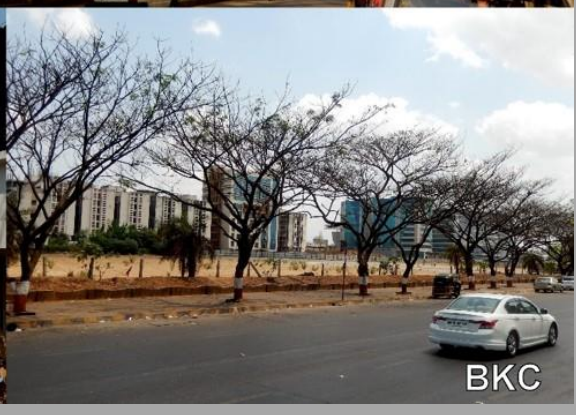
2014

RAIN TREE PRESERVATION

Investigation into the Cause of the Death of the Rain Trees in Mumbai and Suggested Remedial Measures



vanashakti

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Vanashakti is a Mumbai based non-profit environmental NGO whose thrust areas are forest, mangrove and wetland protection, environmental education for schools both urban and rural, livelihoods for forest based communities and scientific investigation into environmental degradation. Vanashakti is founded by citizens who have a commitment to fulfil the constitutional obligation of protecting the environment; coasts, forests, wildlife, wetlands and rivers. We believe that all sections of society need to be sensitised to the need to protect and conserve or natural wealth and resources. We believe that our planet is entrusted to us for caretaking, to be used sustainably and handed over to the next generation with all its glory and values intact. We need to make people aware that they have a stake in the world around them. They must be educated so that they can then take informed decisions. We believe that if we create informed awareness, people will be able to take a stand on issues that could impact them in the short term and in the long run. Vanashakti was born because we believe that India can progress only as long as her people are nurtured and its resources used sustainably. Water security for humans and all forms of life is critical to driving Vanashakti's efforts. For that, the government needs a watchdog. The natural wealth and resources are a treasure to be handed over to the next generations. Sense of personal and collective responsibility needs to be inculcated in the Indian mind-set. Mankind's responsibility towards conservation of wildlife and Forests cannot be undermined or forgotten. Vanashakti is a Public Information Initiative (PII). PIIs have helped open our eyes to a number of issues that would otherwise be swept under the carpet. PIIs seek to inform all the constituents of the interplay between factors. We start with creating awareness of major issues. We recognize the need for people to be aware of various developments and changes made by our government, in the laws and legislation that govern us and our country. Vanashakti addresses issues of Environmental Conservation at all levels using education, awareness and litigation to achieve its objectives. The role of Wetlands in the ecosystem has finally been recognised as a result of our sustained campaigns.

A pond equals ten wells, a reservoir equals ten ponds.
A son equals ten reservoirs, and a tree equals ten sons.

दशकूपसमा वापी दशवापीसमो ह्रदः ।
दशह्रदसमः पुत्रो दशपुत्रसमो द्रुमः ॥

dasha-kūpa-samā vāpī, dasha-vāpī-samo hradaḥ |
dasha-hrada-samaḥ putro, dasha-putra-samo drumaḥ ||

Matsya-purāṇa 154:512

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INTRODUCTION

Mumbai the financial capital of India is also the hub of construction activity and never ending infrastructure projects. In the midst of this the single largest aspect that is on a downslide is the quality of the environment. The transformation from sleepy coastal hamlets to a bustling metropolis has left planners with very little to do in terms of improving the environment of Mumbai. The concrete jungle has managed to dwarf the national park on the outskirts of the city and the vast expanses of coastal wetlands and mangroves that gave the city its share of environmental sanity. Constructions of unimaginable proportions have completely stopped the free flow of wind across the city. The decades old tree cover in the city provides the much needed cooling effect, oxygen and other ecological services to birds and other life forms. By the municipal corporation's own estimated there are 19 lakh trees of 364 species trees in Mumbai (The Times of India; Mumbai; 17 July, 2008;Pg.4) among which is a mixture of avenue trees comprising species like Indian laburnum (*Cassia fistula*), Copper Pod (*Peltophorum pterocarpum*), Pink Cassia (*Cassia grandis*), Gul Mohar (*Delonix*

regia), Pride of India (*Lagerstromia speciosa*) etc.

One species in this stands out majestically different form the others in terms of its girth and canopy. This is the rain tree or *Albizzia saman*. This project centres around the present status of these magnificent trees, the threats faced by them and the methods that need to be employed to retain them.

It has been observed in the past two years that rain trees have been severely infected by some species of fungus killing hundreds of trees in the city. Large leafless skeletons of these trees were seen lining the streets and avenues of the city. This jeopardises the environment of the city which is fast losing its green cover and increasing its temperature. According to leading national dailies, over 200 trees from all over the city have been affected since May 2013. Damages are seen at Matunga, Dadar, King Circle, Khar, Bandra-Kurla Complex, Santa Cruz and Kandivli. A national daily dated July 2013 also reports that two months after 100 city trees were hit by a fungal infection, the municipal corporation has not even been able to identify the infection, let alone save the trees. After claiming it tried to treat the trees using generic pesticides, the municipal corporation cut the shrivelled branches of more than 30 trees in Bandra Kurla Complex.

