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RESEARCH ARTICLES

Misidentification impedes invasion management: report of *Matricaria discoidea* DC., an invasive alien species in Kashmir Himalaya

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Abstract
Invasive alien species are regarded as one of major drivers of global biodiversity loss, and correct taxonomic identification of these species at early stage of introduction is crucial in successful invasion management. Here we report *Matricaria discoidea* DC., an alien plant species, which has currently reached to the invasive stage in Kashmir Himalaya, India. The herbarium records revealed that although this alien species was first collected in the region about 4 decades before, it remained taxonomically misidentified, which impeded its timely management. To clarify the taxonomic identification and nomenclatural confusion of *M. discoidea* and validate its first distribution record in India, we provide a detailed taxonomic account, including description, delimiting characters with closely related species, photographic illustrations of diagnostic characters and distribution map. Our report will facilitate easier field identification of *M. discoidea*, thus inform policy and practice in invasion management and prevent its spread to the neighboring regions of Himalayan biodiversity hotspot.

Keywords Biodiversity · Flora · Invasive plants · Taxonomy · India · Himalaya

Introduction

Worldover, invasive alien species are regarded as one of the major drivers of global biodiversity loss, with impacts on ecology, economy and health sectors (Pyšek et al 2020). In India, plant invasions by alien species introduced intentionally or accidentally have emerged as a serious threat to biodiversity (Sharma et al 2005; Khuroo et al 2011; Reshi and Khuroo 2012), impairing ecosystem functioning (Ahmad et al 2019a, b), affecting life-supporting ecosystem services and inflicting huge economic costs (Diagne et al 2020). Management efforts to eradicate the already established invasive alien species and control their further spread in the country are posing daunting challenges (Kannan et al 2013). Therefore, it becomes crucial to prevent the introduction of potential invasive plant species and proactively monitor and report the initial phase of establishment and naturalization. In this regard, correct taxonomic identification of the potential invasive plant species, particularly at early stages of introduction-naturalization-invasion continuum (Richardson et al 2000) plays a pivotal role in achieving successful management outcomes (Khuroo et al 2012; Arshid et al 2016; Mehraj et al 2018).

During recent botanical surveys, we collected plant specimens from different localities across Kashmir Himalaya—a region located in northwestern side of Himalayan biodiversity hotspot (Fig. 1), which were previously not reported from the region. After critical examination of the plant specimens and perusal of taxonomic literature (Abrams and Ferris 1960; Gandhi and Thomas 1991; Gleason and Cronquist 1991), online floras and databases (FoC 2008; eFoI 2020; FNA 2020; WFO 2020; POWO 2020; Tropicos 2020) and perusal of protologues and types (BHL 2020), the collected plant specimens were identified as *Matricaria discoidea* DC., a species native to North America which was hitherto unreported from entire India. Interestingly, the specimens of *M. discoidea* in vegetative stage have been collected about four decades ago from the Kashmir Himalaya (Specimen Nos. 16417 and 38,652 deposited in KASH herbarium and

