan, 3007 m, 27°10'33"N, 98°45'22"E, 2 May 2004, *Gaoligong Shan Biodiversity Survey 20140* (CAS, KUN); Lishadi Township ["Yaping Township"], vicinity of Yaping Pass near Myanmar border, E side of Gaoligong Shan, 3620 m, 27°12'45"N, 98°41'45"E, 5 May 2004, *Gaoligong Shan Biodiversity Survey 20969* (CAS, KUN); Lishadi Township ["Yaping Township"], ibid., 3700 m, 27°12'45"N, 98°41'45"E, 5 May 2004, *Gaoligong Shan Biodiversity Survey 20975* (CAS, KUN); Lumadeng Township, Yaping Cun, S side of N fork of Yamu He above Shibali, E side of Gaoligong Shan, 3050 m, 27°10'57"N, 98°43'13"E, 8 Aug 2005, *Gaoligong Shan Biodiversity Survey 26754* (CAS, GH, KUN, NY); Lishadi Township, Yaduo Cun, vicinity of Rimagudi, N side of N fork of Yamu He above Shibali, road to Myanmar border, E side of Gaoligong Shan, 3560 m, 27°12'28"N, 98°42'32"E, 12 Aug 2005, *Gaoligong Shan Biodiversity Survey 27029* (BRIT, CAS, KUN); Lumadeng Township, Yaping Cun, below Amero Pass along road back down to confluence of N and S fork of Yamu He, E side of Gaoligong Shan, 3120 m, 27°04'50"N, 98°44'52"E, 13 Aug 2005, *Gaoligong Shan Biodiversity Survey 27161* (CAS, KUN); Lumadeng Township, Yaping Cun, vicinity of Shibali, S side of N fork of Yamu He, E side of Gaoligong Shan, 2510 m, 27°10'03"N, 98°46'18"E, 16 Aug 2005, *Gaoligong Shan Biodiversity Survey 28501* (CAS, KUN); Dayou to Guadi, 3350 m, 1 Aug 1979, *Q. Lin 79-2037* (KUN [2]); Lishadi Township, Yaduo Cun, N side of N fork of Yamu He above Shibali, road to Myanmar border, E side of Gaoligong Shan, 3519 m, 27°12'40.1"N, 98°42'25.1"E, 2 Jul 2014, *L. Lu LL-2014-31* (CAS, KUN); Lumadeng Township, Ouliudi, W slope of Biluo Xue Shan, 3300 m, 28 May 1982, *Qinghai-Xizang Expedition 6998* (KUN [2], PE [2] n.v. (online images!)). **Gongshan County:** valley above and below Dong Shao Fang Forest Station, 3200 m, 27°42'N, 98°34'E, 21 Sep 1997, *H. Li 9494* (MO); E side of divide above Dong Shao Fang Forest Station on Nan Mo Wang Shan, 3400 m, 27°41'N, 98°27'E, 22 Sep 1997, *H. Li 9570* (MO); Cikai Township, E side of Gaoligong Shan, W of Gongshan, along Pula He, trail from Qiqi to Dongshaofang and Dulongjiang Valley, 2770–3050 m, 27°42'28"N, 98°29'49"E, 15 Jul 2000, *H. Li 12551* (CAS, GH, KUN); ibid., 2900 m, 27°42'54"N, 98°30'08"E, 1 May 2002, *H. Li 14794* (CAS); Dulongjiang Township, Gongshan Pass to Dulongjiang, year 1979, *Q. Lin & X.F. Dong 79-0558* (KUN [2]); Cikai Township, Dongshaofang Pass, Gaoligong Shan, 3100–3200 m, 4 Jun 2006, *L. Lu 06-0001* (CAS, GH, NY [2]); Cikai Township, E slope of Gaoligong Shan, trail between No. 12 bridge and Dong Shao Fang Pass, 2800–3000 m, 4 Jun 2006, *L. Lu 06-0003* (CAS); ibid., 2800–3000 m, 4 Jun 2006, *L. Lu 06-0004* (CAS); Cikai Township, Dongshaofang Pass, Gaoligongshan, 3200–3500 m, 4 Jun 2006, *L. Lu 06-0014 p.p.* (CAS, GH, KUN, all mixed variously with *G. major*, *G. sinensis*, and *G. stenophylla*); ibid., 3100–3200 m, 4 Jun 2006, *L. Lu 06-0015* (CAS, GH, KUN); Cikai Township, Gaoligong Shan, vicinity of tunnel at Heipu Pass along road from Gongshan to Dulongjiang, 3400 m, 27°46'42.4"N, 98°27'29.4"E, 13 Sep 2013, *L. Lu LL-2013-15A* (CAS, KUN); Dulongjiang Township, Gaoligong Shan, vicinity of tunnel at Heipu Pass along road from Gongshan to Dulongjiang, 3357 m, 27°46'30.0"N, 98°26'49.1"E, 15 Sep 2013, *L. Lu LL-2013-20* (CAS, GH, KUN); Cikai Township, Gaoligong Shan, Qiqi River drainage, along trail from No. 12 Bridge to Dong Shao Fang and pass, 3100 m, 27°41'50.3"N, 98°29'18.1"E, 18 Sep 2013, *L. Lu LL-2013-34* (CAS, GH, KUN, PE); Bangdang Township, Biluo Xue Shan, Balagong spur, trail from Dimaluo to Balagong Pass, 3599 m, 27°57'49.8"N, 98°44'26.4"E, 23 Sep 2013, *L. Lu LL-2013-41* (CAS mixed with *G. obovata*); ibid., *L. Lu LL-2013-42* (CAS, GH, KUN [2]); Bangdang Township, Biluo Xue Shan, trail from Siwanongba Valley to Sila Pass, 3569 m, 27°59'40.9"N, 98°46'59.0"E, 24 Sep 2013, *L. Lu LL-2013-48* (CAS, GH, KUN); Dulongjiang Township, vicinity of tunnel at Heipu Pass along road from Gongshan to Dulongjiang, W side of Gaoligong Shan, 3357 m, 27°46'30.0"N, 98°26'49.1"E, 26 Jun 2014, *L. Lu LL-2014-4* (CAS, KUN); Cikai Township, Danzhu Cun, road from Danzhu to Myanmar, along Damawadi He (N branch of W-most origin of Danzhu He), E side of Gaoligong Shan, 2880 m, 27°38'6.5"N, 98°36'25.0"E, 28 Jun 2014, *L. Lu LL-2014-10* (CAS, KUN); Dulongjiang Township, from Gongshan to Dulongjiang, 2700 m, 9 May 1979, *Nujiang Expedition 79-0086* (KUN [2]); Cikai Township, from Jidu Forestry Station to Dongshaofang, 2600 m, 22 Jul 1982, *Qinghai-Xizang Expedition 8345* (PE [2] n.v. (online images!) mixed with *G. stenophylla*). Cikai Township, Hepu [Heipu] Shan, on road to Dulongjiang Village, 3200 m, Jul 2005, *S. Yang Y0010* (CAS). **Lushui County:** Pianma Township, W slope of Pianma Yakou, Fengxue Yakou, 3000 m, 27 Jul 1978, *Bijiang Expedition 1351 p.p.* (KUN0531321 (as *1351 "A"*; mixed with *G. cardiosepala*), KUN0532610); Pianma Pass, 2950 m, 14 Sep 1996, *H. Li (Gaoligong Shan Expedition) 7175* (MO [3]); ibid., 3000 m, 14 Sep 1996, *H. Li (Gaoligong Shan Expedition) 7282* (MO [2]); road from Pian Ma to Liuku, below Pian ma Ya Kou, W slope of Salween/

Table 2. Comparison of morphological features among *Gaultheria ciliisepala, G. hypochlora,* and *G. stenophylla*.

| Character | *G. ciliisepala* | *G. hypochlora* | *G. stenophylla* |
|---|---|---|---|
| Stem orientation | Prostrate-ascending | Ascending-erect | Ascending-erect or pendent |
| Petiole length (mm) | 0.4–1.0 | 1.0–1.2 | 0.4–1.2 |
| Leaf blade length versus width | 1.7–2.4 times as long as wide | 1.8–2.1 times as long as wide | 2.0–3.4 times as long as wide |
| Leaf blade shape | Elliptic to slightly obovate | Obovate to broadly obovate | Narrowly elliptic to slightly oblanceolate |
| Leaf blade trichome number abaxially | 1 to ca. 23 on at least some leaves | 4 to ca. 100 | 1 to 35 on at least some leaves |
| Leaf blade trichome distribution abaxially | Along or near midvein | Along midvein and usually spread across surface | Along or near midvein |
| Leaf blade midvein thickness abaxially at the apex | Thickened | Not thickened or occasionally thickened | Not thickened to slightly thickened |
| Flower length (mm) | 3.5–7.5 | 3.3–5.0 | 5.0–7.0 |
| Calyx color | Red or green flushed red | Green | Green |
| Fruiting calyx shape | Crateriform to broadly cupuliform | Broadly turbinate or broadly cupuliform | Ellipsoid or long-cupuliform, occasionally cupuliform |

Irrawaddy divide, 25°58'55"N, 98°40'14"E, 2920 m [on MO specimen; 3220 m on KUN specimen], 4 October 1997, *H. Li (Gaoligong Shan Expedition) 9980* (KUN, MO); Pianma Township, Pianma Yakou, 3300 m, 8 Jun 2006, *L. Lu 06-0021* (CAS [2], GH [2], MO, NY); ibid., 3122 m, 25°58'23.8"N, 98°40'48.2"E, 3 Jul 2014, *L. Lu LL-2014-39* (CAS, KUN); ibid., 3122 m, 25°58'23.8"N, 98°40'48.2"E, 3 Jul 2014, *L. Lu LL-2014-40* (CAS, KUN); ibid., 3150 m, 4 Aug 1978, *Nujiang Zhou Investigative Expedition 1834* (KUN [2]); vicinity of Wan Zhuanghe, 3100 m, 30 Jun 1964, *S.K. Wu 007333* (KUN [2]). **Yingjiang County:** Daniang Mountain, Zhina Village, trail to No. 7 Boundary Monument, 2749 m, 25°14'22.99N; 97°58'0.02"E, 27 Apr 2017, *T. Zhang et al. s.n.* (KUN). **MYANMAR. Kachin. Myitkyina District:** Hsawlaw Township, Chimili Woods, 10,800 ft, 4 Aug 1919, *R.J. Farrer 1191* (E); Hsawlaw Township, Shing Hong Pass, 10,500 ft, 16 Jun 1920, *R.J. Farrer 1622* (E); Hsawlaw Township, Chawng Maw Kha drainage, ridge above Laktang (Kang-fang route), 8000–11,000 ft, 19 May 1925, *F. Kingdon-Ward 3062* (E).

**6. Gaultheria crassifolia** (Airy Shaw) P.W. Fritsch & Lu Lu, Phytotaxa 201(1):9. 2015. Basionym: *Gaultheria sinensis* J. Anthony var. *crassifolia* Airy Shaw, Bull. Misc. Inform. Kew 1940:326. 1941. Type: CHINA. Xizang. Zayü County: Salwin-Kiu Chiang divide, 28°40'N, 98°15'E, Oct 1919, *G. Forrest 19286* (holotype: K000227996; isotype: E00225813).

**Stems** ascending-erect to 10 cm long. Current-year branchlets pale green, occasionally flushed red, to 3.5 cm long, with sparse white puberulence, with basally uncinate and more distally ascending straight or slightly curved setae 0.28–0.54 mm long, setae in cross section above base ± narrowly flattened tangentially to rounded. Internodes averaging ca. 1.1–1.3 mm. **Leaves:** petioles 0.7–1.5 mm long, abaxially glabrous or with sparse ascending setae, adaxially with sparse white puberulence, margin often entire but on at least some leaves 1- to 3-toothed (-setose) per side; blades oblanceolate, 8.9–12.0 × 4.0–5.7 mm, 1.9–3.0 times as long as wide, coriaceous, planar, abaxially dull whitish green except glossy and occasionally flushed maroon near margin, glabrous or occasionally some leaves with 1 to 9 appressed or ascending setae scattered on midvein (setae 0.26–0.40 mm long), adaxially glossy deep green, glabrous except with white puberulence on midvein proximally, midvein abaxially raised, not thickened immediately below apical gland, adaxially impressed, secondary veins abaxially obscure or occasionally 1 to 3 faintly evident on each side of midvein, adaxially obscure, base cuneate, margin serrulate throughout, planar or slightly revolute, often strongly so proximally, apex obtuse to rounded, tip with strongly abaxially directed apical gland, marginal teeth (setae) 10 to 15 per side, all oriented off leaf surface, 0.14–0.28 mm long. Overwintering flower bud pedicels 1.2–2.3 mm long, glabrous; overwintering flower buds slightly compressed laterally, 1.7–3.4 × 1.3–2.0 mm, 1.2–1.8 times as long as wide, glabrous, bracteoles slightly keeled, margin eciliolate. **Flowers** ca. 5 mm long. Calyx green, 2.7–3.5 mm long; lobes narrowly ovate-deltoid, 1.5–3.2 × 1.0–1.8 mm, adaxially glabrous, apex narrowly acute, eciliolate, smooth, the very tip blunt. Corolla white, urceolate, ca. 4.0 × 2.5 mm; lobes 1.0–1.2 × 0.8–1.0 mm. Stamens 10; filaments 0.9–1.2 mm long; anther body 0.30–0.44 mm long, awns 1 or 2 per theca, 0.33–0.45 mm long. Style 1.4–2.5 mm long; stigma pink. Fruiting pedicel 2.0–3.5 mm long. **Fruit:** calyx subglobose, closed,

6–9 × 6–9 mm, outer wall dark bluish purple, inner wall light blue or bluish purple; lobes incurved, long-deltoid, 3.5–5.0 mm long, apex eciliolate. Capsule green, exceeded by calyx lobes. **Seeds** brown.

***Chinese Name.—***厚叶白珠 hou ye bai zhu

***Images.—***Fritsch et al. 2015b: fig. 1(L–P).

***Illustration.—***Fritsch et al. 2015b: fig. 4.

***Phenology.—***Flowering June, July; fruiting August–October.

***Distribution and Elevation Range.—***China (Xizang, Yunnan) Myanmar (Kachin); 3048–4200 m.

***Discussion.—****Gaultheria crassifolia* is easily distinguished from all other species of the series (excluding its hybrid with *G. major*) by the combination of eciliolate calyx margins, urceolate corollas, a short fruiting pedicel (2.0–3.5 mm long), and blue closed fruiting calyces.

See comments under *Gaultheria* ×*biluoensis* and *G. major*, and those under *G. major* in Fritsch et al. (2015b).

Additional specimens examined. **CHINA. Xizang. Zayü County:** Ri Dong Qu, 4200 m, 8 Sep 1982, *Qinghai-Xizang Expedition 10107* (KUN, PE n.v. (online image!)). **Yunnan. Deqin County:** SE Tibet, Ka-gwr-pu, Mekong-Salwin divide, 12,000 ft, 28°25′N, Jul 1917, *G. Forrest 14216 p.p.* (E mixed with the lectotype of *G. sinensis*); Yanmen Township, Biluo Xue Shan, E slope just below Sila Pass, 3936 m, 28°00'8.5"N, 98°47'54.8"E, 24 Sep 2013, *L. Lu LL-2013-53* (CAS, GH, KUN [2]). **Fugong County:** Lishadi Township, Yaduo Cun, N side of N fork of Yamu He above Shibali, road to Myanmar border, E side of Gaoligong Shan, 3519 m, 27°12'40.1"N, 98°42'25.1"E, 2 Jul 2014, *L. Lu LL-2014-30* (CAS, KUN). **Gongshan County:** Bingzhongluo Township, ca. 3.4 direct km S of Gawagapu Mtn. and ca. 15.8 direct km WSW of Bingzhongluo in next basin E of Chukuai lake, E side of Gaoligong Shan, 3710 m, 27°58'46.2"N, 98°28'25.6"E, 30 Aug 2006, *Gaoligong Shan Biodiversity Survey 31683* (BRIT, CAS, KUN, MO); Cikai Township, Gaoligong Shan, Dongshaofang Pass, 3100–3200 m, 4 Jun 2006, *L. Lu 06-0001A* (CAS); Cikai Township, Gaoligong Shan, vicinity of tunnel at Heipu Pass along road from Gongshan to Dulongjiang, 3400 m, 27°46'42.4"N, 98°27'29.4"E, 13 Sep 2013, *L. Lu LL-2013-13* (CAS, GH, KUN [2]); Cikai Township, Gaoligong Shan, Qiqi River drainage, along trail from No. 12 Bridge to Dong Shao Fang and pass, 3498 m, 27°41'37.6"N, 98°27'38.1"E, 18 Sep 2013, *L. Lu LL-2013-33* (CAS, GH, KUN); Cikai Township, vicinity of tunnel at Heipu Pass along road from Gongshan to Dulongjiang, E side of Gaoligong Shan, 3400 m, 27°46'42.4"N, 98°27'29.4"E, 26 Jun 2014, *L. Lu LL-2014-2* (CAS, KUN); Cikai Township, road from Gongshan to Dulong River, 3800 [3300?] m, 16 Sep 2003, *S.K. Wu et al. 055* (KUN); Dulongjiang Xiang, Salwin-Kiukiang divide, Parolaka, 3500 m, 13 Oct 1938, *T.T. Yü 20683* (A, E, KUN). **MYANMAR. Kachin. Putao District:** Adung Valley, 10,000 ft, 28°20'N, 97°40'E, 29 Jun 1931, *F. Kingdon Ward 9628A* (NY).

**7. Gaultheria dolichopoda** Airy Shaw, Bull. Misc. Inform. Kew 1940:321. 1941. TYPE. CHINA. Xizang: Tsangpo Gorge, near Sechen La, 10,000–11,000 ft, 1 Dec 1924, *F. Kingdon-Ward 6331* (HOLOTYPE: K000227986).

**Stems** decumbent to 15(–23) cm long. Current-year branchlets pale green, to 4(–5) cm long, without or with sparse white puberulence, with basally uncinate and more distally ascending straight setae 0.34–0.38 mm long, setae in cross section above base ± narrowly flattened tangentially to rounded. Internodes averaging ca. 0.7–1.1 mm. **Leaves:** petioles 0.6–1.0(–1.6) mm, abaxially glabrous, adaxially glabrous or occasionally with very sparse white puberulence, margin entire; blades elliptic-oblanceolate, 6.0–10.6(–13.0) × 1.3–2.0(–4.5) mm, 3.0–4.8 times as long as wide, coriaceous, planar, abaxially dull light green to light brown except glossy green near margin, glabrous, adaxially glossy green to brown, glabrous except occasionally with very sparse white puberulence on midvein proximally, midvein abaxially raised, not thickened immediately below apical gland, adaxially impressed, secondary veins obscure on both sides, base cuneate, margin entire anywhere between first ca. 25–60% of length then serrulate distally, planar or slightly revolute, apex acute to obtuse, tip with planar or occasional slightly abaxially directed apical gland, marginal teeth (setae) 4 to 7 per side, all oriented off leaf surface, 0.10–0.18 mm long. Overwintering flower bud pedicels 9–32 mm or possibly longer (maximal length during winter not clear), glabrous; overwintering flower buds compressed laterally, 0.7–0.8(–1.7) × 0.5–0.6(–0.9) mm, 1.3–1.7 times as long as wide, bracteoles glabrous, rounded, margin eciliolate. **Flowers:** calyx 3–4 mm long; lobes ovate-deltoid, 1.9–3.0 × 1.2–1.7 mm, adaxially glabrous, apex acuminate, eciliolate, smooth, the very tip sharp. Corolla white to pink, broadly urceolate, ca. 5 × 4 mm; lobes ca. 0.5 mm. Stamens 10; awns 2 per theca. Style ca. 3 mm long. Fruiting pedicel (9–)13–17 mm long or probably longer (based on observations of the overwintering stage). **Fruit:** calyx prolate, turbinate, closed, 6.8–8.4 × 6.1–8.5 mm, outer wall vivid blue; lobes incurved, elongate-deltoid, 3–4 mm long, apex eciliolate. Capsule exceeded by calyx lobes. **Seeds** light brown.

***Chinese Name.—***长梗白珠 chang geng bai zhu

***Images.—***Fritsch et al. 2008: fig. 8; Fig. 7.

***Illustration.—***Airy Shaw 1948: fig. 4; see note in Fritsch et al. (2008: 161).

***Phenology.—***Flowering August; fruiting October.

***Distribution and Elevation Range.—***China (Xizang, Yunnan), Myanmar (Kachin); 2700–3353 m.

***Discussion.—****Gaultheria dolichopoda* is easily distinguished from all other species of *Gaultheria* ser. *Trichophyllae* by its long pedicels (9–32 mm as observed in the overwintering bud stage or possibly longer (versus 0.1–5.0 mm long)). As based on the few specimens collected it appears to be uncommon. Although it has been described on the label of *F. Kingdon-Ward 10130* (n.v.; Airy Shaw 1941) as "gregarious," this likely refers to its formation into locally extensive mats. The type has notably larger leaves than the rest of the specimens examined, with petioles to 1.6 mm long (versus to 0.6–1.0 mm long) and blades to 13.0 × 4.5 mm (versus to 10.6 × 2.0 mm).

We were not able to observe flowers of *Gaultheria dolichopoda* either in the field or in herbarium material, and so floral characters are from the literature. The flowers are still poorly characterized in this species, and special efforts should be made to make flowering collections.

Additional specimens examined. **CHINA. Yunnan. Gongshan County:** Dulongjiang Township, vicinity of Xixiaofang on trail from Bapo to Gongshan via Qiqi, W side of Gaoligong Shan, 2970 m, 30 Oct 2004, *Gaoligong Shan Biodiversity Survey 22005* (CAS, KUN); Xi Shao Fang Pass, trail from Xishaofang to Sandui, Gaoligong Shan, 5 Jun 2006, *L. Lu 06-0005* (CAS, KUN); Xi Shao Fang, W side of Gaoligong Shan, 2700–2900 m, 4 Jun 2006, *L. Lu 06-0058A* (CAS, KUN); along the road from Gongshan to Dulongjiang, W side of Gaoligong Shan, 3096 m, 27°07'40.4"N, 98°52'42.1"E, 29 Jun 2014, *L. Lu LL-2014-25* (CAS, KUN). **MYANMAR. Kachin. Putao District:** Nogmung Township, Mungku Hkyet, 9000–10,000 ft, 19 Aug 1937, *F. Kingdon-Ward 13005* (BM, MO).

**8. Gaultheria eciliata** (S.J. Rae & D.G. Long) P.W. Fritsch & L.H. Zhou, Proc. Calif. Acad. Sci., ser. 4, 59:165. 2008. Basionym: *Gaultheria trichophylla* Royle var. *eciliata* S.J. Rae & D.G. Long, Notes Roy. Bot. Gard. Edinburgh 45:334. 1988. Type: BHUTAN. Mongar: Pung La, 12,000 ft, 9 Jul 1949, *F. Ludlow, G. Sherriff & J.H. Hicks 20904 p.p.* (lectotype, designated by Fritsch et al. 2015b: BM001122162, photograph of lectotype E00225772).

