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Invasiveness and Colonizing Ability of *Ipomoea carnea* Jacq. and Attempts at its Management

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ABSTRACT

Ipomoea carnea Jacq., also called *Ipomoea fistulosa*, is among the world's 100 most invasive weeds. Its ability to grow explosively on land as well as in wetlands gives it a unique competitive advantage over other major weeds like Lantana, Prosopis and water hyacinth, which are either aquatic or terrestrial. This paper presents an overview of the invasiveness and colonizing ability of *Ipomoea* in the context of the its attributes that facilitate its spread. The manner in which *Ipomoea* infestation harms the environmental health is also described. The numerous ways that have been explored to utilize *Ipomoea* have been enumerated. In the context of the inadequacy of these attempts, an emerging technology, which promises to solve the *Ipomoea* problem, is described.

INTRODUCTION

Ipomoea, with approximately 500 species, is the largest genus in the family Convolvulaceae (Meira et al. 2012). The species of this genus are usually found in the tropics, but some of the species also exist in temperate regions (Cao et al. 2005). Over half of all the *Ipomoea* species are native to the Americas (Austin & Huaman 1996). India hosts about 60 species of *Ipomoea* (Bhellum 2012).

Whereas, about 10% of all *Ipomoea* species have been identified as weeds (Holm et al. 1979), some like *I. batatas* and *I. aquatica* are used as food (Bovell & Benjamin 2007) and several like *I. cairica, I. digitata, I. hederacea, I. purpurea, I. alba* and *I. pes-caprae*, are used in traditional medicine (Silveria et al. 2005, Zia-Ul-Haq et al. 2012). But, it is the invasiveness and negative impact of *I. carnea* that dominates all concerns about the genus *Ipomoea*. In this state-of-the-art assessment, a review of the invasiveness and colonizing ability of *I. carnea* (henceforth referred to as *Ipomoea*) is presented and attempts at the weed's utilization have been surveyed.

INVASIVENESS AND COLONIZING ABILITY OF *IPOMOEA CARNEA*

Even as *I. aquatica* is also a major weed, and *I. indica, I. purpurea, I. alba, I. pes-tigridis, I. hederacea, I. cairica, I. coccinee* and *I. turbinata* are also weedy, none can match the extreme hardiness, regenerative ability, adaptability, resilience and dominance of *Ipomoea carnea.*

Ipomoea is capable of growing with equal ease on land, in water, and in regions of land-water interface (Chari & Abbasi 2003, 2005). This extraordinary flexibility in terms of habitats (Figs. 1 and 2) gives *Ipomoea* an edge over other dreaded weeds which are either aquatic (e.g. water hyacinth, *Salvinia*), or terrestrial (e.g. *Lantana, Parthenium*). *Ipomoea* is now common throughout the tropical and sub-tropical world spanning South America, Africa, South Asia and parts of Australia (Boulos 2000). It is found all over India, being particularly dominant in the western, central, southern and southeastern states (Cook 1987, Kumar, 2017c).

Like many other weeds that have colonized India and the rest of the tropical and sub-tropical regions of the world, *Ipomoea* is also a native of tropical South America (Hussain et al. 2015, 2016). Its easy-to-establish nature and large, colourful, and scented flowers (Fig. 2) have been attracting farmers to use it as a garden and hedge plant. This has helped its spread because once planted in any area, *Ipomoea* is almost impossible to eradicate from there. Its refusal to fade away even when mercilessly hecked and its roots dug out, has earned it the sobriquets of 'besharam' and 'behaya', both Hindi words meaning shameless, though its English sobriquet morning glory is much more honourable.

Ipomoea is an amphibious plant, equally at home on dry soils and in wetlands (Fig. 1). It produces pale rose, pink or light violet flowers, glabrous capsule-like fruits, and viable silky seeds (Fig. 2). It can propagate sexually as well as vegetatively; its stem fragments on being sown develop roots within a few days.

