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Invasive Succulents in Malabar Region of Kerala, India

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***Abstract*:** The present study identified a total of 49 invasive succulent species under 31 genera, belonging to 20 families have been recorded. Among these, dicotyledons were represented by 14 families, while monocotyledons were represented by 6 families. In terms of nativity, majority of invasive plants were reported from Mexico followed by Madagascar, North America and Central America, etc. Life form analysis reveals that herbs (36 species) were dominant followed by shrubs (11 species) and climbers (2 species). The outcome of the present study will be useful to make an understanding of invasive species diversity, life form and habitat in order to implement successful invasive species management.

***Keywords*:** Invasive succulents, Nativity, Malabar Region, Western Ghats, Kerala

The increased movement of humans around the world has facilitated the deliberate and accidental transfer of species away from their original ranges, often in a way that can facilitate invasions (Wilson et al 2009). Many of these introduced species have notable benefits to humans, but some have undesirable effects that can lead to significant financial costs and changes to entire ecosystems and social systems (Kumschick et al 2012). The threat to biodiversity due to invasive alien species is contributed second only to that of habitat destruction. They are serious hindrance to conservation and sustainable use of biodiversity. The impacts of bioinvasions are so widespread and significant and that they are a recognized component of global change. Invasive alien plants are a large and growing concern around the world, posing a threat to ecosystem integrity and the services they give to humans. Because of their aggressive nature, invasive plants thrive in disturbed soil in a short period of time, inhibiting the growth of native plants (Zhou et al 2020). Climate change, on the other hand, lowers the habitat's resistance to biological incursions. Invasive alien species must be incorporated into climate change policies. This has the potential to weaken natural habitats, agricultural systems and urban areas resilience to climate change. This includes biosecurity efforts to prevent them from spreading to new places as a result of climate change, as well as fast response methods to track and destroy alien species that may become invasive as a result of climate change (Mooney 2005). These invasive substances are widely distributed in all types of ecosystems around the world and include all categories of organisms (Singh 2005). Invasive plants have a greater capacity for efficient uptake of resources in low-resource environments than native plants (Funk and Vitousek 2007). Changes in plant communities caused by invasive plants are often caused by mechanisms that alter the recruitment rates of native species (Yurkonis and Meiners 2004). In India, there are about 40% of the flora are alien of which 25% are invasive. A variety of invasive plants have established themselves in India, and have serious environmental, socio-economic, and health consequences for the indigenous people. The analysis of taxonomical patterns among invasive plants could reveal stabilized trends that could then be used to suggest which plant groups or types of plants should be subjected to the greater level of surviving prior to allowing their importation to new geographical region. Comprehensive studies on invasive succulent species and succulent invasions are still lacking in Kerala. The current research aimed to document the invasive succulent species in Malabar region of Kerala.

MATERIAL AND METHODS

Study area: The Western Ghats, a hotspot that runs along Kerala's eastern border and creates a continuous mountain wall. The Malabar region of Kerala is located between the Western Ghats and the Arabian Sea. This includes the northern part of Kerala. Malabar region of Kerala comprises the districts of Kasaragod, Kannur, Wayanad, Kozhikode, Malappuram, and Palakkad. The Malabar region, which stretches from 74°30'E to 77°E longitude and 10°N to 12°30'N latitude, covers 17,461km^2. Kerala is bordered on the north by Karnataka, on the south and east by Tamil Nadu, and on the west by the Arabian Sea coastline.

Floristic analysis: Intensive field visits were conducted in

the Malabar region of Kerala from 2019 to 2021 to document invasive succulent plants floristic diversity. Specimens were collected for scientific study, voucher specimen preparation and identified using appropriate floras, revisions, monographs and relevant literatures (Sasidharan 2004, Sasidharan 2013). Herbarium studies were also carried out to confirm the identity of species using specimens from the Bharathiar University Herbarium and the Madras Herbarium (MH). The voucher specimens were prepared according to the standard procedures (Jain and Rao, 1976) and deposited in the Bharathiar University Herbarium. The nativity of the invasive plants was recorded from the published literature (Maheswari and Paul 1975, Nayar 1977, Sharma and Pandey 1984, Hajra and Das 1982, Saxena 1991, Pandey and Parmer 1994, Reddy and Raju 2002, Murthy et al 2007, Negi and Hajra 2007). The International Plant Name Index (IPNI) and the World Checklist of Selected Plant Families were used to update botanical names.