The situation demanded immediate investigation and an action plan put in place to conserve these beautiful, shade giving, and long living trees. Vanashakti began investigating this issue in December 2013. Beginning with a baseline survey the entire city was surveyed for the trees; the survey continues today also. The cause of death was also being investigated simultaneously, with work being carried out both in the field and in the laboratory. The city authorities were also petitioned seeking help and co-operation. This document is an interim report which details the story of the death of the city's rain trees and Vanashakti's efforts in investigating the cause of the death and saving them from death

THE RAIN TREE

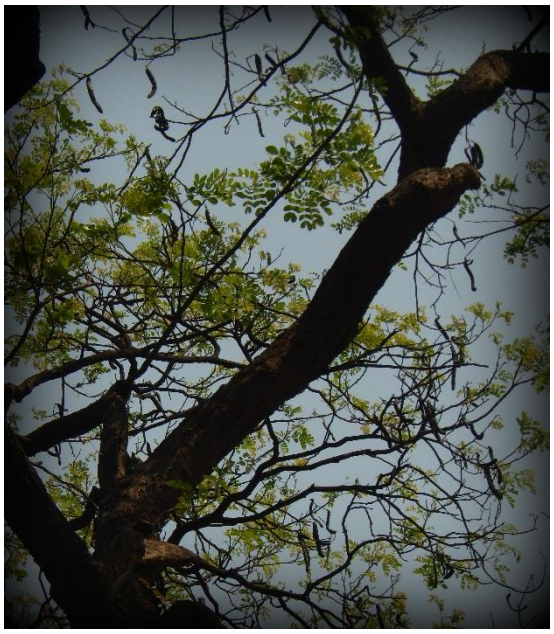
Rain trees (*Albizia saman*), as they are commonly known, is a species of flowering tree in the pea family, Fabaceae that is native to the Neotropics. Common names include saman, rain tree and monkeypod. Formerly known as *Samanea saman*, it is native to open woodland areas and prairies from Central America to Brazil. It has been introduced and has naturalized in a number of tropical areas around the world. It is easily recognized by its characteristic umbrella—shaped canopy. When grown in the open, the tree usually reaches 15-25 m (50-80 ft) in height with a canopy diameter wider than the tree. Rain tree is most important as a shade tree on small farms, along roads, in parks and pastures. Leaves are compound and bipinnate (upto 12-15" long) with leaflets that grow up to 1.5" long. Leaves fold up on cloudy or rainy days and at night. When it rains, water can more

easily reach the grass under the tree because of the folded leaves, often resulting in greener grass under the tree, hence the common name of rain tree. Rain tree generally attains maximum heights of 15-25 m (50-80 ft). In rare cases it can reach a height of 50 m (160 ft). The crown typically reaches 30 m (100 ft) in diameter.

Trunk of a Raintree

Very large trees may reach 50-60 m (I60-I95 ft) in diameter. Rain trees usually have a short, stout trunk of about1-2 m (3-6. 5 ft) in diameter at breast height (dbh), but the trunk can attain 2-3 m (6. 5-10 ft) dbh in exceptional cases. Under dense planting conditions, trees may attain greater height (to 40 m, 130 ft) with a narrower crown diameter than when planted in the open.

Rain tree is cultivated and naturalized throughout the tropics. In the Pacific, rain tree is known to occur on the following islands: American Samoa (Tutuila), Commonwealth of the Northern Mariana Islands (Saipan,Rota), Federated States of Micronesia (Chuuk, Kosrae,Pohnpei), Fiji (Kanacea, Taveuni, Vanua Levu, Viti Levu), French Polynesia (Tles Tubuai [Rurutu],Tahiti, Marquesas, Moorea, Raiatea), Guam, Hawaii, Marshall Islands (]aluit, Kwajalein), Niue, Palau (Koror), Papua New Guinea, the Philippines, Pitcairn, Rotuma, Samoa (‘Upolu), and Tonga (Tongatapu, ‘Eua, Vava‘u, Lifuka/Foa). The species is also naturalized in a number of the Caribbean Islands including Puerto Rico. It is almost certainly even more widespread than the foregoing list indicates.



Pods on a Raintree

Rain tree has a distinctive, umbrella—shaped crown. The crown is typically broad and domed; the horizontal spread is greater than the height when grown in spacious, open settings. Under plantation conditions, the crown is more vase—shaped.

Flowers of a Raintree

Rain tree is a moderately fast—growing tree with typical growth rates of 0.75-1.5 m/yr (2.5-5 ft/yr). Nursery—grown seedlings 3-5 months old are usually 20-30 cm (8-12 in) tall when ready for out planting. Initial growth is slow but survival is good. Two months after transplanting, seedlings begin to look vigorous and grow rapidly. Two—year— old saplings in mixed plantations attained 2.9 m (9.5 ft) in height and in monospecific plantings at a 3 x 3 m (10 x 10 ft) spacing reached 4.8 m (16 ft) tall and 6.6 cm (2.6 in) dbh. Well-tended specimens may attain 15 cm (5.9 in) diameter in 5 years. Flowering begins at a young age and has a definite seasonality, beginning at the end of the dry season just after the leaves and mature pods drop.

Massive lateral roots of a Raintree

New foliage flushes out and flowering begins more or less simultaneously. Trees may have flowers present in almost any month of the year, especially in areas with year round rainfall. Tiny flowers appear in mass in rounded, fluffy, pompom-like flower heads (each to 1 1/2 across). Protruding stamens (white below but crimson-pink above) give the flower head an overall pink appearance from a distance. Flowers are attractive to bees. One (infrequently two) flowers per head are followed by a flattened, bean-like seed pod (each to 8" long with 15-20 seeds per pod). Pulp inside the pod is sticky, sweet and edible for humans. Seeds are imbedded in the pulp. The tree has a massive surface root system, extending up to the drip line of the tree. The large surface roots common in the species occur most often on clayey and rocky soils but are not as extensive on sandy or gravely soil. The genus is named in honour of Filippo degi Albizzia who introduced the genus (*Albizia julibrissin*) to Italy in 1749

Division	Spermatophyta
Sub Division	Angiospermae
Class	Dicotyledoneae
Order	Fabales
Family	Fabaceae
Genus	Albizia
Species	saman

Sources: *(Staples & Elevitch, 2006); USDA, ARS, National Genetic Resources Program (2014)*

THE PROBLEM

In mid-2013, hundreds of rain trees were seen dying in Mumbai mysteriously. Some attributed the death to some pest – an insect or a fungi but no concrete cause was seen underlying these deaths. Pesticides were sprayed by the municipal corporation, but in vain.

