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ADDITIONS TO INVASIVE FLORA OF PAKISTAN INCLUDING TWO NEW GENERIC RECORDS

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Abstract

Three globally expanding invasive species are presented as new records for the flora of Pakistan, also comprising two new generic records. *Anredera cordifolia* (Basellaceae) was observed in various localities of Swat, Rawalpindi and Islamabad districts, *Dentella repens* (Rubiaceae) was observed around Rawal Lake, Islamabad while *Oenothera laciniata* (Onagraceae) was observed in the Botanical Conservatory at National Agricultural Research Centre, Islamabad. Their descriptions and illustrations are provided for easy identification and global ranges are portrayed on maps.

Key words: *Anredera cordifolia,* Madeira vine*, Dentella repens*, *Oenothera laciniata*, invasive plants, weeds, Pakistan.

Introducation

There has been an increased number of new plant records including alien invasive species from Pakistan in the last couple of decades (Ishaq *et al*., 2020; Bahadur *et al*., 2020; Hussain *et al*., 2019; Ali *et al*., 2017, Islam *et al*., 2016; Qureshi & Raana, 2014; Qureshi *et al*., 2014; Ajaib & Khan, 2012; Khan *et al*., 2010; Marwat *et al*., 2009; Qaiser & Abid, 2002) including the most hazardous invasive species like *Parthenium hysterophorus* (Arshad *et al*., 2006) that have serious ecological consequences and cause significant economic loss. The non-native flora especially the invasive species are widely recognized as one of the major global threats to biodiversity (e.g. Sakai *et al*., 2001; Sax & Gaines, 2003; Glogov *et al*., 2019). International trade in plants and seeds of species used for agricultural, horticultural, ornamental, and forestry purposes is rapidly expanding, involving more and more countries, using the opportunities provided by the Internet and booming globalization. This process, which reflects the natural desire to improve human nutrition and health and to satisfy both basic vital needs and aesthetic feelings, is deeply rooted in human nature, and thus the trend cannot be reversed. Deliberately or unintentionally, new species will be introduced to new areas, often quite distant from their original ranges (Protopopova *et al*., 2006). Therefore, the documentation of alien plant species is extremely important for monitoring their ecological consequences on a country's flora and agriculture that lead to huge economical losses. With the completion of spermatophyte Flora of Pakistan in 2020, henceforth, the documentation of new plant introductions will either rely on taxonomic revisions, regional checklists or individual research papers. In this context, the current study reports the occurrence of *Dentella repens, Anredera cordifolia* and *Ludwigia laciniata* from Pakistan. These plants are not documented in Stewart's annotated catalogue (1972) or the account of the families Rubiaceae (Nazimuddin & Qaiser, 1989), Basellaceae (Malik, 1984) and Onagraceae (Hoch & Raven, 1981) in the Flora of Pakistan and thus represent new records for Pakistan. These species are known to have become naturalized/invasive or adventive in other parts of the world.

Morphological descriptions and geographic distribution

***Anredera cordifolia* (Tenore) Steenis:** Perennial tuberous climbers, stems glabrous often pinkish, bearing axillary tubers, leaves cordate, acute or obtuse, 1.5-4.5 cm in diameter, glabrous, petiole 0.3 to c. 1.3 cm or longer. Inflorescence axillary or terminal simple or branched racemes c. 20 cm or longer. Flowers 5 mm in diameter, pedicel c. 2 mm, bract subulate, c. 2 mm, bracteoles 2, 2 x 1.5 mm in diameter, rotundate. Perianth white, tepals 2-2.5 x 1-1.5 mm, obtuse, filament c. 2.5 mm, anther c. 1 mm, pistil c. 2.5 mm bearing three clavate stigmas, ovary, c. 0.5 mm, style c. 1 mm and stigma c. 1 mm. (Figs. 1-3).

Specimens examined: PAKISTAN, Khyber Pakhtunkhwa, Swat district, Gulibagh, *A. Sultan and S. Ahmad,* no. 1418, 30-11-2018, escape from cultivation (RAW 100408).

Notes: During a collection expedition in lower Swat, Kohistan and Hazara *Anredera cordifolia* was recorded between Bisham and Thakot. Plants were also seen between Panjar and Nararh in Rawalpindi district. A flowering specimen was collected growing as an escape at Gulebagh in lower Swat which helped confirm its identity as *Anredera cordifolia* (RAW 100408). Besides, the collected plants, this species has been seen in various locations in Swat. The vine is also being grown as an ornamental in Rawalpindi-Islamabad.

