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# TUBERIFEROUS *ERIOCAULON* L. (ERIOCAULACEAE) IN INDIA: AN ADAPTIVE STRATEGY FOR SURVIVAL

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The presence of root tubers in *Eriocaulon* L. is so far reported in three species *viz*. *E. idukkianum* Manudev, Robi & Nampy, *E. meenachilense* Anoop & Robi and *E. tuberiferum* A.R.Kulk. & Desai. During our survey, careful observations on *E. dalzellii* Körn. showed the presence of tubers on root stock. The presence of tubers in rootstock of *E. dalzellii* is the first record for this species, bringing the total number of tuber-forming *Eriocaulon* species in India to four. It has been noted that tuber formation is an additional strategy of these species for their survival to overcome adverse periods.

**Keywords:** Endemic, Eriocaulaceae, tuber, Western Ghats

*Eriocaulon* L. the largest and most widespread genus of Eriocaulaceae, with about 482 species is distributed widely in tropics and subtropics of the world (Govaerts 2019). Ansari and Balakrishnan (2009) reported 85 species of *Eriocaulon* including 5 taxa of doubtful occurrence in India. However, three taxa previously described or recorded by different authors (Myrthong *et al.* 1983, Yadav *et al.* 2008) are not included in this study. Since then, 25 taxa have been added (Shimpale *et al.* 2009, Shimpale *et al.* 2010, Vivek *et al.* 2010, Nampy *et al.* 2011, Biju *et al.* 2012, Swapna *et al.* 2012, Sunil *et al.* 2013, Sunil *et al.* 2014, Rashmi *et al.* 2014, Manudev *et al.* 2015, Manudev *et al.* 2017, Darshetkar *et al.* 2017, Paithane *et al.* 2017, Biju *et al.* 2018, Darshetkar *et al*. 2019, Khanna and Kumar 2019, Francis *et al*. 2020, Anoop and Robi, 2021) accounting for about 109 species for the country. Of the 109 *Eriocaulon* species, about 60% are endemic to India. Four endemic tuberiferous *Eriocaulon* species *viz. E. dalzellii* Körn., *E. idukkianum* Manudev, Robi & Nampy, *E. meenachilense* Anoop & Robi and *E. tuberiferum* A.R.Kulk. & Desai are recorded from India.

Eriocaulaceae is a taxonomically well-defined and easily recognizable family in the field. However, identification at species level especially in large genus like *Eriocaulon* is difficult because of minute flowers, fragile floral parts and reductions in floral parts. In India, the family was neglected by botanists because of difficulty in observing characters of minute flowers, minute size of some of the species and occurrence of many species in remote areas of the Western Ghats. However, interest of young researchers in exploration of the genus in India to discover novelties has resulted in discovery of about 25 species in the recent decade.

## MATERIALS AND METHODS

Live plant specimens, along with rootstocks were collected through field visits in different months from July to October. Careful observations were made on root tubers in natural habitat and under stereo-microscope (CMZ-6 stereomicroscope, Labomed, Japan) available in the research laboratory. Dry tubers of *E. dalzellii* were placed in-between two blotting papers and watered to study sprouting of tubers. The identity of the species under study was confirmed by consultation of protologue and relevant literature (Ansari and Balakrishnan 2009).