We began our investigation with a baseline survey of the trees. Beginning with the southernmost tip of the city, trees were surveyed from Colaba in South Mumbai up to Dahisar and Mulund at the northern end.

The following was carried out:

1. Each tree was photographed and geo tagged.
2. Each tree was studied for mensural data – height, canopy, diameter at breast height and girth.
3. Condition of the tree was noted.

4. Bark and leaf samples were collected for laboratory analysis.
5. Ambiguities if any in the tree and in its vicinity were noted.
6. Soil samples were collected from under those trees whose base was not concretised.

It was noted that:

1. Most rain trees in the city had dried up, were leafless.
2. Leafless trees had heavy infestation of a white scaly insect.
3. Bark of these trees had powdery growth.
4. Trees with leaves were also seen with this insect.
5. Most of the trees in the city had concretized and/or paved bases.

Samples of bark from the trees and type specimens of the white scaly insect were collected and sent for identification. Laboratory analysis identified the white scaly insect as *Dysmicoccus neobrevipes* a mealy bug and the powdery growth to be fungus. The bug and fungus were thus visibly suspected to be the primary cause of the infestation, leaf drying and death. Literature survey was carried out to study the morphology, distribution, life cycle and behaviour of the bug

Top: The girth of a tree being measured.

Left: Measuring dimensions of the concrete box around the tree.

Top: Samples of leaves and bark collected from tress at various locations bagged for laboratory analysis. Samples from both healthy and infested trees were collected.
Bottom: Left: Girth of a tree being measured.
Right: Girth of a lateral root being measured. This live, healthy Raintree was found uprooted by the southwest monsoon, exposing its roots.

Month	Weather Data				Tree Count			Area
	Avg. Temp. (°C)		Avg. Humidity (%)		No. of Trees Counted	No. of Trees Normal	No. of Trees Infested	
	High	Low	High	Low				
December	32	17	84	36	72	0	72	Parts of Khar
					31	4	27	Parts of Mulund
					54	0	54	Parts of BKC
January	29.6	19.3	84	35	45	0	45	Santacruz (7th
					43	0	43	Borivli Rly. Station (West)
					171	14	157	BKC
					45	1	44	Khar
February	29	20	84	34	194	9	185	Santacruz
					230	42	188	Sion
					101	6	95	Matunga
					143	143	0	Goregaon
								(Aarey Colony)
					51	28	23	Andheri
March	37	22.7	86.75	37.75	150	101	49	Goregaon
					16	4	12	Bandra
					54	52	2	Kanjurmarg
April	33.8	22.2	47	29	-	-	-	-
May	34.4	23.3	88	47	161	1	160	Dadar
					41	37	4	Bycula
					52	0	52	Parel
June	31.00	27	91.00	63.00	38	11	27	Powai
					30	9	21	Dahisar
					39	0	39	Kandivali
					41	37	4	Byculla
					50	0	50	Versova
					48	43	5	Ghatkopar
					36	35	1	Vikhroli
					29	29	0	CST
Total					**1965**	**606**	**1359**	

Trees counted and studies in the baseline survey

MEALY BUG

Mealybugs (Hemiptera: Pseudococcidae) are small, soft-bodied plant sap-sucking insects that constitute the second largest family of scale insects (Hemiptera: Coccoidea), with more than 2,000 described species and circa 290 genera (Downie and Gullan, 2004; Ben-Dov, 2006). Mealybugs are severe agricultural pests with 158 species of mealybugs being recognized as pests worldwide (Miller *et al.*, 2002). These species most frequently originate from the Palearctic region (29%), followed by the Nearctic (17%), Neotropical (16%), Oriental (15%), Afrotropical (12%) and Australasian (11%) regions (Miller *et al.*, 2002). They are sexually dimorphic: females appear as nymphs, exhibiting reduced morphology, and lack wings, although unlike many female scale insects, they often retain legs and can move. Males are smaller, gnat-like and have wings. Mealy bug females feed on plant sap, normally in roots or other crevices, and in a few cases the bottoms of stored fruit.

They attach themselves to the plant and secrete a powdery wax layer used for protection while they suck the plant juices. Male citrus mealy bugs fly to the females and resemble fluffy gnats. Some species of mealy bug lay their eggs in the same waxy layer used for protection in quantities of 50–100; other species are born directly from the female. However, male mealy bugs do exhibit a radical change during their life cycle, changing from wingless, ovoid nymphs to wasp-like flying adults.

Mealy bugs only tend to be serious pests in the presence of ants because the ants protect them from predators and parasites. Fossil specimens of *Acropyga* genus ants have been recovered from the Burdigalian stage Dominican amber deposits and several individuals are preserved carrying the extinct mealy bug genus *Electromyrmococcus* (Johnson *et. al.* 2001). These fossils represent the oldest recorded record of the symbiosis between mealy bugs and *Acropyga* species ants. Mealybugs are known to offer ants with their sugary excretion (honeydew) (Tanwar *et. al.* 2010). Phillips (1934) hypothesized that mealy bugs are associated with ants in pineapple field because: 1) ants protect mealy bugs from natural enemies; 2) ants protected mealy bugs from adverse weather by building earthen shelters around them and moving them to protected places; 3) ants transport mealy bugs from plant to plant between and within fields, thus facilitating mealy bug dispersal; 4) ants stimulate increased feeding by mealy bugs; and 5) ants remove honeydew from mealy bugs, thereby preventing fungi from attacking mealy bugs. Rohrbach *et al.* (1988) hypothesized that honeydew feeding by ants could benefit mealy bugs by preventing the accumulation of honeydew on the mealy bugs themselves. Presumably, immature mealy bugs get stuck in honeydew and die if ants do not remove it.