**Stems** prostrate or prostrate-ascending to 7 cm long. Current-year branchlets pale green, strongly flushed red above, to 3 cm long, without or with sparse white puberulence, with basally uncinate and more distally ascending setae 0.15–0.24 mm long, setae in cross section above base ± narrowly flattened tangentially to rounded. Internodes averaging ca. 1.0–2.5 mm long. **Leaves:** petioles 0.4–0.8 mm long, abaxially glabrous, adaxially glabrous or with very sparse translucent puberulence, margin entire or often 1-toothed (-setose) per side; blades elliptic, narrowly elliptic, lanceolate, slightly oblanceolate, or slightly rhomboid, 3.5–6.5 × 1.5–2.4 mm, 2–3 times as long as wide, subcoriaceous, at least some cupped, others planar, abaxially glossy pale green except green or occasionally maroon near margin, glabrous or rarely with 1 to 3 appressed or ascending setae scattered on midvein (longer setae 0.1–0.2 mm long), adaxially glossy deep green, glabrous except with very sparse translucent puberulence on midvein proximally, midvein abaxially planar or raised, not thickened immediately below apical gland, adaxially planar to impressed, secondary veins abaxially obscure or 1 to 4 faintly evident on each side of midvein, adaxially obscure, base cuneate to subrounded, margin serrulate throughout or entire anywhere up to first ca. 55% of length then serrulate distally, planar, apex acute to acuminate or occasionally obtuse, tip with planar apical gland, marginal teeth (setae) 3 to 8 per side, all teeth oriented off leaf surface or more commonly proximal teeth off surface and distal teeth incurved and lying atop or adjacent to upper leaf surface, 0.10–0.14 mm long. Overwintering flower bud pedicels 0.6–1.8 mm long, glabrous or with sparse translucent puberulence; overwintering flower buds compressed laterally, 1.3–2.2 × 1.0–1.3 mm, 1–2 times as long as wide, glabrous, bracteoles keeled, margin eciliolate or often ciliolate. **Flowers** 3.0–4.5 mm long. Calyx green, 2.5–3.0 mm long; lobes deltoid or elongate-deltoid, 1.3–1.9 × 0.9–1.9 mm, adaxially pubescent, apex acute, ciliolate, slightly erose or smooth, the very tip sharp or slightly blunt. Corolla white, broadly campanulate, 3.0–3.5 × 3.2–6.0 mm; lobes 1.0–2.5 × 1.1–1.8 mm. Stamens 8 to 10; filaments 0.8–1.1 mm long; anther body 0.5–0.6 mm long, awns 1 per theca, 0.16–0.28 mm long. Style 0.7–1.3 mm long; stigma pink. Fruiting pedicel 1.4–3.0 mm long. **Fruit:** calyx oblate, crateriform, open, 4.3–6.0 × 5.0–9.0 mm,

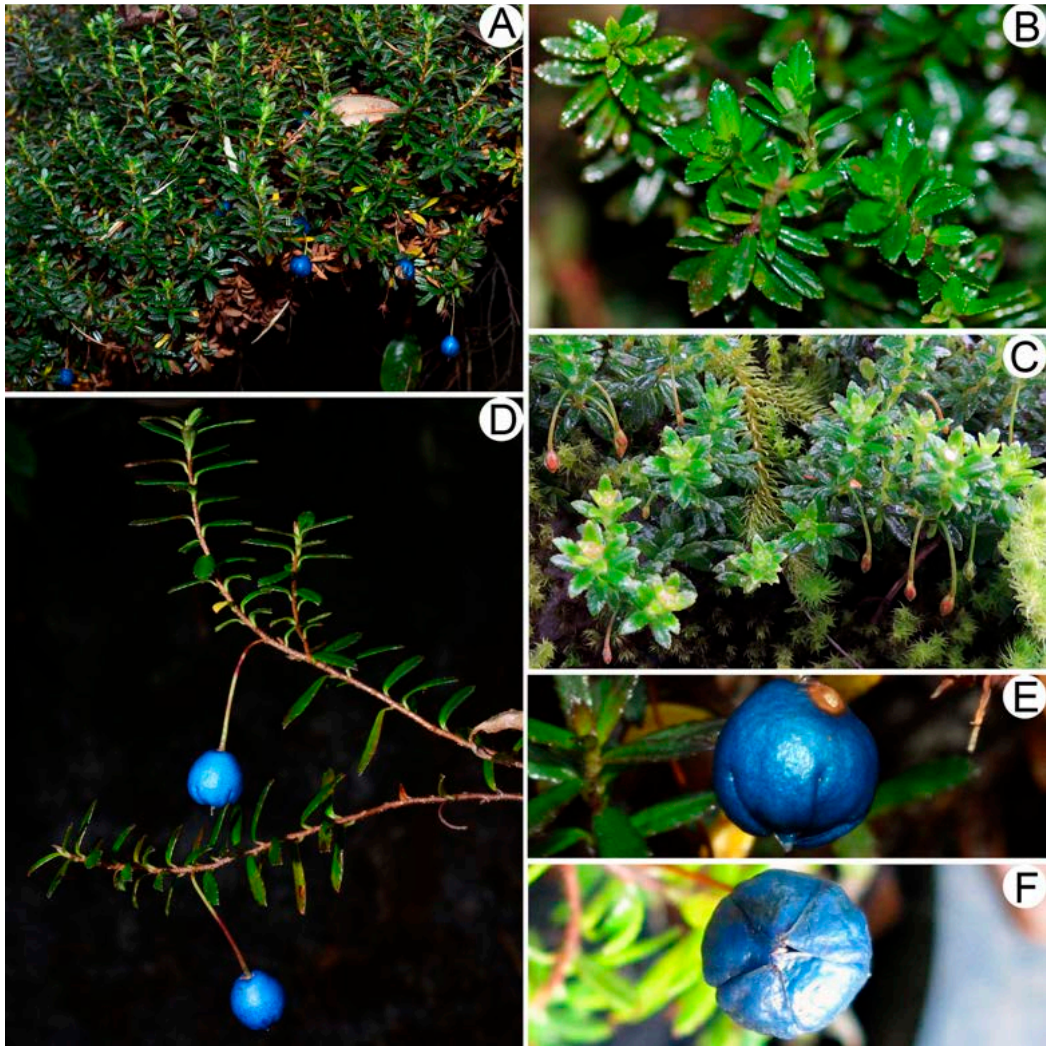


Fig. 7. *Gaultheria dolichopoda*. **A.** Habit. **B.** Branchlets. **C.** Branchlets with flower buds. **D.** Fruiting branchlets. **E.** Fruit, lateral view. **F.** Fruit, apical view. [Photos A, D–F by Jie Cai et al.; B by L.L.; C by P.W.F.; A, C–F, *L. Lu LL-2014-25* (with A, D–F photos from the same population taken in November 2014); B, *L. Lu 06-0005*.

outer wall light to deep sky blue, inner wall white; lobes erect to incurved, broadly deltoid, 1.5–3.8 mm long, apex ciliolate. Capsule green, exceeded by calyx lobes. **Seeds** light brown or brown.

***Chinese Name.—***须毛白珠 xu mao bai zhu

***Images.—***Fritsch et al. 2015b: fig. 6(A–E).

***Illustration.—***Fritsch et al. 2015b: fig. 5.

***Phenology.—***Flowering June–July; fruiting August–October.

***Distribution and Elevation Range.—***Bhutan, China (Xizang, Yunnan); 3200–4280 m.

***Discussion.—****Gaultheria eciliata* has one of the smallest leaves among the species of *Gaultheria* ser. *Trichophyllae*, near the sizes of those in *G. albiflora*, *G. bryoides*, and *G. marronina*. It is easily distinguished from these species by its ciliolate calyx lobe margins (versus eciliolate). The species was originally confused

with *G. albiflora*, and a lectotype was required because specimens of both *G. eciliata* and *G. albiflora* occurred on the type (Fritsch et al. 2015b).

This species tends to prefer less well drained substrates than the other species, being often found at the edges of lakes and ponds, and in seepages. It can form extensive mats or occur as individual plants.

See also comments under this species in Fritsch et al. (2015b).

Additional specimens examined. **CHINA. Xizang. Motuo County:** Duoxiongla, trail to Lage, 3700 m, 29°29'N, 94°55'E, 24 Jul 2007, *L. Lu LL-07149* (KUN). **Zayü County:** Linzhi Prefecture, road from Bomê to Mêdog, Galongla Pass, 4280 m, 29°45'22"N, 95°42'18"E, 25 Sep 2009, *H. Sun et al. Sun H-07ZX-2664 p.p.* (KUN mixed with *G. obovata* and *G. sinensis*). **Yunnan. Gongshan County:** Bingzhongluo Township, Champutong, 3500–3700 m, 10 Sep 1940, *K.M. Feng 7675 p.p.* (KUN [2] mixed with *G. sinensis*); Dulongjiang Township, N side of pass above tunnel on road between Gongshan and Kongdang, W side of Gaoligong Shan, 3530 m, 27°46'20"N, 98°26'48"E, 2 Oct 2002, *Gaoligong Shan Biodiversity Survey 16874* (CAS, KUN); Cikai Township, N of road from Gongshan to Kongdang, E side of Gaoligong Shan, u-shaped valley draining into upper reaches of Pula He, 3429 m, 27°47'35"N, 98°27'57"E, 3 Oct 2002, *Gaoligong Shan Biodiversity Survey 16952* (KUN); Cikai Township, Yipsaka Lake, 2.4 direct km SE of Heipu Pass tunnel on new road from Gongshan to Dulongjiang Valley, E side of Gaoligong Shan, 3500 m, 27°45'14"N, 98°27'33"E, 12 Aug 2006, *Gaoligong Shan Biodiversity Survey 32019 p.p.* (CAS mixed with *G. albiflora*, KUN); Cikai Township, Heipu Pass along road from Gongshan to Dulongjiang Valley, E side of Gaoligong Shan, 3490 m, 27°46'19.6"N, 98°26'47.6"E, 12 Aug 2006, *Gaoligong Shan Biodiversity Survey 32041* (CAS, KUN); Cikai Township, Yipsaka Lake, 2.4 direct km by SE of Heipu Pass tunnel on new road from Gongshan to Dulongjiang Valley, E side of Gaoligong Shan, 3560 m, 27°45'22.2"N, 98°27'45.4"E, 12 Aug 2006, *Gaoligong Shan Biodiversity Survey 32078* (CAS, KUN); Cikai Township, ca. 1.2 direct km SSE of Heipu Pass tunnel on new road from Gongshan to Dulongjiang Valley, E side of Gaoligong Shan, 3350 m, 27°45'41.7"N, 98°27'2.3"E, 13 Aug 2006, *Gaoligong Shan Biodiversity Survey 32102* (CAS, KUN); Cikai Township, Gaoligong Shan, vicinity of tunnel at Heipu Pass along road from Gongshan to Dulongjiang, 3360 m, 27°47'8.6"N, 98°27'37.4"E, 11 Sep 2013, *L. Lu LL-2013-3* (CAS, KUN); Cikai Township, Gaoligong Shan, Ypisaka (= "alpine") Lake (Heipu Yipu Laka), 3463 m, 27°45'21.8"N, 98°27'37.8"E, 12 Sep 2013, *L. Lu LL-2013-5* (CAS, KUN); Dulongjiang Township, Gaoligong Shan, vicinity of tunnel at Heipu Pass along road from Gongshan to Dulongjiang, 3357 m, 27°46'30.0"N, 98°26'49.1"E, 15 Sep 2013, *L. Lu LL-2013-21* (CAS, KUN); Cikai Township, Gaoligong Shan, Qiqi River drainage, along trail from No. 12 Bridge to Dong Shao Fang and pass, 3498 m, 27°41'37.6"N, 98°27'38.1"E, 18 Sep 2013, *L. Lu LL-2013-32* (CAS, GH, KUN); Cikai Township, vicinity of tunnel at Heipu Pass along road from Gongshan to Dulongjiang, E side of Gaoligong Shan, 3400 m, 27°46'42.4"N, 98°27'29.4"E, 26 Jun 2014, *L. Lu LL-2014-3* (CAS, KUN); Cikai Township, Danzhu Cun, road from Danzhu to Myanmar, along Damawadi He (N branch of W-most origin of Danzhu He), E side of Gaoligong Shan, 3243 m, 27°37'25.0"N, 98°34'32.3"E, 28 Jun 2014, *L. Lu LL-2014-13* (CAS, KUN); Dulongjiang Township, Salwin-Kiukiang divide, Lunguailaka, 3200 m, 16 Sep 1938, *T.T. Yü 20336* (A, E, KUN).

**9. Gaultheria gonggashanensis** P.W. Fritsch & Lu Lu, Nordic J. Bot. 33:582. 2015. TYPE: CHINA. Sichuan. Luding County: Moxi Township, E slope of Gongga Shan, Hailuogou Glacier Park, W of Moxi, 3196 m, 29.56506°N, 101.98169°E, 15 Sep 2011, *L. Lu & P.W. Fritsch LL-2011-33* (LECTOTYPE, here designated: KUN1248596; ISOLECTOTYPES: CAS No. 1124916, E, KUN1248595).

**Stems** prostrate-ascending to 10 cm long. Current-year branchlets pale green, to 4.7 cm long, with sparse white puberulence, with basally uncinate and more distally ascending straight, curved, or slightly undulate setae 0.36–0.60(–0.76) mm long, setae in cross section above base ± narrowly flattened tangentially to rounded. Internodes averaging 0.9–1.4 mm. **Leaves:** petioles 0.5–1.0 mm long, abaxially glabrous or with sparse ascending setae, adaxially glabrous or with very sparse puberulence, margin entire, blades narrowly elliptic or oblanceolate, 5.7–9.5 × 2.5–3.5 mm, 2.3–2.9 times as long as wide, thick-chartaceous to subcoriaceous, planar, abaxially dull pale green except glossy green near margin, at least some leaves with 1 to 7 appressed or ascending setae scattered on midvein (setae 0.20–0.44 mm long), adaxially glossy green, glabrous, midvein abaxially raised, not thickened immediately below apical gland, adaxially impressed, secondary veins abaxially obscure or 1 to 3 faintly evident on each side of midvein, adaxially obscure or 1 to 4 faintly evident on each side of midvein, base narrowly cuneate, margin serrulate throughout or entire anywhere up to first ca. 30% of length then serrulate distally, slightly revolute, apex obtuse, tip with planar or slightly abaxially directed apical gland, marginal teeth (setae) 6 to 8 per side, all oriented off leaf surface, 0.18–0.24 mm long. Overwintering flower bud pedicels 3.0–4.5 mm long, glabrous; overwintering flower buds subglobose, 2.3–3.0 × 2.3–2.6 mm, 1.0–1.2 times as long as wide, glabrous, bracteoles rounded, margin eciliolate. **Flowers** 4–7 mm long. Calyx green flushed dull pink, 2–4 mm long; lobes broadly ovate-deltoid, 1.0–3.5 × 2.5–2.7 mm, adaxially glabrous, apex obtuse, eciliolate, slightly erose, the very tip blunt. Corolla white except flushed pink medially on lobes, campanulate, ca. 4–5 × 5.7–7.0 mm; lobes 1.3–1.7 × 2.3–3.0 mm. Stamens 10; filaments 0.7–1.0 mm long; anther body 0.3–0.6 mm long, awns 2 per theca, 0.20–0.44 mm long. Style ca. 1.5 mm long; stigma pink. Fruiting

pedicel 3.0–4.5 mm long. **Fruit:** immature calyx (field obs.) open, outer wall pale blue; mature fruit (known only in sicco) 6.5–8.5 × 8.5–9.0 mm; lobes 3.5–4.5 × 4.0–5.0 mm, apex eciliolate.

***Chinese Name.—***贡嘎山白珠 gong ga shan bai zhu

***Images.—***Fritsch et al. 2015a: fig. 1.

***Illustration.—***Fritsch et al. 2015a: fig. 2.

***Phenology.—***Flowering September; fruiting August.

***Distribution and Elevation Range.—***China (Sichuan); 3048–3200 m.

***Discussion.—****Gaultheria gonggashanensis* is endemic to Luding and Wenchuan counties in Sichuan. It is most similar to *G. sinensis* but most clearly distinguished from that species by the characters in the key. In addition, the leaves appear to persist along the branchlet for a longer time, thus leaving only a short distance between the bottom leaves and the base of the branchlet, unlike in typical *G. sinensis*. Based on a reassessment of character measurements for this study in comparison to those of Fritsch et al. (2017), several values in the ranges of measurements cited in the protologue must be revised: branchlet setae were newly measured as 0.36–0.60(–0.76) mm long, flowers as 4–7 mm long, calyx length as 2–4 mm, calyx lobe dimensions as 1.0–3.5 × 2.5–2.7 mm, and corolla length 4–5 mm. Thus, some of these measurements overlap too strongly to distinguish *G. gonggashanensis* from *G. sinensis*, as stated in Fritsch et al. (2015a). Nonetheless, all floral measurements are based on only a few flowers from one collection and more data are still needed to document the morphological range of variation in the species.

From phylogenetic analysis based on whole plastid genomes (Zhang et al. 2017), *Gaultheria gonggashanensis* groups outside of the clade that includes *G. sinensis* with strong statistical support. It groups instead with *G. eciliata*, from which it can easily be distinguished by the eciliolate calyx lobe margins (versus ciliolate), among other characters. In the present study, *G. sinensis* has been documented from Wenchuan County, Sichuan, and thus the report of distinct geographic distributions of *G. gonggashanensis* and *G. sinensis* in Fritsch et al. (2015a) is negated.

Two sheets of the type collection of *Gaultheria gonggashanensis* were mounted and deposited at KUN and given separate barcodes, and these two sheets were not distinguished in the protologue; this second sheet was intended for CDBI but apparently not sent and instead mounted at KUN. We have lectotypified on KUN1248596 because it has slightly more fertile material than does KUN1248595.

See also comments on this species in Fritsch et al. (2015a).

Additional specimens examined. **CHINA. Sichuan. Precise locality uncertain:** Sikong Province, 1941, *S.Y. Hu s.n.* (KUN). **Luding County:** Moxi Township. Qiang-Huo-Peng, Gonghe Village, 3200 m, 14 Sep 1980, collector not indicated, *23523* (CDBI). **Wenchuan County:** Sikong Province, Tsao Puh, 10,000 ft, Aug 1942 [A specimen], year 1941 [KUN specimen], *S.Y. Hu 2594* (A mixed with *G. hypochlora*, KUN).

**10. Gaultheria hypochlora** Airy Shaw, Bull. Misc. Inform. Kew 1940:324. 1941. TYPE: CHINA. Xizang, South Tibet [INDIA. Arunachal Pradesh]: Delei Valley, 10,000 ft, 31 May 1928, *F. Kingdon-Ward 8266* (HOLOTYPE: K000442409).

**Stems** ascending-erect to 15 cm long. Current-year branchlets pale green, occasionally slightly flushed red, to 4.5 (to 6.0) cm long, with sparse white puberulence, with basally uncinate and more distally ascending slightly undulate setae 0.36–0.74 mm long, setae in cross section above base ± narrowly flattened tangentially to rounded. Internodes averaging ca. 1.3–5.0 mm. **Leaves:** petioles 1.0–1.2 mm long, abaxially glabrous or usually with ascending or appressed setae, adaxially with sparse white puberulence, margin often entire but on at least some leaves 1- to 3-toothed (-setose) per side; blades obovate to broadly obovate (smaller leaf blades obovate or elliptic), 9.6–13.5 × 4.5–7.2 mm, 1.8–2.1 times as long as wide, subcoriaceous, planar, abaxially dull whitish green except glossy deep green near margin and with 4 to ca. 100 appressed or ascending setae scattered on midvein and usually also spread across surface, often to near margin (setae 0.30–0.46 mm long), adaxially glossy deep green, glabrous except with white puberulence on midvein proximally, midvein abaxially raised, usually not thickened or occasionally thickened immediately below apical gland, adaxially impressed, secondary veins abaxially 2 to 4 on each side of midvein, adaxially obscure or 1 to 3 on each side of midvein, base cuneate, margin serrulate throughout, slightly revolute, often strongly so proximally, apex

obtuse to rounded, tip with planar or abaxially directed apical gland, marginal teeth (setae) 11 to 17 per side, all teeth oriented off leaf surface, 0.12–0.30 mm long. Overwintering flower bud pedicels 0.8–1.6 mm long, glabrous or with white puberulence and/or appressed setae; overwintering flower buds compressed laterally, 1.6–2.7 × 1.3–2.0 mm, 1.0–1.5 times as long as wide, glabrous, bracteoles keeled, margin eciliolate or occasionally sparsely ciliolate. **Flowers** 3.3–5.0 mm long. Calyx green, 2.4–2.8 mm long; lobes elongate-deltoid, 1.8–2.0 × 1.1–1.6 mm, adaxially pubescent, apex acute, ciliolate, smooth, the very tip blunt. Corolla white, narrowly campanulate, 2.1–4.5 × 3.6–4.5 mm; lobes 1.0–1.8 × 1.5–1.8 mm. Stamens 10; filaments 0.8–0.9 mm long; anther body 0.40–0.86 mm long, awns (1 or) 2 per theca, 0.20–0.48 mm long. Style 1.6–1.8 mm long; stigma green. Fruiting pedicel 1.2–2.5 mm long. **Fruit:** calyx oblate, broadly turbinate or rarely broadly cupuliform, open, 7–16 × 11–16 mm, outer wall light sky blue or rarely white, inner wall white; lobes incurved, elongate-deltoid, 3.0–7.0 mm long, apex ciliolate. Capsule green, exceeded by calyx lobes. **Seeds** light brown.

***Chinese Name.—***绿背白珠 lü bei bai zhu

***Images.—***Fig. 8.

***Illustrations—***Fig. 9; see note in Fritsch et al. (2008: 180).

***Phenology.—***Flowering May–July; fruiting July–October.

***Distribution and Elevation Range.—***China (Sichuan, Xizang, Yunnan), China (South Tibet [India, Arunachal Pradesh]), Myanmar (Kachin); 2300–4115 m.

***Discussion.—****Gaultheria hypochlora* is one of the most common and widespread species of *Gaultheria* ser. *Trichophyllae*. Leaf size and shape can vary substantially throughout its range (Fig. 9) but this variation does not seem to be correlated with geography or elevation.

*Gaultheria hypochlora* has been described as having two awns per theca (e.g., Fang & Stevens 2005) but one collection that we observed (*J.F.C. Rock 8804*) has flowers with apparently one awn per theca.

For distinguishing this species from other species of the series with ciliolate calyx lobe margins and for phylogenetic relationships, see discussion under *Gaultheria ciliisepala* and Table 2.

Additional specimens examined. **CHINA. Sichuan. Precise locality uncertain:** Sikong Province, Tsio-hai-ping, 2300 m, 29 Aug 1939, *C.Y. Chiao 2089* (A); Sikong Province, year 1941, *S.Y. Hu s.n.* (KUN). **Tianquan County:** Yazikou Pass, old state road from Tibet to Sichuan, above tunnel on Hwy G318, summit ridge of Erlang Shan, 2908 m, 29.86113°N, 102.29115°E, 16 Sep 2011, *L. Lu & P.W. Fritsch LL-2011-39* (CAS, KUN). **Wenchuan County:** Tsao-puh, 25 Jul 1942, *S.Y. Hu 2455* (A); Sikong Province, Tsao Puh, 10,000 ft, Aug 1942 [A specimen], year 1941 [KUN specimen], *S.Y. Hu 2594* (A mixed with *G. gonggashanensis*, KUN); Tsao Puh, 10,000 ft, Aug 1942, *S.Y. Hu 2596* (A). **Xizang. Motuo County:** Duoxiongla, on trail to Lage, 3600 m, 29°29'N, 94°55'E, 24 Jul 2007, *L. Lu LL-07135* (CAS, KUN). **Zayü County:** Mt. Wuli-La, E of the Salwin River and N of Alulaka, 13,500 ft, Jun–Jul 1932, *J.F.C. Rock 22407* (A, E, MO, NY, P). **Yunnan. Deqin County:** Cizhong Village, 3500–3650 m, 3 Jul 1940, *K.M. Feng 4995* (KUN [2]); Yanmen Township, Biluo Xue Shan, E slope just below Sila Pass, 3503 m, 28°00'4.4"N, 98°49'1.6"E, 24 Sep 2013, *L. Lu LL-2013-55* (CAS, KUN); Yanmen Township, Tsch Chung Mts., mountains above Tseku and Tschchung [= Cizhong], Mekong-Salwin divide, year 1923, *J.F.C. Rock 8804* (A); Mekong-Salwin divide, Londjrela, 3600 m, 6 Oct 1938, *T.T. Yü 23260* (A, E, KUN). **Fugong County:** Lishadi Township, vicinity of Yaping Pass near Myanmar border, E side of Gaoligong Shan, 3620 m, 27°12'45"N, 98°41'45.0"E, 5 May 2004, *Gaoligong Shan Biodiversity Survey 20970* (BRIT, CAS, KUN); Lumadeng Township, Yaping Cun, SE Amero Pass along the ridge that forms the border between China and Myanmar, E side of Gaoligong Shan, 3460 m, 27°03'38"N, 98°45'23"E, 13 Aug 2005, *Gaoligong Shan Biodiversity Survey 27221* (BRIT, CAS, KUN); Lishadi Township, Yaduo Cun, vicinity of Luodigoulu, N side of N fork of Yamu He, E side of Gaoligong Shan, 2520 m, 27°10'02"N, 98°46'25"E, 16 Aug 2005, *Gaoligong Shan Biodiversity Survey 28441* (CAS, KUN); Lishadi Township, Yaduo Cun, NE of Yaping Yakou at Myanmar border, N side of N fork of Yamu He, E side of Gaoligong Shan, 3840 m, 27°13'04"N, 98°42'19"E, 17 Aug 2005, *Gaoligong Shan Biodiversity Survey 28628* (CAS, KUN); ibid., *Gaoligong Shan Biodiversity Survey 28629* (CAS, KUN); Lishadi Township, Yaduo Cun, along trail between road to Myanmar through Yaping Pass and border marker S of the pass, 3699 m, 27°12'17.5"N, 98°41'45.0"E, 2 Jul 2014, *L. Lu LL-2014-27* (CAS). **Gongshan County:** Bingzhongluo Township, Chang Pu Tong, 3600–3800 m, 15 Sep 1940, *K.M. Feng 7804* (KUN); Mekong-Salween divide, 28°10'N, 12,000 ft, Oct 1914, *G. Forrest 13428* (E); Mekong-Salween divide, 28°12'N, 12,000–13,000 ft, Aug 191?, *G. Forrest 14735* (A, E); Cikai Township, Hei Pu Shan, 9 Oct 1940, *K.M. Feng 8313* (KUN); Dulongjiang Township, Xishaofang, 3400 m, 15 Oct 1996, *Gaoligong Shan Biodiversity Survey 7758* (KUN); Dulongjiang Township, N side of pass above tunnel on road between Gongshan and Kongdang, W side of Gaoligong Shan, 3530 m, 27°46'20"N, 98°26'48"E, 2 Oct 2002, *Gaoligong Shan Biodiversity Survey 16876* (CAS, KUN [2]); Cikai Township, N of road from Gongshan to Kongdang, E side of Gaoligong Shan, u-shaped valley draining into upper reaches of Pula He, 3429 m, 27°47'35"N, 98°27'57"E, 3 Oct 2002, *Gaoligong Shan Biodiversity Survey 16950 p.p.* (CAS, KUN [2], all mixed with *G. stenophylla*); Dulongjiang Township, E side of pass of road from Gongshan to Kongdang, W side of Gaoligong Shan near crest of range, 3670 m, 27°46'18"N, 98°27'02"E, 5 Oct 2002, *Gaoligong Shan Biodiversity Survey 17007 p.p.* (CAS, KUN, both mixed with *G. sinensis*, KUN); Dulongjiang Township, W side of pass on road from Gongshan to Kongdang, E side of Gaoligong Shan near crest of range, 3750 m, 27°46'16"N, 98°26'29"E, 5 Oct 2002, *Gaoligong Shan Biodiversity Survey 17032* (CAS, KUN [2]);


**Fig. 8.** ***Gaultheria hypochlora*****. A.** Habit. **B.** Branchlets. **C, D.** Flowers from two different populations, lateral view. **E.** Flower from D, apical view. **F.** Fruit, lateral view. **G.** Fruit, apical view. **H.** Close-up of G showing ciliolate calyx lobes. **I.** A white-fruited individual. [Photos A–E, G, H by L.L.; F, I by P.W.F; A, *L. Lu LL-2013-44*; B, G, H, *L. Lu LL-2013-11*; C, *L. Lu LL-2014-27*; D, E, *L. Lu LL-2014-9*; F, *L. Lu LL-2013-22*; I, *L. Lu LL-2013-12*.]