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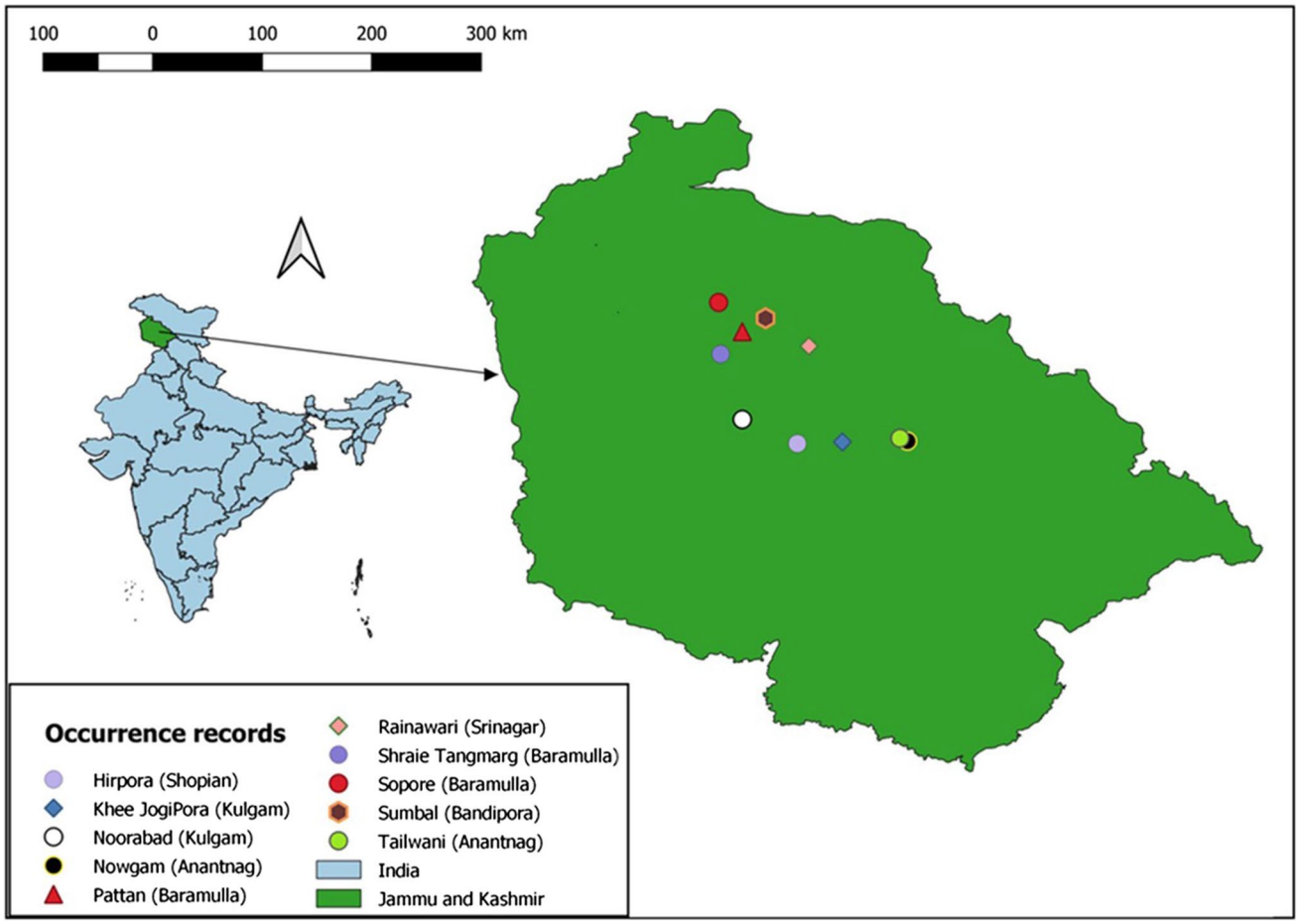


Fig. 1 Distribution map of *Matricaria discoidea* DC. in Kashmir Himalaya

collected in the year 1983 and 1984, respectively). However, due to morphological similarity in vegetative characters, these specimens have been misidentified as *Anthemis cotula* L.—another widespread weed species in the region (Reshi et al 2012).

To clarify the taxonomic identification and nomenclatural confusion of *M. discoidea* and validate its first distribution record for India, the present study provides detailed taxonomic account, including description, delimiting characters with closely related species, photographic illustrations of diagnostic characters based on plant material collected from Kashmir Himalaya, India (Figs. 2 and 3).

Materials and methods

The present study was conducted in the Kashmir Himalaya, covering an area of ~ 15,000 km^2 with 64% of the area being mountainous (Rashid et al 2020). The altitude in the region ranges from *ca.* 1600 to 5420 m asl (Khuroo et al 2007). The climate is primarily of continental temperate type with cold and wet winters and relatively dry and hot summers (Rashid et al 2019). The temperature of the region ranges from an average daily maximum of 31 °C and minimum of 15 °C during summer to an average daily maximum of 4 °C and minimum of − 4 °C during winter and receives an average annual precipitation of 1055 mm, mostly in the form of snow. The natural vegetation of the region mostly consists of alpine meadows and coniferous forests (Khuroo et al 2007). During floristic surveys, standard taxonomic methods have been followed for collection, drying and further processing of the herbarium specimens (Bridson and Forman 1998). The specimens have been deposited in University of Kashmir herbarium (KASH) with proper voucher specimen numbers. The field photographs were taken by Mobile phone camera (Make: Redmi Note). The microphotography of the diagnostic characters was carried out under a stereozoom microscope (Make: Leica S9D, Germany) integrated with image processing software (LASX).

