



Orobanche cumana (Orobanchaceae), an addition to the flora of India from Himachal Pradesh (Western Himalaya) with a new host record

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Abstract

Orobanche cumana Wallroth, collected from lower Kullu Valley of Himachal Pradesh in Western Himalaya, is reported here as a new record for the flora of India with *Artemisia japonica* Thunberg as a host recorded for the first time. This is a distinct species widely distributed from Eastern Europe to Siberia and Western and Northern China but yet unreported from India. The species belongs to *Orobanche* Linnaeus section *Inflatae* (Beck) Rouy series *Cernua* Novopokrovskij and is very closely related to *O. cernua* Linnaeus from which it differs by a combination of characters: longer, lax inflorescence, smaller flowers held distantly on scape, and host range. The detailed description, photographs, discussion/comments on confusion with related taxa, ecology and pollination of the species are also provided.

Résumé

Orobanche cumana Wallroth a été collecté dans la basse vallée de Kullu de l'Himachal Pradesh dans l'Himalaya occidental, ce qui constitue une addition à la flore de l'Inde. C'est également la première fois que *Artemisia japonica* Thunberg est observé comme hôte. Il s'agit d'une espèce distincte largement distribuée depuis l'est de l'Europe jusqu'en Sibérie et à l'ouest et au nord de la Chine, mais non encore signalée en Inde. L'espèce appartient à *Orobanche* Linnaeus section *Inflatae* (Beck) Rouy série *Cernua* Novopokrovskij et est très étroitement apparentée à *O. cernua* Linnaeus dont elle diffère par une combinaison de caractères : inflorescence plus longue et lâche, fleurs plus petites distantes l'une de l'autre sur la hampe et type d'hôtes. Une description détaillée de l'espèce, accompagnée de photographies, une discussion relative à la confusion avec les taxons apparentés, des données sur son écologie et sa pollinisation sont proposées.

Keywords: *Artemisia japonica*, holoparasitic plant, Kullu valley, parasite, taxonomy.

Mots clés : *Artemisia japonica*, parasite, plante holoparasitaire, taxinomie, vallée de Kullu.

Introduction

Orobanche Linnaeus (1753: 632) is a morphologically complex genus of holoparasitic plants comprising 160-180 species worldwide, the majority of them being distributed in temperate and subtropical regions across the northern hemisphere of old world (Mabberley, 2017; POWO, 2019; WCVP, 2020). The updated Index of Orobanchaceae (Sanchez Pedraja *et al.*, 2016) lists 119 species of *Orobanche* [excluding 64 species of *Phelipanche* Pomel (1874: 102)]. The members of the genus are achlorophyllous, leafless, root parasitic herbs and some of them are restricted to particular host families. For nutrition, they completely depend on their host plants and get food by establishing direct contact with host roots. Hooker (1884) described 11 species of *Orobanche* in British India. Presently, the genus is represented by 13 species in India (Anilkumar, 2000), all of which are distributed in Western Himalaya. Based on the phytogeography of *Orobanche* in India, Western Himalaya clearly stands out as the richest phytogeographical zone. Wallroth (1825: 58) described *Orobanche cumana*, based on plants collected by Marschall von Bieberstein in Volga area (Astrakhan desert),

SW Russia but Beck (1930) considered this species as a variety of *O. cernua* Linnaeus in Loeffling (1758: 152) (*O. cernua* var. *cumana*) and reported central Asia to South-eastern Europe as the main distribution area. Originally, *O. cumana* was known to parasitize exclusively *Artemisia* spp. (Venkov & Bozoukov, 1994) in the wild but after the introduction and large scale cultivation of sunflower (*Helianthus annuus* Linnaeus, 1753: 904) in Russia, plants of *O. cumana* were detected for the first time parasitizing this crop in Voronev in 1866 (Morozov, 1947). In the 20th century this species spread to many other European and Western Asian Countries and become a serious parasitic weed of mainly (but not limited to) sunflower crop and this variety affecting crops is now called as *O. cumana* var. *helianthi* Tzvelev (2015: 214) which is actually different from the type species. We report here first confirmed record of *O. cumana* for the Indian flora based on the specimens collected from wild habitat and exclusively parasitizing *Artemisia japonica* Thunberg (1784: 310) which itself is a new host record for any *Orobanche* species.