Bingzhongluo Township, along N side of Nianwaluo He, trail from Fucai to Chukuai Lake, ca. 13.2 direct km WSW of Bingzhongluo, E side of Gaoligong Shan, 3470 m, 27°59'8.4"N, 98°29'54.2"E, 17 Aug 2006, *Gaoligong Shan Biodiversity Survey 31158* (BRIT, CAS, KUN); Cikai Township, Yipsaka Lake, 2.4 direct km SE of Heipu Pass tunnel on new road from Gongshan to Dulongjiang valley, E side of Gaoligong Shan, 3560 m, 27°45'22.2"N, 98°27'45.4"E, 12 Aug 2006, *Gaoligong Shan Biodiversity Survey 32074* (CAS, KUN); ibid., *Gaoligong Shan Biodiversity*

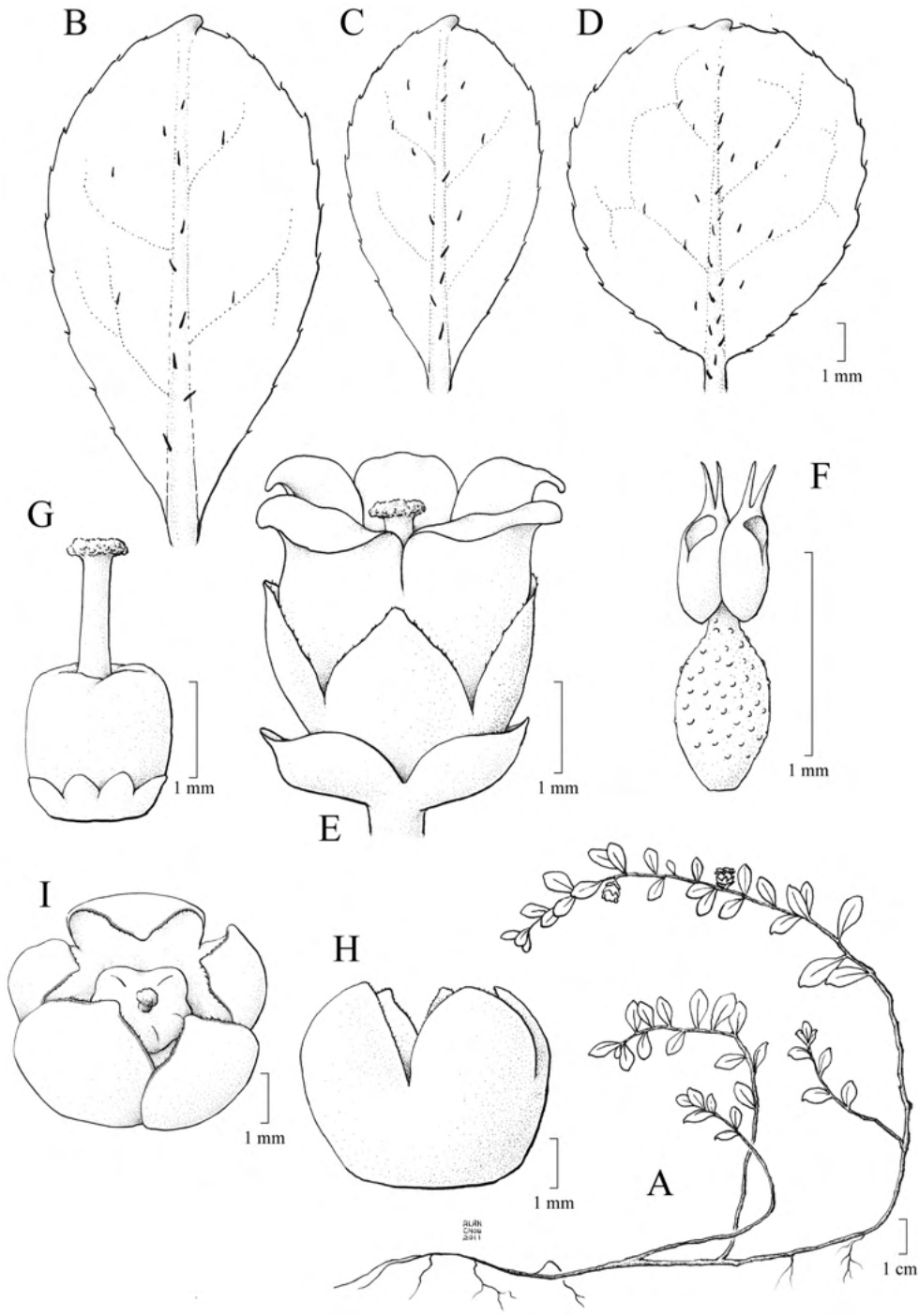


Fig. 9. *Gaultheria hypochlora*. **A.** Flowering plant. **B–D.** Leaves in abaxial view showing variation in shape and distribution of setae. **E.** Bracteoles and flower. **F.** Stamen. **G.** Nectary glands and gynoecium. **H.** Fruit, lateral view. **I.** Fruit, apical view. [A, B drawn from the holotype *F. Kingdon-Ward 8266* (K); C, E, F, G drawn from *F. Kingdon-Ward 6845* (K); D drawn from *Gaoligong Shan Biodiversity Survey 28629* (CAS); H, I drawn from *Gaoligong Shan Biodiversity Survey 16876* (CAS), and images of living plants (*L. Lu LL-2013*-22).]

*Survey 32080* (CAS, KUN); Cikai Township, vicinity of Danghatu near Km 49 on road from Gongshan to Kongdang and ca. 20.4 direct km WNW of Gongshan, E side of Gaoligong Shan, 3360 m, 27°47'3.5"N, 98°27'39"E, 21 Aug 2006, *Gaoligong Shan Biodiversity Survey 33929* (CAS, KUN); Cikai Township, Danzhu Cun, along the Damawadi He (N branch of W-most origin of the Danzhu He) ca. 0.5 km E of Myanmar border and ca. 15.5 direct km WSW of Danzhu, E side of Gaoligong Shan, 3220 m, 27°37'13.8"N, 98°34'30"E, 24 Aug 2006, *Gaoligong Shan Biodiversity Survey 34106* (CAS, KUN); prope fines Tibeto-Birmanicas inter fluvios Ludiang (Salween) et Djiou-djiang (Irrawadi or sup.), in jugi Tschiangschel, 3500–3800 m, 5 Jul 1916, *H.F. v. Handel-Mazzetti 9382* (A); Cikai Township, Dong Shao Fang Pass, Gaoligong Shan, 3200–3500 m, 4 Jun 2006, *L. Lu 06-0012* (CAS [2], GH, KUN); ibid., *L. Lu 06-0016* (GH); Cikai Township, vicinity of the tunnel at Heipu Pass along the road from Gongshan to Dulongjiang, 3400 m, 27°46'42.4"N, 98°27'29.4"E, 13 Sep 2013, *L. Lu LL-2013-11* (CAS, KUN [2]); ibid., *L. Lu LL-2013-12* (CAS, KUN); ibid, *L. Lu LL-2013-15* (CAS, KUN [2]); Dulongjiang Township, vicinity of the tunnel at Heipu Pass along road from Gongshan to Dulongjiang, 3357 m, 27°46'30.0"N, 98°26'49.1"E, 15 Sep 2013, *L. Lu LL-2013-22* (CAS, KUN [2]); Cikai Township, Qiqi River drainage, along trail from No. 12 Bridge to Dong Shao Fang and the pass, 27°41'37.6"N, 3498 m, 98°27'38.1"E, 18 Sep 2013, *L. Lu LL-2013-38* (CAS, KUN [2]); Bangdang Xiang, Biluo Xue Shan, Balagong spur, trail from Balagong Pass to Siwanongba Valley, 3659 m, 27°58'35.3"N, 98°46'3.4"E, 23 Sep 2013, *L. Lu LL-2013-44* (CAS, KUN [2]); Dulongjiang Township, vicinity of the tunnel at Heipu Pass along road from Gongshan to Dulongjiang, 3357 m, 27°46'30.0"N, 98°26'49.1"E, 26 Jun 2014, *L. Lu LL-2014-9* (CAS, KUN); Jinggu Dai and Yi County, *Z.W. Lü 623* (KUN); Bingzhongluo Township, Dong Ta, 3600 m, 25 Jun 1982, *Qinghai-Xizang Expedition 7580* (KUN, PE n.v. (online image!)); Bingzhongluo Township, Si-gi-tung, Champutung, 3000 m, Oct 1935, *C.W. Wang 67196* (A, KUN, PE [2] n.v. (online images!)); Taron-Taru divide, Mt. Tarulaka, 3000 m, 3 Sep 1938, *T.T. Yü 20058* (KUN); Tsukuai, 3600 m, 16 Oct 1938, *T.T. Yü 20709* (A, E, KUN); Mekong-Salwin divide, Sewalongba, 3500 m, 31 August 1938, *T.T. Yü 22606* (A, E, KUN); Salwin-Kiukiang divide, Haipuh, 3500 m, 2 Nov 1938, *T.T. Yü 22945* (A). **CHINA. South Tibet** [**INDIA. Arunachal Pradesh]:** Delei Valley, 11,000–12,000 ft, 28°15'N, 96°35'E, 23 Aug 1928, *F. Kingdon-Ward 8562* (K). **MYANMAR. Kachin. Myitkyina District:** Chewchi Pass, 11,000 ft, 2 Jul 1920, *R.J. Farrer 1676* (E); ibid., 12,500 ft, 18 Jul 1920, *R.J. Farrer 1737* (E); Waingmaw Township, Base of Seinghku, 10,000 ft, 6 Apr 1924, *F. Kingdon-Ward 6845* (K [2]). Putao District: Putao Township, Hponganrazi Wildlife Sanctuary, between Ye Khe Sap camp and Hponganrazi summit, 27°30'52.6"N, 96°56'30.5"E, 3176 m, 22 Oct 2016, *K. Armstrong et al. 2004* (NY n.v., image!).

**11. Gaultheria jingdongensis** R.C. Fang, Novon 9:166. 1999. TYPE: CHINA. Yunnan. Jingdong County: Jingdong Shan [= Wuliang Shan], Huangcaoba to Gongpinghe, 2700 m, 1 May 1959, *S.K. Wu 4774* (HOLOTYPE: KUN1208575; ISOTYPE: KUN1208576).

**Stems** ascending-erect to 30 cm long. Current-year branchlets pale green, to 5 cm long, without or with sparse white puberulence, with basally ± straight or occasionally undulate and more distally ± erect straight, curved, or slightly undulate setae 1.2–2.0 mm long, setae in cross section above base ± narrowly flattened tangentially to rounded. Internodes averaging ca. 2.0–5.7 mm. **Leaves:** petioles 9–16 mm, adaxially with white puberulence, abaxially with ascending straight, curved, or slightly undulate setae, margin 1- to 3-toothed (-setose) per side; blades elliptic to oblanceolate, 16–22 × 6–11 mm, 1.8–3 times as long as wide, subcoriaceous, planar, abaxially pale green except glossy green near margin (usually hidden) with 70 to 160 or more ± erect straight, curved, or slightly undulate setae scattered throughout midvein and surface (setae 0.9–1.4 mm long), adaxially glossy deep green, glabrous except with white puberulence on midvein proximally, midvein abaxially raised, slightly to strongly thickened immediately below apical gland, adaxially impressed, secondary veins abaxially obscure or 1 to 3 on each side of midvein, adaxially obscure or 1 to 3 on each side of midvein, base cuneate, margin serrulate throughout, strongly revolute, apex obtuse to rounded, tip with planar or often abaxially directed apical gland, marginal teeth (setae) 19 to 25 per side, oriented off leaf surface or inward over abaxial leaf surface and off or just touching the surface, 0.7–1.0 mm long. Overwintering flower bud pedicels 0.3–1.0 mm long, with straight, curved, or slightly undulate setae; overwintering flower buds strongly compressed laterally, 1.7–3.6 × 1.4–2.3 mm, 1.4–2.3 times as long as wide, glabrous, bracteoles keeled, margin ciliolate at apex. **Flowers** 6.5–8.0 mm long. Calyx white or white flushed red at apices of lobes, 3.4–5.5 mm long; lobes elongate-deltoid, 2.6–3.4 × 1.4–2.5 mm, adaxially densely pubescent, apex narrowly acute, ciliolate (as well as much of margin), smooth, the very tip blunt. Corolla white with pale pink line medially on each petal segment, campanulate, 6–9 × 7–10 mm; lobes 3.3–6.0 × 1.9–3.0 mm. Stamens 10; filaments 1.5–3.7 mm long; anther body 0.8–1.1 mm long, awns 1 per theca, 0.6–0.8 mm long. Style 2.8–3.8 mm long; stigma green. Young fruiting pedicels 3–5 mm long.

***Chinese Name.—***景东白珠 jing dong bai zhu

***Images.—***Fig. 10.

***Illustration.—***Fang 1999: fig. 3.

***Phenology.—***Flowering March–May; fruit unknown.

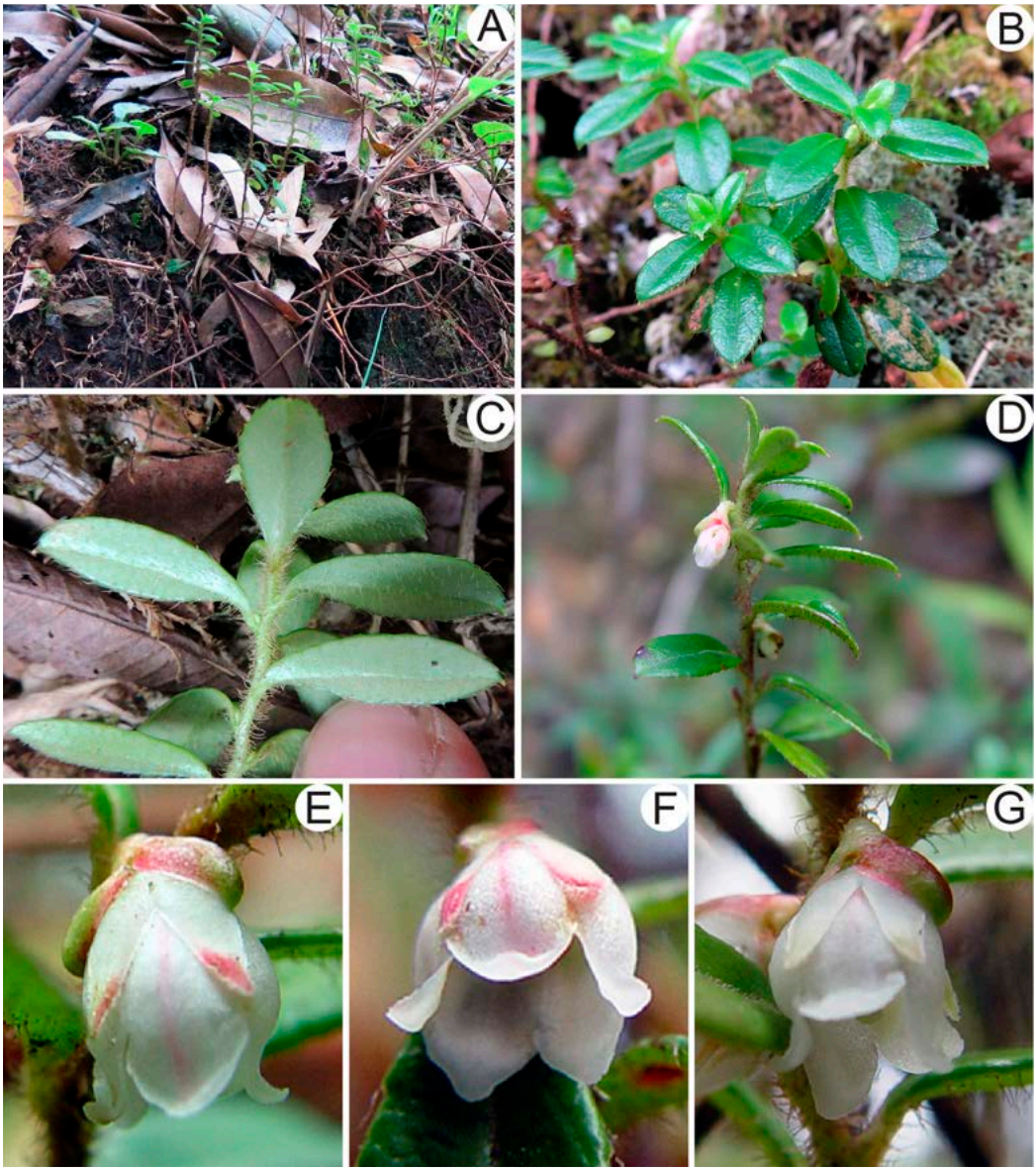


Fig. 10. *Gaultheria jingdongensis*. **A.** Habit. **B.** Branchlets with leaves in adaxial view. **C.** Branchlet with leaves in abaxial view. **D.** Branchlet with nearly open flower bud. **E–G.** Flowers from three different plants showing floral variation. [Photos B, C by P.W.F.; A, D–G by L.L.; A–C, *L. Lu LL-2013-58*; D, *L. Lu 06-19*; E–G, *L. Lu 06-19A*.]

***Distribution and Elevation Range.***—China (Yunnan); 2200–3000 m.

***Discussion.***—*Gaultheria jingdongensis* is the largest species of *Gaultheria* ser. *Trichophyllae* in several characters, including stem length (up to 30 cm), stem setae length (1.2–2.0 mm), leaf blade length (16–22 mm) and width (6–11 mm), and corolla length (6–9 mm). With any of these characters it is thus readily distinguished from all other species of the series. The fruit of the species is still unknown and a special effort should be made to collect and document its fruiting characters.

See also discussion under *Gaultheria ciliisepala*.

Additional specimens examined. **CHINA. Yunnan. Jingdong County:** Mo-Dau-He, 2200 m, 9 Mar 1940, *M.K. Li 3545* (KUN [2]); Modao Village, trail to Shanshengmiao Pass, 2700–2900 m, 6 May 2006, *L. Lu 06-19* (CAS, KUN); Mo-Dao River, Shanshenmiao, Dayakow, 2700–2900 m, 16 May 2006, *L. Lu 06-19A* (CAS, KUN); Linjie Township, Modao He Village area, Wuliang Shan, Shan Shen Miao Pass, 2913 m, 24°26'27.4"N, 100°40'47.8"E, 13 Oct 2013, *L. Lu LL-2013-58* (CAS, KUN [2]); Wuliang Shan, Modauhe Village, 2900 m, 29 Oct 1956, *B.Y. Qiu 52915* (KUN [2]); Wuliang Shan, Luoshuidong Village, 3000 m, 17 May 1963, *Q.A. Wu 9234* (KUN); Huangcaoba to Gongpinghe, 2900 m, 28 May 1963, *Q.A. Wu 9399* (KUN [2]).

**12. Gaultheria major** (Airy Shaw) P.W. Fritsch & Lu Lu, Phytotaxa 201(1):14. 2015. Basionym: *Gaultheria sinensis* J. Anthony var. *major* Airy Shaw, Bull. Misc. Inform. Kew 1940:325. 1941 (as '*maior*'). Type: CHINA. Yunnan: Kari Pass, Mekong-Yangtze divide, 11,000 ft, 27°40'N, Aug 1914, *G. Forrest 12938* (holotype: K000227995; isotypes: BM000834402, E00231016, PE00195888 n.v. (online image!)).

**Stems** prostrate or prostrate-ascending to 12 cm long. Current-year branchlets pale green and strongly flushed red above, to 8 cm long, with sparse to moderate white puberulence, with basally uncinate and more distally ascending straight, curved, or usually slightly undulate setae 0.46–0.96 mm long, setae in cross section above base ± narrowly flattened tangentially to rounded. Internodes averaging ca. 1.1–2.3 mm. **Leaves:** petioles 0.6–1.3 mm long, abaxially glabrous or with sparse appressed or ascending setae, adaxially with sparse white puberulence, margin entire or 1-toothed (-setose) per side; blades elliptic or narrowly so to slightly oblanceolate, 7.5–18.0 × 2.8–6.9 mm, 1.5–3.2 times as long as wide, subcoriaceous, planar, abaxially dull whitish green except glossy and occasionally flushed maroon near margin, at least some leaves with 1 to 23 appressed or ascending setae scattered on midvein or rarely also on surface but near midvein (setae 0.34–0.80 mm long), adaxially glossy green, glabrous except with white puberulence on midvein proximally, midvein abaxially raised, not thickened immediately below apical gland, adaxially impressed, secondary veins abaxially obscure or 2 to 4 on each side of midvein, adaxially obscure, base cuneate to subrounded, margin serrulate throughout, slightly revolute, apex acute to rounded, tip with planar apical gland, marginal teeth (setae) 8 to 15 per side, all teeth oriented off leaf surface, 0.34–0.84 mm long. Overwintering flower bud pedicels 1.8–4.1 mm long, glabrous; overwintering flower buds slightly compressed laterally to subglobose, 1.8–3.7 × 1.7–3.0 mm, 1.0–1.6 times as long as wide, glabrous, bracteoles rounded to slightly keeled, margin eciliolate. **Flowers** ca. 5.6 mm long. Calyx dull pink, 2.8–3.5 mm long; lobes broadly deltoid, 2.0–2.2 × 2.0–2.6 mm, adaxially glabrous, apex acute, eciliolate, smooth, the very tip blunt. Corolla white, campanulate, 5.0–5.2 × ca. 7.0 mm; lobes 2.3–2.6 × 1.8 mm. Stamens 10; filaments ca. 1 mm long; anther body ca. 0.6 mm long, awns 2 per theca, 0.4–0.5 mm long. Style 1.0–2.5 mm long; stigma pink. Fruiting pedicel 2.0–4.1 mm long. **Fruit:** calyx prolate to subglobose, broadly cupuliform, open, 7–10 × 8–18 mm, outer wall deep sky blue, inner wall white; lobes erect or slightly incurved, broadly deltoid, 3.0–3.5 mm long, apex eciliolate. Capsule green, exceeded by calyx lobes. **Seeds** light brown.

***Chinese Name.—***大叶华白珠 da ye hua bai zhu

***Images.—***Fritsch et al. 2015b: fig. 6(F–J), 8(F).

***Illustration.—***Fritsch et al. 2015b: fig. 7.

***Phenology.—***Flowering May, June, September; fruiting June–October.

***Distribution and Elevation Range.—***China (Xizang, Yunnan); 3200–4200 m.

***Discussion.—****Gaultheria major* is a widespread and common species in western Yunnan and also occurs just to the north of Yunnan in Zayü County in Xizang. Although morphology suggests that the closest relative of *G. major* is *G. sinensis* (as indicated by the characters in the key leading to couplets 19 and 22, respectively), from phylogenetic analysis with whole plastid genomes (Zhang et al. 2017) it is instead strongly supported as sister to *G. crassifolia*.

Some specimens have leaves that are shorter than normal for *Gaultheria major*, i.e., in the range of *G. obovata* or *G. sinensis* (e.g., *T.T. Yü 10554*, Deqin County, Yunnan), but can be distinguished by the longer stem setae and thinner leaves.

See also comments under this species in Fritsch et al. (2015b).