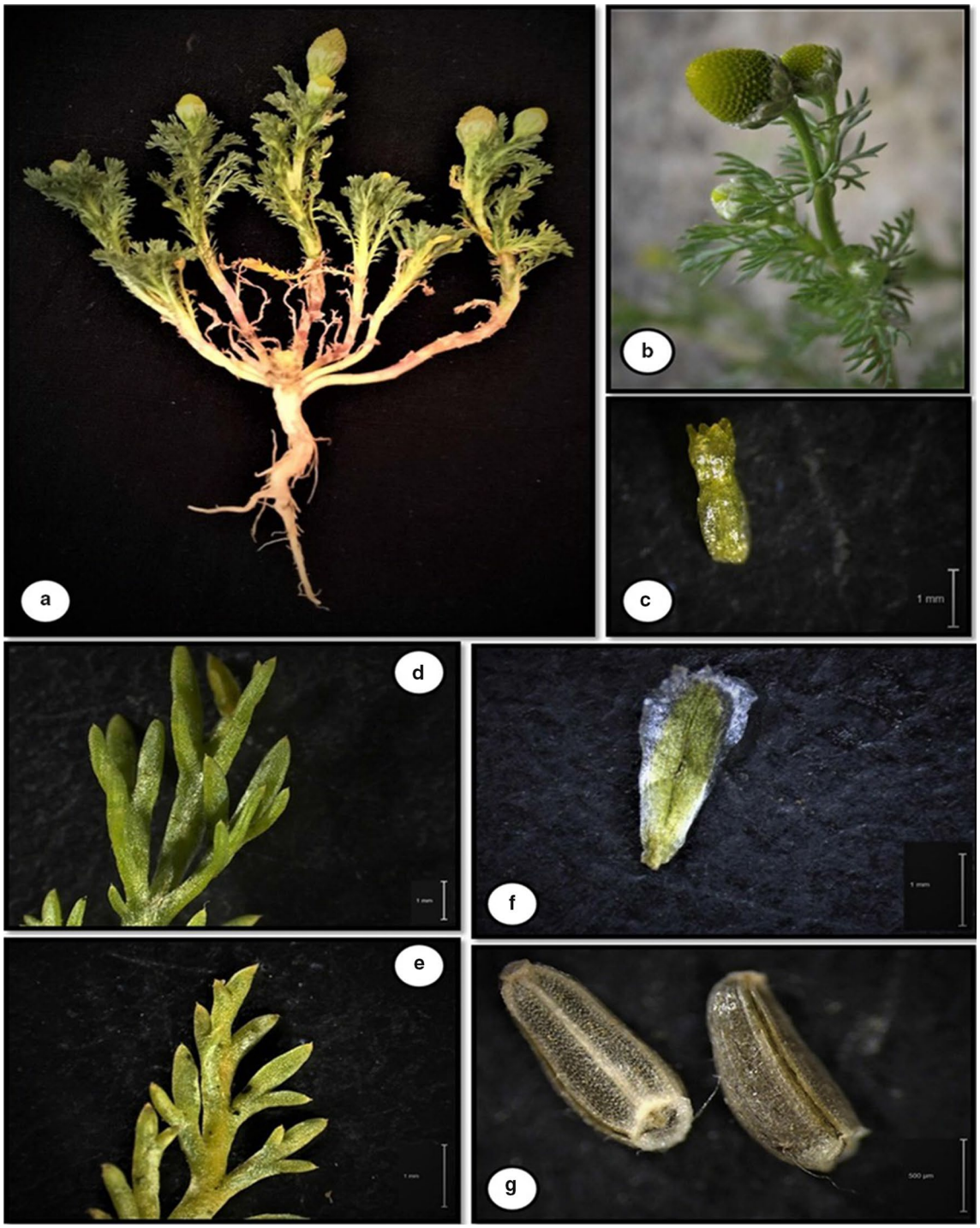


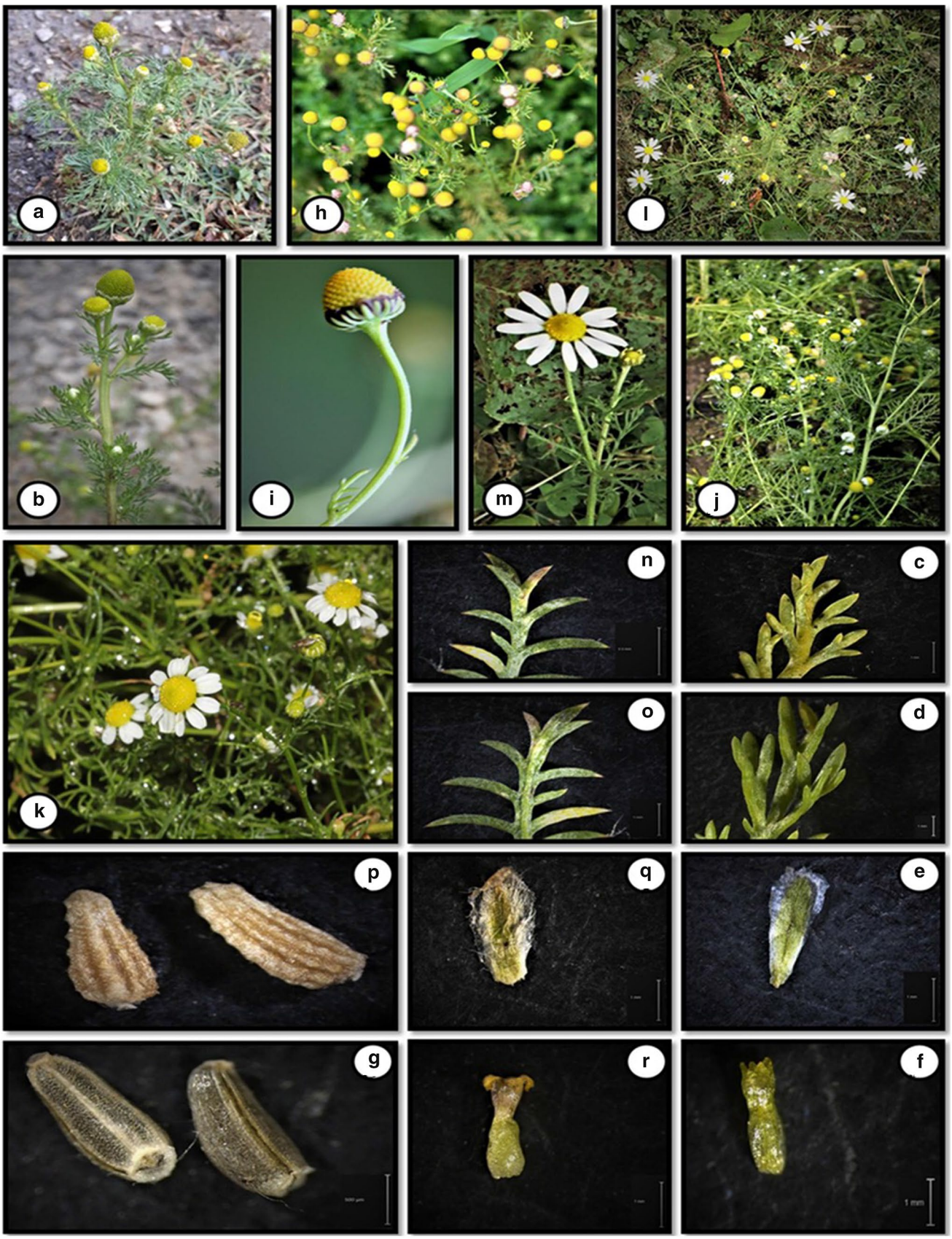
Fig. 2 *Matricaria discoidea* DC.: **a** Whole plant; **b** Branch with capitula; **c** Disc floret; **d, e** Leaves—different views; **f** Phyllary; **g** Fruits (Photo credits: TI, AAK, GS)

Results and discussion

Taxonomic treatment

Matricaria discoidea DC., Prodr. [A. P. de Candolle] 6: 50 (1838). (Fig. 2).

Synonyms *Chamomilla suaveolens* (Pursh) Rydb., *Matricaria suaveolens* (Pursh) Buchenau, *Santolina suaveolens* Pursh, *Lepidotheca suaveolens* (Pursh) Nutt.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◂**Fig. 3** Comparison of diagnostic characters of *Matricaria discoidea* DC. with similar species: **a–g** *M. discoidea* DC.; **h**, **i** *M. aurea* (Loefl.) Sch.Bip.; **j**, **k** *M. chamomilla* L.; **l–r** *Anthemis cotula* L. (Photo credits: TI, AAK, GS)

Holotype Muséum National d'Histoire Naturelle Paris, United States, 1833, Douglas, P02429296; Prodromus Systematis Naturalis Regni Vegetabilis 6: 50 1837 [1838].