Material and Methods

The first author has been exploring plant diversity of Himachal Pradesh, India, for the last four years and, during a routine plant exploration in lower Kullu valley of Himachal Pradesh, he came across a small population of an interesting *Orobanche* sp. parasitizing exclusively *Artemisia japonica* (Fig. 1). Identification of these specimens through consultation of herbaria of BSD, DD, CAL, GUH and relevant local literature (Collett, 1921; Chowdhery & Wadhwa, 1984; Polunin & Stainton, 1984; Stainton, 1988; Aswal & Mehrotra, 1994; Dhaliwal & Sharma, 1999; Singh & Rawat, 2000; Srivastava & Shukla, 2015; Singh, 2018), account of the genus in *Flora of British India* (Hooker, 1885), revision of the family Orobanchaceae in India (Anilkumar, 2000), and account of the genus in floras of adjacent countries (Schiman-Czeika, 1964; Jafri, 1976; Zhang & Tzvelev, 1998; Press *et al.*, 2000) was not successful. These specimens were finally determined as *Orobanche cumana* with the help of Dr. Óscar Sánchez Pedraja (GBC, Liérganes, Spain). This species, known to be distributed in Central Asia to South-eastern Europe, was not yet reported from India. Hence, these specimens are described here with images of live plants, new host record and associated information.



Figure 1. *Orobanche cumana*

A, plant in its habitat along with host; B, loosely held (distant) flowers; C, host plant *Artemisia japonica* with parasite *Orobanche cumana* showing root connection.

[Images by Ashutosh Sharma]

Taxonomic account

Orobanche cumana Wallroth, *Orobanches Generis Diaskeue [romanized] ad Carolam Mertensium. Francofurti ad Moenum* : F. Wilmans: 58 (1825).

Plants annual or biennial, total root parasite, achlorophyllous. Stem slender, thin, 15-45 cm long, unbranched, up to 1 cm in diameter at base, purplish with brown streaks at base, completely covered with glandular trichomes. Rhizomes highly variable in shape and size, covered with yellowish/brown scales, establishing connection with a thin root of the host. Roots shallow, clustered and rudimentary. Leaves reduced to scales, alternate, limited to the axis below the flowers, pale purple to yellow, turning into brown, 4-5 × 8-10 mm, ovate, acute to minutely acuminate, tips dry down and wither soon. Inflorescence racemose, spicate, 10-25 cm long, consisting of 12-30 sessile flowers, arranged spirally in acropetal succession, ca. 1-2 cm distant at base, inter-flower distance gradually decreasing towards apex. Bracts as long as or slightly longer than calyx but always shorter than corolla tube, 4-5 × 8-10 mm, similar in shape and size to scales, persistent; bracteoles absent. Flowers sessile, purplish, 14-18 mm long. Calyx adaxially covered with glandular trichomes including the edges, deeply 2-lobed, lobes lateral, separation reaching the base, 7-9 mm long, each lobe bipartite, segments unequal and variable, smaller segment anterolateral, 2-3 mm long, ca. 1 mm wide, thinner, partly or entirely concealed beneath the bract, larger segment posterolateral, 3-5 mm long, free from bract. Corolla tubular, dark purple, 14-18 mm long, slightly curved, slightly constricted above insertion of filaments, glandular hairy outside, 5-lobed, lobes nearly equal, curved outwards, margins irregularly dentate, inter-lobal distance between posterior pair slightly shorter than the distance between the three anterior lobes. Stamens 4, epipetalous, dark yellow colour prominent at the junction of filament and corolla, partially didynamous, posterior pair inserted on corolla tube ca. 1-2 mm lower than anterior pair; filaments ca. 8 mm long, nearly glabrous at base and minutely pubescent towards apex, inserted at 5-6 mm above the base of corolla tube, curved inwards near the apex, thus positioning anthers facing each other; thecae equal, parallel, both fertile, more pubescent at sutures/openings, mucronate at base. Pistil ca. 13 mm long; ovary oblong or ovoid, 7-8 mm long, glabrous, unilocular with 4 parietal placentae; style curved just below the stigma, ca. 7 mm long, persistent; stigma bilobed, covered with minute glandular trichomes, white. Fruit an unilocular