Additional specimens examined. **CHINA. Precise locality uncertain:** without locality, 24 Jun 1937, *W.P. Fang 57736* (E). **Xizang. Zayü County:** Tsarong, Salwin-Kiu Chiang divide, 13,000 ft, 28°24'N, 98°24'E, Aug 1921, *G. Forrest 20040* (A, E, K, P). **Yunnan. Dali City:** Tsang Chan, 3500 m, 10 Jun 1885 ["1888"], *J.M. Delavay s.n.* (*or 183 or No. 1877*) *p.p.* (A [2], K, P, all variously mixed with *G. cardiosepala* and *G. trichophylla*); Tali Range, 8 Oct 1929, *G. Forrest 28035* (E); Tsangshan Range, W of Talifu, 13,000 ft., Aug 1922, *J.F.C. Rock 6325* (A); no locality indicated, 3000 m, May 1935, *C.W. Wang 63284* (A, PE n.v. (online image!)). **Deqin County:** Cizhong Village, 3800 m, 5 Jul 1940, *K.M. Feng 5130* (KUN [2]); mtn. behind Cizhong Village, 3500–3700 m, 9 Aug 1940, *K.M. Feng 6468* (KUN); Salwin-Mekong divide, mtns. behind Yongzi Village, 3700–3800 m, 16 Aug 1940, *K.M. Feng 6724* (KUN mixed with *G. sinensis*); Mekong-Salween divide, Schöndsula, 3850 m, 28°4'N, 22 Sep 1915, *H.F. v. Handel-Mazzetti 8243* (A, E, P); Yanmen Township, Biluo Xue Shan, E slope just below Sila Pass, 3936 m, 28°00'8.5"N, 98°47'54.8"E, 24 Sep 2013, *L. Lu LL-2013-51* (CAS, GH, KUN [2]); GLORIA Summit "DYI", just above treeline scattered dwarf fir just below, 4100 m, 27°45'14"N, 98°55'50"E, 7 Sep 2013, *Shangri La Alpine Botanical Garden & Missouri Botanical Garden 2013-155* (MO); near Ba Ding Village for GLORIA site: Ma Jian Wa (CN-MJW), 4100 m, 13 Oct 2006, *Shangri La Alpine Botanical Garden & Missouri Botanical Garden MJW95* (MO); Atuntze, Mt. Miyetzimu, 3400 m, 14 Oct 1937, *T.T. Yü 10554* (A, BM, KUN). **Eryuan County:** vicinity of Niujie, near main peak of Maer Shan, 3450 m, 3 Jul 1963, *Jinsha River Expedition 63-6113* (KUN [2], PE n.v. (online image!)). **Gongshan County:** Bingzhongluo Township, ca. 2.1 direct km S of Gawagapu Mtn. and ca. 15.2 direct km WSW of Bingzhongluo in next basin E of Chukuai Lake, E side of Gaoligong Shan, 4000 m, 27°59'29.3"N, 98°28'36.3"E, 28 Aug 2006, *Gaoligong Shan Biodiversity Survey 32809 p.p.* (CAS, KUN, both mixed with *G. sinensis*); Cikai Township, Dongshaofang Pass, Gaoligongshan, 3200–3500 m, 4 Jun 2006, *L. Lu 06-0014 p.p.* (CAS, GH, KUN, all mixed variously with *G. ciliisepala, G. sinensis*, and *G. stenophylla*); Cikai Township, Gaoligong Shan, Qiqi River drainage, along trail from No. 12 Bridge to Dong Shao Fang and pass, 3498 m, 27°41'37.6"N, 98°27'38.1"E, 18 Sep 2013, *L. Lu LL-2013-37* (CAS, GH, KUN); Bangdang Township, Biluo Xue Shan, Balagong spur, trail from Dimaluo to Balagong Pass, 3599 m, 27°57'49.8"N, 98°44'26.4"E, 23 Sep 2013, *L. Lu LL-2013-40* (CAS, GH, KUN [2]); Che-tse-luo, top of Pi-lo [Biluo] Shan, 4000 m, 25 Aug 1934, *H.T. Tsai 58172* (A, KUN, PE [2] n.v. (online images!)); Bangdang Township, Mekong-Salwin divide, Sila, 4000 m, 12 Aug 1938, *T.T. Yü 22316* (KUN [2]); ibid., 2 Oct 1938, *T.T. Yü 22748* (A, E, KUN [2]). **Heqing County:** Machang, Baishanmu, *R.C. Ching 23490* (KUN). **Lanping County:** Biluo Snow Mtns., Jiumingfang, 4200 m, *S.K. Wu 8767* (KUN [2]). **Weixi County:** Wei-Hsi area, *G. Forrest 30556* (E); Yezhi Township, E slope of Biluo Xue Shan, trail from Bading Village to Majiwa Peak, 3579 m, 27°49'07.5"N, 99°05'20.3"E, 25 Sep 2014, *L. Lu LL-2014-52* (CAS, KUN); Yezhi Township, W slope of Erdelie Xue Shan (Yunlin divide), road from Zili Village to Erdelie Xue Shan Peak, 3644 m, 27°49'18.9"N, 99°05'16.7"E, 26 Sep 2014, *L. Lu LL-2014-60* (CAS, KUN); Lidiping, 3000 m, 20 Jul 1956, *P.Y. Mao 00138* (KUN [2]); Mt. Shang-Ma-Kou, N of Wei-Hsi, Aug 1928, *J.F.C. Rock 17172* (A); Yezhi Township, Yeh-Chih Community, 3600 m, Aug 1935, *C.W. Wang 68551* (A, KUN, PE [2] n.v. (online images!)); Yezhi Township], Yeh-Chih Community, 3600 m, Aug 1935, *C.W. Wang 68633* (A, KUN, PE n.v. (online image!)). **Yulong County:** W Lijiang, summit of mtns. behind Tamichung, 25 Aug 1939, *R.C. Ching 21460* (A, KUN); Lijiang City, Judian Township, Ludian, Xinzhu Village, W slope of Geniwa Shan (Weixi and Lijiang divide), trail from Xinzhu Village to Geniwa Peak, 3630 m, 27°14'53"N, 99°24'39"E, 28 Sep 2014, *L. Lu LL-2014-64A* (CAS, KUN); Lijiang City, Judian Township, Ludian, Xinzhu Village, W slope of Geniwa Shan (Weixi and Lijiang divide), trail from Xinzhu Village to Geniwa Peak to Lidiping Village, 3689 m, 27°19'2.9"N, 99°25'11.9"E, 28 Sep 2014, *L. Lu LL-2014-64B* (CAS, KUN).

**13. Gaultheria marronina** P.W. Fritsch & Lu Lu, Nordic J. Bot. 34:545. 2016. TYPE: CHINA. Sichuan. Tianquan County: Yazikou Pass, old state road from Tibet to Sichuan, above tunnel on Highway G318, summit ridge of Erlang Shan, 2908 m, 29.86113°N, 102.29115°E, 16 Sep 2011, *L. Lu and P.W. Fritsch LL-2011-37* (LECTOTYPE, here designated: KUN1248335; ISOLECTOTYPES: CAS No. 1200454, E, GH, K, KUN1248337, KUN1248591, KUN1248592, MO).

**Stems** prostrate to 4 cm long. Current-year branchlets pale green and strongly flushed red above, to 2.5 cm long, without puberulence, with basally uncinate and more distally appressed or ascending straight, curved, or slightly undulate setae 0.34–0.50 mm long, setae in cross section above base ± narrowly flattened to rounded tangentially. Internodes averaging 0.65–1.10 mm long. **Leaves:** petioles 0.4–0.6 mm long, abaxially glabrous, adaxially glabrous or with sparse white puberulence, margin entire; blades elliptic, slightly rhombic, or slightly obovate, planar to cupped, 5.1–6.2 × 2.1–3.1 mm, 1.8–2.4 times as long as wide, thick-chartaceous to subcoriaceous, abaxially dull pale green except glossy green near margin, glabrous, adaxially glossy green, glabrous except for often sparse white puberulence on midvein proximally, midvein abaxially planar or raised, not thickened immediately below apical gland, adaxially impressed, secondary veins obscure on both sides, base cuneate, margin entire anywhere between first ca. 20–70% of length then serrulate distally, slightly revolute, apex acute to obtuse, tip with planar or adaxially directed apical gland, marginal teeth (setae) 3 to 6 per side, often incurved and lying atop or adjacent to upper leaf surface, 0.14–0.20 mm long. Overwintering flower bud pedicels 0.5–0.8 mm long, glabrous; overwintering flower buds slightly compressed laterally, 0.9–1.3 × 0.6–1.0 mm, 1.3–1.5 times as long as wide, glabrous, bracteoles slightly keeled, margin eciliolate. **Flowers** 3.0–3.5 mm long. Calyx green, 3.0–3.4 mm long; lobes narrowly deltoid, 2.2–3.0 × 1.3–1.7 mm, adaxially glabrous, apex acute, eciliolate, smooth, the very tip sharp. Corolla greenish white or white, campanulate, 2.8–3.2 × 3.0–4.2 mm; lobes 1.0–1.2 × 1.0–1.7 mm. Stamens 10; filaments 0.5–0.6 mm long; anther body 0.5–0.6 mm

long, awns 1 per theca, 0.12–0.30 mm long. Style 1.0–1.5 mm long; stigma pink. Fruiting pedicel 1.5–2.0 mm long. **Fruit:** calyx subglobose-cupuliform, truncate at base in outline, slightly open or rarely closed, 5–8 × 6–8 mm, outer and inner wall pure white; lobes erect or usually incurved, deltoid, 2.5–4.5 mm long, apex eciliolate. Capsule maroon, exceeded by calyx lobes. **Seeds** light brown.

***Chinese Name.—***绛蒴白珠 jiang shuo bai zhu

***Images.—***Fritsch et al. 2016: fig. 1.

***Illustration.—***Fritsch et al. 2016: fig. 2.

***Phenology.—***Flowering June; fruiting June, August, September.

***Distribution and Elevation Range.—***China (Sichuan); 2500–3000 m.

***Discussion.—***Four sheets of the type collection of *Gaultheria marronina* were mounted and deposited at KUN and given separate barcode numbers, and these four sheets were not delimited in the protologue. We have lectotypified on KUN1248335 because it has more fruits than the other sheets.

See discussion under *Gaultheria bryoides* in the present treatment, and comments on *G. bryoides* in relation to *G. marronina* in Fritsch et al. (2016).

Additional specimens examined. **CHINA. Sichuan. Precise location uncertain:** Sikang Province, year 1931, *S.Y. Hu 2517* (KUN). **Dujiangyan City:** Kuailongzigou, Hongkou Village, 31°19'16"N, 103°35'50"E, 28 May 2012, *B. Xu & Y.D. Gao s.n.* (CAS, CDBI). **Hongya County:** Wawu Shan, 3000 m, 13 Aug 1930, *W.P. Fang 8213* (SZ); **Tianquan County:** Yazikou Pass, old state road from Tibet to Sichuan, above tunnel on Highway G318, summit ridge of Erlang Shan, 2918 m, 29.52797°N, 102.29208°E, 10 Jun 2015, *L. Lu & M.Y. Zhang LL-2015-01* (CAS, KUN). **Wenchuan County:** Sikang, Tsao-puh, 9500 ft., Jul 1942, *S.Y. Hu 2454* (A, KUN); Tsao-puh, 8000 ft, Aug 1942, *S.Y. Hu 2700* (A).

**14. Gaultheria minuta** Merr., Brittonia 4:152. 1941. TYPE: MYANMAR. Kachin. Putao District: Nogmung Township, Adung Valley, 12,500 ft, 28°20'N, 97°45'E, 25 Jun 1931, *F. Kingdon-Ward 9701* (HOLOTYPE: A00014989, photograph of A in K; ISOTYPE: BM000996565 n.v. (online image!)).

*Gaultheria sinensis* J. Anthony var. *layaensis* S.J. Rae & D.G. Long, Notes Roy. Bot. Gard. Edinburgh 45:334. 1989. TYPE: BHUTAN. Gasa District: Laya, Upper Mo Chu, 14,000 ft, 9 Jun 1949, *F. Ludlow, G. Sherriff & J.H. Hicks 16465* (HOLOTYPE: BM000839437; ISOTYPES: A00969476, E00225805).

**Stems** creeping or ascending-erect to 4 cm long. Current-year branchlets pale green and flushed red, to ca. 1.7 cm long, with dense white puberulence, with sparse basally ± straight ascending to nearly erect straight, curved, or undulate setae 0.50–1.25(–1.60) mm long, setae in cross section above base ± narrowly flattened tangentially to rounded. Internodes averaging ca. 0.5–3.0 mm. **Leaves:** petioles 0.3–1.4 mm long, without setae prevalent at base, abaxially glabrous, adaxially with sparse white puberulence, margin entire; blades ovate, suborbicular, or occasionally elliptic, 2.7–7.5 × 1.7–4.8 mm, 1.2–2.5 times as long as wide, coriaceous, planar or slightly cupped, abaxially glossy deep maroon except green near margin and lighter maroon on midvein, or glossy green throughout, glabrous, adaxially glossy green or dark green, glabrous except with white puberulence on midvein proximally, midvein abaxially raised, not thickened immediately below apical gland, adaxially impressed, secondary veins abaxially obscure or 1 to 3 faintly evident on each side of midvein, adaxially obscure or 1 or 2 faintly evident on each side of midvein, base subrounded to rounded, margin entire anywhere between first ca. 20–65% of length then serrulate distally, slightly revolute, apex acute to broadly obtuse or rounded, tip with planar or slightly abaxially directed apical gland, marginal teeth (setae) 3 to 8 per side, all teeth oriented off leaf surface (although often curved inward above surface), 0.5–0.8(–1.2) mm long. Overwintering flower bud pedicels 1.1–1.5 mm long, glabrous or with white puberulence; overwintering flower buds subglobose to compressed laterally, 1.5–2.1 × 1.1–2.0 mm, 1.3–1.4 times as long as wide, glabrous, bracteoles rounded to slightly keeled, margin eciliolate. **Flowers** 3.3–5.0 mm long. Calyx 2.3–3.7 mm long; lobes elongate-deltoid, 1.7–2.8 × 1.2–1.7 mm, adaxially glabrous, apex acute, eciliolate, smooth, the very tip blunt. Corolla pale pink to deep rose, campanulate, 2.3–4.5 × 2.2–5.3 mm; lobes ca. 1.8 × 1.8 mm. Stamens 10; filaments 0.8–1.0 mm long; anther body 0.3–0.8 mm long, awns 2 per theca, ca. 0.30–1.0 mm long, occasionally inner awn on each theca much shorter (ca. 0.1 mm long) than outer awn. Style 1.0–2.0 mm long. Fruiting pedicel 1.5–3.3 mm long. **Fruit:** calyx slightly oblate, subglobose to broadly turbinate, open, 6–8 × 7–9 mm,

outer wall light lavender or reportedly deep blue, inner wall white; lobes incurved, deltoid or long-deltoid, 3–4 mm long, apex eciliolate. Capsule green, exceeded by calyx lobes. **Seeds** light brown.

***Chinese Name.—***袖珍白珠 xiu zheng bai zhu

***Images.—***Fig. 11.

***Illustration.—***None known to us.

***Phenology.—***Flowering June, July; fruiting July, September, October.

***Distribution and Elevation Range.—***Bhutan, China (Xizang, Yunnan), India (Himachal Pradesh, Jammu and Kashmir [union territory]), Myanmar (Kachin), Nepal; 3563–4724(–4827?) m. This species occurs perhaps as high as 4827 m according to *S.K. Ghimire et al. s.n.*, but only a range of elevations is provided for the specimen, perhaps merely denoting the general range of elevations over the collections of the expedition and not this collection specifically.

***Discussion.—***Although the distribution of *Gaultheria minuta* spans a wide range from the western Himalaya to northwestern Yunnan, it is still represented by only a few collections. In describing *G. minuta*, Merrill (1941) stated that "I have not hesitated to characterize this very striking form, for I find nothing described in botanical literature that conforms to it." Merrill did not include a specific comparison of this species to others, but we consider the species as being most similar to *G. trichophylla*. The range of *G. minuta* is nested nearly completely with the range of *G. trichophylla*, and these species are the only two within *Gaultheria* ser. *Trichophyllae* from the western limit of the series in Pakistan east to Yadong County, China (Fig. 1). However, the substantially higher number of collections of *G. trichophylla* than of *G. minuta* suggests that *G. trichophylla* is much more common.

Perhaps in part because of its rarity, *Gaultheria minuta* has been confused with *G. trichophylla*, both in the literature (Fritsch et al. 2008) and collections, and they can be difficult to distinguish. An apparently reliable floral character that distinguishes them is the presence of two awns per anther theca in *G. minuta* (versus one). The three flowering specimens of *G. minuta* available to us, i.e., *F. Ludlow, G. Sherriff & J.H. Hicks 16465*, *E.F. Norton Exped. S. Tibet 172*, and *F. Kingdon-Ward 9701*, have two awns per anther theca. In contrast, *G. trichophylla* always has one awn per anther theca, although occasionally the awns can bifurcate at some point along the distal half of the awn. The protologue of *G. minuta* states that the anthers are minutely bicorniculate; however, we clearly observed two awns per anther theca on the type material that we have examined. More specimens should be collected in flower to confirm the reliability of this character for distinguishing the two species. The type of *G. sinensis* var. *layaensis* matches the type of *G. minuta* in all respects except that the leaves are somewhat smaller and green abaxially. The dark maroon abaxial leaf surfaces conspicuous on the type of *G. minuta* from the Adung Valley, Myanmar, and also in our collection from Yubeng Village, Yunnan (*L. Lu & P.W. Fritsch LL-2011-23*), also occur sporadically throughout the range of *G. trichophylla* and with variable depth of color. Thus dark maroon abaxial leaf surfaces are not reliable in distinguishing these two species. We have identified the collections *N. Parmanand 295 and O. Polunin 56/636* only tentatively as *G. trichophylla*, based on the presence of one awn per theca. These specimens have stem setae that are not notably clustered at the base of petiole as would be expected in *G. trichophylla*. They both have glabrous leaf blades abaxially (i.e., they lack setae), a character that is consistent in *G. minuta* but variable in *G. trichophylla* and therefore not diagnostic.

The collection of *Gaultheria minuta* from Yubeng Village, Deqin County, Yunnan (*L. Lu & P.W. Fritsch LL-2011-23*) was found growing with another population that is close morphologically to both *G. tetracme* and *G. trichophylla* (*L. Lu & P.W. Fritsch LL-2011-22*). However, the former is easily distinguished from the latter by several distinctive features, e.g., leaf blades ovate and dark maroon beneath (versus elliptic and green beneath) and a fruiting calyx that is open and light lavender (versus closed and vivid blue). Samples from both of these were included in a phylogenetic analysis based on whole plastid genomes (Zhang et al. 2017). The results placed the green-leaved sample from Yubeng as sister to a sample of *G. tetracme* from Luding County in Sichuan with strong support, and these two grouped with the sample of *G. minuta* from Yubeng, also with strong support. A phylogenetic analysis based on four plastid genes (P.W. Fritsch & L. Lu, unpubl. data) shows that two other samples of *G. trichophylla*, one from Cang Shan, Yunnan, the other from Gaoligong Shan,


Fig. 11. *Gaultheria minuta*. **A.** Habit (small dark green leaves) with single fruit center left. **B.** Branchlets with leaves in adaxial view. **C.** Branchlet with leaves in abaxial view. **D.** Fruit, oblique-lateral view. **E.** Fruit, apical view. [Photos by P.W.F.; A–E, *L. Lu LL-2011-23*.]

Yunnan, group together but well away from this clade with strong support. These phylogenetic analyses together support the species distinction of *G. minuta* from both *G. tetracme* and *G. trichophylla*. Nonetheless, *G. minuta* is still not well characterized both morphologically and molecularly, and more study of populations will be needed to confirm the distinctness of this species, especially relative to *G. trichophylla*.

We observed a light lavender fruiting calyx in the Yubeng population; it is unclear whether this color of the fruiting calyx is consistent throughout the species. On the holotype, collected on 25 June 1931, F.

Kingdon-Ward wrote a note on 2 July 1931: "Berries large, deep blue, ripening now." Like Merrill (1941), we could not locate material of *Gaultheria* ser. *Trichophyllae* collected by Kingdon-Ward on this date, and we agree with Merrill that the note may or may not apply to *G. minuta* because of the frequency with which multiple species of *Gaultheria* ser. *Trichophyllae* grow together. The label of *F. Ludlow et al. 6348* describes the fruiting calyx as a "pale slaty blue;" the label of *R.E. Cooper 5675* describes it as blue.

We have not been able to examine the type of *Gaultheria trichophylla* Royle var. *ovata* S. Panda & Sanjappa. Although we have placed this taxon in synonymy under *G. trichophylla* as an ovate-leaved variant without formal recognition, more study may justify the formal recognition of this variety (see discussion under *G. trichophylla*). However, the variety is too poorly characterized in the protologue for us to confidently exclude it from *G. minuta*, and it may well be *G. minuta* instead of *G. trichophylla*.

See also discussion under *Gaultheria tetracme* and *G. trichophylla*, and discussion in Fritsch et al. (2017).

Additional specimens examined. **CHINA. Xizang: Tingri County:** N Samchung La (Kharta), 15,500 ft, 20 Jun 1922, *E.F. Norton Exped. S. Tibet 172* (K). **Zayü County:** Tsari Province, Bimbi La, 12,000 ft, 28°50'N, 93°28'E, 15 Oct 1938, *F. Ludlow et al. 6348* (E). **Yunnan. Deqin County:** E slope of Meili Xue Shan, above 1991 Sino-Japanese Base Camp, W of Upper Yubeng Village, 3563 m, 28.39948°N, 98.76363°E, 10 Sep 2011, *L. Lu & P.W. Fritsch LL-2011-23* (CAS, KUN). **INDIA**. **Himachal Pradesh:** Pan Jache Kulu, 14,000 ft, 11 Jul 1916, *R.E. Cooper 5128* (E [2]). Sorang Kulu, 13,000 ft, 23 Sep 1916, *R.E. Cooper 5675* (E [2]). **Jammu and Kashmir (union territory):** Mantnar Nullah, Bringhi Valley, 13,000 ft, 4 Sep 1940, *F. Ludlow & G. Sherriff 8053* (E). **NEPAL. Taplejung District:** Mechi Zone, Kachenjunga Conservation Area, near Ghunsa Village, Summit: GLORIA sites NP-KCJ-SMA, 3884–4827 m, 27°39'57"–27°41'05"N, 87°53'28"–87°53'56"E, 1–7 Sep 2010, *S.K. Ghimire et al. TUCH-MO KCJ 108* (MO).

**15. Gaultheria nivea** (J. Anthony) Airy Shaw, Bull. Misc. Inform. Kew 1940:326. 1941. Basionym: *Gaultheria sinensis* var. *nivea* J. Anthony, Notes Roy. Bot. Gard. Edinburgh 18:20. 1933. Type: CHINA. Xizang. Zayü County: Tsarong, Salwin-Kiu Chiang divide, 28°40'N, 98°15'E, Jul 1919, *G. Forrest 19269* (holotype: E00169465; isotypes: A00115072, K000227997).

**Stems** erect to 10 cm long. Current-year branchlets green or flushed red, with dense white puberulence, without or with basally uncinate and more distally ascending straight to slightly undulate setae 0.40–0.62 mm long, setae in cross section above base ± narrowly flattened tangentially to rounded. Internodes averaging ca. 0.6–1.7 mm. **Leaves:** petioles 0.4–1.0 mm long, abaxially glabrous, adaxially with white puberulence, margin entire; blades elliptic, 5.5–8.0 × 1.8–3.0 mm, 2.1–3.5 times as long as wide, coriaceous, planar, abaxially dull light green to light brown except glossy and occasionally flushed maroon near margin, glabrous, adaxially glossy green or brown, glabrous except with white puberulence on midvein proximally, midvein abaxially raised, not thickened immediately below apical gland, adaxially impressed, secondary veins obscure on both sides, base cuneate to subcuneate, margin serrulate throughout or entire anywhere up to first ca. 40% of length then serrulate distally, planar or slightly revolute, apex acute to obtuse, tip with planar or slightly abaxially directed apical gland, marginal teeth (setae) 5 to 11 per side, all oriented off leaf surface, 0.10–0.18 mm long. Overwintering flower bud pedicels 1.2–2.0 mm long, glabrous; overwintering flower buds subglobose, 1.2–1.5 × 1.0–1.4 mm, 1.0–1.2 times as long as wide, glabrous, bracteoles rounded, margin eciliolate. **Flowers** 3.0–3.6 mm long. Calyx 2.1–3.0 mm long; lobes ovate-deltoid, 1.6–2.7 × 1.3–1.8 mm, adaxially glabrous, apex acuminate, eciliolate, smooth, the very tip sharp. Corolla white, campanulate, 2.9–3.6 × 3.0–5.5 mm; lobes 1.2–1.5 × 1.4–2.3 mm. Stamens 10; filaments 0.8–0.9 mm long; anther body ca. 0.8 mm long, awns 2 per theca, 0.4–0.7 mm long. Style ca. 1.5 mm long. Fruiting pedicel ca. 3.5 mm long. **Fruit:** calyx oblate, widely turbinate, closed or nearly so, 8–14 × 9–13 mm, outer and inner wall white; lobes incurved to erect, elongate-deltoid, 5–7 mm long, apex eciliolate. Capsule green, exceeded by calyx lobes. **Seeds** tawny to tawny brown.

***Chinese Name.—***白果华白珠 bai guo hua bai zhu

***Images.—***Fig. 1(E–H).

***Illustration.—***Fig. 12.

***Phenology.—***Flowering July; fruiting August, September.

***Distribution and Elevation Range.—***China (Xizang, Yunnan); 3500–3962 m.

***Discussion.—***Two samples identified as *Gaultheria nivea* were included in a phylogenetic study based on whole plastid genomes (Zhang et al. 2017). The results of that study placed *G. nivea* sample "a" (*L. Lu et al.*

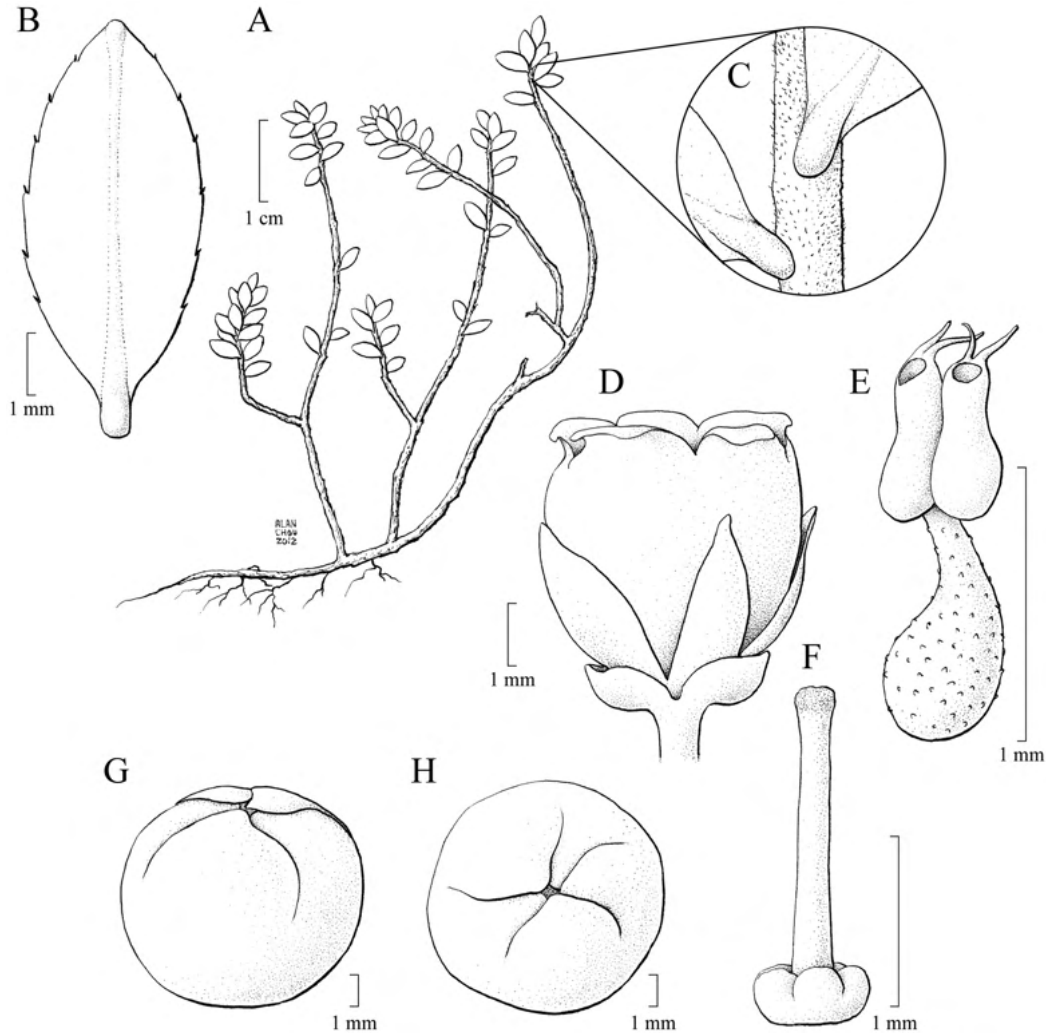


Fig. 12. *Gaultheria nivea*. **A.** Whole plant. **B.** Leaf in abaxial view. **C.** Section of branchlet showing stem puberulence and leaf bases in abaxial view. **D.** Flower. **E.** Stamen. **F.** Gynoecium. **G.** Fruit, lateral view. **H.** Fruit, apical view. [A–F drawn from the holotype *G. Forrest 19269* (E); G, H drawn from *G. Forrest 13310* (E).]