Description Annual herb, stem erect or ascending, 5–40 cm high, branched from base or in upper part, glabrous or densely pubescent below capitula. Leaves sessile; leaf blade oblanceolate or oblong, 2–3 × 0.6–1 cm, 2-pinnatisect: segments shortly linear, glabrous. Capitula homogamous, intermittently corymbose or solitary at branch apices, pedunculate: peduncle 5–10 mm. Involucre cupuliform, phyllaries in 3 rows, equal, oblong, 2–3 × 0.5–1 mm, scarious margin hyaline with obtuse apex, abaxially glabrous. Ray florets absent. Disc florets bisexual, pale yellow–green, 0.8–1.3 mm, corolla tubular, 5-lobed. Cypselae oblong, fairly curved, 1.6 × 0.5 mm, apex diagonally truncate, with 2 or 3 adaxial white thin ribs and one red thin strip on both sides. Pappus whitish, coroniform.

Flowering and fruiting May–July.

Habitat Mostly disturbed habitats, along roadsides, borders of crop fields, orchards, human habitations.

Distribution: Native to North America; introduced to Eurasia, South Australia and northern Africa.

Common names Pineapple weed, Rayless Chamomile.

Local (Kashmiri) name "Thool-e-baber".

Specimens examined INDIA: Jammu and Kashmir: Baramulla, Sopore, 34° 17′ 20.46″ N, 74° 26′ 46.41″ E, 1594 masl, 14–07–2020, Tajamul and Khuroo 45,049; Anantnag, Nowgam, 33° 41′ 38.35″ N, 75° 15′ 24.44″ E, 1749 m asl, 16–07–2020, Tajamul and Khuroo 45,050; Shopian, Hirpora, 33° 40′ 59.38″ N, 74° 47′ 3.28″ E, 2146 masl, 26–07–2020, Tajamul and Khuroo 45,051; Kulgam, Noorabad, 33° 47′ 12.44″ N, 74° 32′ 52.3″ E, 2161 masl, 01–08–2020, Ruquia, Tajamul and Khuroo 45,052.

Specimens correctly determined in KASH INDIA, Jammu and Kashmir, Baramulla, Sumbal, 1983, A. Ahmad 16,417; Srinagar, Buchipora, 16–7–1984, A.R. Naqshi 38,652.

Taxonomic note

The genus *Matricaria* L., belonging to family (Asteraceae), globally comprises of 6 species (Oberprieler et al. 2007). The different species of this genus are mainly distributed in northern Africa, Macaronesia, western Asia, southwestern Asia and central Asia, and western North America. The *Matricaria* taxa possess erect to prostrate, leafy and glabrous stems which are branched profusely or sparsely; capitula solitary, either homogamous or heterogamous (*M. chamomilla* L.); lack ray florets; comprise of disc florets showing radial symmetry (Bremer and Humphries 1993; Singh et al 2011). First of all, Hooker (1882) has reported *M. aurea* Loefl. (*Cotula aurea* L.) from India. In addition to this, two more species of *Matricaria* with radiate heads have been reported from India: *M. recutita* L. (currently accepted name *M. chamomilla* L.) and *M. disciformis* DC. (currently recognised under separate genera *Tripleurospermum disciforme* Sch.Bip.) (Hajra et al 1995). Morphologically, *M. discoidea* is often confused in vegetative phase with *Anthemis cotula* in Kashmir Himalaya, and with related congeneric species such as *M. aurea* and *M. chamomilla* in having an annual habit, stem erect, leaves pinnatisect and corymbiform inflorescences; however, *M. discoidea* differs from these three species in the length of peduncle, nature of phyllaries margin and shape of capitulum (Table 1, Fig. 3).