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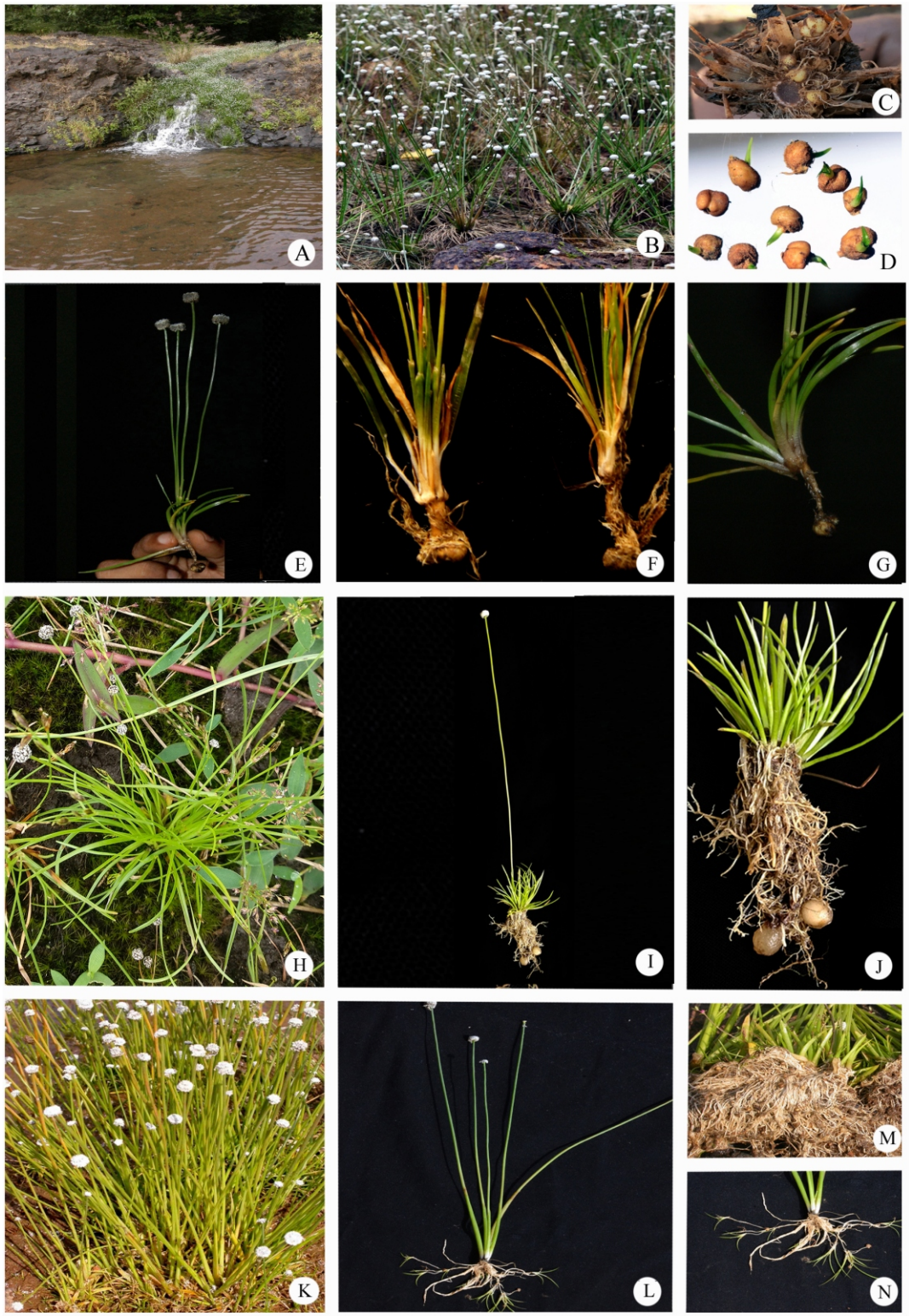


**Figure 1. A-D.** *Eriocaulon dalzellii* Koernicke: A & B. Plants in habitat; C. Roots and sheaths of peduncles; D. Isolated tubers germinated in petriplates. **E-G** ***E.*** *idukkianum* Manudev, Robi & Nampy: E & F. Plants with tuber on rootstock; G. Rootstock with tuber-close up view. **H-J.** *E. meenachilense* Anoop & Robi: H. Plants in habitat; **I.** Plants with root tubers; **J.** Tuft of roots with tubers; **K-N.** *E. tuberiferum* Kulkarni & Desai: K. Plants in habitat; L. Plants with root tubers; M Tuft of roots with tubers; N. Germinated tubers.

**SPECIMENS EXAMINED:** *Eriocaulon dalzellii* Körn.: India, Maharashtra, Kolhapur district, Suleran, 16º04'58.1" N, 74º06'16.9" E, ±688 m, 29.01.2020, *R.N. Mane* and *S.R.Yadav* RNM 94 (SUK).
*Eriocaulon idukkianum* Manudev, Robi & Nampy: India, - Kerala, Palakkad district, Koodam, Silent Valley National Park, ±2300 m elevation, 31.10.2013, *Manudev* 135136 (CALI).
*Eriocaulon tuberiferum* A.R.Kulk. & Desai: India, Maharashtra, Satara district, Mhavashi plateu, 04.10.2019, *R.N. Mane, M.M. Lekhak* and *S.R. Yadav* RNM86 (SUK)

## OBSERVATIONS

An occurrence of tubers in root stock of four indigenous species of *Eriocaulon* has been recorded. The place of origin and number of tubers per plant varies with species. Details of tubers in three species are as below:

*Eriocaulon dalzellii* Körn. Fig.1 (A-D).

It is a unique species adapted to grow on lateritic rocky substratum of seasonal flowing streams in the Western Ghats and coastal plains of West coast of Maharashtra and Karnataka (Fig.1A, B). It is a robust elegant aquatic species with 2-3 cm long root stock, filiform leaves and 20-30 cm long bunched peduncles with white spherical heads. During late monsoon, when the streams dry up, the plants start to develop sessile tubers in their root stock zone, among the sheaths of peduncles of scapes. Each branch of rootstock possesses 5-10 tubers covered by dried leaf sheaths, roots and sheaths of peduncles (Fig.1C). The size of the tubers ranges from 2-4 mm. The isolated tubers brought to the laboratory germinated in Petri plates (Fig.1D) in normal room temperature which confirms that these tubers serve as perennating organs in the species.