*LL-2013-16*) as sister to a clade of *G. thymifolia* and *G. nivea* sample "b" (*L. Lu et al. LL-2013-56*) with strong support, suggesting that *G. nivea* is paraphyletic. However, in reviewing the specimens for the present study, we realized that *G. nivea* sample "a" (*L. Lu et al. LL-2013-16*) is actually a specimen of *G. thymifolia*, suggesting instead that *G. thymifolia* is paraphyletic.

See also discussion under *Gaultheria cardiosepala*.

Additional specimens examined. **CHINA. Yunnan. Deqin County:** Cizhong Village, 3500–3700 m, 6 Jul 1940, *K.M. Feng 5161* (KUN, PE n.v. (online image!)); Yanmen Township, Biluo Xue Shan, E slope just below Sila Pass, 3503 m, 28°00'4.4"N, 98°49'1.6"E, 24 Sep 2013, *L. Lu LL-2013-56* (CAS, KUN [2]). **Gongshan County:** Bingzhongluo Township, Mekong-Salwin divide, 13,000 ft, 28°10'N, Sep 1914, *G. Forrest 13310* (E, K); Bingzhongluo Township, ca. 3 direct km SSW of Gawagapu Mtn. and ca. 16 direct km WSW of Bingzhongluo in the basin E of Chukuai Lake, E side of Gaoligong Shan, 3770 m, 29 Aug 2006, *Gaoligong Shan Biodiversity Survey 31581* (CAS, KUN).

**16. Gaultheria obovata** (Airy Shaw) P.W. Fritsch & Lu Lu, Phytotaxa 201(1):17. 2015. Basionym: *Gaultheria trichophylla* Royle var. *obovata* Airy Shaw, Bull. Misc. Inform. Kew 1940:324. 1941. Type: MYANMAR. Kachin. Myitkyina District: Waingmaw Township, Upper Burma, Seinghku Wang, 11,000 ft, 28°08'N, 97°24'E, 17 Jun 1926, *F. Kingdon-Ward 6944* (holotype: K000227987).

**Stems** prostrate-ascending to 8 cm long. Current-year branchlets pale green, strongly flushed red, to 4 cm long, without or with sparse white puberulence, with basally ± straight and more distally appressed to nearly erect straight, curved, or slightly undulate setae 0.7–1.2 mm long, setae in cross section above base ± narrowly flattened tangentially to rounded. Internodes averaging ca. 1.7–3.2 mm. **Leaves:** petioles 0.6–1.3 mm long, abaxially glabrous or with sparse ascending to nearly erect setae, adaxially with sparse white puberulence, margin entire; blades broadly elliptic to slightly obovate, 6.2–12.0 × 3.5–6.2 mm, 1.4–2.2 times as long as wide, subcoriaceous, planar, abaxially dull whitish green except glossy and occasionally flushed maroon near margin, at least some leaves with 1 to 9 (to 22) ascending to nearly erect setae scattered on midvein or rarely also on surface but near midvein (setae 0.64–1.10 mm long) or rarely glabrous, adaxially glossy deep green, glabrous except with white puberulence on midvein proximally, midvein abaxially raised, not thickened immediately below apical gland, adaxially impressed, secondary veins obscure or 1 to 4 on each side of midvein on both sides, base broadly cuneate to subrounded, margin serrulate throughout or entire anywhere up to first ca. 70% of length then serrulate distally, planar or slightly revolute, apex obtuse to rounded, tip with planar apical gland, marginal teeth (setae) 8 to 14 per side, all oriented off leaf surface, 0.7–1.3 mm long. Overwintering flower bud pedicels 1.7–3.8 mm long, glabrous; overwintering flower buds slightly compressed laterally to subglobose, 1.0–2.1 × 0.8–2.0 mm, 0.9–1.3 times as long as wide, glabrous, bracteoles rounded, margin eciliolate. **Flowers** ca. 5 mm long. Calyx green proximally with lobes green flushed pale pink, 2.7–4.2 mm long; lobes broadly deltoid, 1.2–2.0 × 1.4–2.1 mm, adaxially glabrous, apex obtuse, eciliolate, slightly erose, the very tip blunt. Corolla white, campanulate, 3.0–4.0 × 3.0–5.3 mm; lobes 0.9–2.4 × 0.9–2.0 mm. Stamens 10; filaments 0.8–1.0 mm long; anther body 0.4–0.6 mm long, awns 2 per theca, 0.1–0.3 mm long. Style 1.0–1.7 mm long; stigma pink. Fruiting pedicel 2.0–4.1 mm long. **Fruit:** calyx oblate, crateriform to cupuliform, widely open, 4.5–10.0 × 6.0–12.0 mm, outer wall deep sky blue, inner wall white; lobes erect to slightly incurved, broadly deltoid, 2.8–5.0 mm long, apex eciliolate. Capsule green, exceeded by calyx lobes. **Seeds** light tawny brown.

***Chinese Name.—***倒卵叶白珠 dao luan ye bai zhu

***Images.—***Fritsch et al. 2015b: fig. 6(K–N).

***Illustration.—***Fritsch et al. 2015b: fig. 9.

***Phenology.—***Flowering June, September; fruiting July–September.

***Distribution and Elevation Range.—***China (Sichuan, Xizang, Yunnan), Myanmar (Kachin); 3200–4572 m.

***Discussion.—***From phylogenetic analysis based on whole plastid genomes (Zhang et al. 2017), *Gaultheria obovata* groups as sister to *G. sinensis*, with strong support.

See also comments under *Gaultheria obovata* in Fritsch et al. (2015b).

Additional specimens examined. **CHINA. Xizang. Bomi County:** Linzhi Prefecture, road from Bomê to Mêdog, Galongla Pass, 4280 m, 29°45'22"N, 95°42'18"E, 25 Sep 2009, *H. Sun et al. SunH-07ZX-2664 p.p.* (KUN mixed with *G. eciliata* and *G.* cf. *sinensis*). **Gongbujiangda County:** Nambu La, 14,800 ft, 24 Sep 1947, *F. Ludlow et al. 15775* (E). **Markam County:** Sikang Province, Hi-ma-la, Tsa-wa-rung, 3400 m, Aug 1935, *C.W. Wang 65593* (A). **Motuo County:** Duoxiongla, trail to Lage, 3500–3700 m, 29°29'N, 94°55'E, 24 Jul 2007, *L. Lu LL-07155* (CAS, KUN); Pailong Village, trail from Linzhi to Pailong, 3700 m, 7 Aug 2007, *L. Lu LL-07308* (CAS). **Zuogong County:** Pi-tu La, 14,000–15,000 ft, 7 Sep 1922, *F. Kingdon-Ward 5389* (E). **Yunnan. Deqin County:** Meili Snow Mtns., Yubeng Village, trail to Dabenying, 3600–3800 m, Aug 2007, *L. Lu LL-07400* (CAS, KUN); E slope of Meili Xue Shan, just below 1991 Sino-Japanese Base Camp at river, W of Upper Yubeng Village, 3563 m, 28.39948°N, 98.76363°E, 10 Sep 2011, *L. Lu & P.W. Fritsch LL-2011-21* (CAS, GH, KUN); Melixueshan (Meili Snow Mtns.), foot trail from Yubeng Village to Xiaonong (sacred meadow), W of Xiaonong, 3800–3900 m, 28°23'56"N, 98°45'09"E, 23 Jul 2001, *H.H. Schmidt et al. 4097* (CAS, GH, MO); Tehching (Atuntze), atunze, 3200 m, 22 Jun 1937, *T.T. Yü 8702* (KUN); Zhashibugong, 4100 m, 6 Nov 1937, *T.T. Yü 10642* (KUN [2]). **Gongshan County:** Bangdang Township, Biluo Xue Shan, Balagong spur, trail from Dimaluo to Balagong Pass, 3599 m, 27°57'49.8"N, 98°44'26.4"E, 23 Sep 2013, *L. Lu LL-2013-41* (CAS mixed with *G. ciliisepala*, GH, KUN [2]); Bangdang Township, Biluo Xue Shan, vicinity of Sila Pass, 3912 m, 27°59'46.0"N, 98°47'23.4"E, 24 Sep 2013, *L. Lu LL-2013-49* (CAS, GH, KUN [2]); Dulongjiang Township, Upper Kiukiang Valley, (Clulung) Chialahmuto, 3600–4000 m, 7 Aug 1938, *T.T. Yü 19732* (A, E, KUN). **MYANMAR.**

**Kachin. Putao District:** Nogmung Township, Adung Valley, 12,000–13,000 ft, 15 Jun 1931, *F. Kingdon-Ward 9639 p.p.* (A; mixed with *G. thymifolia*).

**17. Gaultheria sinensis** J. Anthony, Notes Roy. Bot. Gard. Edinburgh 18:19. 1933. TYPE: CHINA. Yunnan. Deqin County: Tsarong, SE Tibet, Ka-gwr-pu, Mekong-Salwin divide, 12,000 ft, 28°25'N, Jul 1917, *G. Forrest 14216 p.p.* (LECTOTYPE, designated by Fritsch et al. 2015b: E00029787 (upper plant of two on sheet); ISOLECTOTYPE: K000227994).

**Stems** prostrate-ascending to 10 cm long. Current-year branchlets pale green, strongly flushed red above, occasionally brown proximally, to 4 cm long, without or with sparse white puberulence, with basally uncinate and more distally ascending straight or slightly curved setae 0.26–0.48 mm long, setae in cross section above base ± narrowly flattened tangentially to rounded. Internodes averaging ca. 0.8–2.5 mm. **Leaves:** petioles 0.3–1.0 mm long, abaxially glabrous or with sparse appressed or ascending setae, adaxially with white puberulence, margin entire or 1- to 2-toothed (-setose) per side; blades broadly to narrowly elliptic, obovate, or oblanceolate, shorter leaves often rounder, 4.5–10.7 × 2.9–4.9 mm, 1.5–2.7 times as long as wide, subcoriaceous or coriaceous, planar or some blades cupped, abaxially dull whitish green except glossy and occasionally flushed maroon near margin, abaxially glabrous or at least some leaves with 1 to 11 appressed to ascending setae scattered on midvein (setae 0.34–0.50 mm long), adaxially glossy green, glabrous except with white puberulence on midvein proximally, midvein abaxially raised, not thickened immediately below apical gland, adaxially impressed, secondary veins obscure or 1 to 4 faintly evident on each side of midvein on both sides, base cuneate to subrounded, margin serrulate throughout or entire anywhere up to first ca. 15% of length then serrulate distally, planar or slightly revolute, occasionally more strongly so proximally, apex acute to subrounded, tip of at least some leaves with slightly abaxially directed apical gland, other leaf tips with planar gland, marginal teeth (setae) 6 to 12 per side, all oriented off leaf surface or in at least some leaves lying atop or adjacent to upper leaf surface, 0.1–0.4 mm long. Overwintering flower bud pedicels 2.2–5.0 mm long, glabrous; overwintering flower buds slightly compressed laterally to subglobose, 1.7–3.0 × 1.5–2.8 mm, 0.9–1.6 times as long as wide, glabrous, bracteoles rounded, margin eciliolate. **Flowers** 4.1–5.5 mm long. Calyx dull pink to pale maroon, occasionally green proximally, 2.5–3.5 mm long; lobes deltoid or ovate-deltoid, 1.3–2.7 × 1.6–2.5 mm, adaxially glabrous, apex acute or short-acuminate, eciliolate, slightly erose or smooth, the very tip blunt. Corolla white or white flushed dull purplish pink, campanulate, 3.6–4.5 × 3.3–6.0 mm; lobes 1.0–3.0 × 1.2–2.5 mm. Stamens 10; filaments 0.8–1.6 mm long; anther body 0.6–0.8 mm long, awns 2 per theca, 0.2–0.4 mm long. Style 0.7–2.2 mm long; stigma pink. Fruiting pedicel 2.8–5.0 mm long. **Fruit:** calyx oblate, crateriform to broadly cupuliform, open, 5–10 × 7–15 mm, outer wall deep sky blue or rarely dark blue, inner wall white; lobes erect, broadly deltoid, 3–4 mm long, apex eciliolate. Capsule green, exceeded by or often equal to or exceeding calyx lobes. **Seeds** light brown.

***Chinese Name.—***华白珠 hua bai zhu

***Images.—***Fritsch et al. 2015b: fig. 8(A–F).

***Illustration.—***Fritsch et al. 2015b: fig. 10.

***Phenology.—***Flowering June–September; fruiting April, July–October.

***Distribution and Elevation Range.—***China (Sichuan, Xizang, Yunnan), China (South Tibet [India, Arunachal Pradesh]), Myanmar (Kachin); 2870–4400 m.

***Discussion.—****Gaultheria sinensis* is a widespread and common species. From our observations it occurs more often as individual plants or populations with a low number of scattered individuals than other species. It is one of the few species that is variable in the presence or consistent absence of setae on the leaf blade midvein abaxially among collections.

Some specimens of *Gaultheria sinensis* exhibit atypically smaller and thinner leaves, e.g., *Gaoligong Shan Biodiversity Survey 27113A* from Fugong County, Yunnan. Among the collections of the species from Duoxiongla, Motuo County, some exhibit features typical of the species (*L. Lu LL-07130* and *L. Lu LL-07133*), whereas in others (*L. Lu LL-07128* and *L. Lu LL-07134*), some individuals on the sheets have smaller and more delicate leaves and the fruits are smaller than normal. In a photograph taken in situ of one of these individuals, the fruit is dark blue instead of the typical sky blue of *G. sinensis*. The flowers of these smaller plants have not

been documented. The taxonomic significance of these differences, if any, remain unclear, and further investigation with morphological and molecular data is warranted.

See also comments under *Gaultheria major and G. obovata*, and, in Fritsch et al. (2015b), comments under *G. obovata* and *G. sinensis*.

Additional specimens examined. **CHINA. Sichuan. Li County:** Li-Fan, Tsa-kuh-nao [Za Gu Nao], Aug 1942, *S.Y. Hu 2718* (A). **Wenchuan County:** Tsao-puh, 12,000 ft, 7 Aug 1942, *S.Y. Hu 2672* (A). **Xizang. Bomi County:** Vicinity of Galong Pass, 23 Aug 1983, *S.Z. Chen & B.S. Li 7026* (KUN). **Gongbujiangda County:** Lusha Chu, 12,500 ft, 10 Jun 1938, *F. Ludlow et al. 4750* (A, E); Doshang La, 13,000 ft, 17 Jul 1938, *F. Ludlow et al. 5293* (A, E); above Showa Dzong, 11,000 ft, 11 Jun 1947, *F. Ludlow et al. 13146* (E). **Motuo County:** Gedang, Bengbeng Mtn., S side, 4000–4400 m, 9 Oct 1982, *B.S. Li & S.Z. Chen 01185* (KUN); Duoxiongla Mtn., N slope, 4000 m, 13 Jul 1983, *B.S. Li & S.Z. Chen 05484* (KUN); Duoxiongla, trail to Lage, 3200–3750 m, 29°29'N, 94°55'E, 24 Jul 2007, *L. Lu LL-07128* (CAS); ibid., *L. Lu LL-07130* (CAS); ibid., *L. Lu LL-07133* (CAS, GH, KUN [2]); ibid., *L. Lu LL-07134 p.p.* (CAS1158101, KUN, CAS102632 mixed with *G. stenophylla*); Duoxiongla Pass, 3700 m, 30 Jul 1974, *Qinghai-Xizang Expedition 74-3770* (KUN [2], PE [2] n.v. (online images!)). **Zayü County:** Deyang La, 13,000 ft, 6 Jun 1947, *F. Ludlow & G. Sherriff 15158* (A, E [2]); Ri Dong Qu, 4100 m, 9 Sep 1982, *Qinghai-Xizang Expedition 10228* (KUN, PE n.v. (online image!)). **Bomi or Motuo County:** Jingzhula Mtn. Pass, W side, 3800–4300 m, 5 Sep 1982, *B.S. Li & S.Z. Chen 00701* (KUN). **Yunnan. Deqin County:** Yanmen Township, Mekong-Salwin divide, near Cizhong, Sila, 3800 m, 12 Jul 1940, *K.M. Feng 5333* (KUN [2]); Salwin-Mekong divide, mtns. behind Yongzi Village, 3700–3800 m, 16 Aug 1940, *K.M. Feng 6724* (KUN mixed with *G. major*); Yanmen Township, Biluo Xue Shan, E slope just below Sila Pass, 3936 m, 28°00'8.5"N, 98°47'54.8"E, 24 Sep 2013, *L. Lu LL-2013-52* (CAS, GH, KUN [2]). **Fugong County:** Lumadeng Xiang, Yaping Cun, S of Yaping Yakou in a cirque with a small lake in the bottom, just below the border with Myanmar, E side of Gaoligong Shan, 3620–3710 m, 27°12'22"N, 98°41'53"E, 12 Aug 2005, *Gaoligong Shan Biodiversity Survey 27113* (KUN), *27113A* (GH; possibly *Potentilla* on some duplicate sheets of *27113*). Lishadi Township, Yaduo Cun, along trail between road to Myanmar through Yaping Pass and border marker S of pass, E side of Gaoligong Shan, 3699 m, 27°12'17.5"N, 98°41'45.0"E, 2 Jul 2014, *L. Lu LL-2014-28* (CAS, KUN). **Gongshan County:** Binzhongluo Township, Champutong, 3500–3700 m, 10 Sep 1940, *K.M. Feng 7675 p.p.* (KUN mixed with *G. eciliata*); Dulongjiang Xiang, E side of pass of road from Gongshan to Kongdang, W side of Gaoligong Shan near crest of range, 3670 m, 27°46'18"N, 98°27'02"E, 5 Oct 2002, *Gaoligong Shan Biodiversity Survey 17007 p.p.* (CAS, KUN, both mixed with *G. hypochlora*); Bingzhongluo Xiang, ca. 3 direct km SSW of Gawagapu Mtn. and ca. 16 direct km WSW of Bingzhongluo in next basin E of Chukuai Lake, E side of Gaoligong Shan, 3770 m, 27°59'2.1"N, 98°28'13.6"E, 29 Aug 2006, *Gaoligong Shan Biodiversity Survey 31589* (CAS, KUN); Cikai Zheng, ca. 1.2 direct km SSE of Heipu Pass tunnel on new road from Gongshan to Dulongjiang Valley, E side of Gaoligong Shan, 3350 m, 27°45'41.7"N, 98°27'2.3"E, 13 Aug 2006, *Gaoligong Shan Biodiversity Survey 32150* (CAS mixed with *G. stenophylla*); ibid., *Gaoligong Shan Biodiversity Survey 32170* (CAS, KUN); Bingzhongluo Township, ca. 2.1 direct km S of Gawagapu Mtn. and ca. 15.2 direct km WSW of Bingzhongluo in next basin E of Chukuai Lake, E side of Gaoligong Shan, 4000 m, 27°59'29.3"N, 98°28'36.3"E, 28 Aug 2006, *Gaoligong Shan Biodiversity Survey 32809 p.p.* (CAS, KUN both mixed with *G. major*); Cikai Township, Dongshaofang Pass, Gaoligongshan, 3200–3500 m, 4 Jun 2006, *L. Lu 06-0014 p.p.* (CAS, GH, KUN, all mixed variously with *G. ciliisepala, G. major*, and *G. stenophylla*); Cikai Township, Gaoligong Shan, vicinity of tunnel at Heipu Pass along road from Gongshan to Dulongjiang, 3400 m, 27°46'42.4"N, 98°27'29.4"E, 13 Sep 2013, *L. Lu LL-2013-14* (CAS, GH, KUN [2]); Bangdang Xiang, Biluo Xue Shan, Balagong spur, trail from Balagong Pass to Siwanongba Valley, 3659 m, 27°58'35.3"N, 98°46'3.4"E, 23 Sep 2013, *L. Lu LL-2013-45* (CAS, KUN); Cikai Township, Gongshan to Dulongjiang, E slope of Gaoligong Shan, 3600 m, 26 Jul 1982, *Qinghai-Xizang Expedition 8726* (KUN [2]); Binzhongluo Township, Lung-pan-la Champutung, 3000 m, Oct 1935, *C.W. Wang 67099* (A, KUN, PE n.v. (online image!)). **Heqing County:** Xintun, Dafudi, 2870 m, 5 Sep 1984, *J.H. Yang 360* (KUN). **Luquan County:** Wumeng Mtn., Daheiqin, 3650 m, 26 May 1952, *P.Y. Mao 1026* (KUN [2]). **CHINA. South Tibet [INDIA. Arunachal Pradesh]:** Delei Valley, 11,000–12,000 ft, 28°15'N, 96°35'E, 28 Aug 1928, *F. Kingdon-Ward 8605* (K). **MYANMAR. Kachin. Myitkyina District:** Waingmaw Township, Seinghku Wang, 13,000 ft, 28°08'N, 97°24'E, 10 Jul 1926, *F. Kingdon-Ward 7094* (K).

**18. Gaultheria stenophylla** P.W. Fritsch & Lu Lu, Phytotaxa 201(1):22. 2015. TYPE: CHINA. Yunnan. Gongshan County: Cikai Township, Gaoligong Shan, vicinity of tunnel at Heipu Pass along road from Gongshan to Dulongjiang, 3400 m, 27°46'42.4"N, 98°27'29.4"E, 13 Sep 2013, *L. Lu LL-2013-7* (LECTOTYPE, here designated: KUN1248926; ISOLECTOTYPES: CAS435518, GH01155236, KUN1248938).

**Stems** ascending-erect or sometimes slightly pendent to 15 cm long. Current-year branchlets pale green, occasionally flushed red, to 7 cm long, with sparse white puberulence, with basally uncinate and more distally appressed or ascending straight or slightly curved setae 0.28–0.74 mm long, setae in cross section above base ± narrowly flattened to rounded tangentially. Internodes averaging ca. 1.3–5.0 mm. **Leaves:** petioles 0.4–1.2 mm long, abaxially glabrous or with sparse appressed setae, adaxially with white puberulence, margin often entire but on at least some leaves 1- or 2-toothed (-setose) per side; blades narrowly elliptic to slightly oblanceolate, shorter leaf blades often relatively broader, (6.2–)7.0–14.0(–17.0) × 2.4–5.0(–5.5) mm, 2.0–3.4 times as long as wide, subcoriaceous to occasionally coriaceous, planar, abaxially dull whitish green except glossy green and often flushed maroon near margin, at least some leaves with 1 to 35 appressed setae scattered on or usually near midvein (setae 0.18–0.40 mm long), adaxially glossy deep green, glabrous except with white puberulence

on midvein proximally, midvein abaxially raised, not thickened to slightly thickened immediately below apical gland, adaxially impressed, secondary veins abaxially obscure or 2 or 3 on each side of midvein, adaxially obscure, base cuneate to subrounded, margin serrulate throughout or entire anywhere up to first ca. 20% of length then serrulate distally, slightly to strongly revolute, apex acute to subrounded, tip with planar or occasionally abaxially directed apical gland, marginal teeth (setae) 8 to 15 per side, all oriented off leaf surface, 0.12–0.28 mm long. Overwintering flower bud pedicels 0.8–2.2(–3.7) mm long, glabrous or with white puberulence and/or minute setae proximally; overwintering flower buds compressed laterally, 2.0–3.6 × 1.1–2.1 mm, 1.4–1.9 times as long as wide, glabrous, bracteoles keeled, margin eciliolate or often sparsely ciliolate at apex. **Flowers** 5.0–7.0 mm long. Calyx green, 3.7–4.5 mm long; lobes narrowly ovate-deltoid, 2.0–3.2 × 1.5–2.4 mm, adaxially (and rarely abaxially at apex) puberulent, apex blunt-acute, ciliolate, smooth, the very tip blunt. Corolla white, campanulate, 4.0–6.5 × 4.5–9.0 mm; lobes 2.2–4.0 × 2.0–2.9 mm. Stamens 10; filaments 0.9–1.5 mm long; anther body 0.7–1.1 mm, awns (1) or 2 per theca, 0.3–0.7 mm long. Style 1.8–3.5 mm long; stigma pink. Fruiting pedicel 1.7–7.2 mm long. **Fruit:** calyx prolate, usually ellipsoid or long-cupuliform, occasionally cupuliform, open but not widely so and sometimes nearly closed, 8–16 × 10–14 mm, outer wall dark blue or occasionally light sky blue or pure white, inner wall white; lobes erect to incurved, long-deltoid, 4–7 mm long, apex sparsely ciliolate. Capsule green, exceeded by calyx lobes. **Seeds** brown.

***Chinese Name.—***狭叶白珠 xia ye bai zhu

***Images.—***Fritsch et al. 2015b: fig. 8(G–N).

***Illustration.—***Fritsch et al. 2015b: fig. 11.

***Phenology.—***Flowering May–July; fruiting June–October.

***Distribution and Elevation Range.—***Bhutan, China (Xizang, Yunnan), China (South Tibet [India, Arunachal Pradesh]), India (Sikkim); 2400–3750 m.

