polishing industries. Its utility has widened to water filtration industries in recent years. India is endowed with vast garnet resources of beach and dune sand origin all along its coastal zone. Bulk of the garnet production in the country comes from beach and dune sand deposits of TN with subordinate amounts from AP and Odisha[1]. However, GSI has estimated about 17 million metric tonnes of garnet in the top 1 m of seabed in shallow waters off Odisha, AP and the southwest coast of India (Kerala–TN sector).

The concentration of rare earth elements and yttrium (REY) in some samples is encouraging, especially in view of the heavy demand for REY in strategic applications, hybrid vehicles, magnets, rechargeable batteries, etc.

Sc occurs in many ores in trace amounts, but has not been found in sufficient concentration to be mined as a primary product. The crustal abundance of Sc is 21.9 ppm (ref. 3). As a result of its low concentration, Sc has been produced exclusively as a by-product during processing of various ores or recovered from previously processed tailings or residues. Coal can contain significant Sc. Average Sc concentration in a wide variety of coals from Asia ranges from 0.85 to 16.0 ppm, with an overall average of 4.3 ppm and maximum value of 230 ppm (ref. 4). Consequently, coal fly ash can also contain significant Sc, generally several tens of parts per million[5]. The Sc concentration in monazite pertaining to Chavara and Varkala beaches in Kerala varies from 4.5 to 11 ppm (ref. 6). Scandium rarely concentrates in nature. It does not selectively combine with the common ore-forming anions; so time and geologic forces rarely form Sc concentrations over 100 ppm (ref. 7).

Commercially viable grades (>200–300 g/t) of Sc are rare[8]. The Sc concentration in some of the garnets analysed in this study is found to be between 244 and 386 ppm, which are promising and commercially viable.

Sc is a costly metal and its global production is small (~10 tonnes per year) as a by-product from mining of ores of titanium, rare earths, apatite and uranium[9]. Despite its scarcity, over the past two decades, there have been multiple potential, high-value commercial uses for Sc. The principal uses are in Sc–Al alloys and in solid oxide fuel cells. Minor amounts of Sc are also used in a variety of other applications, including electronics, lasers, mercury vapour lamps and lighting.

All garnet samples collected from different domains do not have high concentrations of Sc and REY. Hence, characterization of garnets having high values of Sc, Y and REE, and their delineation in the coastal sands are of paramount importance.


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ACKNOWLEDGEMENTS. We thank Shri S. V. Hegde, DDG (Rtd), GSI for encouragement to take up this work; Shri D. K. Saha and N. Maran (DDG, GSI, Mangalore) and A. V. Gangadharan (DDG, GSI, Kolkata), for constant support; Shri G. V. Vidyasagar, DDG and Dr V. Ambili, Director (GSI, Visakhapatnam) for providing samples pertaining to Andhra Pradesh coast; Shri G. Nagendran (GSI, Mangalore) for providing samples from Tamil Nadu coast; Shri C. Saha (IREL, Kollam) for providing facilities to process the samples to enrich garnet fraction; Dr Sabu Joseph (IREL, Kollam) for support while processing the samples and for providing enriched garnet samples from Manavalakurichi beach; Shri K. Balachandran (AMD, Thiruvanathapuram) for providing enriched samples from Uvary beach and Dr Rajnai P. Ramesh, Sr Geologist (MCSD, Mangalore) for support during chemical analysis of the samples at NIO, Goa.

Received 3 December 2018; revised accepted 12 April 2019



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# Seediness as an invasive trait in *Mimosa diplotricha* Sauvalle in a tropical grassland

For successful invasion into an ecosystem, a species always depends upon some traits such as high growth rate, successive reproduction, higher number of seeds with low mass, seed viability and seedling mortality[1]. Among these traits, the reproductive behaviour of a plant is mainly associated with its invasiveness[2]. Seed production and germination are the two key processes associated with the initial phase of plant establishment, which determine the fate of an invasive plant in a new region[1], and that is especially true for annuals reproducing exclusively by seed[3].

*Mimosa diplotricha* Sauvalle is a fast-growing, thorny, biennial or perennial shrub native to Tropical America. In India, the plant is invasive from Kerala and Northeast Indian states (http://www.fao.org/forestry/13377-0977cb34791475-aa6a7a360640f09778.pdf accessed on 25 March 2014). In Northeast India, it had become invasive in the protected grasslands of Brahmaputra floodplains including Kaziranga National Park and Rajiv Gandhi Orang National Park which are important habitats for threatened mega-herbivores and other important fauna of the region[4–7]. The present study was carried out in Rajiv Gandhi Orang National Park, Assam (92°16′–92°27′E and 26°29′–26°40′N). The park covers an area of 78.8 km$^2$ and is located in the Brahmaputra floodplain region of Darrang and Sonitpur districts of Assam. The area comprises grasslands dotted with woodlands and water bodies.