capsule, ca. 10 mm long, glabrous, laterally dehiscent. Seeds numerous, minute, oblongoid, dark brown, ca. 0.3 mm long, nearly half as broad as long (Fig. 2).

O. cumana can be separated from its close relative *O. cernua* by its long, lax inflorescence, smaller flowers placed distantly on scape (at least at base) and its host range. This species has unbranched stem, distinctly lacks bracteoles, flowers are sessile, calyx is incised into 2 lateral lobes which are further 2-partite. The characters like corolla with elongated tube usually more or less inflated below the place of insertion of the stamens, slightly narrowed and then again spreading upwards, insertion of stamens at corolla tube one-third from base or above, indicate its position in *Orobanche* sect. *Inflatae* (Beck) Rouy (1909: 167) [= *Orobanche* subsection *Inflatae* Beck (1882: 124)]. Complementary characters such as plant glandular-pubescent, parasitic on Asteraceae members, corolla tube strongly curved forward, with distinct constriction above the place of insertion of the stamens, somewhat below the middle of corolla tube, sub-glabrous anthers, clearly indicate its position in series *Cernua* Novopokrovskij (1930: 314).

Ecology and distribution: *Orobanche cumana* was collected at 1100-1200 meters a.s.l. from Jhiri village area, lower Kullu Valley (Mandi district) of Himachal Pradesh which lies between Pir Panjal and Dhauladhar mountain ranges. The individuals of this species were found growing on exposed, rocky pastures, dominated by *Imperata cylindrica* (Linnaeus, 1759: 878) Palisot Beauvois (1812: 165), *Koeleria macrantha* (Ledebour, 1815: 515) Schultes (1824: 345), *Lotus corniculatus* Linnaeus (1753: 775), *Micromeria biflora* Bentham (1834: 378), *Leptorhabdos parviflora* Bentham (1846: 510), *Artemisia japonica* Thunberg (1780: 209), *A. vestita* Wallich ex Besser (1834: 25), *A. nilagirica* (Charles Baron Clarke, 1876: 162) Pampanini (1926: 452) and *A. scoparia* Waldstein & Kitaibel (1801: 66).

Specimens examined: INDIA, Himachal Pradesh, Mandi District (Kullu Valley), Jhiri, on dry *Artemisia* species-rich hilly pastureland, 31°83'24" N, 77°16'53" E, 1150 m a.s.l., 14 April 2020, Ashutosh Sharma, CAL0000047245; CAL0000047246; CAL0000047247; CAL0000047248; FRLH124703.

Accessed online: INDIA, Cachemire:

P 02968095 <http://mediaphoto.mnhn.fr/media/1441353151109AvL9SS1y3K38nTqd>,

P 02968090 <http://mediaphoto.mnhn.fr/media/1441353151012Nzadu6r6oIBysKfu>,

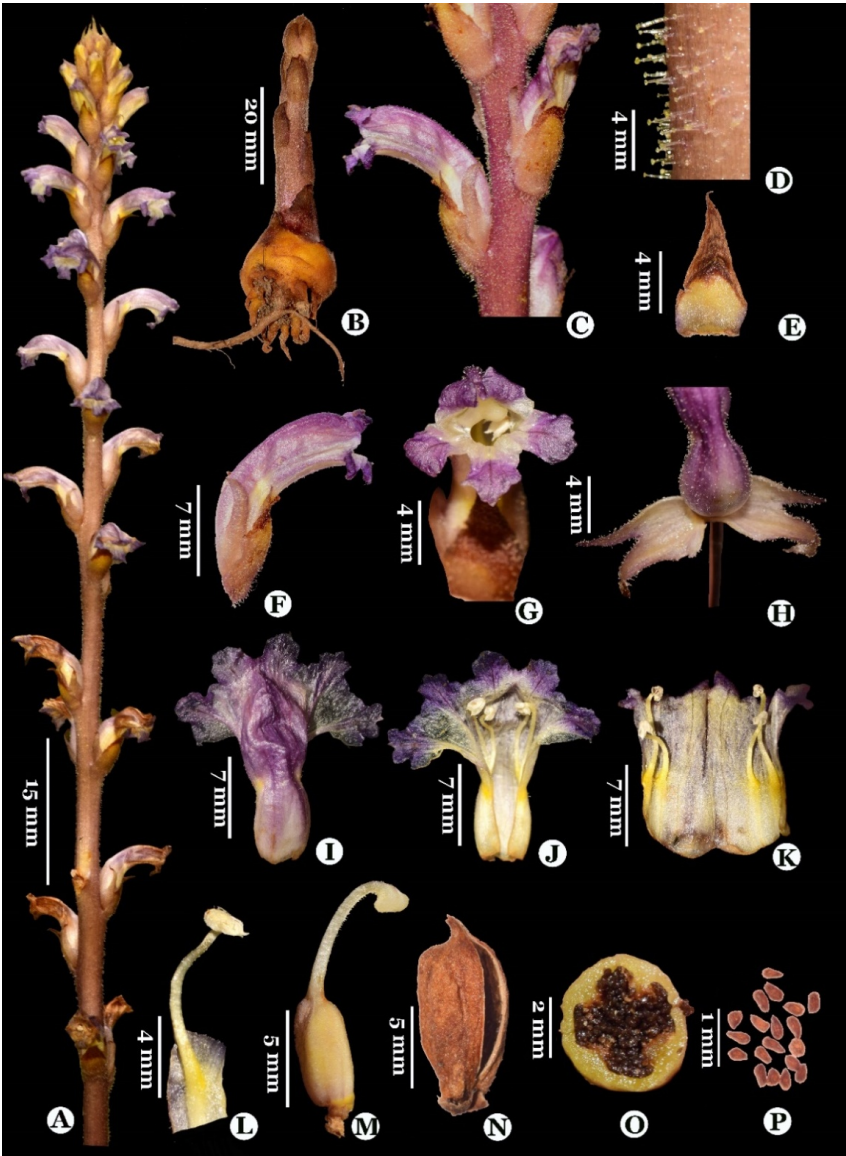


Figure 2. *Orobanche cumana*

A, inflorescence; B, shoot emerging from rhizome with intact host root connection; C, a part of scape; D, stem showing glandular trichomes; E, bract/scale; F, flower side view; G, flower front view; H, calyx; I, corolla exterior; J, corolla interior; K, corolla spread open; L, stamen attached to corolla tube; M, pistil; N, mature capsule; O, ovary (transverse section); P, seeds. [Images by Ashutosh Sharma.]

Coimbatore, Tamil Nadu:

K 000061383 <http://specimens.kew.org/herbarium/K000061383>

K 000061384 <http://specimens.kew.org/herbarium/K000061384>

RUSSIA, Old Sarpeta:

P 02968103 <https://mediaphoto.mnhn.fr/media/14413531512615OWFuwo01cLAOHTC>

P 04410446 <https://mediaphoto.mnhn.fr/media/1441359764088E2Avf8x7ni3fS1sZ>

COI 00056874 <https://coicatalogue.uc.pt/index.php?t=specimen&COINumber=56874>

Host: *Orobanche cumana* belongs to series *Cernua*, where members are parasitic usually on members of Asteraceae (Novopokrovskij and Tzvelev, 1958). In the wild, *O. cumana* is mostly found growing on several *Artemisia* species and the first reports of *O. cumana* parasitizing on sunflower came from Voronev, Russia in 1866 (Morozov, 1947). In 20th century, this species reached agricultural fields in several parts of Europe and Asia where it is reported parasitic on various cultivated plants e.g., Sunflower (*Helianthus annuus*), Tomato (*Solanum lycopersicum* Linnaeus, 1753: 185), Aubergine (*Solanum melongena* Linnaeus, 1753: 186) and Tobacco (*Nicotiana tabacum* Linnaeus, 1753: 180) (Novopokrovskij & Tzvelev, 1958; Labrousse *et al.*, 2001; Piwowarczyk *et al.*, 2019). But interestingly, our recently discovered population of *O. cumana* has been found to be precisely host-specific in nature with the host invariably being *Artemisia japonica*. Repeated and careful observations of the population revealed that in spite of presence of three more *Artemisia* species, viz. *A. vestita*, *A. nilagirica*, and *A. scoparia* in the same locality and soil, it has been seen to establish connection with the roots of its specific host (*A. japonica*) only (Fig. 3). Further, it is noteworthy that its confirmed host species, *A. japonica*, has not been recorded as host of any *Orobanche* species till now (Sánchez Pedraja *et al.*, 2016).

Flowering/fruiting and pollination: Flowering is recorded from early April to May, gradually followed by fruiting from late April to late May.

Pollination is done by a couple of species of small Carpenter Bees, particularly by *Ceratina simillima* Smith, characterised by having pubescence on head and legs, which helps it in carrying pollen. It is one of the few pollinators visiting its flowers, because large insects are not able to enter the flowers, the mouth of which is smaller (less than 5 mm) than many other potential pollinators.