RESULTS AND DISCUSSION

A total of 49 species distributed in 31 genera and 20 families were recorded as invasive succulent species in the Malabar region of Kerala (Table 1). Among these, the dicotyledons were represented by 14 families, 17 genera and 25 species whereas monocotyledons were represented by 6 families, 14 genera and 24 species. A total of 18 different geographic regions in terms of nativity are recorded in the present study. The analysis of the plant habitat reveals that all invasive succulent species were terrestrials. This can be compared with the results of Swapna and Joy (2016), as they recorded a total of 17 invasive species, out of which 11 were terrestrial invasive plants from the Arookkutty Panchayath of Kerala. Zingthoi and Prabhat (2021) recorded 68 species from 53 genera and 30 families of invasive plants from the moderately disturbed Patches of Hailakandi district in an Indo Burma Hotspot Region. The study also discovered that land use change has a substantial impact on the spread of invasive alien plants over the landscape and plays an important part in the spread of invasive alien species over the landscape.

Invasive succulents were most abundant in wastelands, cultivated fields, road sides, river banks and forest edges. This suggests that an infertile soil is a critical prerequisite for successful invasion by exotic species. Sharma et al (2005) reported that a habitat characterized by disturbance is more prone to invasion than an undisturbed habitat. The recorded exotic species were originated from range of countries with 12 succulent species are native to Mexico followed by 6 species are native to Madagascar, 4 species are native to North America and Central America each, 3 species are native to Brazil and South Africa each, 2 species are native to South America and Tropical Africa each and remaining geographical region represented by one species each (Fig. 1). The preliminary findings support that America is the primary geographical origin of invasive alien plant species in the study area. Liu et al (2006) also suggested that America was the primary geographical origin of most invasive alien species. China, Asia and North America share a wide range of similar environment and related biota, which may result in each region being more susceptible to each other's immigrant species than species from many other parts of the world. The Amaryllidaceae (9 species) is the dominant family followed by Asparagaceae (6 species), Euphorbiaceae (4 species), Apocynaceae, Araceae, Cactaceae, Crassulaceae, Commelinaceae, Portulacaceae (3 species each), Bromeliaceae (2 species) and remaining family with one species each (Figure 2). The genera with the highest number of alien invasive species is *Euphorbia* (4 species); *Hippeastrum, Kalanchoe, Plumeria, Portulaca, Tradescantia and Zephyranthes* (3 species each); *Ananas* (1 species) and the remaining genera with one species each (Table 1). The