Global range: There are 5756 GBIF occurrences for *Anredera cordifolia* of which 4954 are georeferenced (*Anredera cordifolia* (Ten.) Steenis in GBIF Secretariat (2019). GBIF Backbone Taxonomy. Checklist dataset https://doi.org/10.15468/39omei accessed via GBIF.org on 2020-07-20.). The data shows that *A. cordifolia* has been introduced from South America to all the continents except Antarctica. The range of the species includes small pacific islands in the western Pacific, most of the New World, Western Europe, south-eastern Africa, south and east Australia, New Zealand, Malaysia and south-eastern Asia. So far, there were no records of *A. cordifolia* from mainland Asia including south Asia, Central Asia, Russia and the Gulf countries. Our specimen represents the first record from the above-mentioned mainland Asia. The species is grown for ornamental purposes and now may potentially become invasive in our area (Fig. 9A).

Fig. 1. *Anredera cordifolia* specimen A. Sultan and S. Ahmad, no. 1418, Gulibagh, 30-11-2018, escape from cultivation (RAW 100408), illustrated by M. Saleem.

Fig. 2. *Anredera cordifolia* vegetative branches.

Fig. 3. *Anredera cordifolia* tubers.

Anredera cordifolia (Tenore) Steenis is native to South America from Paraguay to southern Brazil and northern Argentina (Wagner *et al*., 1999) and has become invasive in many regions across the globe (Vivian-Smith, 2007). *Anredera cordifolia* is known by the common name Madeira vine. The only other member of Basellaceae known from Pakistan is *Basella alba* Linn., which is often grown for its edible foliage. *Basella alba* differs from *Anredera cordifolia* in the lack of aerial tubers, larger stem diameter, larger leaves, sub-sessile flowers and persistent fleshy perianth in fruiting. *Anredera cordifolia* represents a new generic record for Pakistan. Production of a large number of stem tubers makes *Anredera cordifolia* a very heavy climber and it can cause entire trees to collapse because of its enormous weight. Propagation is mostly by vegetative means through the production of numerous axillary tubers, which readily detach from the parent plant and give rise to new vines. Tuber densities of over 1500 m^{-2} have been recorded on the floor in forests heavily infested with Madeira vine (Stockard, 1983; Stockard *et al*., 1985; Floyd, 1985). At two sites on Raoul Island in New Zealand, 7.5 tonnes of tubers were removed during a four-year eradication campaign (West, 2002). By smothering entire trees it also reduces the amount of light available for photosynthesis thereby weakening the trees. Another climber native to South America *Macfadyena unguis-cati* (Linn.) A. Gentry probably also initially introduced as an ornamental has already become invasive in various localities of Islamabad where it is often seen growing on *Dalbergia sissoo* trees, often resulting in mortality of trees when the climber completely covers the canopy. Introduction of *Anredera cordifolia* and its cultivation in various parts of the country as an ornamental necessitates immediate ban on its cultivation. Coupled with *Macfadyena unguis-cati* this climber can seriously impact already fragile forest ecosystems in Himalayan foothills. *Macfadyena unguis-cati* can act as a facilitator species for *Anredera cordifolia* invasion as the increased light levels resulting from canopy collapse caused by *Macfadyena unguis-cati* can create more favourable growth conditions for *Anredera cordifolia* (Floyd, 1989). As invasive species like *Broussonetia papyrifera*, *Lantana camara*, *Leucaena leucocephala* and *Parthenium hysterophorus* have already established in the Pothohar Plateau introduction of yet another invasive will further deteriorate the ecosystem balance in scrub and montane forests of Himalayan foothills.

***Dentella repens* (L.) R. Forster & G. Forster:** Annual creeping herbs, stems spreading, branched, often rooting at the nodes, internodes 1–2 cm long, glabrous. Leaves fleshy, stipulate, stipule membranous, opposite, sub-sessile to 1–2 mm long petiolate, lamina spathulate to obovate to sometimes linear, 3–7 × 1–2 mm, acute to obtuse, margins smooth, base cuneate, midrib visible on abaxial surface, veins obscure, both surfaces glabrous. Flowers axillary or terminal, sessile to short-pedicellate, 2.5–3 × 1–1.5 mm, calyx 5-lobed, 1.6-2 mm long, lobes linear, 1 mm, corolla white, tube 5-6 mm, externally glabrous, slightly hairy within, corolla lobes 1-2 mm, triangular-ovate, anthers 0.5 mm long, ovary globose, 1–2 mm long, covered with transparent, flattened scales, style 0.5-0.7 mm long, stigma bifurcate, 1 mm long. Fruits globose, 2-3 mm diameter and seeds 0.5 mm, angular, black, pitted (Figs. 4-6).