*Eriocaulon idukkianum* Manudev, Robi & Nampy, Fig. 1(E-G).

This species grows in grasslands, marshes nears streams and in rock crevices in southern Western Ghats at higher altitude (2200-2300 m) in Kerala. It is similar to *E. tuberiferum* and produce single terminal subterranean tuber at the tip of a 5 cm long root stock. The tubers are globose and *c.* 1 cm in diameter (Manudev *et al.* 2017). It is observed that the length of rootstock increases as the plant matures. Information on germination of these tubers in natural habitat and laboratory needs to be studied. However, it is believed that the tubers in this species are perennating structures which is evident from the remnants of disintegrated rootstocks of preceding years in few tubers.

*Eriocaulon meenachilense* Anoop & Robi Fig. 1 (H-J).

A recently described species that grows in wet rocky grasslands of southern Western Ghats at Meenachil Taluk in Kottayam District of Kerala. The species is closely similar to *E. tuberiferum* in its root tubers, short, linear leaves and free female sepals but distinguished by solitary, 6-angled peduncles, free male sepals, eglandular male and female petals and seeds without appendages (Anoop and Robi, 2021).

*Eriocaulon tuberiferum* A.R.Kulk. & Desai Fig. 1 (K-N).

It grows in ponds and puddles on higher altitude (800-1200 m) lateritic plateaus in northern Western Ghats (Fig.1K). It is uniquely adapted to local geographic, edaphic and climatic conditions. In addition to seed setting through sexual means, it produces densely hairy, globose to ovoid tubers in root stock (Fig.1-L). The tubers are 2-4 mm in diameter which remain dormant and embedded under soil during extreme

dry period of winter and summer. The seeds remain dormant till the onset of next monsoon, germinate and establish into new plants or sprout in same season giving rise to more plantlets (Fig.1 M, N). Hence, in addition to seed propagation, the species has a better strategy for perennating and reproducing through tubers, which contain sufficient stored food for the development of new plants. In the late monsoon, each plant develops several tubers on rootstocks and the plants die after rainy season. These tubers remains dormant under the soil cover and are able to withstand the dry periods.

## DISCUSSION

Eriocaulaceae can be easily recognized in the field by many-flowered, white, distinctly stalked heads. Due to difficulties in observations of characters of minute flowers and fragile floral parts, the family was neglected in the past but significant academic research interest has been generated in recent years (Darshetkar *et al*. 2019, Giulietti *et al.* 2012, Larridon *et al.* 2019, Stutzel and Trov 2013, Wolowski and Freitas 2015). Intensive and extensive field explorations, careful observations and critical analysis will yield not only many novelties in the genus *Eriocaulon* but also the recognition of many species-specific adaptive strategies for survival, reproduction and pollination. The separation of male and female sexes in flowers or inflorescences is associated with wind pollination (as observed in Cyperaceae and Poaceae), however Eriocaulaceae is an exception due to insect pollinated unisexual flowers. Eriocaulaceae flowers secrete minute quantity of nectar and are pollinated by diverse small insects (Stützel and Trovó 2013). *Eriocaulon odoratum* Dalzell is a common species in paddy fields in peninsular India, named after the odour it produces during flowering which can be sensed from distance. It is, without a doubt, an insect pollination syndrome. Wright and Schiestl (2009) concluded that an important yet commonly overlooked function of floral scent is an improvement in short-term pollinator specificity which provides an advantage to both pollinator and plant over the use of a visual signal alone (Wolowski and Freitas 2015). In *E. odoratum*, the flowers are inconspicuous where odour of flowers plays important role as a signal for insects. Most of the species in India are visited by bees but detailed studies on pollination biology in *Eriocaulon* are lacking.

In addition to sexual reproduction, some *Eriocaulon* species have developed an adaptive strategy of survival that involves the formation of tubers. Water is available in abundance during monsoon season when most of the herbaceous *Eriocaulon* species complete their life cycle. However, during winter and especially summer season there is extreme aridity. As a result, monsoon ephemerals like *Ledebouria , Dipcadi, Drimia, Iphigenia, Crinum, Curculigo, Arisaema* and others have evolved perennating underground bulbs, tubers or corms. In India, *Eriocaulon dalzellii* Körn., *E. idukkianum* Manudev, Robi & Nampy, *E. meenachilense* Anoop & Robi and *E. tuberiferum* A.R.Kulk. & Desai are so far known to produce perennating tubers. The tuber development has only been observed in *Eriocaulon* species from India, but careful study of species from around the world could lead to the discovery of new species with tubers as a perennation strategy.

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