***Discussion.—***For distinguishing this species from other species of the series with ciliolate calyx lobe margins and for phylogenetic relationships, see discussion under *Gaultheria ciliisepala* and Table 2. See also comments under *G. stenophylla* in Fritsch et al. (2015b).

Two sheets of the type collection of *Gaultheria stenophylla* were mounted and deposited at KUN and given separate barcodes, and these two sheets were not delimited in the protologue. We have lectotypified on KUN1248926 because it has more fruit mounted on the sheet than KUN1248938.

Additional specimens examined. **BHUTAN. Bumthang:** Rudo La (E side), 10,500–12,000 ft, 18 May 1949, *F. Ludlow et al. 18885* (E). **Trashiyangtse:** Lao, Trashiyangsi Chu, 9500 ft, 10 May 1949, *F. Ludlow et al. 20617A* (E). **CHINA. Xizang. Motuo County:** Duoxiongla, trail to Lage, 3200–3400 m, 29°29'N, 94°55'E, 24 Jul 2007, *L. Lu LL-07118* (CAS, KUN); ibid., *L. Lu LL-07119* (CAS, GH, KUN); ibid., *L. Lu LL-07122* (KUN); ibid., *L. Lu LL-07134 p.p.* (CAS102632 mixed with *G. sinensis*); Lage, 3250 m, 31 Jul 1974, *Qinghai-Xizang Expedition 74-3778* (KUN [2], PE [2] n.v. (online images!)); Lage, Duoxiongla Shan, 3300 m, 25 Oct 1992, *H. Sun, Z.K. Zhou, H.Y. Yü Expedition to Mêdog 0623* (KUN). **Yunnan. Fugong County:** Lishadi Township, Yaduo Cun, above Shibali to Myanmar border at Yaping Yakou, N side of N fork of Yamu He, E side of Gaoligong Shan, 2750 m, 27°10'23"N, 98°46'03"E, 10 Aug 2005, *Gaoligong Shan Biodiversity Survey 26921* (CAS, KUN). **Gongshan County:** Cikai Township, road from Gongshan to Kongdang, E side of Gaoligong Shan, 3340 m, 27°46'50"N, 98°28'06"E, 1 Oct 2002, *Gaoligong Shan Biodiversity Survey 16817* (CAS, KUN); Cikai Township, N of road from Gongshan to Kongdang, E side of Gaoligong Shan, u-shaped valley draining into upper reaches of Pula He, 3350 m, 27°47'04"N, 98°27'38"E, 3 Oct 2002, *Gaoligong Shan Biodiversity Survey 16918* (CAS, KUN [3]); ibid., 3429 m, 27°47'35"N, 98°27'57"E, 3 Oct 2002, *Gaoligong Shan Biodiversity Survey 16950 p.p.* (CAS, KUN [2], all mixed with *G. hypochlora*); Cikai Township, E side of Gaoligong Shan at Km 48, road from Gongshan to Kongdang, 3330 m, 27°47'04"N, 98°27'40"E, 11 Nov 2004, *Gaoligong Shan Biodiversity Survey 22409* (CAS, KUN); ibid., *Gaoligong Shan Biodiversity Survey 23018* (CAS, KUN); Cikai Township, Heipu Pass, road from Gongshan to Dulongjiang Valley, E side of Gaoligong Shan, 3490 m, 27°46'19.6"N, 98°26'47.6"E, 12 Aug 2006, *Gaoligong Shan Biodiversity Survey 32036* (BRIT, CAS, GH, KUN); ibid., *Gaoligong Shan Biodiversity Survey 32053* (CAS, KUN); ibid., *Gaoligong Shan Biodiversity Survey 32060* (CAS, KUN); Cikai Township, ca. 1.2 direct km SSE of Heipu Pass tunnel on new road from Gongshan to Dulongjiang Valley, E side of Gaoligong Shan, 3350 m, 27°45'41.7"N, 98°27'2.3"E, 13 Aug 2006, *Gaoligong Shan Biodiversity Survey 32127* (CAS, KUN); ibid., *Gaoligong Shan Biodiversity Survey 32150* (CAS mixed with *G. sinensis*, KUN); ibid., *32150A* (CAS); Cikai Township, near Yipsaka Lake, 2.1 direct km SSE of Heipu Pass tunnel on new road from Gongshan to Dulongjiang Valley, E side of Gaoligong Shan, 3450 m, 27°45'18.1"N, 98°27'21"E, 13 Aug 2006, *Gaoligong Shan Biodiversity Survey 32235* (CAS, KUN); Cikai Township, vicinity of Danghatu near Km 49 on road from Gongshan to Kongdang and ca. 20.4 direct km WNW of Gongshan on E side of Gaoligong Shan, 3360 m, 27°47'3.5"N, 98°27'39"E, *Gaoligong Shan Biodiversity Survey 34488* (KUN); Cikai Township, Dongshaofang Pass, Gaoligongshan, 3200–3500 m, 4 Jun 2006, *L. Lu 06-0014 p.p.* (CAS, GH, KUN, all mixed variously with *G. ciliisepala, G. major*, and *G. sinensis*); Cikai Township, Gaoligong Shan, vicinity of tunnel at Heipu Pass along road from Gongshan to Dulongjiang, 3335 m, 27°46'10.4"N,

98°26'49.2"E, 11 Sep 2013, *L. Lu LL-2013-1* (CAS, GH, KUN [2]); ibid., *L. Lu LL-2013-2* (CAS, KUN); ibid., 3400 m, 27°46'42.4"N, 98°27'29.4"E, 13 Sep 2013, *L. Lu LL-2013-8* (CAS, KUN); ibid., *L. Lu LL-2013-9* (CAS, GH, KUN [2]); ibid., 3360 m, 27°47'8.6"N, 98°27'37.4"E, 13 Sep 2013, *L. Lu LL-2013-10* (CAS, KUN); Cikai Township, Gaoligong Shan, Qiqi River drainage, along trail from No. 12 Bridge to Dong Shao Fang and pass, 2770 m, 27°42'54.3"N, 98°30'8.9"E, 17 Sep 2013, *L. Lu LL-2013-28* (CAS, KUN); Dulongjiang Township, vicinity of tunnel at Heipu Pass along road from Gongshan to Dulongjiang, W side of Gaoligong Shan, 3357 m, 27°46'30.0"N, 98°26'49.1"E, 26 Jun 2014, *L. Lu LL-2014-5* (CAS, KUN); Cikai Township, vicinity of tunnel at Heipu Pass along road from Gongshan to Dulongjiang, E side of Gaoligong Shan, 3335 m, 27°46'10.4"N, 98°26'49.2"E, 26 Jun 2014, *L. Lu LL-2014-8* (CAS, KUN); Cikai Township, Danzhu Cun, road from Danzhu to Myanmar, along Damawadi He (N branch of W-most origin of Danzhu He), E side of Gaoligong Shan, 3243 m, 27°37'25.0"N, 98°34'32.3"E, 28 Jun 2014, *L. Lu LL-2014-11* (CAS, KUN); ibid., 2880 m, 27°38'6.5"N, 98°36'25.0"E, Jun 28, 2014, *L. Lu LL-2014-12* (CAS, KUN); Dulongjiang Township, along road from Gongshan to Dulongjiang, W side of Gaoligong Shan, 3275 m, 27°49'29.1"N, 98°26'56.7"E, 29 Jun 2014, *L. Lu LL-2014-22* (CAS, KUN); Cikai Township, Gaoligong Shan, road from Qiqi to Twelfth Bridge, 2400–2600 m, 3 Jun 2006, *L. Lu & R.F. Lu 06-0040* (CAS, KUN); Cikai Township, from Jidu Forestry Station to Dongshaofang, 2600 m, 22 Jul 1982, *Qinghai-Xizang Expedition 8345* (KUN [2], PE [2] n.v. (online images!) mixed with *G. ciliisepala*); Dulongjiang Xiang, Taron-taru divide, Ahtehmai, 2500 m, 29 Aug 1938, *T.T. Yü 20049* (A, E, KUN); Dulongjiang Xiang, Salwin-Kiukiang divide, Lunguailaka, 3600 m, 14 Sep 1938, *T.T. Yü 20262* (A, E, KUN); ibid., 3200 m, 16 Sep 1938, *T.T. Yü 20324* (A, E, KUN). **CHINA. South Tibet [INDIA. Arunachal Pradesh]:** Pachakshiri District, Nyug La, 8000–9500 ft, 28°45'N, 94°00'E, 11 May 1938, *F. Ludlow et al. 3733* (A, E). **INDIA. Sikkim:** East Himalaya, Kanghasi, 11,000 ft, 25 Jun 1912, *G.H. Cave s.n.* (E); West District, Phedang to Tsoka, S of Dzongri, 3300 m, 27°26'N, 88°10'E, 26 Jul 1992, *D.G. Long et al. 742* (E).

**19. Gaultheria tetracme** (Airy Shaw) P.W. Fritsch & Lu Lu, J. Bot. Res. Inst. Texas 11:344. 2017. Basionym: *Gaultheria trichophylla* Royle var. *tetracme* Airy Shaw, Bull. Misc. Inform. Kew 1940:323. 1941. Type: CHINA. Sichuan: 14,000 ft, Jul 1904, *E.H. Wilson 3915* (holotype: K000227993; isotypes: A00014981, A00014982).

**Stems** ascending-erect to 10 cm long. Current-year branchlets pale green and strongly flushed red above, to 4 cm long, with sparse white puberulence, with scattered basally ± straight and more distally ascending to nearly erect straight, curved, or slightly undulate setae 1.4–1.8 mm long, setae in cross section above base ± narrowly flattened to rounded tangentially. Internodes averaging ca. 1.4–2.5 mm. **Leaves:** petioles 0.9–1.3 mm long, at least some with several setae present at base, abaxially glabrous, adaxially with white puberulence on midvein, margin entire, blades ovate-elliptic or elliptic, 11.0–14.0 × 5.0–7.3 mm, 1.9–2.2 times as long as wide, subcoriaceous, planar, abaxially dull whitish green except glossy green or occasionally flushed maroon toward margin, glabrous, adaxially glossy green, glabrous except white puberulence on midvein proximally, midvein abaxially raised, not thickened immediately below apical gland, adaxially impressed, secondary veins abaxially obscure or 1 to 3 faintly evident on each side of midvein, adaxially obscure or 1 to 5 faintly evident on each side of midvein, impressed, base broadly cuneate to subrounded, margin serrulate throughout or entire anywhere up to first ca. 20% of length then serrulate distally, slightly revolute, apex acute to subrounded, tip with planar or usually distinctly abaxially directed apical gland, marginal teeth (setae) 9 to 18 per side, all oriented off leaf surface, 1.1–1.4 mm long. Overwintering flower bud pedicels 2–3 mm long, glabrous; overwintering flower buds slightly compressed laterally, 1.2–2.6 × 1.0–1.7 mm, 1.1–1.5 times as long as wide, glabrous, bracteoles slightly keeled, margin eciliolate. **Flowers** 4–6 mm long. Calyx pink proximally, green on distal part of lobes, 2.7–3.4 mm long; lobes elongate deltoid, 1.7–2.7 × 1.4–1.8 mm, adaxially glabrous or occasionally with sparse puberulence, apex acute, eciliolate or occasionally sparsely ciliolate, smooth, the very tip blunt. Corolla white, flushed pink in lines near petal midveins, campanulate, 3.0–4.5 × 4.3–7.1 mm; lobes 1.5–3.2 × 2.0–3.0 mm. Stamens 10; filaments 0.8–1.0 mm long; anther body 0.6–0.9 mm long, awns 2 per theca, inner two occasionally nearly abortive, 0.12–0.40 mm long. Style ca. 1.7 mm long; stigma pink. Fruiting pedicel 2.5–5.0 mm long. **Fruit:** calyx slightly oblate, subglobose, closed, 7–10 × 8–12 mm, outer wall turquoise blue, inner wall white; lobes incurved, narrowly deltoid, 3–6 mm long, apex eciliolate. Capsule green, exceeded by calyx lobes. **Seeds** light brown.

***Chinese Name.—***四芒刺毛白珠 si mang ci mao bai zhu

***Images.—***Fritsch et al. 2017: fig. 1.

***Illustration.—***Fritsch et al. 2017: fig. 2.

***Phenology.—***Flowering June, July, September; fruiting August, September.

***Distribution and Elevation Range.—***China (Sichuan); 2700–4267 m.

***Discussion.—***Two collections from northwestern Yunnan, *L. Lu & P.W. Fritsch LL-2011-22* (CAS, KUN) from the Meili Xue Shan, Yunnan, and *L. Lu LL-2013-47* (CAS, KUN) from the Biluo Xue Shan, both collected

in fruit, are similar to *Gaultheria tetracme* in most characters but differ by stems with dense puberulence (versus sparse), smaller leaves (4.5–6.7 × 2.3–3.5 mm versus 11.0–14.0 × 5.0–7.3 mm), trichomes never clustered at the petiole base (versus at least some with several setae present at base), fewer setae on the leaf blade margin (6 to 12 per side versus 9 to 18), shorter flowering bud pedicels (0.8–1.2 mm long versus 2.0–3.0 mm), and generally smaller flowering buds (1.2–1.7 × 1.0–1.3 mm versus 1.2–2.6 × 1.0–1.7 mm; the possible fruit character difference cited in Fritsch et al. 2017 appears not to hold). From phylogenetic analyses based on whole plastid genomes (Zhang et al. 2017) and four chloroplast gene regions (P.W. Fritsch & L. Lu, unpublished data), these plants group with *G. tetracme* with strong support and group outside of the clade of *G. trichophylla* from Cang Shan and Gaoligong Shan. Although these plants could be conspecific with *G. tetracme*, the known character differences suggest that these populations represent an undescribed species, but flowers are needed.

See also discussion in Fritsch et al. (2017).

Additional specimens examined. **CHINA. Sichuan. Precise locality uncertain:** Near Tachienlu [Kangding], 9000–13,000 ft, *A.E. Pratt 833* (E, GH, K n.v., P [2]). **Emeishan City:** Emei Shan, along the road from Jinding Peak to Taizi Ping, 2900 m, 10 Aug 1964, *K.J. Guan et al. 04077* (MO); Mt. Omei, Chin-ting, 3100 m, 17 Aug 1946, *L.Y. Tai T330* (A). **Luding County:** Jiang Zhou, year 1930, *Z.P. Huang et al. 01950* (KUN); Moxi Township, Hailuogou Glacier, above Goupengzi Village, 2900 m, 8 Jun 1980, *Z.A. Liu & Q.Q. Wang 22174* (CDBI [2]); Moxi Township, E slope of Gongga Shan, Hailuogou Glacier Park, W of Moxi, 3187 m, 29.56643°N, 101.98308°E, 15 Sep 2011, *L. Lu & P.W. Fritsch LL-2011-31* (CAS, KUN [2]); ibid., 11 Jun 2015, *L. Lu & M.Y. Zhang LL-2015-06* (BRIT, CAS, KUN); ibid., 3576 m, 29.55088°N, 101.96997°E, 11 Jun 2015, *L. Lu & M.Y. Zhang LL-2015-14* (KUN); Moxi Township, Gonghe Village, Qianghuopeng, 3000 m, 7 Jun 1983, *Vegetation Survey Team (Zhi-Bei-Zu) 30999* (CDBI [2]); ibid., 3400 m, 9 Jun 1981, *G.H. Xu 25479* (CDBI [2]); Gongga Shan, > 3000 m, Aug 2007, *S.D. Zhang & W.B. Yu 013* (CAS, GH, KUN, MO). **Tianquan County:** Yazikou Pass, old state road from Tibet to Sichuan, above tunnel on Hwy G318, summit ridge of Erlang Shan, 2908 m, 29.86113°N, 102.29115°E, 16 Sep 2011, *L. Lu & P.W. Fritsch LL-2011-36* (CAS, KUN [2]); ibid., 2872 m, 29.86172°N, 102.2912°E, 10 Jun 2015, *L. Lu & M.Y. Zhang LL-2015-03* (BRIT, CAS, KUN).

**20. Gaultheria thymifolia** Stapf ex Airy Shaw, Bull. Misc. Inform. Kew 1940:322. 1941. TYPE: MYANMAR. Kachin. Myitkyina District: Chipwi Township, NE Upper Burma, W flank of the N'Maikha-Salwin divide, 11,000 ft, 26°24'N, 98°48'E, Jun 1925, *G. Forrest 26867* (HOLOTYPE: K000227985; ISOTYPES: AU045662 n.v. (online image!), BM000834397, E00231094, NY02651432, S08-3001 n.v. (online image!)).

**Stems** decumbent to erect, to 10 cm tall. Current-year branchlets green, without or usually with sparse white puberulence, with basally uncinate and more distally ascending straight setae 0.24–0.34(–0.60) mm long, setae in cross section above base ± narrowly flattened tangentially to rounded. Internodes averaging ca. 0.4–1.3 mm. **Leaves:** petioles 0.2–0.8 mm long, abaxially glabrous, adaxially glabrous or with white puberulence, margin entire; blades linear-oblanceolate or oblanceolate, 6.2–9.4 × 1.3–2.2(–2.5) mm, 3.6–6.2 times as long as wide, coriaceous, planar, abaxially dull light green to light brown except glossy near margin, glabrous, adaxially glossy green to brown, glabrous except often with white puberulence on midvein proximally, midvein abaxially raised, not thickened immediately below apical gland, adaxially impressed, secondary veins obscure on both sides, base cuneate, margin entire anywhere between first ca. 30–60% of length then serrulate distally, planar or revolute, apex acute to obtuse, tip with planar or abaxially directed apical gland, marginal teeth (setae) 3 to 8 per side, all oriented off leaf surface, 0.14–0.24 mm long. Overwintering flower bud pedicels 1.2–1.6 mm long, glabrous; overwintering flower buds slightly compressed laterally to subglobose, 1.0–1.3 × 0.7–1.1 mm, 1.2–1.6 times as long as wide, glabrous, bracteoles rounded to slightly keeled, margin eciliolate. **Flowers** ca. 3–4 mm long. Calyx light green, occasionally flushed pink on margin of lobes, ca. 3–4 mm long; lobes ovate-deltoid, 2.0–3.0 × 1.0–1.8 mm, adaxially glabrous, apex acute, eciliolate, smooth, the very tip blunt. Corolla white or maroon, broadly campanulate, 2.3–3.8 × 2.8–4.6 mm; lobes 1.0–2.0(–2.5) × 1.1–2.0 mm. Stamens 10; filaments 0.7–1.0 mm long; anther body 0.4–0.7 mm long, awns 2 per theca, 0.2–0.3 mm long. Style ca. 1.5 mm long; stigma green. Fruiting pedicel ca. 2 mm long. **Fruit:** calyx oblate, broadly cupuliform, closed, 6–8 × 8–11 mm, outer wall white to occasionally pink; lobes incurved, elongate-deltoid, 2.5–4.5 mm long, apex eciliolate. Capsule exceeded by lobes. **Seeds** light tawny brown.

***Chinese Name.—***细叶白珠 xi ye bai zhu

***Images.—***Fritsch et al. 2008: fig. 42 (but may be *G. nivea*); Fig. 13.

***Illustrations.—***None known to us.

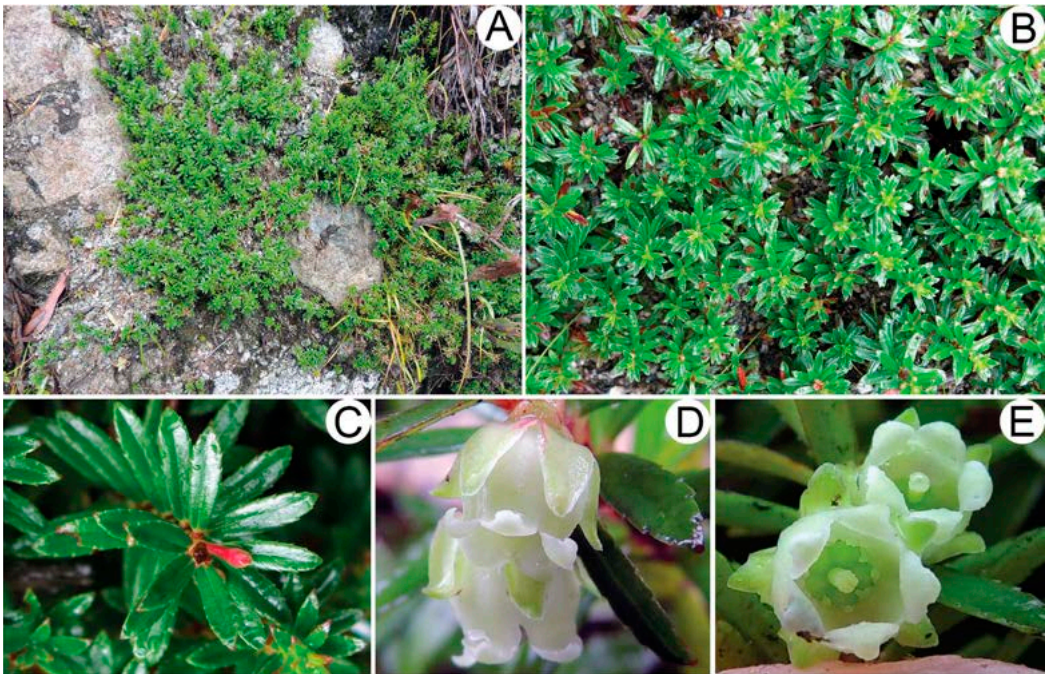


Fig. 13. *Gaultheria thymifolia*. **A, B.** Habit. **C.** Branchlet with overwintering flower bud. **D.** Flowers, lateral view. **E.** Flowers of female plant, apical and oblique-apical view showing filaments without anthers in lower flower. [Photos A, D, E by P.W.F; B, C by L.L.; A–C, *L. Lu LL-2013-23*; D, E, *L. Lu LL-2014-7*.]

***Phenology.***—Flowering June, July, October; fruiting August–October.

***Distribution and Elevation Range.***—China (Xizang, Yunnan), Myanmar (Kachin); 2800–3962 m.

***Discussion.***—See comments under *Gaultheria cardiosepala*.

Additional specimens examined. **CHINA. Xizang. Zayü County:** Prope fines Tibeto-Birmanicas inter fluvios Lu-djiang (Salween) et Djioudjiang (Irrawadi orient. super.), in glarea granitica ad rivum supra vicum Schutsche ad flumen Irrawadi, 3000–3150 m, 27°58'N, 9 Jul 1918, *H.F. v. Handel-Mazzetti 9441* (A00014975, P00715758 n.v. (online image!), WU0043083 n.v. (online image!)). **Yunnan. Gongshan County:** Cikai Township, Hei Pu Shan, 13 Oct 1940, *K.M. Feng 8417* (KUN, PE n.v. (online image!)); Bingzhongluo Township, ca. 2.6 direct km SSW of Gawagapu Mtn. and ca. 15.5 direct km WSW of Bingzhongluo in the next basin E of Chukuai Lake, E side of Gaoligong Shan, 3880 m, 27°59'12.8"N, 98°28'26.4"E, 25 Aug 2006, *Gaoligong Shan Biodiversity Survey 31446* (CAS); Cikai Township, Gaoligong Shan, vicinity of the tunnel at Heipu Pass along the road from Gongshan to Dulongjiang, 3400 m, 27°46'42.4"N, 98°27'29.4"E, 13 Sep 2013, *L. Lu LL-2013-16* (KUN); Cikai Township, Gaoligong Shan, Km 45 to 48 along the road from Gongshan to Dulongjiang, 3238 m, 27°46'56.6"N, 98°29'5.3"E, 15 Sep 2013, *L. Lu LL-2013-23* (CAS, PE); Cikai Township, along the road from Gongshan to Dulongjiang, 2998 m, 27°47'18.9"N, 98°30'34.5"E, 26 Jun 2014, *L. Lu LL-2014-7* (CAS); Cikai Township, Danzhu Cun, road from Danzhu to Myanmar, along the Damawadi He (N branch of W-most origin of the Danzhu He), E side of Gaoligong Shan, 3243 m, 27°37'25.0"N, 98°34'32.3"E, 28 Jun 2014, *L. Lu LL-2014-15* (CAS); Dulongjiang Township, Gongshan Yakou to Dulongjiang, 1979, *Nujiang Expedition 79-0714* (KUN); Mt. Kenyichunpo and region of Champutong, Salween-Irrawadi Watershed, 1923, *J.F.C. Rock 10252* (A); Dulongjiang Township, W of Chang Pu Tong, 2800 m, Oct 1935, *C.W. Wang 67194* (A, KUN, PE [2] n.v. (online images!)); Dulongjiang Township, Salween-Kiu Chiang divide, Parolaka, 3300 m, 10 Oct 1938, *T.T. Yü 20613* (A, KUN); Dulongjiang Township, Salween-Kiu Chiang divide, Panbahlung, 3800 m, 21 Oct 1938, *T.T. Yü 20821* (A, E, KUN). **Tengchong County:** The seventh district, 1 Jul 1963, *J.S. Yang & X.N. Wang 63-1351* (KUN). **MYANMAR. Kachin. Myitkyina District:** Hsawlaw Township, Chevochi Pass, 11,800 ft, 24 Sep 1947, *R.J. Farrer 1677* (E); Waingmaw Township, advance base, Seinghku Wang, 10,000–11,000 ft, 5 Jun 1926, *F. Kingdon-Ward 6849* (K); North Triangle (Tama Bum), 10,000 ft, 20 Jun 1953, *F. Kingdon-Ward 21010* (A, E). **Putao District:** Nogmung Township, Adung Valley, 12,000–13,000 ft, 15 Jun 1931, *F. Kingdon-Ward 9639 p.p.* (A, mixed with *G. obovata*).