Dysmicoccus neobrevipes also known as Gray Pineapple Mealybug was described from specimens collected in Hawaii (Beardsley, 1959). It is reported to be a pest on *Acacia farnesiana*, *Achras zapota* fruit, *Agave sisalana*, *Annona reticulata*, banana, *Barringtonia speciosa*, coconut caps, coffee, *Cresentia alata*, *Garcinia mangostana*, Guettarda, *Musa paradisiaca sapientum*, *Opuntia megacantha*, pandanas, pineapple, Pipturus argentea, Piscidia piscipula, *Albizzia saman* (Raintree), sisal, *Theobroma cacao* and tuberose. The life cycle of this insect was extensively studied by Ito (1938). The "gray form" mentioned in his paper is presently known as the gray pineapple mealybug. This

insect goes through three larval stages before becoming an adult. The life span (first instar to death as an adult) varies from 59 to 117 days, averaging at 90 days. This species does not lay eggs. Instead they are ovoviviparous, meaning the eggs hatch within the female thus, births live young (nymphs). Larvae, called "crawlers", are the primary dispersal stage in all mealybug species. They have flattened bodies with long hair which aid in their dispersal by wind. Larvae only feed during the first instar and the early part of the second instar. Adults appear predominantly gray in color as their common name implies. In actuality their bodies are brown to grayish-orange, but take on a grayish appearance in combination with the waxy exudation that covers them. The body is broadly oval and measures about 1/17 inch long by 1/25 inch wide. The back is heavily coated with tiny tufts of white mealy wax. Short filaments of wax extend from around the margin of the entire body. Lateral wax filaments are usually less than one fourth as long as the breadth of the body and those towards the back of the insect are one-half as long as the body. Each female produces about 350 larvae, but there are some that produce up to 1000 young. Females die about four days after they cease to produce young. Duration of adult life varies from 48-72 days, averaging at about 61 days. Compared with females, the males are short lived. The winged males live from 2 to 7 days. The gray pineapple mealybug is normally found on the aerial parts of its hosts such as leaves, stems, aerial roots, and flower and fruit clusters. These sites of attack differ from that of the pineapple mealybug, *Dysmicoccus brevipes* (Cockerell), which inhabits the base of their host plants such as the lower portions of stems and exposed roots of grasses and herbaceous plants, the butts of pineapple plants and the lower stalks of sugar cane.

The cotton mealybug, *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae) is an invasive polyphagous pest in Pakistan (Abbas *et al*., 2005), in Nigeria (Akintola and Ande, 2008), in China (Wu and Zhang, 2009), Australia (Charleston *et al*., 2010) and in Iran (Moghaddam and Bagheri, 2010). Cotton mealy bug is cottony in appearance, small, oval, soft-bodied, sucking insect covered with white mealy wax. It proliferates on field crops, fruits, vegetables and ornamental plants. Cotton mealy bug has a broad host range and infested over 194 plants (Vennila *et al*., 2011). It sucks a large amount of cell sap from leaves and stems depriving plants of essential nutrients showing the retarded growth and total drying of the plant (Joshi *et al*., 2010). Leaf drying was observed also in case of the rain trees. The cotton mealy bug appeared as a major pest of commercial cotton (Tanwar *et al*., 2011) and yield losses due to this pest were estimated up to 50% (Joshi *et al*., 2010). Mealy bug caused a reduction in cotton production equal to 1.3 million bales in Pakistan (Abdullah, 2009). *P. solenopsis* female is parthenogenetic

Mealybug cluster on the twig of an infested Raintree

and can produce between 128 to 812 crawlers (Vennila *et al*., 2010). The potential distribution expanded dramatically, indicating that *P. solenopsis* presents a great economic threat to cotton in Asia and other parts of the world (Wang *et al*., 2010). The cotton mealybug, *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae) is an invasive polyphagous pest in Pakistan (Abbas *et al*., 2005), in Nigeria (Akintola and Ande, 2008), in China (Wu and Zhang, 2009), Australia (Charleston *et al*., 2010) and in Iran (Moghaddam and Bagheri, 2010). Cotton mealy bug is cottony in appearance, small, oval, soft-bodied, sucking insect covered with white mealy wax. It proliferates on field crops, fruits, vegetables and ornamental plants. Cotton mealy bug has a broad host range and infested over 194 plants (Vennila *et al*., 2011). It sucks a large amount of cell sap from leaves and stems depriving plants of essential nutrients showing the retarded growth and total drying of the plant (Joshi *et al*., 2010). Leaf drying was observed also in case of the rain trees. The cotton mealy bug appeared as a major pest of commercial cotton (Tanwar *et al*., 2011) and yield losses due to this pest were estimated up to 50% (Joshi *et al*., 2010). Mealy bug caused a reduction in cotton production equal to 1.3 million bales in Pakistan (Abdullah, 2009). *P. solenopsis* female is parthenogenetic and can produce between 128 to 812 crawlers (Vennila *et al*., 2010). The potential distribution expanded dramatically, indicating that *P. solenopsis* presents a great economic threat to cotton in Asia and other parts of the world (Wang *et al*., 2010). Mealybugs are difficult to control once they have had time to establish themselves and while chemical control is still the most common control tactic used, the cryptic behavior of mealybugs, their typical waxy body cover and clumped spatial distribution pattern render the use of many insecticides ineffective (Franco et al., 2009). Repeated insecticide use, especially of broad-spectrum chemicals, also adversely impacts the mealybugs' natural enemies and insecticide resistance has caused the use of some chemicals to be unsustainable (Franco *et al.*, 2009). Furthermore, many of these products are increasingly unacceptable because of their human toxicity and low selectivity; some are no longer available and others are targeted for reduction under national programs and regulations for sustainable use of pesticides, in light of their risk or hazard assessments (Franco et al., 2004; Charles et al., 2006; Walton et al., 2006).