Among numerous chemicals, of which several are bioactive (Meira et al. 2012, Akram et al. 2014), *Ipomoea* contains alkaloids swansonine and calystegines which impart it mammalian toxicity and strong allelopathy (Hueza et al. 2005, Meira et al. 2012). Cattle, sheep and goats grazing upon *Ipomoea* may develop serious intoxication of the nervous system which is clinically characterized by depression, soft faeces, weight loss, disorders of behavior and consciousness, discoordinated gait, intense tremors, spastic paresis, abnormal postural reactions, nystagmus, hyperreflexia, hypersensitivity to sound, head tilting and loss of equilibrium (Dalo & Moussatche 1978, De Balogh et al. 1999, Haraguchi et al. 2003, Sharma & Bachheti 2013). The allelopathic effect of *Ipomoea* helps it to discourage other vegetation from growing around it, and monopolize the natural resources of the areas it occupies. The combined impact is a catastrophic loss of biodiversity.

With its ability to adapt to habitats that range from xeric to aquatic, *Ipomoea* has a unique competitive advantage over other dreaded weeds. The diversity of habitats in which *Ipomoea* can thrive, and the ease with which it propagates vegetatively, has created a fear that in times to come *Ipomoea* may overtake other invasives to become the most prevalent and dominant of all plants (Shaltout et al. 2010).

In a study of *Ipomoea* invasion in Egypt, Shaltout et al. (2010) record that the growing season of *Ipomoea* encompasses most of the year. The almost ubiquitous presence of *Ipomoea* in the region where this author works, on dry lands as well as in wetlands (Figs. 1-3), seems to confirm this.

ATTEMPTS AT UTILIZATION OF *IPOMOEA*

Ipomoea is among the plants that has been used in traditional medicine (Meira et al. 2012, Akram et al. 2014) on the basis of its anti-bacterial, anti-inflammatory and immunostimulant attributes which make it a wound healer (Hueza et al. 2011). It has also been explored for treating insomnia (Akram et al. 2014), AIDS (Woradulaypinij et al. 2005), and hypertension (Lamidi et al. 2000), and in generating energy (Abbasi et al. 1990, Ramasamy & Abbasi 2000), and volatile fatty acids (Ganesh et al. 2005).

Other attempts to use *Ipomoea* span a gamut, as summarized in Table 1. But despite these valiant efforts which have spanned several decades, no commercially viable methods have been developed with which even a sizeable fraction, let alone most of, the *Ipomoea* biomass can be put to use.

ATTEMPTS AT CONTROLLING *IPOMOEA*

There have also been equally valiant attempts to destroy or control *Ipomoea* with the use of chemical pesticides, biocontrol agents, mechanical removal, or combinations of these approaches. But, as the example given in Fig. 3 indicates, such attempts have been totally unsuccessful despite prohibitively huge investments. Worse, the use of both chemical and biocontrol agents can have massively, as well as unforeseen, harmful spin offs. The former can toxify soil, water, and air in unpredictable and irreversible ways, while the latter can become serious pests themselves (Abbasi et al. 1988).

As a result, *Ipomoea* is not only continuing to thrive, but is continuing to invade ever newer territories, colonizing ever larger areas. Its colonization of landmasses interferes with all other uses of land while its colonization of water bodies affects fisheries, irrigation and navigation (Chari & Abbasi 2005). Its infestation also defaces the water bodies and robs them of much of their recreational value (Abbasi & Chari 2008).