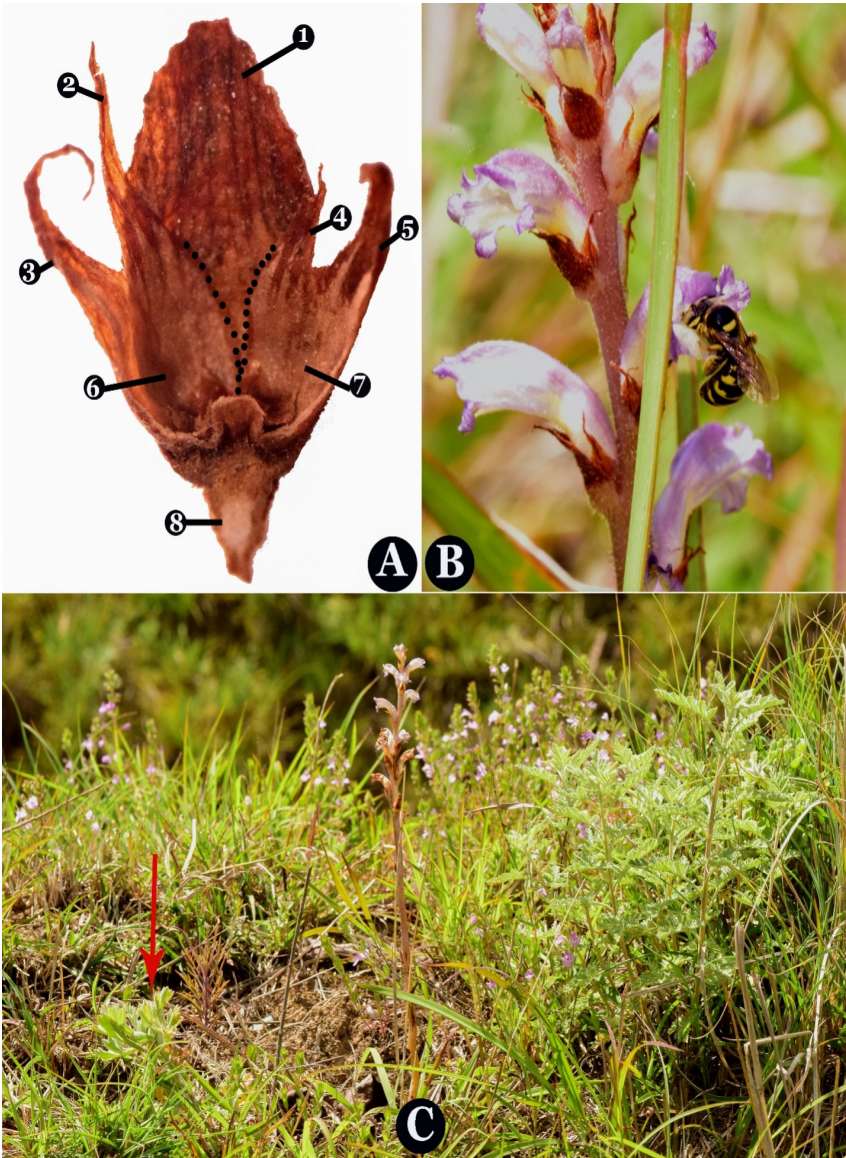


Figure 3. *Orobanche cumana* in situ

A, bract and calyx, 1-bract, 6 & 7-calyx lobes, 2 & 4-anterolateral segments of calyx lobes, 3 & 5-posterolateral segments of calyx lobes, 8-point of attachment with stem;
 B, pollinator *Ceratina simillima* visiting the flower; C, plant in its habitat, with non-host *Artemisia vestita* growing in proximity on right side and its young host plant of *A. japonica* on left side (indicated by arrow). [Images by Ashutosh Sharma]

Identity confusion with *Orobanche cernua*

Orobanche cernua was described based on materials collected by Pehr Löfling (Loefling) near Aranjuez, central Spain. It parasitizes different species of the Asteraceae, being most frequently found on plants of the genus *Artemisia* in the wild much like *O. cumana* which itself is a polymorphous species, very closely allied to *O. cernua*, although the differences between these two species cannot always be easily expressed (Novopokrovskij & Tzvelev, 1958; Tzvelev, 1981; Pujadas & Velasco, 2000). The *Orobanche cernua* populations attacking sunflower seem to be unable to attack tobacco and *vice versa* (Musselman, 1994) so, according to some authors, they should be taxonomically distinguished either as separate subspecies or as two species, indicating the sunflower broomrape as *O. cumana* (Dhanapal 1996: 10, sub *O. cernua*). So *Orobanche cumana* was earlier considered a subspecies of *O. cernua*, until Joel (1988), Jacobsohn *et al.* (1991) and Paran *et al.* (1997) clearly differentiated two species on the basis of morphological and host range differences; later this separation was also supported by seed-oil fatty acid profiles (Pujadas & Thalouarn, 1998; Pujadas-Salvà & Velasco, 2000), seed morphology (Plaza *et al.*, 2004) and at the molecular level (Román *et al.*, 2003; Pineda-Martos *et al.*, 2014). These two species can be distinguished when comparing typical specimens (e.g., when comparing specimens of *O. cumana* growing on cultivated plants) but this is not easy when the specimens are less typical. On the other hand, the staminal indumentum is variable (glabrous/hairy) and may be of no value in differentiating the two taxa (e.g., *O. cernua* from *locus classicus* has hairy stamens) as some authors think (Novopokrovskij & Tzvelev, 1958; Tzvelev, 1981). The form of "*O. cernua* subsp. *cumana*" parasitizing sunflower is the result of anthropogenic activity, which, in any case, cannot be considered as the typical subspecies *cumana* (Tzvelev, 1981).

The most important differentiating character between both taxa is the size of the corolla. It is smaller in length and diameter in *O. cumana*. Other characters, such as the number of flowers or the density of the inflorescence, are sometimes quite variable and have led to the description of numerous forms. However, in general *O. cumana* is a more graceful herb having less dense inflorescence, with fewer flowers than *O. cernua* (Novopokrovskij & Tzvelev, 1958).