The biological control of mealy bugs, is widely recommended (Franco *et al*., 2009) 

EXPERIMENTATION FOR REVIVAL

Upon the completion of the baseline study and laboratory analysis, it was hypothesised that the causes of the death of the rain trees were:

1. Fungal infection that had set in the bark and branches.
2. Mealy bug infestation that was causing the death of the stressed trees that were unable to combat the infestation.
3. Air, water and nutrient stress resulting from concretized tree bases

Attempts were thus made to revive the dying trees. Some of the attempts described below were first conducted *ex situ* and then replicated *in situ* (This is further elaborated in the following sections where relevant).

Hydration

As the study progressed in mid-summer, it was hypothesised that the trees could be stressed for water and that hydration could revive them, enabling them to combat the bug infestation.

Tree bases were de concretized and cleared off debris and other dump, and watered twice a week for two months.

A stretch of 20 trees in Dahisar was selected for this experiment. 50% revival was seen in the trees with new foliage developing on these trees. We acknowledge the ground support of the R-North ward of the MCGM

Deconcretized/Depaved trees being watered in the mid-summer months

Nourishment

Deconcretized /Depaved tree base being administered with Lactobacillus suspension

Besides hydration, trees also needed nourishment. Concretized tree bases, in addition to preventing surface water seepage also prevent humus formation, a natural phenomenon where in leaf litter decompose in the soil under the tree forming nutrient rich organic compost. For nourishing the trees Lactic Acid Bacteria (LAB) was used. LAB are known to improve human and animal health (probiotics) and recognized as safe (Stiles, 1996). LAB have also been used for treatment of cattle manure and sewage for odour abatement and as an inoculant to accelerate the composting of organic wastes (Okada, 1988). Curd being the most common and readily available source of LAB was used to prepare suspension of LAB. This experiment was first conducted *ex situ* in controlled conditions and then replicated *in situ*. 100 gm. of curd was diluted in the ratio of 1:10 with water and the suspension was administered at the roots of potted rain tree saplings procured from a local nursery. 2 three month old saplings were administered with this suspension once a week for 1 week and 1 three month old sapling that was watered regularly served as the control.

Saplings administered with LAB showed healthier leaves than the control. This was then replicated *in situ* on dry, leafless, infested trees at various locations viz., Khar, Dadar and Dahisar with higher curd: water ratio. 10 trees were treated once a week for 2 weeks. This administration showed a significant effect on the infested trees wherein the trees showed regeneration and revival with increased foliation.

Revival and flowering of an infested, leafless raintree upon regular, periodic watering and administration of Lactobacillus suspension

Natural Predator

Chemical control of cotton mealybug with conventional insecticides is difficult as the pest is covered with the waxy material (Joshi *et al*., 2010). Early-chemical control efforts against *P. solenopsis* proved unsatisfactory in Texas, United States (Fuchs et al., 1991). Therefore, biological control of this pest is being tested in different regions of its invasive occurrence. In India the coccinellid beetle *Cryptolaemus montrouzieri* Mulsant has provided spectacular control of heavy infestations of sucking pests, especially mealy bugs (Mani 1990; Mani and Krishnamoorthy 2008) and some soft scales (Kumar and Prakasam 1984; Mani and Krishnamoorthy 1990). The predator was also reported to feed on citrus mealybug, *Planococcus citri* (Singh 1978), and pink mealy bug, *Maconellicoccus hirsutus* (Green) (Mani and Thontadarya 1988; Reddy and Narayan 1986). *C. montrouzieri* was found to be a most

efficient predator among coccinellids, *Hyperaspis maindroni*, *Scymnus coccivora* and *Nephus regularis* for *P. solenopsis* in New Delhi, India (Fandi *et. al*. 2010). Moore (1988) also stated that despite the frequent use of predators, only the coccinellid *C. montrouzieri* can be considered successful. Studies conducted by Harmeet Kaur *et al*., 2011 indicate that *C. montrouzieri* has the potential to be exploited as a biocontrol agent in North India and that inoculative releases of 4th instar larvae and adults may provide instant control of *P. solenopsis*.

Larva of Cryptolaemus montrouzieri released on the bark of a raintree. Note the resemblence with the mealybug female

Kingdom	**Animalia**
Phylum	Arthropoda
Class	Insecta
Order	Coleoptera
Family	Coccinellidae
Genus	*Cryptolaemus*
Species	*montrouzieri*

Cryptolaemus montrouzieri (Coleoptera: Coccinellidae), or Mealybug Ladybird is ladybird species endemic to Queensland and Wales, Australia. Unlike many of the often brightly coloured Coccinellidae, it is predominantly brown and has no spots. It is a small (1/5 inch long), redish-brown lady beetle with dark-brown wing covers. Adult beetles are 3.8-4.6 mm in length and 2.7-3.3 mm in breath, having black shining elytra with apices reddish yellow. Fore legs in males are reddish yellow and in females completely black. The predator is capable of feeding on a wide host range of mealybugs and has been reported feeding on 45 species including *P. solenopsis* (Gosalwad *et al*., 2009) which support the reproduction and development. However, it has been recorded from another 35 hosts, but these hosts do not support the reproduction and development.

Keeping in mind the efficacy of C. montrouzieri on mealybug on crop plants, their larvae were procured from a reputed institution in Bangalore for release on infested trees as a biocontrol measure. In all 500 larvae were released on 5 trees at dusk. Dawn and dusk are a time that

mealy bugs are least active. As a larva it apparently looks like the mealybugs they prey on, a case of aggressive mimicry.

Results were not favourable though. This could be attributed to the fact that rain trees thrive in uncontrolled urban conditions as unlike agricultural fields which do not experience various stress factors like pollution, water stress.