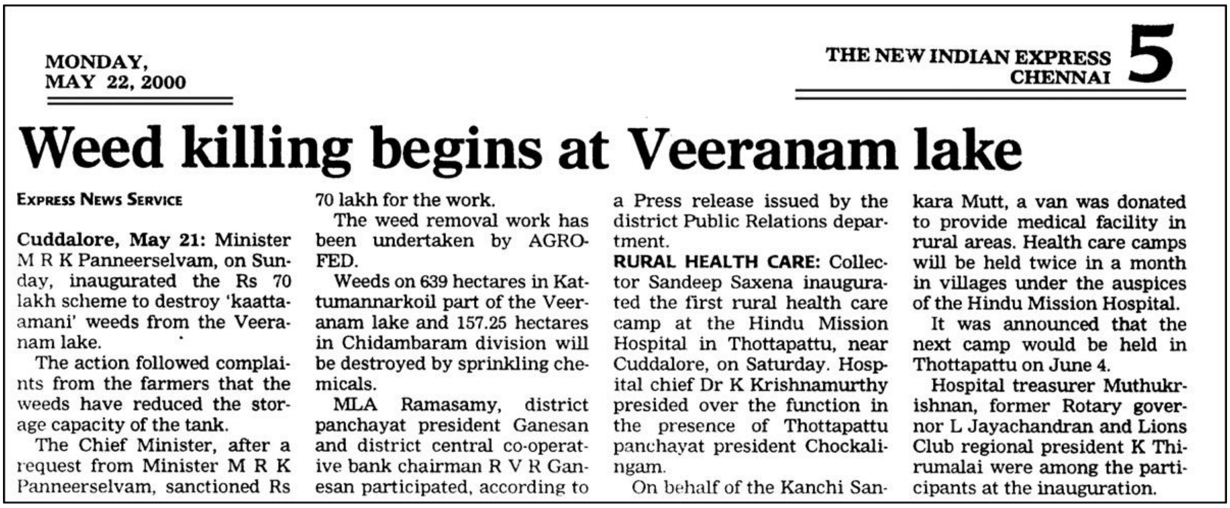
CONTRIBUTION OF *IPOMOEA* INFESTATION TO GLOBAL WARMING

Nearly a third of *Ipomoea* biomass, comprising of leaves and tender stem (Fig. 2) is amenable to relatively easy biodegradation via composting, vermicomposting or anaerobic fermentation (Ganesh et al. 2008, Abbasi & Abbasi 2010).

When the fallen leaves and dead plants of *Ipomoea* degrade in the open they generate either carbon dioxide or a 2:1 (v/v) methane-carbon dioxide mixture, depending on whether the degradation had occurred under aerobic conditions or anaerobic (Abbasi et al. 2012, Tauseef et al. 2013a). In wetlands infested with aquatic weeds, photosynthetic replenishment of dissolved oxygen (DO) in the epilimnion is inhibited due to the shading caused by the weeds. The DO is further stressed by the biochemical oxygen demand (BOD) exerted by the weeds' debris (Abbasi & Nipaney 1986, 1993). When the infestation of a water body by weeds like *Ipomoea* increases, the DO levels in the water body's hypolimnion gradually fall to zero. As the degradation of the debris mostly occurs in the hypolimnion and the underlying sediments, it is predominantly anaerobic. But the 60-65% methane that is generated during anaerobic degradation has 34 times greater global warming potential (GWP) than carbon dioxide (Schindell et al. 2009). It is this ever-increasing anaerobic degradation occurring in the increasingly polluted (and consequently weed-infested) wetlands which is believed to have substantially enhanced anthropogenic global warming emissions of methane in recent decades (Abbasi & Abbasi 2012, Abbasi & Abbasi 2011). This realization gives an additional sense of urgency and importance to the control of *Ipomoea*.

Fig. 1: Typical Ipomoea infestation on land (left) and in water (right).

Fig. 2: *Ipomoea* flowers in bloom (left) and brush-like seeds (right).



MONDAY,
MAY 22, 2000

THE NEW INDIAN EXPRESS
CHENNAI 5

Weed killing begins at Veeranam lake

EXPRESS NEWS SERVICE

Cuddalore, May 21: Minister M R K Panneerselvam, on Sunday, inaugurated the Rs 70 lakh scheme to destroy 'kaattaamani' weeds from the Veeranam lake.

The action followed complaints from the farmers that the weeds have reduced the storage capacity of the tank.

The Chief Minister, after a request from Minister M R K Panneerselvam, sanctioned Rs 70 lakh for the work.

The weed removal work has been undertaken by AGRO-FED.

Weeds on 639 hectares in Kattumannarkoil part of the Veeranam lake and 157.25 hectares in Chidambaram division will be destroyed by sprinkling chemicals.