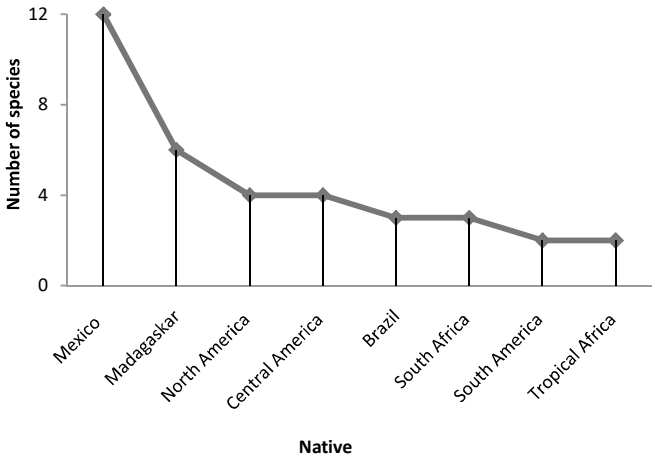

Fig. 1. Native of invasive succulent species

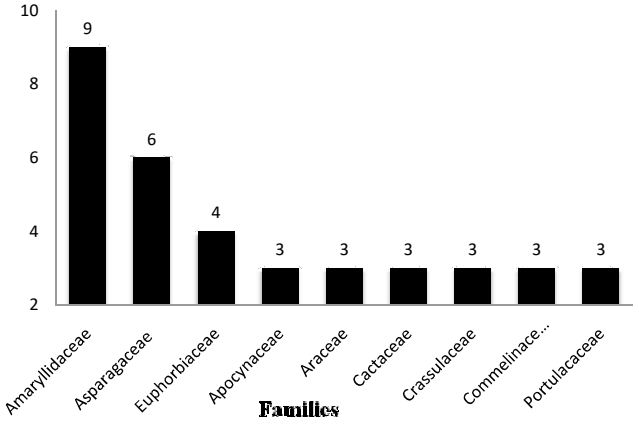

Fig. 2. Dominant families of invasive succulent species

Table 1. Invasive succulents in Malabar Region of Kerala

Binomial Name	Family	Habit	Habitat	Succulent part	Nativity
Agapanthus africanus (L.) Hoffmanns.	Amaryllidaceae	H	Te	Le	South Africa
Agave americana L.	*Asparagaceae*	S	Te	Le	South America
A.salmiana var. *ferox* (K.Koch) Gentry	*Asparagaceae*	S	Te	Le	Mexico
A.sisalana Perrine	*Asparagaceae*	S	Te	Le	Mexico
Alocasia macrorrhizos (L.) G.Don	Araceae	H	Te	Pl, Pe, Tu	Australia
Ananas comosus (L.)Merr.	Bromeliaceae	H	Te	Le	South America
A.comosus var. *microstachys* (Mez) L.B.Sm.	*Bromeliaceae*	H	Te	Le	Central America
Asparagus racemosusWilld.	*Asparagaceae*	C	Te	Tu	Tropical Africa
Begonia grandis Dryand.	Begoniaceae	H	Te	Pe, Pl	Central China
Caladium bicolor (Aiton) Vent.	Araceae	H	Te	Pe, Pl, Tu	Central America
Canna indica L.	Cannaceae	H	Te	St	Tropical America
Cereus pterogonus Lem.	Cactaceae	S	Te	St	Colombia
Chrysothemis pulchella (Donn ex Sims) Decne.	Gesneriaceae	H	Te	St	Mexico
Dracaena trifasciata (Prain) Mabb.	*Asparagaceae*	H	Te	Le	West Africa
Eclipta prostrata (L.) L.	Asteraceae	H	Te	St	North America
Euphorbia milli Des Moul.	Euphorbiaceae	H	Te	St	Madagascar
E.neohumbertii Boiteau	Euphorbiaceae	H	Te	St	Madagascar
E.tithymaloides L.	Euphorbiaceae	S	Te	St	North America
E.viguieri Denis	Euphorbiaceae	H	Te	St	Madagascar
Furcraea foetida (L.) Haw.	Asparagaceae	S	Te	Le	North America
Hippeastrum puniceum(Lam.) Voss	Amaryllidaceae	H	Te	Bu, Le, Pe	Tropical America
H.reginae (L.) Herb.	Amaryllidaceae	H	Te	Bu, Le, Pe	Peru
H.reticulatum (L'Hér.) Herb.	Amaryllidaceae	H	Te	Bu, Le, Pe	Brazil
Centella macrodus (Spreng.) B.L.Burtt	Apiaceae	C	Te	St	South Africa
Hymenocallis littoralis (Jacq.) Salisb.	Amaryllidaceae	H	Te	Bu, Le,Pe	Mexico
Impatiens walleriana Hook.f.	Balsaminaceae	H	Te	St	Kenya
Kalanchoe blossfeldiana Poelln.	Crassulaceae	H	Te	Le, St	Madagascar
K.delagoensis Eckl. &Zeyh.	Crassulaceae	H	Te	Le, St	Madagascar
K.pinnata (Lam.) Pers.	Crassulaceae	H	Te	Le, St	Madagascar
Leuenbergeria bleo (Kunth) Lode	Cactaceae	S	Te	St	Panama
Mirabilis jalapa L.	Nyctaginaceae	H	Te	St	Mexico
Opuntia cochenillifera (L.) Mill.	Cactaceae	S	Te	Le/ Cl	Mexico
Oxalis triangularis A.St.-Hil.	Oxalidaceae	H	Te	Pe, Pl	Peru
Peperomia pellucida (L.) Kunth	Piperaceae	H	Te	St	Tropical America
Pilea microphylla (L.) Liebm.	Urticaceae	H	Te	Le, St	Mexico
Plumeria alba L.	Apocynaceae	S	Te	St	North America
P. pudica Jacq.	Apocynaceae	S	Te	St	Panama
P. rubra L.	Apocynaceae	S	Te	St	Mexico
Portulaca grandiflora Hook.	Portulacaceae	H	Te	Le, St	Bolivia
P. oleracea L.	Portulacaceae	H	Te	Le, St	Europe
P. pilosa L.	Portulacaceae	H	Te	Le, St	Central America
Scadoxus multiflorus (Martyn) Raf.	Amaryllidaceae	H	Te	Bu, Pe	Tropical Africa
Tradescantia pallida (Rose) D.R.Hunt.	Commelinaceae	H	Te	St	Mexico
T. spathacea Sw.	Commelinaceae	H	Te	St	Mexico
T. zebrina Bosse	Commelinaceae	H	Te	St	Mexico
Xanthosoma sagittifolium (L.) Schott	Araceae	H	Te	Pe, Pl, Tu	Central America
Zephyranthes minuta (Kunth) D.Dietr.	Amaryllidaceae	H	Te	Bu, Pe, Le	Mexico
Z. candida (Lindl.) Herb.	Amaryllidaceae	H	Te	Bu, Pe, Le	Brazil
Z. robusta (Herb.) Baker	Amaryllidaceae	H	Te	Bu, Pe, Le	Brazil