**21. Gaultheria trichophylla** Royle, Ill. Bot. Himal. Mts. 260, t. 63. 1835. *Brossaea trichophylla* (Royle) Kuntze, Revis. Gen. Pl. 2:387. 1891. Type: INDIA. Uttarakhand: Jumnotri [Yamunotri], *J.F. Royle 102/1* (see Harrison 1978) (holotype: LIV n.v.; isotypes: K000442408 (specimens on lower half of sheet), LE00015808 n.v. (online image!)).

*Gaultheria nana* C.Y. Wu & T.Z. Hsu, Acta Bot. Yunnan. 3:432. 1981. TYPE: CHINA. Xizang. Dingjie County: 3400 m, 5 Jun 1975, *Qinghai-Xizang Expedition 5534* (HOLOTYPE: KUN0482996; ISOTYPES: HNWP48791 n.v. (online image!), PE00195456 n.v. (online image!)).

*Gaultheria trichophylla* Royle var. *ovata* S. Panda & Sanjappa, Bull. Bot. Surv. India 48:159. 2006. TYPE: INDIA. Sikkim. West Sikkim: Dzongri, 4350 m, 15 May 2002, *S. Panda 29949* (HOLOTYPE: CAL n.v.; ISOTYPE: CAL n.v.).

**Stems** prostrate or ascending-erect to 5 cm long. Current-year branchlets pale green, often flushed red, to 3.5 cm long, without or with sparse to moderately dense (or rarely dense) white puberulence, with dense basally ± straight or uncinate and more distally generally ascending but also nearly appressed or nearly erect, curved, or undulate setae 0.8–1.6 mm long, setae in cross section above base narrowly to broadly flattened tangentially or rounded. Internodes averaging ca. 1.0–2.5 mm. **Leaves:** petioles 0.4–1.0 mm long, at least some with several setae present at base, abaxially glabrous or often with 1 to 4 ascending or nearly erect setae, adaxially with white puberulence, margin entire or 1- or 2-toothed (-setose) per side; blades elliptic, broadly elliptic, ovate, suborbicular, oblanceolate, or obovate, 3.7–12.0 × 2.5–4.8 mm, 1.3–3.6 times as long as wide, subcoriaceous, planar, abaxially dull whitish green except glossy and occasionally flushed maroon near margin, or occasionally flushed maroon throughout, glabrous or at least some leaves (usually only several) with 1 to 3 ascending to nearly erect setae on midvein proximally (setae 0.5–1.0 mm long), adaxially glossy deep green, glabrous except with white puberulence on midvein proximally and occasionally on surface, midvein abaxially raised, not thickened immediately below apical gland, adaxially impressed, secondary veins abaxially obscure or 1 to 5 faintly evident on each side of midvein, adaxially obscure or 1 to 4 faintly evident on each side of midvein, base cuneate to rounded, margin serrulate throughout or entire anywhere up to first ca. 30% of length then serrulate distally, planar or revolute, apex acute to rounded, tip with planar or slightly abaxially directed apical gland, marginal teeth (setae) 6 to 14 per side, all oriented off leaf surface, 0.6–1.4 mm long. Overwintering flower bud pedicels 0.6–1.8 mm long, glabrous or with white puberulence; overwintering flower buds slightly compressed laterally, 1.1–2.5 × 0.9–1.7 mm, 1.0–2.2 times as long as wide, glabrous, bracteoles rounded to slightly keeled, margin eciliolate. **Flowers** 4.8–8.0 mm long. Calyx pink or red proximally, abruptly or rarely gradually green on distal part of lobes, 2.5–4.3 mm long; lobes elongate-deltoid, 2.0–3.2 × 1.0–2.4 mm, adaxially glabrous, apex acute to abruptly acuminate, eciliolate, smooth, the very tip blunt. Corolla white, white flushed with pink, pink, or red, if pink or red then with white or pale pink lobes distally, campanulate or broadly urceolate, 3.0–8.0 × 2.5–9.2 mm; lobes 1.0–4.2 × 1.0–3.3 mm. Stamens 10; filaments 0.7–1.2 mm long; anther body 0.6–1.0 mm long, awns 1 per theca but occasionally bifurcate at some point along distal half, 0.06–0.50 mm long. Style 1.3–3.0 mm long; stigma white or light purple. Fruiting pedicel 0.8–2.5 mm long. **Fruit:** calyx oblate to prolate, subglobose to turbinate, closed or open, 6–13 × 6–15 mm, outer wall deep blue, turquoise blue, sky blue, or rarely light purple or white flushed with blue, inner wall white; lobes incurved, narrowly deltoid, 3–4 mm long, apex eciliolate. Capsule green, exceeded by calyx lobes. **Seeds** light brown.

***Chinese Name.—***刺毛白珠 ci mao bai zhu

***Images.—***Fig. 14.

***Illustrations.—***Xu 1986b: fig. 277(2); Panda & Sanjappa 2006: fig. 2; Fig. 15.

***Phenology.—***Flowering April–September; fruiting July–October.

***Distribution and Elevation Range.—***Bhutan, China (Xizang, Yunnan), China (South Tibet [India, Arunachal Pradesh]), India (Himachal Pradesh, Jammu and Kashmir [union territory], Sikkim, Uttarakhand), Nepal, Pakistan (Azad Kashmir); 2743–4572 m.

***Discussion.—***Problems with the taxonomy of *Gaultheria trichophylla* were reviewed by Fritsch et al. (2017) as they were understood at that time. In the present study, some of these problems have been resolved through the recognition that some specimens identified previously as *G. trichophylla* are the distinct species *G. minuta* (see discussion under *G. minuta*). Further resolution has resulted from a phylogenetic analysis based on whole plastid genomes (Zhang et al. 2017), in which collections from the Meili Xue Shan and Biluo Xue Shan in Yunnan (*L. Lu & P.W. Fritsch LL-2011-22* and *L. Lu LL-2013-47*, respectively), which are similar to both *G. tetracme* and *G. trichophylla*, are supported as more closely related to (and perhaps conspecific with) *G. tetracme* instead of *G. trichophylla* (Zhang et al. 2017 and P.W. Fritsch & L. Lu, unpublished data; see also

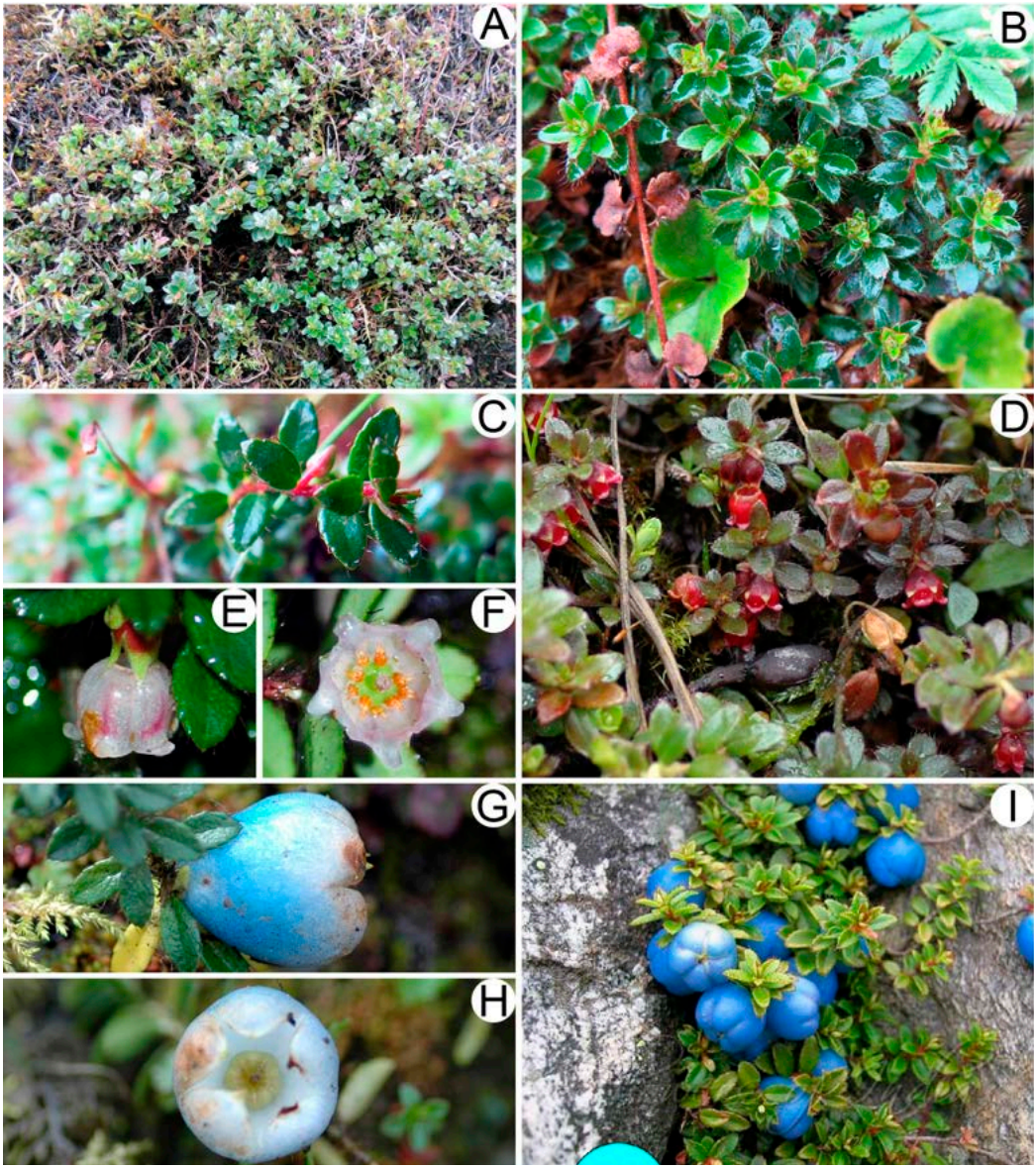


Fig. 14. *Gaultheria trichophylla*. **A.** Habit. **B.** Branchlets. **C.** Branchlet with overwintering flower bud. **D.** Flowering branchlets with red corolla. **E, F.** Flowering branchlets with white corolla flushed with pale pink in lateral (E) and apical (F) views. **G–I.** fruit showing variation in color and apex. **G, H.** Open light blue fruit from Cang Shan, Yunnan, China in lateral (G) and apical (H) views. **I.** Closed sky blue fruit from the Himalaya. [Photos A by P.W.F.; B–H, by L.L.; I, used with the permission of Dr. Fiaz Alam.]

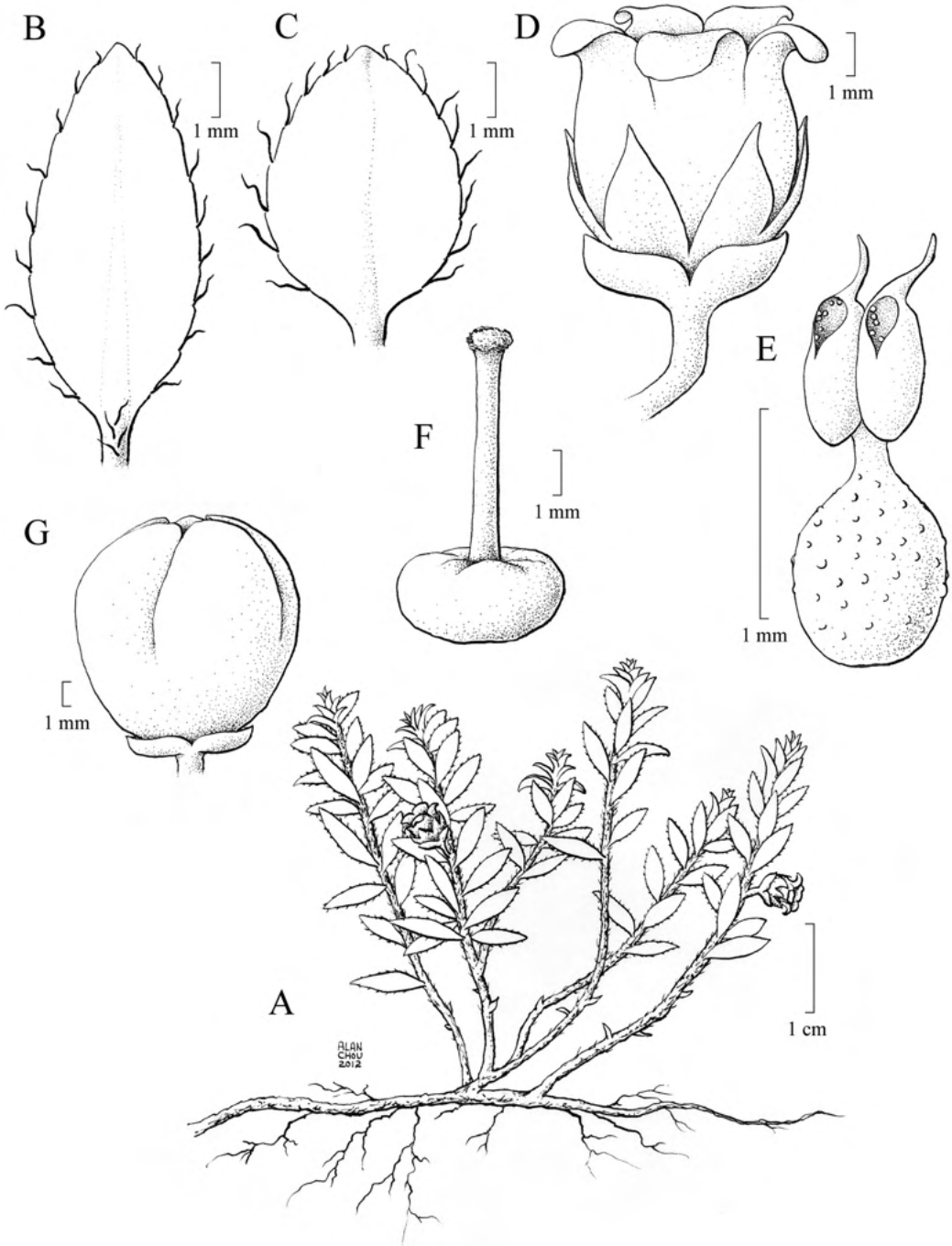


Fig. 15. *Gaultheria trichophylla*. **A.** Flowering plant. **B, C.** Leaves from two individuals in abaxial view showing variation in shape. **D.** Pedicel, bracteoles, and flower. **E.** Stamen. **F.** Gynoecium. **G.** Bracteoles and fruit, lateral view. [A, B, D–F drawn from *J.D.A. Stainton 4541* (E); C drawn from *F. Ludlow et al. 19160* (E); G drawn from *J.D.A. Stainton 7914* (E).]

discussion under *G. minuta* and *G. tetracme*). Nonetheless, there are still several unresolved taxonomic issues involving the morphological variation remaining within *G. trichophylla* as now circumscribed. The variable characters involved in this taxonomic uncertainty are the size and shape of the leaf blades, presence versus absence of setae on the leaf blades abaxially, the length of the marginal setae on the leaf blades, the color of the corolla, the number of awns per anther theca, the shape and color of the mature fruiting calyx, and whether the mature fruiting calyx is open or closed, as discussed below.

In regard to leaf variation, Panda and Sanjappa (2006) distinguished *Gaultheria trichophylla* var. *ovata* from the nominate variety by ovate (versus elliptic) and smaller leaves. It is yet unclear if this variation is correlated with other characters, and here we place it in synonymy with the caveat that more field study is needed to document any possible correlated characters (see also discussion under *G. minuta*). Conversely, some specimens of *G. trichophylla* have leaf blades that are much narrower than normal, up to 3.4 times as long as wide (e.g., *R.E. Cooper 2587*, *F. Ludlow et al. 16363*, *J. Sinclair 4168a*). In some of the extreme narrow-leaved forms, the shape can be obovate and the marginal setae can be up to 14 per side but these setae are shorter than normal, i.e., up to ca. 0.4–0.5 mm long. The leaf blades of several collections are completely glabrous abaxially, i.e., they lack setae (e.g., *G.H. Cave 166/47*, *F.B.I. III.457*, *J. Mohd J48*, *O. Polunin et al. 4162*, *J.D.A. Stainton et al. 1016*, *1536*, and *3480*).

As noted previously (Fritsch et al. 2017), in Gongshan County of Yunnan at the pass near Dongshaofang in the Gaoligong Shan, we observed plants with deep red corollas, unlike the white or at most pink corollas that we have observed or that have been reported in other plants of *Gaultheria trichophylla*. The Gongshan plants have more rounded leaves, as in the variation encompassed by *G. trichophylla* var. *ovata*. It is yet unclear if flower color is correlated with this leaf shape difference. An online photograph, however, exhibits deep rose corollas but has (broadly) elliptic leaves (https://www.flickr.com/photos/himalayanbotany/24392409448).

Fang and Stevens (2005) state that their nominate variety of *Gaultheria trichophylla* (*G. trichophylla* excluding *G. eciliata* and *G. tetracme* to us) has one awn per anther theca, and this has been confirmed by our observations. Occasionally the anther awns deviate from those typical of *G. trichophylla* in having at least some of the awns bifurcate at some point along their distal half (i.e., *G.H. Cave 166/47*, *D.G. Long et al. 378F*, *Ludlow et al. 3905*, and *Qinghai-Tibet Expedition 5534*). In one collection (*O. Polunin et al. 4162*), the thecae are 1-awned but the awns are very short and barely visible, but otherwise the specimen is typical of *G. trichophylla*.

As noted previously (Fritsch et al. 2017), the fruiting calyces on the plants of *Gaultheria trichophylla* from Cang Shan in western Yunnan differ from all others in the species that we have examined by their turbinate shape (versus subglobose), open condition (versus closed), and sky blue color (versus deep blue, turquoise blue, or rarely light purple or white flushed with blue). The leaves of these plants are elliptic and at least some have abaxial setae, the corollas are pale pink with five deep pink lines, and the anther thecae have one awn and are not bifurcate. The plants seem to have atypically narrower calyx lobes that taper to a stronger point.

Online in situ images of *Gaultheria trichophylla* exhibit two apparent fruiting calyx color variants: a white form flushed with blue (https://www.projectnoah.org/spottings/1585270540) and a light purple form (www.jansalpines.com). The taxonomic significance of these variants, if any, remains unclear.

The holotype of *Gaultheria trichophylla* was not indicated in the protologue. Harrison (1978) has provided evidence that a single specimen of *G. trichophylla* collected by Royle is housed at LIV, the original herbarium of Royle.

Additional specimens examined. **Precise locality uncertain:** NW Himalaya, Beshar, year 1890, *J.H. Lace s.n.* (E); in monte Himalaya, Kanaor inférieur, *J.F. Royle s.n.* (P [2]). **BHUTAN. Bumthang:** Geyzamchu, 27°22'N, 91°01'E, 2800 m, 9 Jun 2001, *Y. Dorji 219* (MO); Patria Thang (3200), Chamsa (3500)–Kohina (3000)-= Yabu, 3400 m, 15 May 1967, *H. Kanai et al. 12555* (KUN). **Gasa:** near Ghasa Dzong, Mo Chu, 12,000 ft, 11 Jun 1949, *F. Ludlow et al. 16496* (E); Laya, 28°06'N, 89°42'E, 3950 m, 30 Jul 1983, *C. Sargent 121* (E); above Laya, 28°07'N, 89°44'E, 4100 m, 19 Sep 1984, *I.W.J. Sinclair & D.G. Long 5153* (E). **Punakha:** Joregong, Punakhang, 14,000 ft, 23 Sep 1914, *R.E. Cooper 2200* (E). **Thimphu:** Parshay Timpu, 11,000 ft, 28 Jul 1914, *R.E. Cooper 2587* (E [3]); SE of Pajoding, 27°29'N, 89°35'E, 3400 m, 19 Jul 1979, *A.J.C. Grierson & D.G. Long 2746* (E); ibid., *A.J.C. Grierson & D.G. Long 2789* (E); below Barshong, Thimbu Chu, 11,000 ft, 26 May 1949, *F. Ludlow et al. 16363* (E). **Trashiyangtse:** Lao, Trashi Yangsi Chu, 9500 ft, 10 May 1949, *F. Ludlow et al. 20617B* (E); NE Bhutan, Shingbe (Me La), 12,000 ft, 16 Aug 1949, *F. Ludlow et al. 21191* (E). **Wangdue Phodrang:** Pangotang, Tsampa, 12,000–13,000 ft, 16 Jun 1949, *F. Ludlow et al. 19160* (E). **CHINA. Precise locality uncertain:** without label, KUN No. 0778839 (KUN). **Xizang.** Xingeng to Riwu, 4250 m, year 1975,