The comparison between *O. cernua* and *O. cumana* by Pujadas-Salvà and Velasco (2000) in the Iberian Peninsula is actually between *O. cernua* s. str.

and *O. cumana* var. *helianthi* and not the typical wild *O. cumana*. The same is true of Joel (1988), Jacobsohn *et al.* (1991) and Paran *et al.* (1997), as they compared *Orobanch*e that parasitizes tomato (as *O. cernua*) with the one that parasitizes sunflower (as *O. cumana*). Additionally, they do not compare the types of both taxa in Spain and Russia respectively. In our opinion, the ratio between the length of the corolla and the width of the corolla on the throat is smaller in *O. cumana* along with lax inflorescence and lesser number of flowers in wild population. These measures may be more convincing, if they are done on the individuals from their own locality, and specifically those which are parasitizing wild species rather than crop plants, like *O. cumana* var. *helianthi*.

Discussion and conclusion

*Orobanch*e is a complicated genus, on account of complex morphology (owing to intraspecific variations), short reproductive phase, reduced vegetative parts and also the non-preservation of distinguishing characters while preparing herbarium material. The specimens quickly lose important characteristics like colour and shape of corolla etc. during preservation (Anilkumar, 2000). Due to these factors, Indian herbaria lack good and correctly identified specimens of the genus. A thorough study of this genus in India, based on live material as well as herbarium specimens is much needed. Some of the Indian species are very little known, as for instance *O. kashmirica* C.B. Clarke ex Hooker (1884: 324) is not even represented in any Indian herbarium and is only known by its type at K (<http://specimens.kew.org/herbarium/K000061388> Digital Image).

In the past, most of the studies dealing with *O. cumana* have been done on the plants that parasitize sunflower, i.e. *O. cumana* var. *helianthi* and not on true specimens of *O. cumana* collected from *locus classicus* (Astrakhan desert, Russia). In Europe, *O. cumana* var. *helianthi* is the only species that attacks several crops and we think the same may be true in India, along with *Phelipanche aegyptiaca* (Persoon) Pomel (1874: 107) (= *O. aegyptiaca* Persoon, 1806: 181) which is another major crop-infesting species in India. So further field work is needed to inspect and reconfirm identities of what is known as *O. cernua* affecting tobacco and few other agricultural crops in India. There are reports of *O. cumana* [*terra classicus*] parasitizing tobacco plants according to Becker's collection (COI 00056874) <https://coicatalogue.uc.pt/index.php?t=specimen&COINumber=56874> so

there are good possibilities that even the forms that parasitize tobacco and other Solanaceae species in India would be included in *O. cumana* [*O. nicotianae* Wight (1850: 179) and *O. cernua* subsp. *rajahmundrica* Teryokhin (1996: 246)]. Also, as we examined online specimens from India by accessing the data available on Index of Orobanchaceae (Sánchez Pedraja *et al.*, 2016 onwards), we found an interesting specimen from Kashmir (P02968095) (Chagnoux, 2021) identified as *O. cf. cumana* that looks near similar to our plant specimens. As this locality is from neighbouring union territory, this gives more evidence that true wild occurring population of *O. cumana* may be more widespread in Western Himalayan region. However, other specimens from India given in this database (particularly from South India and growing on crops) having much dense inflorescence with very high number of flowers, thick and often branched scapes need further detailed work and field analysis to confirm their true identity, which otherwise is not possible to confirm from merely herbarium specimens.

By perusal of literature related to Indian species of this genus, it has been reflected that the specific identification of the host has not been given due priority. Consequently, the hosts of many of the Indian *Orobanche* spp. are known only at the genus level, like *Artemisia* spp. However, a recent study (Schneider *et al.*, 2016) has suggested that host specificity and host switching are important drivers of speciation in *Orobanche*. Therefore, it is opined here that future collections and studies of this genus must also include species identification of the host plants. Knowing the exact host species will lead to better understanding of complexes like *O. cernua* and such findings may even invoke discoveries of new cryptic taxa.

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