Specimens examined: PAKISTAN, Islamabad Capital Territory, Rawal Dam near Bani Gala road, *A. Sultan*, 2015 (RAW 100236); Rawal Dam near Bani Gala road, *A. Sultan and Muhammad Saleem*, 30 August 2019 (RAW 100773).

Global range: There are 980 occurrences of *Dentella repens* in GBIF database of which 528 are georeferenced records (*Dentella repens* J.R. Forst. and G. Forst. In GBIF Secretariat (2019). GBIF Backbone Taxonomy. Checklist dataset https://doi.org/10.15468/39omei accessed via GBIF.org on 2020-07-20.). The data depicts that the species has a native range in Tropical and Subtropical Asia and has been introduced as a weed to Northern Australia, Western Pacific Islands, Central America, Madagascar, Southeast Asia and India. The plant has now been introduced to Pakistan. The most probable route of migration is through India as it expands in a north-western direction. There are no records of *Dentella repens* from sub-temperate regions and above (Fig. 9B).

Rubiaceae is represented by 33 genera and c. 87 species in Pakistan, about half cultivated or introduced for ornamental purposes (Nazimuddin & Qaiser, 1989). *Dentella repens* represents the first generic record from Pakistan.

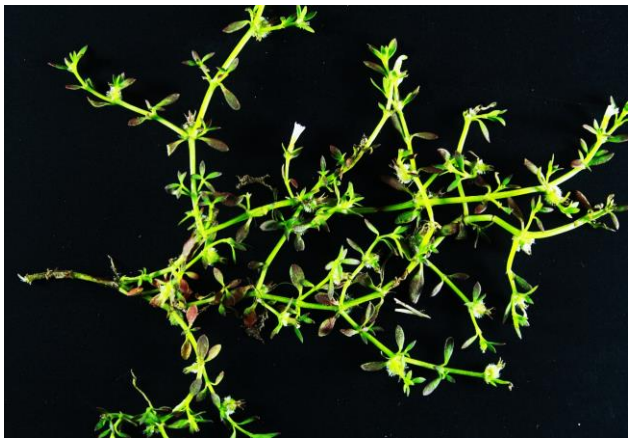

Fig. 4. *Dentella repens* habit.

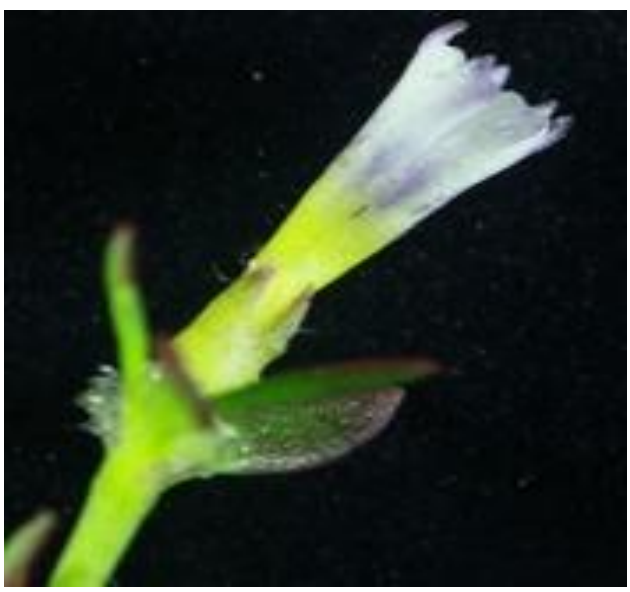

Fig. 5. *Dentella repens* flower.

Fig. 6. *Dentella repens* fruit.

***Oenothera laciniata* Hill:** Stem densely pubescent with long spreading and short appressed hair, leaves oblong, 2-4 x 0.6-1.6 cm, lobes 1.5-9 mm, pinnatifid, sessile to shortly petiolate, margin ciliate, acute. Flowers axillary, sessile, tube c. 2 cm, sepals, linear, acuminate, 8-10 x 1 mm, pilose with spreading hair, petals linear, 7 x 2 mm, stamens 8, filament 4.5 mm, anther 3.5 x 0.8 mm, style c. 4.5 mm, stigma deeply bilobed c. 3.5 mm. Capsule linear, 2.7-3 x 2.5-3 mm, pubescent with long and short appressed hair, dehiscing by four apical valves, seeds 1-1.2 x 0.8 mm, ovate, angular, pale brown, pitted (Figs. 7-8).

Specimens examined: PAKISTAN, Islamabad Capital Territory, National Agricultural Research Centre, Botanical Conservatory, *A. Sultan*, 4 June 2020 (RAW 101352).