MLA Ramasamy, district panchayat president Ganesan and district central co-operative bank chairman R V R Ganesan participated, according to a Press release issued by the district Public Relations department.

RURAL HEALTH CARE: Collector Sandeep Saxena inaugurated the first rural health care camp at the Hindu Mission Hospital in Thottapattu, near Cuddalore, on Saturday. Hospital chief Dr K Krishnamurthy presided over the function in the presence of Thottapattu panchayat president Chockalingam.

On behalf of the Kanchi Sankara Mutt, a van was donated to provide medical facility in rural areas. Health care camps will be held twice in a month in villages under the auspices of the Hindu Mission Hospital.

It was announced that the next camp would be held in Thottapattu on June 4.

Hospital treasurer Muthukrishnan, former Rotary governor L Jayachandran and Lions Club regional president K Thirumalai were among the participants at the inauguration.

Fig. 3: Despite spending massive sums in trying to control *Ipomoea* by chemical means, as reflected in this news item, the Veeranam lake continues to be infested by *Ipomoea* and other weeds.

Table 1: Attempts to utilize *Ipomoea carnea*.

S. No.	Type of use	Plant component used	Key findings	References
1.	Antioxidant potential	Not stated	Methanolic extract showed antioxidant potential.	Abbasi et al.(2010)
2.	Source of enzymes	Latex	Enzymescarneinand ICChlwith chitinase lysosome and exochitinase activity werea extractable.	Patel et al. (2007, 2008, 2009, 2010)
3	Source of chemicals	Leaves	GC-MS analysis revealed thirteen major compounds, including, N-isopropyl acryl amide, N-acetyl- L- alanine, 3-(diethylamino)-1 propanol, 1:3 methoxy phenyl 1 propane, 6,10,14 trimethyl 2 pentadecanone, 1,2 diethyl phthalate, hexadecanoic acid, n-octadecanol, stearic acid 4,8,12,16 tetramethyl heptadecane-4-olide, octacosane, hexatriacontane and tetracontane.	Adsul et al. (2010)
			Dibutyl phthalate.	Adsul et al. (2012)
			Aromatic easter.	Adsul et al. (2015)
		Stems	Dibutyl phthalate.	Adsul et al. (2012)
		Leaves and stem	Thin layer chromatography (TLC) revealed presence of steam volatiles, phenols, acids, bases and neutral constituents in the ethanol extracts.	Adsul et al. (2010)
			Dodecyl- p-coumarate, methyl- p-coumarate, octyl- p-coumarate, umbelliferone, escopoletin, 3-oleanone, β -sitosterol and stigmasterol	Saleem et al. (2011)
		Leaves,stems,and flowers	Phenol and flavonoids.	Khatiwora et al.(2010a,b)
4	Source of pulp for paper making	Stem	Ipomoea stemyields 53.5% pulp. Mechanical strength is increased by blending the pulps of thelonger and shorter fibre lengths.	Dutt et al. (2005, 2008, 2009, 2010)
			Ipomoea can form a potential source of raw material for paper making industries.	Nandkumar et al. (2011)
5	Phyto- accumulator	Whole plant	While applying Pb in 50-800 mg kg-1 levels to shrink-swell soil in which the *Ipomoea* was grown, no retardation in the weeds growth was observed. Indicative of potential as a phytoaccumulator	Adhikari et al. (2010)
6	Antibacterial	Leaves	Crude methanolic extract and other fractions displayantibacterial, antioxidant and wound healing properties.	Rout & Kar et al. (2015)
		Stem	Acetone and methanol extracts showed promising results against gram negative bacteria Proteus mirabilis (ATCC12453), Escherichia coli (ATCC10536), Klebseillapneumoniae (ATCC33495),Pseudomonas aeruginosa (ATCC10662), and gram positive becteria Staphylococcus aureus (ATCC1026), Bacillus subtilis (ATCC11774), and Bacillus cereus (ATCC10876).	Khatawora et al. (2010)
			Quambalariafungus, isolated from the stem, displayed anti-microbial activity against clinically significant microorganisms.	Padhi & Tayung et al. (2013)
		Leaves ,stem and seeds	The endophytic fungal metabolites showed antibacterial activity against pathogenicbacteria Staphylococcus species, *B.subtilis, E.coli*, Salmolellatyphi, Pseudomonas flurescens and Shigelladysentriae.	Tayung et al. (2012)
7.	Antiviral	Not stated	Water extracts showed HIV-1RT inhibition greater than 90% at a concentration of 200 μg/mL.	Woradulayapinij et al. (2005)
8.	Repellent	Root and stem	Source of essential oils.	Sahayaraj et al. (2015)
9.	Pesticides	leaves	Hot water and petroleum extracts of *Ipomoea* control the harmful filariasis vector Culexquinquefasciatus.	Rahuman et al. (2009)
			Water extracts of reveal the presence of secondary metabolites such as alkaloids, phenolics and terpenoids,whichshow potential against larval and pupal mortality and alsorestrict the ecdyseal process in experimental animals.	Sujatha et al. (2010)
			Terpenoid and alkaloid compounds from extractsexhibit toxicity against Rhizoctoniasolani, a causative agent of sheath blight disease in rice.	Kagale et al. (2011)