*M. diplotricha* produces seeds in pods, which are found in clusters (Figure 1). In the present study, 16 individual plants were selected from different grassland areas of the park during January–February 2013. The total number of seeds produced by *M. diplotricha* was calculated following the formula: (no. of seeds per plant) = (no. of pod-clusters of that plant) × (no. of pods per pod-cluster of that plant) × (no. of seeds per pod)[8]. The total number of pod-clusters in each plant were counted, out of which 10 pod-clusters were selected, each randomly from four different plants. The pods were counted from each pod-cluster, out of which 10 pods were selected randomly. The length of each selected pod was measured with a vernier calliper, and the number of seeds was recorded. Seeds were categorized into healthy and damaged based on visual observation[9,10].

*M. diplotricha* produced 128 ± 49.41 SE, at 95% CI ($n = 16$) number of pod clusters per plant. Each pod cluster produced 30 ± 2.21 SE, at 95% CI ($n = 40$) number of *Mimosa* pods with a range of 14–50 pods per cluster. Each pod produced 3 ± 0.11 SE, at 95% CI ($n = 400$) seeds with a range of 1–6 seeds per pod. There was a significant relationship between the pod length and the number of seeds per pod ($r = 0.7$, $P < 0.01$, $df = 398$). Out of the three seeds, 2 ± 0.15 SE, at 95% CI ($n = 400$) seeds with a range of 1–6 were firm and healthy; while 1 ± 0.12, at 95% CI ($n = 400$) seeds (range 1–5) were damaged per pod. Significantly more number of seeds (74%) were healthy than damaged (26%) ($t = 7.41$, $P < 0.01$). An individual *M. diplotricha* plant produced an average of 13121 ± 5057, at 95% CI ($n = 16$) seeds per plant with a range of 2457–42274 seeds.

High seed production is characteristic of plants that follow *R* selection strategy[11]. By producing seeds in bulk, these plants are capable of outcompeting others and invade an area easily. Seeds of *M. diplotricha* are known for their high viability and can stay viable up to 50 years[12]. The germination percentage of *M. diplotricha* seeds can exceed 90% when subjected to scarification followed by exposure to favourable temperature conditions[13]. This may be the reason for higher germination in *M. diplotricha* when they are burnt in the field[12]. As the grasslands are subjected to fire annually during the months of February–March for management purpose, *M. diplotricha* is facilitated to fulfil their prerequisite for mass germination[14]. In the following months, due to the pre-monsoon shower and favourable temperature condition, the seeds germinate profusely. We also observed mass germination in *M. diplotricha* just after the pre-monsoon showers during March–April. As the seeds were small, they easily mixed with soil at the surface layer; moreover, the pods of *M. diplotricha* are also provided with hairy coating, which makes them suitable for zoochory (http://www.cabi.org/isc/datasheet/34196 accessed on 8 August 2016). *M. diplotricha* is also helped in dispersal by dominant mega herbivores[15,16] like Greater One-Horned Rhino (*Rhinoceros unicornis*), which carries it along for long distances (personal observation). High seed production with low seed mass in *M. diplotricha* is one of the major traits that makes it a successful invader in its non-native environment. An understanding of seed production and germination behaviour will help in preparing a better management plan for countering the invasive species in the National Park where it is wreaking havoc by degrading the grassland habitat.

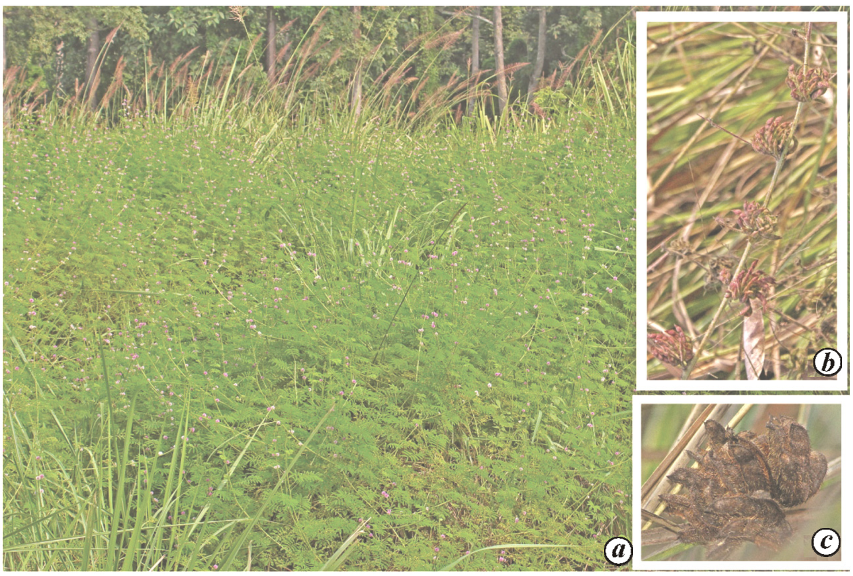


**Figure 1.** Different stages of *Mimosa diplotricha*: ***a***, Flowering thicket; ***b***, Pod-clusters; ***c***. Mature pods.