Global range: It is represented by 7026 occurrences and 3140 geo-referenced records in GBIF (*Oenothera laciniata* Hill in GBIF Secretariat (2019). GBIF Backbone Taxonomy. Checklist dataset https://doi.org/10.15468/39omei accessed via GBIF.org on 2020-07-20.). The data shows that it is a New World species with most populations in Central America and most of Southern United States of America. It has migrated to Western Europe, South Africa, East and West Australia, Far East Asia. The plant was first reported in India from Bijnor district of Uttar Pradesh by Khan *et al.,* (1984) and was more recently from east Punjab, India by Kaur *et al*., (2018). The species is probably introduced in our area through seed contamination (Fig. 9C).

Onagraceae is represented in Pakistan by four genera viz., *Circaea, Epilobium, Ludwigia* and *Oenothera*. *Oenothera* is represented by four species viz., *Oenothera affinis* Cambess., *Oenothera glazioviana* Micheli, *Oenothera rosea* L' Her. ex Ait. and *Oenothera stricta* subsp. *stricta. Oenothera laciniata* is yet another non-native addition to Onagraceae from Pakistan.

Concluding remarks: Our documentation of the three invasive species viz., *Anredera cordifolia, Dentella repens* and *Oenothera laciniata* is an important addition to the weed/alien flora of Pakistan. *Anredera cordifolia* and *Oenothera laciniata* are non-Asian in origin and continue to expand their ranges in the tropical and subtropical regions of the world. *Dentella repens* shows a northwestern range expansion. Besides the neighbouring India and China, it has been recorded from Southeast Asia and Micronesia among other Asian regions. *Anredera cordifolia* has a restricted distribution so far in Asia. It is distributed in China, Japan and Malaysia. In Asia, *O. laciniata* is only found in the Far East that is most likely introduced from the western Pacific Islands or the western United States of America. Pakistan being predominantly subtropical country is a suitable place for the growth of these alien species. These alien species, *A. cordifolia* in particular, are a serious threat for our native plant biodiversity. *Anredera cordifolia* is regarded as a serious environmental weed because of the structural damage it causes to native vegetation (Boyne *et al*., 2013). Therefore, we recommend urgent eradication of this species from wild habitats as well as complete ban for cultivation as an ornamental.

Fig. 7. *Oenothera laciniata* specimen A. Sultan, Islamabad, National Agricultural Research Centre, Botanical Conservatory, 4-6-2020, (RAW 101352).

Fig. 8. *Oenothera laciniata*, capsules.

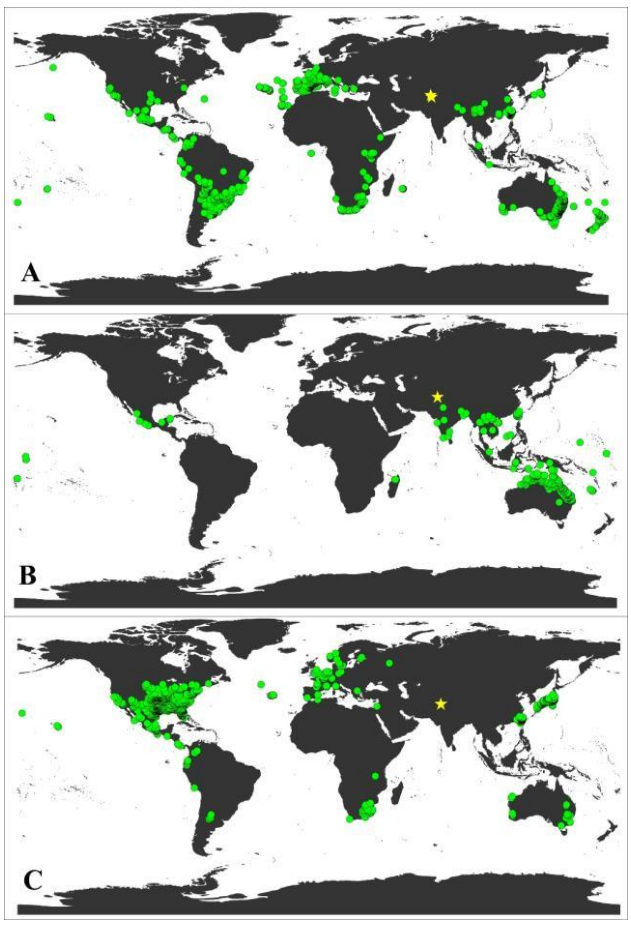

Fig. 9. Geographic map of new records from Pakistan: A: *Anredera cordifolia*. B: *Dentella repens*. C: *Oenothera laciniata*. Yellow asterisks represent localities of the new records from Pakistan.

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