There has been nomenclatural confusion surrounding the two scientific names *Matricaria discoidea* DC. and *Matricaria matricarioides* (Less.) Porter. Although, The Plant list and World Flora Online currently considers *M. matricarioides* (Less.) Porter as an accepted name (The Plant list 2013; WFO 2020). However, Flora of North America, Flora of China, Germplasm Resource Information Network, Euro + Med Plantbase do not recognize *M. matricarioides* (Less.) Porter as a valid name, and *M. discoidea* DC. is treated as the accepted name (FNA 2020; FoC 2008; GRIN 2021; Euro + Med 2006). *M. matricarioides* (Less.) Porter is a misapplied name (Keil 2012) and thus cannot be considered as an accepted name. Further, it is relevant to point out that The Plants of the World Online, in addition to keeping the correct type specimen of *Tanacetum bipinnatum* subsp. *bipinnatum* (K000928643), has wrongly kept the specimens of *M. discoidea* DC. (K000928491–K000928495), and again with wrong identification as *M. matricarioides* which needs to be rectified (POWO 2020).

Ecological note

In Kashmir Himalaya, *M. discoidea* currently occurs across the region (Fig. 1), recorded between altitudes of 1600 to 2150 m asl. Based on Geospatial Conservation Assessment Tool (GeoCAT), the species currently shows an area of 2605.121 km^2 and 40 km^2 as extent of occurrence (EOO) and area of occupancy (AOO), respectively in the region. It produces reproductive off-springs, often in very large numbers, at considerable distances from parent plants and thus have the potential to spread over a considerable area in future as well. Based on the studies conducted in other regions of the world (Europe), it has been reported that other species belonging to this genus possessing the similar traits, have invaded natural habitats and caused much damage to native biodiversity (Alexander et al 2009). Therefore, the

Table 1 Comparative diagnostic characters between *Matricaria discoidea* DC., *M. aurea* (Loefl.) Sch. Bip., *M. chamomilla* L. and *Anthemis cotula* L

Diagnostic Characters	*Matricaria discoidea* DC	*Matricaria aurea* (Loefl.) Sch. Bip	*Matricaria chamomilla* L	*Anthemis cotula* L
Stem	Plants up to 40 cm tall, profusely branched from base	Plants up to 20 cm tall, glabrous or with short sparse whitish hairs	Plants up to 30–40 cm tall, glabrous, erect, striate, much branched in upper part	Plants up to 50 cm tall, sparsely pubescent or sub-glabrescent
Leaves	Cauline leaves sessile; leaf blade oblong or oblanceolate, 2–3 × 0.6–1 cm, 2-pinnatisect; ultimate segments shortly linear	Cauline leaves shortly petiolate to sessile, linear–lanceolate to oblong, 1.5–3 cm long, 2–3-pinnatisect; ultimate segments shortly mucronulate	Lower cauline leaves sessile; leaf blade oblong or oblanceolate, 3–4 × 1.5–2 cm, 2-pinnatisect; ultimate segments linear, apex mucronulate; upper cauline leaves ovate or long ovate	Cauline leaves sessile; leaf blade ovate–oblong, 1.5–6 × 0.5–3 cm, 2-pinnatisect; ultimate segments narrowly linear
Peduncle	Peduncles thicker, 5–10 mm long	Peduncles slender up to 6 cm long	Peduncles up to 3–6 cm long	Peduncles up to 1–2 cm long
Capitulum (Head)	Capitula homogamous, 10–12 mm across, globose	Capitula homogamous, 5–6 mm across, tapering above	Capitula heterogamous, apically corymbose, 1–1.5 cm in diameter	Capitula heterogamous, terminal, solitary, long pedunculate, 1–2 cm in diameter
Fruit	Cypselae 1.6 × 0.53 mm, with 2–3 narrow white ribs brown and 1 red thin stripe on each side	Cypselae 0.5–0.7 mm, mildly 3-ribbed on each side, 2 thin white ribs and 1 reddish	Cypselae 0.8–1 mm, with 5 adaxial thin ribs	Cypselae oblong–turbinate, 1–1.5 mm, tuberculate, obscurely 8–10-ribbed
Phyllaries	Phyllaries 2–3 × 0.5–1 mm, 3-seriate, margin hyaline	Phyllaries 2-seriate, outer often with brown margins	Phyllaries in 2- seriate, margin broadly white scarious, apex obtuse	Phyllaries 3-seriate, oblong, scarious margin narrow, apex obtuse

species can be recognized to have reached to the invasive stage (sensu Richardson et al 2000). Our report will facilitate easier field identification of *M. discoidea*, inform policy and practice in invasion management and control its spread to neighboring regions in the Himalayan biodiversity hotspot.

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Declarations

Conflict of interest The authors declare no conflict of interest.

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