Table cont....

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			An aqueous extract showed discernable inhibition against black rot disease causing pathogenic fungus Corticiumtheae.	Thoudam et al. (2014)
			Extractsrevealed the presence of anthcinglucoside, responsible for toxic effects on pest such as Pseudaleticaunipuncta, Pectinophoragossypiella and Helicoverpasp.	Singh et al. (2014)
		Leaves and seeds	Aqueous extracts cause considerable mortality against in insect pests.	Rajguru et al. (2012)
		Leaves, seeds and bark	Acetone, ethanol and water extracts of *Ipomoea* showed an antifeedent effect against the insects Alphibiusdiaperinus and Sitophilusoryzae.	Kamruzzaman et al. (2005)
		Not stated	Water extracts of *Ipomoea* when used in combination with Isariafu-mosoroseus, a highly reduced mycelial growth of three fungi species Beauveriabassiana, Paecilomycesfumosorosea and Verticilliumlecanii were observed.	Sahayaraj et al. (2011)
		Not stated	Ethanol extracts of *Ipomoea* showed insecticide activity against nymphs of silverleafwhitefly (Bemisiatabaci), a tomato (Lycopersiconesculentum) pest.	De Jesus et al. (2013)
10.	Extraction of heavy metals	Whole plant	Pot study with 10-200 mg Cd kg-1 soil indicated effectiveness in removing Cd fromthe soil.	Ghosh et al. (2005a)
			Ipomoea showed greater potential than Dhaturainnoxia,Phragmyteskarka, Cassiatorra, and Lantana camera) in the extraction of Cr from the soil.	Ghosh et al. (2005b)
			Ipomoea showed a potential for the removal of heavy metals from the fly ash dumpsite of Patrutu thermal station, Jharkhand.	Pandey et al. (2016)
		Not stated	Activated carbon prepared from the *Ipomoea* was effective as adsorbent for the removal of Cu from synthetic waters.	Miranda et al. (2010)
11.	Fuel	Stem	Solid fuel was prepared from pulverized charcoal of Ipomoea stem mixed with aqueous solution of starch.	Konwer et al. (2007)
		Not stated	Biogas was generated on anaerobic digestion of *Ipomoea* (both in freshly chopped and dried crushed form).	Sankar et al. (2008)
			Bio-ethanol was produced from *Ipomoea*.	Kumari & Pramanik (2013)
			Bio-oil was obtained by pyrolysis at 550ºC.	Saikia et al. (2015)
12.	Volatile fatty acids	Leaves	Volatile fatty acids were generated by acid-phase digestion.	Kumar et al. (2015)
13.	Nanoparticles	Leaves	Aqueous extract was used for the rapid synthesis of silver nanoparticles.	Ganaie et al. (2015)
		Leaves, stem and root	Extracts were used for the synthesis of gold nanoparticles, confirmed by EDAX and X ray.	Abbasi et al. (2014) Ganaie et al. (2014) Daniel et al. (2014)
14.	Anthelmintic	Leaves	Chloroform extractshave anthelmintic activity.	Dhembare & Kakad (2012)
15.	Hepatoprotective	leaves	Hepatoprotective activity was displayed by the aqueousextract after chemically induced liver injury by CCl4.	Gupta et al.(2012)
16.	Anticarcinogenic	Leaves	Methanol extracts possessed cytotoxicity against colontumour cells.	Mustafa et al. (2014)
17.	Antifungal	Leaves	Antifungal activity against Colletrotrichumgloeosoporiides, Cladiosporiumcucumerinum,Alternariaalternata and *A.porri*.	Nidiry et al. (2011)
18.	Source of fermentable sugars	Not stated	*Ipomoea* contains a good amount of holocellulose (67.49%) which can be converted into fermentable sugars.	Sharma et al. (2015)
19.	Dye removal	Stem	Activated carbon prepared from *Ipomoea* has been found to have a potential to act as an adsorbent for the removal of Direct green 6 from aqueous solution.	Geetha et al. (2016)
20.	Dye degradation	Roots	*Ipomoea* roots have been observed to cause significant dye degradation (>90%). The diazo dye Acid Red 114 was decolorized to 98%.	Jha et al. (2016)
21.	Dust indicator	Whole plant	*Ipomoea* is suitable for to monitoring dust load in the environment because of having heart shaped leaves which are good dust collectors.	Joshi et al. (2013)
22.	Vermicomposting	Not stated	Vermicast was generated using earthworm species *E.eugeniae*.	Mahanta et al. (2012)
		Leaves	Vermicompostwas generated from Ipomoeausing four species of earthworms *E.eugeinae*, *E. fetida*, *P.excavatus* and *L.mauritii*.	Makhija et al. (2011)