Bio pesticide spraying

As a measure for immediate pest control, pesticides needed to be sprayed on the rain trees. Since the trees are in close proximity of human habitation, the use of a chemical pesticide was not advisable due to toxicity to humans and to the environment. The Pest Control of India Ltd. (PCIL) recommended the use of Lastraw a bio pesticide that acts by dissolving the insect's cuticle causing dehydration and consequently death. Since the raintrees' canopy is at great height, high rise ladders were used to spray the canopies with the formulation. The formulation was used as directed in the pesticide's brochure (Annexure I). Till now, 25 trees from Khar and Dadar have been sprayed and the trees are being monitored. This exercise will be replicated in other areas, depending upon the results obtained from the pilot study

Bio-pesticide Lastraw being sprayed on the canopy using a mister to nebulise the solution into a thin suspension that can raise and coat the canopy efficiently

Lastraw being sprayed on the bark of an infested Raintree

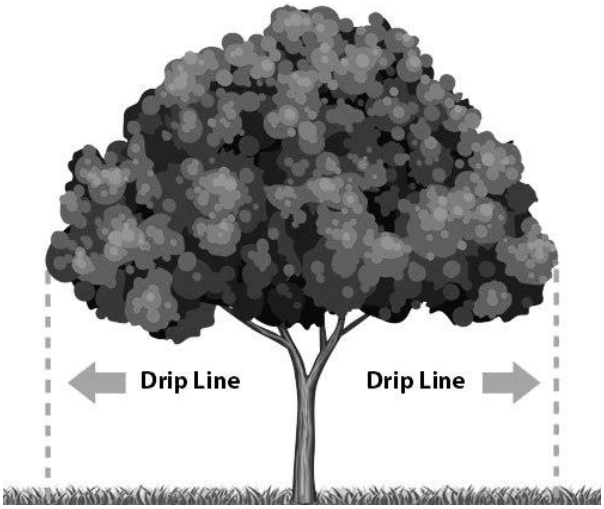
OUTCOME

Both 'hydration' and 'nourishment' needed the bases of the trees to be de-concretized/de-paved. These experiments proved successful; the trees treated under these experiments showing rejuvenation, refoliation and flowering in the flowering season. It can thus be concluded that air, water and nourishment stress are the causes of the tree's compromised health and immunity and consequently their death due to their inability to resist the infestation. The bug exclusively is not the culprit. It is a secondary manifestation of the problems that plague the tree. But one that needs serious attention if the remaining standing trees are to survive.

The following was observed during the course of the study:

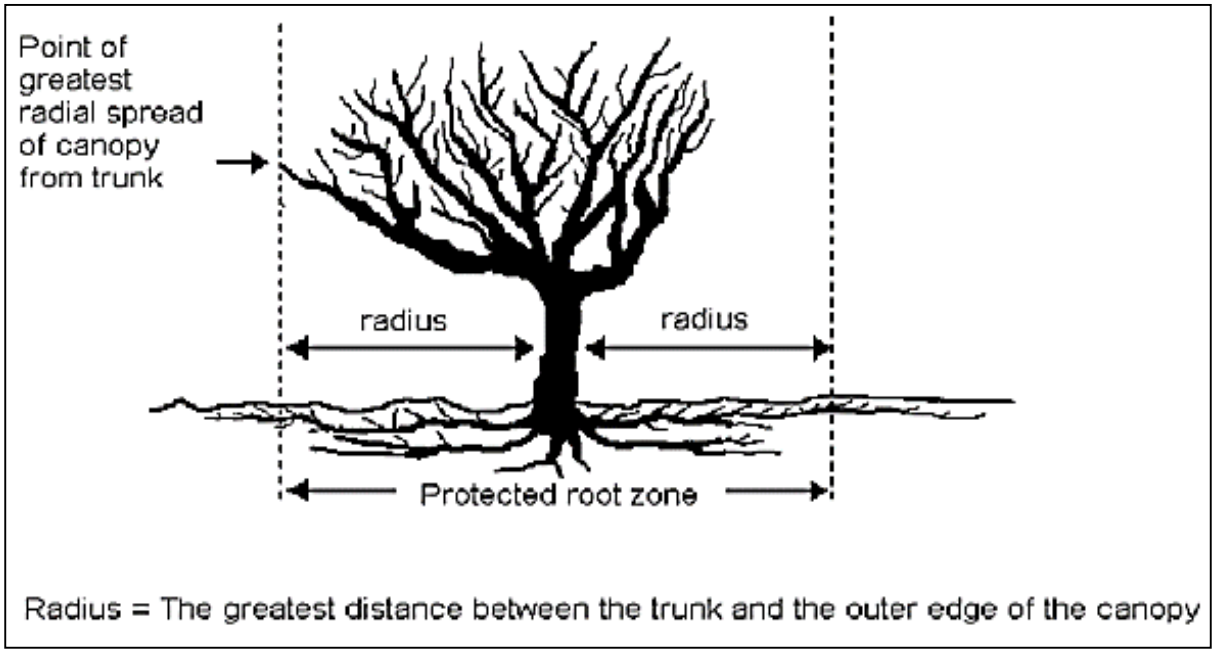
1. **Trees that appeared leafless were heavily infested with mealy bugs.**
2. **Those trees whose bases were concretized were infested or were prone to infestation.**

Concretized tree bases prevent air exchange between the soil and the atmosphere, besides preventing humus formation from the leaf litter that gathers below the tree thus preventing nourishment. Concretized bases also prevent surface water from seeping into the soil. Concretization thus prevents air, water and food from reaching the roots. Rain trees have lateral roots that grow on the surface of the soil that grow to a length of up to 15 ft. Lateral roots aid in balancing the tree and its massive canopy. Concretization prevents the lateral roots from growing healthily. Concretization and paving the base also prevents these lateral roots from surfacing healthily. Additionally, concretization prevents the drip zone of the tree from getting hydrated. Drip zone of a tree is the area under a tree that corresponds to the canopy (See diagram). Moisture from rain and dew



collects in the area below a tree, thus called the drip zone. Thus, concretized tree bases lead to compromised immunity in the trees, making them susceptible to infections and infestation. It was observed that trees in Aarey Colony, Goregaon, Godrej Colony and Nerul did not show any sign of infestation. The bases of the trees in these area were un-concretized thus letting the trees survive and grow in natural conditions like on a forest floor. The trees here thus showed health and uncompromised immunity.