Habit: **H** –Herb; **S-** Shrub; **C-** Climber; **Habitat**: **Te** –Terrestial; **Succulentpart**: **Le** – Leaf; **St-** Stem; **Bu** – Bulb; **Pe** – Peduncle; **Tu-** Tuber; **Pl-** Petiole; **Cl –** Cladode

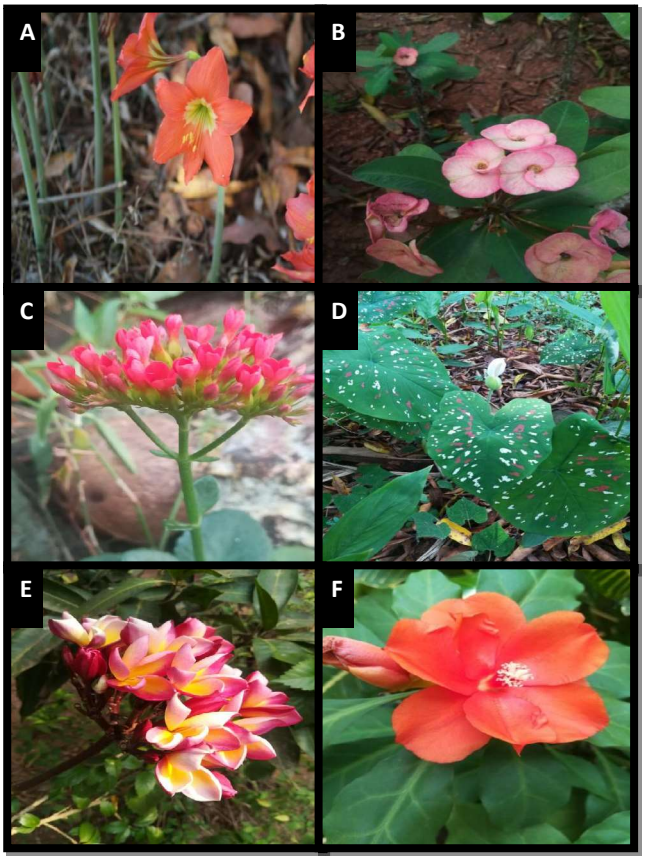

Fig. 3. A. *Hippeastrum puniceum*(Lam.) Voss B. *Euphorbia milli* Des Moul. C. *Kalanchoe blossfeldiana* Poelln. D. *Caladium bicolor* (Aiton) Vent. E. *Plumeria rubra* L.F. *Leuenbergeria bleo* (Kunth) Lode

Fig. 4. G. *Peperomia pellucida* (L.) Kunth H. *Scadoxus multiflorus* (Martyn) Raf. I. *Kalanchoe pinnata* (Lam.) P ers. J. *Opuntia cochenillifera* (L.) Mill. K. *Euphorbia tithymaloides* L. L.*Chrysothemis pulchella* (Donn ex Sims) Decne

plant growth form analysis indicates that herbs were represented by 36 species (74%) whereas shrubs were represented by only 11 species (22%) followed by two climbers (4%). The present study observed that invasiveness in cacti is closely linked to specific growth forms. Angled, cylindrical, flattened-padded, or sprawling are all characteristics of invasive cactus. The ability of taxa in these groups to grow vegetatively from cuttings, allowing for rapid spread, is likely the explanation for the high levels of invasiveness in these growth forms.

CONCLUSION

The current study on invasive succulents distributed in Malabar region of Kerala revealed that there are about 49 invasive succulents that were dominantly introduced from Mexico followed by Madagascar, North America and Central America. All invasive succulent species were terrestrials. The invasive succulent species were mostly found in wastelands, cultivated fields, road sides, river banks and forest edges. Therefore, creating adequate awareness to the public about potential invasive succulent plants and their management is crucial. The outcome of this research is important for defining strategies for preventing harmful invasive succulent species introductions and managing invasive succulent species.

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