RECENT BREAKTHROUGHS

A glimmer of hope has emerged recently from the efforts of S.A. Abbasi and coworkers on direct and efficient vermicomposting of *Ipomoea* (Makhija et al. 2011). Even though a report of a past attempt exists on the vermicomposting of *Ipomoea* (Mahanta 2012), it was based on cow-dung supplementation and took as much as 60 days. This was similar to other past attempts at utilizing different species of phytomass, as reviewed by Abbasi et al. (2015). The common lacunae of these attempts have been:

a. Dependence on pre-composting and/or manure (mainly cow-dung) supplementation
b. Very slow process rate

The combined effect of these constraints has been that the processes become uneconomical and unviable. As a consequence, no instance exists on large-scale vermicomposting of any weed. By developing a paradigm of "high-rate vermicomposting" and associated technology (Abbasi et al. 2009, 2011, 2015, 2018; Sanker Ganesh et al. 2009; Tauseef et al. 2013b, c; Premalatha et al. 2014 a, b), S.A. Abbasi and coworkers have overcome these problems. They have made it possible to directly and efficiently vermicompost *Ipomoea*, lantana and other weeds. They have also demonstrated that vermireactors fed with *Ipomoea* can be operated continuously and indefinitely. They have also shown that the vermicast thus generated is a high-quality organic fertilizer-cum-pesticide (Hussain et al. 2016, 2017). In another related study from the same group, Kumar et al. (2015) have shown that prior to vermicomposting *Ipomoea* leaves, volatile fatty acids (VFAs) can be extracted from them. The VFAs serve as energy precursors as they can be converted into biogas on being fed to an anaerobic digester (Kumar et al. 2017a). This work has since been extended to dried and powdered form of *Ipomoea* (Kumar et al. 2017b). As VFAs comprise of only C, H and O, no NPK or medium/ minor nutrient is lost in the course of VFA extraction from *Ipomoea* (except minor quantities that go into water from *Ipomoea*). Hence the vermicompost of the 'spent' *Ipomoea* (after VFA extraction) is as nutrient-rich as the vermicompost of *Ipomoea* obtained without the VFA extraction. In this manner, even as valuable energy precursors are obtained from *Ipomoea*, all the rest of the weed is totally utilizable as an organic fertilizer via vermicomposting.

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