A stretch of trees in Aarey Colony, Goregaon. Note the health of the trees. The tree bases on this stretch had natural bases like on a forest floor, which is attributed for the health and of the trees. No tree on this stretch were found infested



Month	Weather Data				Tree Count			Area
	Avg. Temp. (°C)		Avg. Humidity (%)		No. of Trees Counted	No. of Trees Normal	No. of Trees Infested	
	High	Low	High	Low				
December	32	17	84	36	72	0	72	Parts of Khar
					31	4	27	Parts of Mulund
					54	0	54	Parts of BKC
January	29.6	19.3	84	35	45	0	45	Santacruz (7th
					43	0	43	Borivli Rly. Station (West)
					171	14	157	BKC
					45	1	44	Khar
February	29	20	84	34	194	9	185	Santacruz
					230	42	188	Sion
					101	6	95	Matunga
					143	143	0	Goregaon
								(Aarey Colony)
					51	28	23	Andheri
March	37	22.7	86.75	37.75	150	101	49	Goregaon
					16	4	12	Bandra
					54	52	2	Kanjurmarg
April	33.8	22.2	47	29	-	-	-	-
May	34.4	23.3	88	47	161	1	160	Dadar
					41	37	4	Bycula
					52	0	52	Parel
June	31.00	27	91.00	63.00	38	11	27	Powai
					30	9	21	Dahisar
					39	0	39	Kandivali
					41	37	4	Byculla
					50	0	50	Versova
					48	43	5	Ghatkopar
					36	35	1	Vikhroli
					29	29	0	CST
Total					**1965**	**606**	**1359**	

Note that trees in Aarey Colony are not infested

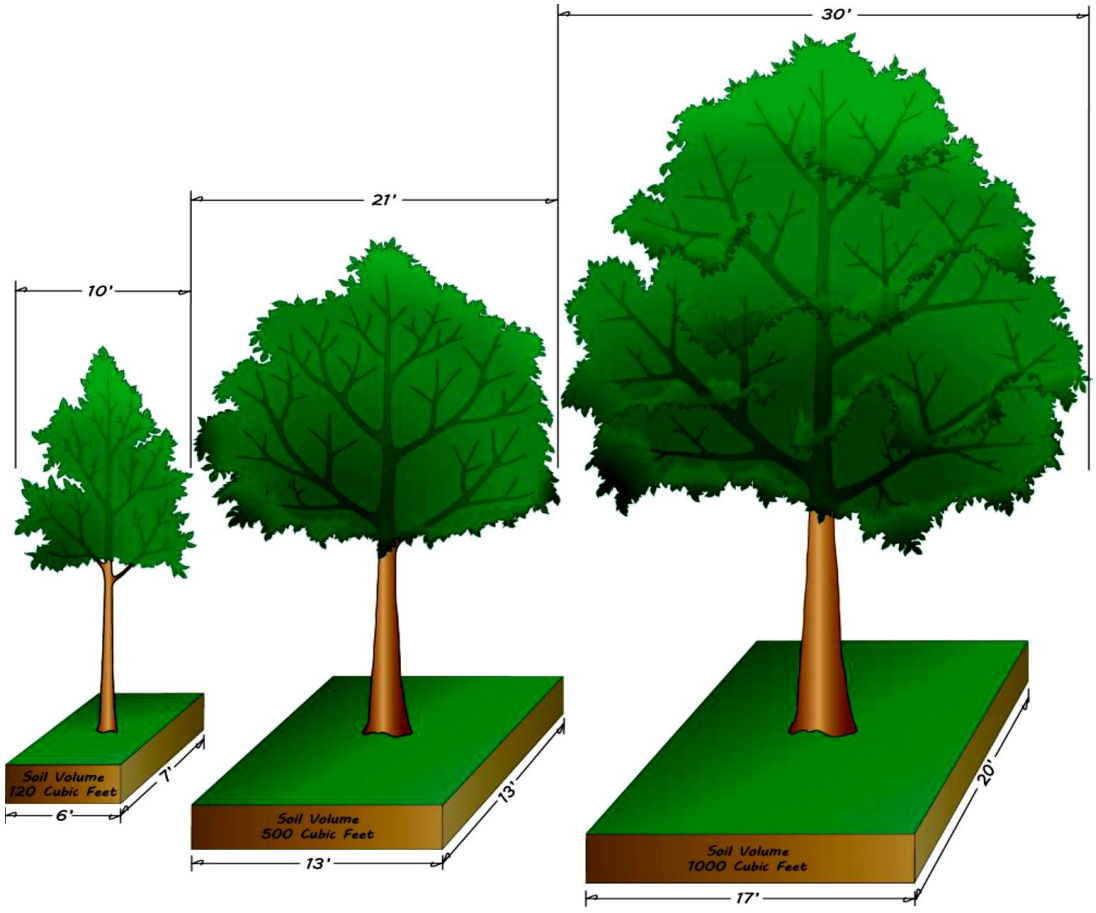
In many areas it was observed that lateral roots of the trees broke through the concrete/ paver blocks to expose themselves (See image). Roots, like any part of a tree tend to grow naturally either in search of food, air or water. The fact that the lateral roots break open the concrete proves that they need to be left in their natural environment and concretization is unnatural for their healthy existence.

Note the massive lateral roots in the three images above

Condition of tree bases in the city. Note te roots growing out of the construction

Upon digging the tree's vicinity it was observed that up to 4-5ft of concrete, tar and other construction material constituted the tree's base without any soil as against the natural soil profile (see image) which comprises 3 ft of fertile top soil and sub soil below it. According to US-EPA's Storm water to Street Trees: Engineering Urban Forests for Storm water Management tree growth is limited by soil volume. To grow big trees, large amounts of un-compacted soil are needed. For a mature tree with a canopy spread of approximately 30 feet, 1,000 cubic feet of soil is needed.