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ACKNOWLEDGEMENTS. We thank the Head, Department of Ecology and Environmental Science, Assam University, Silchar for support. We acknowledge the PCCF (Wildlife) and Chief Wildlife Warden, Department of Environment and Forests, Assam for providing permission, Field Director, Range Officer and other frontline staff of Rajiv Gandhi Orang National Park for their help and support during the fieldwork. M.R.C. acknowledges UGC for Non-NET Fellowship. We also acknowledge Biswajit Chakdar, Dwipendra Narayan Deb, Samrat Sengupta and Anukul Nath for their help in various ways.

Received 10 August 2016; revised accepted 29 April 2019

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# Rapid sedimentation and organic matter accumulation in the Kashmir Himalayan lakes: a challenge for lake managers

Freshwater constitutes a little less than 3% of the total volume of water present on the earth’s surface. However, freshwater ecosystems have a strong bearing on the economy of a country by providing potable water, fish and fodder for the local people. They are also the most vulnerable habitats as they act as major sinks for weathered sediments, sewage and waste disposal from catchment areas. Human interferences within the lacustrine systems have significantly altered them. The primary anthropogenic activities responsible for the degradation of lacustrine ecosystems include massive population growth, deforestation, land reclamation and other land-use/land-cover changes. Two primary concerns regarding the vulnerability of these freshwater ecosystems include extensive sedimentation and accumulation of organic matter. The organic content of the sediments reflects the quantity of living organisms in and around the lake ecosystems, including the level of lake productivity and leaching from humus-rich catchment soils. While the changing climate plays an important role in changing these ecosystems, anthropogenic-induced variations in the nutrient load inputs have had a distinct effect on the freshwater lakes during the past few centuries.

The Kashmir Himalayan lakes (Wular, Dal, Manasbal and Anchar Lake), located within the inter-mountain settings receive exceptionally high amounts of sediments from the tectonically active hinterlands. Furthermore, the unique climate of the Kashmir Himalayan region with intense cold winters and steep slopes augments the physical weathering of the exposed surfaces resulting in increased erosion and subsequent deposition of sediments in these freshwater lakes. The lakes in Kashmir Valley are the potable sources of freshwater for the region, but due to their exploitation for various purposes like drinking, domestic use, agriculture and hydropower, these freshwater ecosystems are getting eutrophicated and are shrinking in area at a rapid pace. The sedimentation rate reported from a few of the Himalayan lakes reveals contribution of sediments due to both natural and human interference. High sedimentation rates are reported from the Kashmir Himalayan lakes[1]. For example, Manasbal Lake shows a sedimentation rate of 0.44 cm/yr, and the average sedimentation rates of the Dal and Mansar lakes are 0.93 and 0.23 cm/yr respectively[1]. Since these lakes also act as hotspot centres for tourism, high anthropogenic gross pollutants settles within these lakes. Traditionally, our lake management strategies are primarily focused on flood management, wherein these lakes act as flood buffer systems by absorbing excess water during the floods[2]. For instance, during the September 2014 Jhelum basin flood, Wular Lake acted as one of the major regulators by absorbing excess water carried by the Jhelum River. However, if the sediment accumulation in the lakes increases and remains unchecked, it will lead to rising bed levels and increased flood risks.

The Wular, Dal, Manasbal and Anchar lakes are classical examples of lacustrine ecosystems where sediment and organic matter management is urgently needed. All these lakes are severely polluted by the human population living in the hinterland. The main culprits are the sewage inputs by local population, floatables, including polythene covers and used plastic bottles, medicinal trash, agriculture fertilizers, etc. (Figure 1).

Therefore, any extensive sediment and organic matter management strategy would involve a proper balance between the local population and lake ecosystems. The situation has further worsened during the past few centuries as the trophic status of these lakes has altered from oligo to eutrophic conditions due to intense human activities. Recently, the Supreme Court of India has directed the Jammu and Kashmir government to concentrate on efforts to restore and ensure proper conservation of the pristine beauty of these lakes. The suggested measures are catchment area treatment, including afforestation and construction of check dams, construction of settle basins at the lake–river interface, marginal dredging, diversion of inflow of sewage and agricultural waste products, selective deweeding, restricted population growth along the lake margins, etc. It is imperative to mention here that in Sydney, Australia, ‘Pratten traps’ (capture netting system) have been used at drainage inlets to capture the trash and other gross pollutants, allowing only water to flow into the lakes. This can be one of the effective systems to trap solid gross pollutants from settling in the lake systems in Kashmir Valley.

Studies regarding the environmental conditions of these lake ecosystems have mostly focused on the impact of increased human population along the hinterlands