collector unknown (KUN). **Bomi County:** Lingchang, Sep 1976, *Qinghai-Xizang Expedition 5862* (KUN [2]). **Cuola County:** Bo Shan, S slope, 3600–3700 m, 9 Oct 1975, *Qinghai-Xizang Expedition 75-1934* (KUN, PE [2] n.v. (online images!)). **Gonjo County:** Kongbo Province, Nepar, near Molo, 12,500 ft, 17 May 1938, *F. Ludlow et al. 6265* (E). **Nielamu County:** Quxiang Community, Deqintan, 19 May 1966, *Y.T. Zhang 3566* (KUN, PE [3] n.v. (online images!)). **Tingri County:** Ronophar Valley, 28 Jun 1924, 11,000 ft, Mount Everest Expedition, *R.W.G. Hingston 9* (K); Karma [Gama] Valley, 12,000 ft, 22 Jun 1922, *E.F. Norton 218* (K). **Yadong County:** Xiayadong, Zelila Shan Pass, 4200 m, 12 Sep 1974, *Qinghai-Xizang Expedition 74-2372* (KUN [2], PE [2] n.v. (online images!)). **Yunnan. Dali City:** Tsang Chan, 3500 m, 10 Jun 1885, *J.M. Delavay s.n.* (*or 183 or No. 1877*) *p.p.* (A [2], K, P, all variously mixed with *G. cardiosepala* and *G. major*); Cang Shan, Zhonghe Peak, 3450 m, 13 May 1997, *R.C. Fang & Lü Zhengwei s.n.* (KUN0002735 (same collection but different sheet, KUN0001429, is *G. cardiosepala*)); E flank of the Dali Range, 12,000 ft, 25°40'N, Aug–Sep 1906, *G. Forrest 4190* (E, K, P); Cangshan, Zhonghe Peak, 3000–3800 m, 10 Jun 2006, *L. Lu & R.F. Lu 06-0019* (CAS); 2800 m, May 1935, *C.W. Wang 63219* (A, PE n.v. (online image!) mixed with *G. cardiosepala*). **Gongshan County:** Cikai Township, Dongshaofang Pass, Gaoligongshan Mountains, 3500 m, 4 Jun 2006, *L. Lu 06-0007* (CAS, KUN). **CHINA. South Tibet [INDIA. Arunachal Pradesh]:** Poshing La, 10,000–11,000 ft, 17 May 1938, *F. Kingdon-Ward 13659* (MO); South-Eastern Tibet, Kongbo Province, Langong Chu, 13,500–14,000 ft, 28°45'N, 94°00'E, 28 May 1938, *F. Ludlow et al. 3905* (E). **INDIA. Precise locality uncertain:** Himalaya, *V. Jacquemont 750* (P [3]); Manideo Pass, U.P., 12,000 ft, 7 May 1948, *(Dr.) W. Koelz 20289* (NY); NW India, *Dr. J.L. Stewart's Collection s.n.* (E). **Himachal Pradesh:** Lahul, Koksar, 12,000 ft, 2 Jun 1941, *N.L. Bor 14542* (E, NY); Punjab, Pan Jache Kulu [Kullu], 12,000 ft, 8 Sep 1916, *R.E. Cooper 5599* (E [2]); ibid., 13,000 ft, 10 Oct 1916, *R.E. Cooper 5604* (E [2]); ibid., 12,000 ft, 15 Sep 1916, *R.E. Cooper 5627* (E [2]); Kangra District, Dharmsala Forest, 10,500 ft, 4 Jun 1901, *G.S. Hart 569* (E); Chanderkani, Kulu, 11,000–12,000 ft, 27–28 Jun 1930, *(Dr.) W. Koelz 91* (P); Lahul, Khoksar [Khokhsar], 11,000[–13,000] ft, 26[–27] Jul 1930, *(Dr.) W. Koelz 705* (NY, P); Khokhsar, Lahul, 13,000 ft., 29 Jul 1930, *(Dr.) W. Koelz 774* (NY); Lahul, Kangra, 11,000 ft, 1 Jul 1933, *(Dr.) W. Koelz 5064* (NY); Koksar, Jahul, 11,000 ft, 6 Jun 1936, *(Dr.) W. Koelz 8353* (NY); above Sdeeling, Bashahr State [Kinnaur and Shimla District], 10,000 ft, 1 Jul 1890, *J.H. Lace 328* (E); Chamba State, Alwas Satrundi, 10,500 ft, 23 Aug 1896, *J.H. Lace 1460* (E); Plants of Kulu and Lahoul, Rotang [Rohtang] Pass, 13,140 ft, 5 Aug 1935, *M. Nath 344* (NY); Chamba State, Bharmaor, Dhan Cho, 10,400 ft, 10 Jul 1919, *R.N. Parker s.n.* (A); Chamba State, Bhandal Valley, above Kundi Maral, 11,000 ft, *R.N. Parker s.n.*, 27 Oct 1920 (A); above Pulga, Parbatti Valley, Kuhn, 9000 ft, 27 May 1934, *C.E. Parkinson 3980* (E). **Jammu and Kashmir (union territory):** Dudheri Pass, near Atholi, Kishtawar District, 10,500 ft, 22 Jul 1943, *F. Ludlow & G. Sherriff 9203* (E); Baramulla District, Jeoni, toward Gulmarg, 13,000 ft, 28 Aug 1955, *J. Mohd J48* (BRIT); Nichinai, 12,500 ft, 2 Sep 1956, *O. Polunin 56/636* (E); Sonamarg, 12,000 ft, 4 Sep 1917, *R.R. Stewart 3553* (NY); ibid., 23 Jul 1928, *R.R. Stewart 9765* (MO, NY); ibid., 12,000–13,000 ft, Jul 1928, *R.R. Stewart 9804-A* (NY); Sekiwas, Yamhar Pass, 9 Sep 1931, *R.R. Stewart 12466* (MO); Mt. opposite Pahlgam, 11,000 ft, 28 Aug 1945, *R.R. Stewart 21788* (NY); Fras Nag, 11,000 ft, 7 Aug 1947, *R.R. Stewart 23252a* (NY); Kishtwar, 10,000 ft, 12 Jun 1848, *T. Thomson s.n.* (E, K upper half of sheet (the type of *G. trichophylla* is on the lower half), NY, P [2]). **Sikkim:** Dzongri, SE slope of Lapsa in valley E of Dzongri campsite, 4000 m, 2 Jul 1983, *AGSES (Alpine Garden Society's Expedition SIKKIM) 279* (E); Nya Tari, 12,000 ft, 15 Jun 1912, *G.H. Cave s.n.* (A, E); Phulul, 11,000 ft, 27 May 1914, *G.H. Cave s.n.* (E); Gonsar, 12,000 ft, 20 Sep 1916, *G.H. Cave s.n.* (E); Chokchilling Chu, 13,000 ft, 1 Sep 1919, *G.H. Cave s.n.* (E); Zemu and Lhonakh Valleys, Yeumthang to Momay, 12,000–15,000 ft, 13 Sep 1947, *G.H. Cave 166/47* (E); Chanpu, 13,000 ft, 29 Jun 1913, *R.E. Cooper 74* (E); Chamnago, 12,000–13,000 ft, 19 Jul 1913, *R.E. Cooper 289* (E); Gnatang, 13,000 ft, 29 Aug 1913, *R.E. Cooper 724* (E); Onglathong, 17 Oct 1938, *B.N. Ghose s.n.* (A); 12,000 ft, *J.D. Hooker s.n.* (E, P); West District, ascent from Prek Chhu Bridge towards Dzongri, 3750 m, 27°30'N, 88°10'E, 25 Jul 1992, *D.G. Long et al. 710* (E); Phedang, 11,300 ft, Sep 1983, *S. McPherson 36* (E); Chanshir Pass, Garhwal, Dehra Dun, 23 Jun 1934, *N. Parmanand 295* (E); East Himalaya, Alsokthan, 15,000 ft, 12 Aug 1913, *Ribu & Rhomoo 980* (E); Singnapyakop, 13,000 ft, 25 Nov. 1911, *Ribu & Rhomoo 5753* (E); East Himalaya, Megu, 14,000 ft, year 1913, *Ribu & Rhomoo 6454* (E); Darjeeling District, Ramon, 24 Apr 1945, *I.W.J. Sinclair 4168a* (E). **Uttarakhand:** Mussoarsi, Kidar Kautha [Kedarkatha], 24 May 1904, *J.R. Drummond 22713* (E); above Doldhari, 12,000 ft, 15 Sep 1885, *F.B.I. III.457* (E); Garhwal, Valley of Flowers, 3600 m, 20 Oct 1963, *M.A. Rau 31722* (P); Kumaoni, Madhari pap, 10,000 ft, year 1843, *R. Strachey & J.E. Winterbottom 1* (P). **NEPAL. Baglung District:** above Dhorpatan, 12,000 ft, 12 Jul 1954, *J.D.A. Stainton et al. 3480* (E); ibid., *J.D.A. Stainton et al. 3481* (A, E). **Humla District:** Between Margor Lagna and Durpa, 10,000 ft, 25 May 1952, *O. Polunin et al. 4162* (A, E). **Manang District:** Rambrong, N. of Pokhara, 10,000–11,000 ft, 27 Apr 1954, *J.D.A. Stainton et al. 5101* (E); Bhurungdi Khola, 10,000 ft, 15 Jun 1954, *J.D.A. Stainton et al. 5805* (E); Gandaki Zone, around Bimtang (3530 m), 3530 m, 28°38'04"N, 84°28'20"E, 11 Aug 1994, *M. Suzuki et al. 9450080* (E, MO). **Mustang District:** Lete, S. of Tukucha, Kali Gandaki, 12,500 ft, 7 Jun 1954, *J.D.A. Stainton et al. 1016* (E); Ghasa, S. of Tukucha, Kali Gandaki, 10,000 ft, 4 Jul 1954, *J.D.A. Stainton et al. 1536* (E); Ganesh Himal, Ankhu Khola, 9000 ft, 28°12'N, 85°5'E, 1 May 1962, *J.D.A. Stainton 3645* (E); Lete, S. of Tukucha, Kali Gandaki, 11,500 ft, 17 Sep 1954, *J.D.A. Stainton et al. 7914* (E). **Ramechhap District:** Janakpur Zone, Deorali (2700 m), Thodung (3000 m), Serdingma (3400 m), 86°20'E, 27°34'N–86°22'E 27°36'N), 6 Jul 1985, *H. Ohba et al. 8570188* (E, KUN); Janakpur Zone, Neju (3651 m)–Choarma (2760 m), 86°31'E, 27°44'N–86°28'E 27°41'N), 2 Aug 1985, *H. Ohba et al. 8571107* (MO); Janakpur Zone, Deorali (2700 m), Thodung (3000 m), Serdingma (3400 m), 86°20'E, 27°34'N–86°22'E 27°36'N, 6 Jul 1985, *H. Ohba et al. 8580146* (E). **Rasuwa District:** Bagmati Zone, Parbati Kund (near Gatlang) (2590 m)–Yure Kharka (3300 m), 3270 m, 28°09'N, 85°14'E, 25 Jul 1994, *F. Miyamoto et al. 9400032* (E). **Sankhuwasabha District:** Pemathang Kharka, S side off Barun Khola, 3500 m, 27°44'N, 87°12'E, 28 Sep 1991, *D.G. Long et al. 378* (E); Koshi Zone, Sankhuwasabha District, Chyakesha (3850 m)–Pangsel Danda (4100 m)–Pokhari Khola (3920 m)–Larkey Buk (4210 m), 4060 m, 27°39'22"N 87°07'39"E–27°40'50"N 87°07'23"E, 25 Aug 1997, *S. Noshiro et al. 9760361* (E); Koshi Zone, Sankhuwasabha District, Kipu Pokhari (3900 m; map 4080 m)–Deurali (3930 m; map 4120 m)–Kharka (3400 m)–Hongaon (2300 m), 3660 m, 27°49'10"N 87°22'00"E–27°46'00"N 87°22'00"E, 24 Aug 1998, *S. Noshiro et al. 9840162* (CAS, E); Koshi Zone, Sankhuwasabha District, Jaljale Himal, Shuwan Kharka (near Panch Pokhari) (4180 m)–a pass (4360 m)–Topke Gola (3570 m) 4130 m, 27°35'N 87°30'E, 7 Aug 1991, *H. Ohba et al. 9154183* (E); Arun Valley, Maghang Khola, E of Num, 11,000 ft, 5 May 1956, *J.D.A. Stainton 233* (A, E); Barun Valley, 14,500 ft, 16 May 1954, *L.W. Swan 307* (CAS). **Solukhumbu District:**

Sagarmatha Zone, Thasing Dingma (3320 m)–Sanu Khola (3515 m)–Saure Kharka (3735 m), 27°39'N, 86°50'E, 3400 m, 4 Aug 1995, *F. Miyamoto et al. 95* (A); Solu Khola, Chiang Gompa, 12,000 ft, 27°33'N, 86°35'E, 14 May 1964, *J.D.A. Stainton 4541* (E). **Taplejung District:** NE, Yampodin/Chairam, 3260 m, 7 Sep 1978, *D. Binns et al. 6* (E); Ghunsa, Yauprua Khola Valley above Pholle, 4000 m, 24 Sep 1985, *Curzon 63* (MO); Tamur Valley, Ghunsa, E. of Walungchung Gola, 13,000 ft, 87–88° E, 27 Jul 1956, *J.D.A. Stainton 1130* (E). **PAKISTAN. Azad Kashmir:** Pathra, Kofan Hozara, 15 Jun 1899, *J.F. Duthie s.n.* (CAS).

APPENDIX 1
List of accepted species.

1. *Gaultheria albiflora* (T.Z. Hsu) P.W. Fritsch & Lu Lu
2. *Gaultheria ×biluoensis* P.W. Fritsch & Lu Lu
3. *Gaultheria bryoides* P.W. Fritsch & L.H. Zhou
4. *Gaultheria cardiosepala* Hand.-Mazz.
5. *Gaultheria ciliisepala* Airy Shaw ex P.W. Fritsch & Lu Lu
6. *Gaultheria crassifolia* (Airy Shaw) P.W. Fritsch & Lu Lu
7. *Gaultheria dolichopoda* Airy Shaw
8. *Gaultheria eciliata* (S.J. Rae & D.G. Long) P.W. Fritsch & L.H. Zhou
9. *Gaultheria gonggashanensis* P.W. Fritsch & Lu Lu
10. *Gaultheria hypochlora* Airy Shaw
11. *Gaultheria jingdongensis* R.C. Fang
12. *Gaultheria major* (Airy Shaw) P.W. Fritsch & Lu Lu
13. *Gaultheria marronina* P.W. Fritsch & Lu Lu
14. *Gaultheria minuta* Merr.
15. *Gaultheria nivea* (J. Anthony) Airy Shaw
16. *Gaultheria obovata* (Airy Shaw) P.W. Fritsch & Lu Lu
17. *Gaultheria sinensis* J. Anthony
18. *Gaultheria stenophylla* P.W. Fritsch & Lu Lu
19. *Gaultheria tetracme* (Airy Shaw) P.W. Fritsch & Lu Lu
20. *Gaultheria thymifolia* Stapf ex Airy Shaw
21. *Gaultheria trichophylla* Royle

APPENDIX 2
Index to exsiccatae.

All specimens examined by the authors are listed alphabetically by collector followed by collection number. Numbers in parentheses correspond to those in the numerical list of accepted species in the text and Appendix 1. If more than two persons participated in the collection, only the first collector listed on the label is cited followed by "et al."

Without label, KUN No. 0778839 (21); 22593 (4).
Collector not indicated, s.n. (21); 23523 (9).
1984 Sino-Amer. Bot. Exped. 579 (4); 846 (4); 1129 (5).
AGSES (Alpine Garden Society's Expedition SIKKIM) 279 (21).
Armstrong, K. 2004 (10).
Bijiang Expedition 1351 (4); 1351A (5).
Binns, D. et al. 6 (21).
Bor, N.L. 14542 (21).
Cave, G.H. s.n. (18); s.n. (21); 166/47 (21).
Chen, S.Z. & B.S. Li 7026 (17).
Chiao, C.Y. 2089 (10).
Ching, R.C. 21460 (12); 23490 (12).
Chungtien-Lijiang-Dali Expedition CLD-90 (4).
Cooper, R.E. 74 (21); 289 (21); 724 (21); 2200 (21); 2587 (21); 5128 (14); 5599 (21); 5604 (21); 5627 (21); 5675 (14).
Curzon 63 (21).
Delavay, J.F. s.n. (or 183 or No. 1877) (4, 12, 21); 301 (4); 4736 (4).
Dorji, Y. 219 (21).
Drummond, J.R. 22713 (21).
Duthie, J.F. s.n. (21).
F.B.I. III.457 (21).
Fang, R.C. & Lü Zhengwei s.n. (4, 21).
Fang, W.P. 8213 (13); 57736 (12).
Farrer, R.J. 895 (4); 1191 (5); 1622 (5); 1676 (10); 1677 (20); 1737 (10).
Feng, K.M. 80-22 (4); 4995 (10); 5130 (12); 5161 (15); 5333 (17); 6468 (12); 6724 (12, 17); 7675 (8, 17); 7804 (10); 8313 (10); 8417 (20).
Forrest, G. 4188 (4); 4190 (21); 4190A (4); 5003 (4); 6784 (4); 8931 (4); 12021 (4); 12938 (12); 13310 (15); 13428 (10); 14216 (6, 17); 14735 (10); 19269 (15); 19286 (6); 20040 (12); 22333 (4); 26867 (20); 28035 (12); 28077 (4); 29668 (4); 30556 (12); 30879 (4).
Gaoligong Shan Biodiversity Survey 7758 (10); 16817 (18); 16874 (8); 16876 (10); 16918 (18); 16950 (10, 18); 16952 (8); 17007 (10, 17); 17032 (10); 20140 (5); 20969 (5); 20970 (10); 20975 (5); 22005 (7); 22409 (18); 22922 (4); 23018 (18); 25749 (4); 26754 (5); 26921 (18); 27029 (5); 27113 (17); 27113A (17); 27161 (5); 27221 (10); 28441 (10); 28501 (5); 28628 (10); 28629 (10); 31158 (10); 31446 (20); 31581 (15); 31589 (17); 31667 (1); 31683 (6); 32019 (1, 8); 32036 (18); 32041 (8); 32053 (18); 32060 (18); 32074 (10); 32078 (8); 32080 (10); 32127 (18); 32150 (17, 18); 32150A (18); 32170 (17); 32235 (18); 32102 (8); 32809 (12, 17); 33929 (10); 34106 (10); 34488 (18).
Ghimire, S.K. et al. TUCH-MO KCJ 108 (14).
Ghose, B.N. s.n. (21).
Grierson. A.J.C. & D.G. Long 2746 (21); 2789 (21).
Guan, K.J. et al. 04077 (19).
Handel-Mazzetti, H.F. v. 6416 (4); 8243 (12); 8722 (4); 9382 (10); 9441 (20).
Hart, G.S. 569 (21).
Hingston, R.W.G. 9 (21).
Hooker, J.D. s.n. (21).
Hu, S.Y. s.n. (9); s.n. (10); 2454 (13); 2455 (10); 2517 (13); 2594 (9, 10); 2596 (10); 2621 (1); 2672 (17); 2700 (13); 2718 (17).
Huang, Z.P. et al. 01950 (19).
Jacquemont, V. 750 (21).
Jinsha River Expedition 63-6113 (12); 4058 (4).
Kanai, H. et al. 12555 (21).
Kingdon-Ward, F. 1691 (4); 3062 (5); 5389 (16); 6331 (7); 6845 (10); 6849 (20); 6944 (16); 7094 (17); 8266 (10); 8562 (10); 8605 (17); 9628A (6); 9639 (16, 20); 9701 (14); 13005 (7); 13216a (3); 13659 (21); 21010 (20).
Koelz, (Dr.) W. 91 (21); 705 (21); 774 (21); 5064 (21); 8535 (21; 20289 (21).
Lace, J.H. s.n. (21); 328 (21); 1460 (21).
Li, B.S. & S.Z. Chen 00701 (17); 01185 (17); 05484 (17).
Li, H. (Gaoligong Shan Expedition) 7175 (5); 7282 (5); 9494 (5); 9570 (5); 9980 (5); 12551 (5); 14794 (5); 15033 (5).
Li, M.K. 1033 (4); 3545 (11).
Lian Da Expedition 11526 (4, 17).
Lin, Q. 79-2037 (5).
Lin, Q. & X.F. Dong 79-0558 (5).
Liu, E. 5016 (4).
Liu, Z.A. & Q.Q. Wang 22174 (19).
Long, D.G. et al. 378 (21); 710 (21); 742 (18).
Lu, L. 05-16 (4); 06-0001 (5); 06-0001A (6); 06-0003 (5); 06-0004 (5);

06-0005 (7); 06-0007 (21); 06-0012 (10); 06-0014 (5, 12, 17, 18); 06-0015 (5); 06-0016 (10); 06-0021 (5); 06-0058A (7); 06-15 (5); 06-19 (11); 06-19A (11); LL-07118 (18); LL-07119 (18); LL-07122 (18); LL-07128 (17); LL-07130 (17); LL-07133 (17); LL-07134 (17, 18); LL-07135 (10); LL-07149 (8); LL-07149A (1); LL-07151 (5); LL-07155 (16); LL-07308 (16); LL-07400 (16); LL-2013-1 (18); LL-2013-2 (18); LL-2013-3 (8); LL-2013-5 (8); LL-2013-7 (18); LL-2013-8 (18); LL-2013-9 (18); LL-2013-10 (18); LL-2013-11 (10); LL-2013-12 (10); LL-2013-13 (6); LL-2013-14 (17); LL-2013-15 (10); LL-2013-15A (5); LL-2013-16 (20); LL-2013-19 (3); LL-2013-20 (5); LL-2013-21 (8); LL-2013-22 (10); LL-2013-23 (20); LL-2013-28 (18); LL-2013-32 (8); LL-2013-33 (6); LL-2013-34 (5); LL-2013-37 (12); LL-2013-38 (10); LL-2013-40 (12); LL-2013-41 (5, 16); LL-2013-42 (5); LL-2013-44 (10); LL-2013-45 (17); LL-2013-47 (species uncertain; see discussion under 19); LL-2013-48 (5); LL-2013-49 (16); LL-2013-50 (1); LL-2013-51 (12); LL-2013-52 (17); LL-2013-53 (6); LL-2013-54 (2); LL-2013-55 (10); LL-2013-56 (15); LL-2013-58 (11); LL-2014-2 (6); LL-2014-3 (8); LL-2014-4 (5); LL-2014-5 (18); LL-2014-6 (3); LL-2014-7 (20); LL-2014-8 (18); LL-2014-9 (10); LL-2014-10 (5); LL-2014-11 (18); LL-2014-12 (18); LL-2014-13 (8); LL-2014-15 (20); LL-2014-22 (18); LL-2014-24 (3); LL-2014-25 (7); LL-2014-27 (10); LL-2014-28 (17); LL-2014-30 (6); LL-2014-31 (5); LL-2014-38 (4); LL-2014-39 (5) LL-2014-40 (5); LL-2014-44 (4); LL-2014-52 (12); LL-2014-60 (12); LL-2014-64A (12); LL-2014-64B (12).

Lu, L. & P.W. Fritsch LL-2011-7 (4); LL-2011-8 (5); LL-2011-9 (4); LL-2011-21 (16); LL-2011-22 (species uncertain; see discussion under 19); LL-2011-23 (14); LL-2011-31 (19); LL-2011-33 (9); LL-2011-36 (19); LL-2011-37 (13); LL-2011-39 (10).

Lu, L. & R.-F. Lu 06-0017 (4); 06-0018 (5); 06-0019 (21); 06-0022 (4); 06-0040 (18).

Lu, L. & M.Y. Zhang LL-2015-01 (13); LL-2015-03 (19); LL-2015-06 (19 ); LL-2015-14 (19).

Lü, Z.W. 623 (10).

Ludlow, F. & G. Sherriff 8053 (14); 9203 (21); 15158 (17).

Ludlow F. et al. 3733 (18); 3905 (21); 4750 (17); 5293 (17); 6265 (21); 6348 (14); 13146 (17); 15775 (16); 15775a (1); 16363 (21); 16465 (14); 16496 (21); 18885 (18); 19160 (21); 20617A (18); 20617B (21); 20904 (1, 8); 21191 (21).

Mao, P.Y. 00138 (12); 05696 (4); 1026 (17); 1033 (4).

Matuszak, S. & A. Favre 072 (4).

McPherson, S. 36 (21).

Miyamoto, F. et al. 95 (21); 9400032 (21).

Mohd, J. J48 (21).

Nath, M. 344 (21).

Norton, E.F. 172 (14); 218 (21).

Noshiro, S. et al. 9760361 (21); 9840162 (21).

Nujiang Expedition 79-0086 (5); 79-0714 (20).

Nujiang Zhou Investigative Expedition 1834 (5); 1853 (4).

Ohba, H. et al. 8570188 (21); 8571107 (21); 8580146 (21); 9154183 (21).

Panda, S. 29949 (21).

Parker, R.N. s.n. (21).

Parkinson, C.E. 3980 (21).

Parmanand, N. 295 (21).

Peng, H. 2577 (4).

Polunin, O. 56/636 (21).

Polunin, O. et al. 4162 (21).

Pratt, A.E. 833 (19).

Qin, R.C. 22863 (4); 24716 (4).

Qinghai-Xizang Expedition 74-2372 (21); 74-3770 (17); 74-3778 (18); 75-1934 (21); 5534 (21); 5862 (21); 6998 (5); 7580 (10); 8345 (5, 18); 8726 (17); 10107 (6); 10228 (17); 10719 (1).

Qiu, B.Y. 52915 (11).

Rau, M.A. 31722 (21).

Ribu & Rhomoo 980 (21); 5753 (21); 6454 (21).

Rock, J.F.C. 6272 (4); 6325 (12); 8804 (10); 9517 (4); 10252 (20); 17172 (12); 22407 (10).

Royle, J.F. s.n. (21); 102/1 (21).

Sargent, C. 121 (21).

Schmidt, H.H. et al. 4097 (16).

Schneider, C. 2797 (4).

Shangri La Alpine Botanical Garden & Missouri Botanical Garden 2013-155 (12); MJW95 (12).

Sinclair, I.W.J. 4168a (21).

Sinclair, I.W.J. & D.G. Long 5153 (21).

Sino-British Expedition to Cangshan 0072 (4); 0241 (4); 0347 (4); 0512 (4); 0824 (4).

Sino-German Exp. 1984 0056 (4); 0377 (4); 0665 (5).

South Tibet Expedition STET-0719 (1).

Stainton, J.D.A. 233 (21); 1130 (21); 4541 (21).

Stainton, J.D.A. et al. 1016 (21); 1536 (21); 3480 (21); 3481 (21); 3645 (21); 5101 (21); 5805 (21); 7914 (21).

Stewart, J.L. s.n. (21).

Stewart, R.R. 3553 (21); 9765 (21); 9804-A (21); 12466 (21); 21788 (21); 23252a (21).

Strachey, R. & J.E. Winterbottom 1 (21).

Sukoe 10080 (4).

Sun, H. 8015 (4).

Sun, H., Z.K. Zhou, H.Y. Yü Expedition to Mêdog 0623 (18).

Sun, H. et al. Sun H-07ZX-2664 (8, 16, 17).

Suzuki, M. et al. 9450080 (21).

Swan, L.W. 307 (21).

Tai, L.Y. T330 (19).

Thomson, T. s.n. (21).

Tsai, H.T. 57715 (4); 58172 (12); 58197 (4).

Vegetation Survey Team (Zhi-Bei-Zu) 30999 (19).

Wang, C.W. 63219 (4, 21); 63235 (4); 63284 (12); 65593 (16); 67099 (17); 67194 (20); 67196 (10); 68551 (12); 68633 (12).

Wilson, E.H. 3915 (19).

Wu, Q.A. 9234 (11); 9235 (4); 9399 (11).

Wu, S.K. 007333 (5); 6886 (4); 8416 (4); 8767 (12).

Wu, S.K. et al. 055 (6); 4774 (11).

Xie, L.S. 0886 (4).

Xu, B. & Y.D. Gao s.n. (13).

Xu, G.H. 25479 (19).

Xu, S.G. 4514 (4).

Yang, J.H. 360 (17).

Yang, J.S. & X.N. Wang 63-1351 (20).

Yang, S. Y0010 (5).

Yin, Z.J. & H.J. Dong 0401 (4); 0602 (5).

Yin, Z.J. et al. 1327 (5); 1357 (4); 1638 (4).

Yü, T.T. 8702 (16); 10554 (12); 10642 (16); 19732 (16); 19877 (1); 20049 (18); 20058 (10); 20262 (18); 20324 (18); 20336 (8); 20613 (20); 20683 (6); 20709 (10); 20821 (20); 22292 (1); 22316 (12); 22351 (1); 22606 (10); 22748 (12); 22945 (10); 23260 (10).

Zhang, S.D. & W.B. Yu 013 (19).

Zhang, T. et al. s.n. (5).

Zhang, Y.T. 3566 (21).

Zhongdian Expedition 63-3811 (4).

APPENDIX 3

Index to the taxonomic treatment of scientific names.

Numbers in parentheses correspond to those in the numerical list of accepted species in the text and Appendix 1. Synonyms are italicized.

**Brossaea** L.
*trichophylla* (Royle) Kuntze (21)—332
**Chiogenes** Salisb.
*suborbicularis* (W.W. Sm.) Ching ex T.Z. Hsu var. *albiflorus* T.Z. Hsu (1)—297
**Gaultheria** L.
albiflora (T.Z. Hsu) P.W. Fritsch & Lu Lu (1)—297
×biluoensis P.W. Fritsch & Lu Lu (2)—298
bryoides P.W. Fritsch & L.H. Zhou (3)—300
cardiosepala Hand.-Mazz. (4)—301
ciliisepala Airy Shaw ex P.W. Fritsch & Lu Lu (5)—306
crassifolia (Airy Shaw) P.W. Fritsch & Lu Lu (6)—308
dolichopoda Airy Shaw (7)—309
eciliata (S.J. Rae & D.G. Long) P.W. Fritsch & L.H. Zhou (8)—310
gonggashanensis P.W. Fritsch & Lu Lu (9)—312
hypochlora Airy Shaw (10)—313
jingdongensis R.C. Fang (11)—317
major (Airy Shaw) P.W. Fritsch & Lu Lu (12)—319
marronina P.W. Fritsch & Lu Lu (13)—320
minuta Merr. (14)—321
*nana* C.Y. Wu & T.Z. Hsu (21)—333
nivea (J. Anthony) Airy Shaw (15)—324
obovata (Airy Shaw) P.W. Fritsch & Lu Lu (16)—326
sinensis J. Anthony (17)—327
var. *crassifolia* Airy Shaw (6)—308
var. *layaensis* S.J. Rae & D.G. Long (14)—321
var. *major* Airy Shaw (12)—319
var. *nivea* J. Anthony (15)—324
stenophylla P.W. Fritsch & Lu Lu (18)—328
tetracme (Airy Shaw) P.W. Fritsch & Lu Lu (19)—330
thymifolia Stapf ex Airy Shaw (20)—331
trichophylla Royle (21)—332
var. *eciliata* S.J. Rae & D.G. Long (8)—310
var. *obovata* Airy Shaw (16)—326
var. *ovata* S. Panda & Sanjappa (21)—333
var. *tetracme* Airy Shaw (19)—330

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