Bases and vicinities of the trees were dug to find out the thickness of the soil layer below ground. Construction material was found in place of soil and organic content.



Tree growth is limited by soil volume. To grow big trees, large amounts of un-compacted soil are needed. For a mature tree with a canopy spread of approximately 30 feet, 1,000 cubic feet of soil is needed.

Illustration from Casey Trees, 2008.

Source: Storm water to Street Trees: Engineering Urban Forests for Storm water Management, US-EPA

A natural soil profile: In natural conditions trees anchor and grow in the soil. The top soil and sub soil providing nourishment (food and water) and anchorage. Urban trees lack this basic necessity which consequently weakens the trees.

An iron rod was hammered into the soil around the tree base ensuring no damage to the roots, to find out the depth of the soil in the box below the tree base. The soil layer was found to be only 8 inches deep

Determination of sugar in phloem sap

In order to testify the water stress condition, an experiment was conducted wherein the sugar content of the tree was estimated. In this experiment, twigs of three healthy (with un concretized tree base) and three bug stressed (leafless trees whose bases were concretized) trees were collected and the phloem sap was extracted. The titre of sugar was then estimated in the sap using standard colorimetric method. Mean value of sugar content in healthy trees was obtained at 0.051 gm/10ml of plant extract whereas that of infested trees was obtained at 0.067 gm/10ml of plant extract. This increase in the level of sugar in the sap only testifies the fact that in a stressed tree the titre of sugar in the phloem sap is higher which means lesser dilution with water. This higher titre of sugar will only lead to a higher infestation with mealy bugs, thus jeopardizing the situation.

It appears that mealy bugs are not capable of killing a healthy tree; i.e. they are not harmful pests. They are part of the ecosystem and only those trees that have grown weak with time have lost the ability to fight a pest attack and this has eventually caused death

RECOMMENDATIONS

Note that the tree on the left side of the image with a natural unconcretized base stands healthy whereas the stretch of trees on the right with concretized bases stand leafless and dry. Location: Bandra Kurla Complex

We recommend the following measures, in the order given below:

1. De paving/ De concretizing: We recommend that the base of the trees be de-paved and/or de-concretised. Bases should be left un-concretized up till the extent of a tree's Protected Root Zone (PRZ). This is the extent of the roots under the soil which extends around the radius of a tree (Refer diagram in 'Outcome'). Any construction work, concretization etc. damages the PRZ, which is why it is also known as the Critical Root Zone (CRZ). Depaving the tree bases up to a distance of minimum 12 ft x 8ft x 6ft box all around the tree. Alternatively, trees should be planted in channels/trenches of soil as against restricting concrete blocks. The PRZ also corresponds with the drip line of a tree. The tree's Protection

Zone should be fenced so as to prevent construction or any other earthwork. In the drip zone concretized surface if any should be drilled to allow water to percolate into the sub soil. Paver blocks to be mounted on un-compacted soil on walk ways.

2. Spraying bio-pesticides: Mealy bugs occupy the undersides of leaves. Spraying the undersides of the leaves or the entire canopy at least thrice every fortnight for three months can eliminated the pest considerably.

3. Release of natural predators: A substantial stock of *Cryptolaemus montrouzieri* should be readily available at regional or local level in the city and/or its neighbourhood. This would help aid in situations of emergency should there be a sudden pest attack.

4. Nourishment and hydration: Mulch, compost and other organic nutrients should be administered to the trees periodically. Top soil should also be replaced periodically. Both the above have to be done meticulously using handheld tools to avoid damaging the roots. Mulch will only nourish the soil but also prevent evaporation of soil moisture. Lactobacillus suspension should also be administered in the loosed top soil every fortnight. Fortnightly watering should be undertaken in the summer months till the onset of the south-west monsoon.

5. Tree Committees: Tree Committees should be set up in every Municipal Ward for the preservation and upkeep of trees.

Annexure I

LASTRAW™

Formulation of Organic Salt for Management of Sucking Pests

LASTRAW™ is specially formulated water soluble organic salt of fatty acids of vegetable oil origin, developed for management of soft bodied sucking pests on contact. It is biodegradable, does not leave any residue and is safe to environment.

TARGET PESTS: All types of soft-bodied sucking pests such as mites, aphids, thrips, mealy bugs, white flies, soft scales and plant hopper on houseplants, vegetables, fruits, shrubs, trees or plants grown in greenhouses.

MODE OF ACTION: LASTRAW™ acts by dissolving the waxy layer of insect cuticle, leading to severe dehydration.Its unique mode of action does not allow development of resistance by pests.

- Affected pests drop down from the plant only 2-3 days after application, since the process of dehydration is slow.
- Presence of shriveled insects on plants can be mistaken for live ones, unless observed closely.

METHOD OF APPLICATION:

- Mix @ 5ml/ litre of water to prepare spray solution
- Mix the product with required water in a tank and stir well
- Spray immediately after preparation.
- Repeat application as and when required on noticing re-infestation.

RECOMMENDATIONS:

- Apply only when sucking pests are present
- Spray thoroughly on upper & lower leaf surface to ensure proper coverage.
- Apply 2-3 times at weekly intervals for effective control
- In case of severe infestation repeat application at least once within a week after first spray to control nymphs emerging from eggs that are not affected by LASTRAW™
- Compatible with chemical pesticides

ADVANTAGES:

- LASTRAW™ is an organically certified product.
- Safe, non-toxic and environ- mentally friendly.
- Odorless and leaves no taint or residue on the plant.
- Totally and rapidly biodegradable.
- No waiting period restrictions prior to harvest.

PRECAUTIONS:

- Use gloves while preparing tank mixture.
- Avoid contact with eyes. If eyes are contaminated wash with plenty of water.
- Avoid spraying in bright sunny conditions, at high temperature or when plants are under stress
- At recommended doses LASTRAW™ does not cause phytotoxicity. Avoid higher doses.

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