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Pandanus fasicularis Lamk. (Kewda): The Prime Vegetation in the Hinterland Biodiversity of Coastal Odisha, With Unique Ethnic Utility, Genetic Variation and Economics- A Review

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ABSTRACT The plant, *Pandanus fasicularis* Lamk., has a special ethno-ecological existence in the Ganjam district coastal hinterlands of Odisha, with unique phytogeography, seen nowhere else in the globe. In this scientific age, the flowers are extracted following the traditional technology by local people instead of adapting any modern know-how. The vegetation accounts nearly 90 percent production of commercial perfumes in the country, which is 50 percent of the world's production. The ethnic utility of the plant is a rich source of ethno-medicines and cottage industry; acts as the main source of bread and lively hood of the rural mass, especially of poor people. The plant in general is poorly affected by pest and/or diseases. The Kewda *Rooh* has antibacterial activity and probably the scent of the flower is repulsive for the pests. The residential micro flora over the leaf platform of Kewda protects it from the pathogens at their first step interaction with the host. The densely grown impenetrable vegetation of the plant forms itself a biotope, which forms an arboretum for aerial, arboreal and furrowing or bottom dwelling animals; that constitutes the micro-fauna of unique niche. The uniqueness of the plant is that none of its' part left unused by people of this area. Kewda is a rich source of Ayurveda medicaments used against diseases like rheumatic arthritis, diseases related to blood, debility, swooning, vertigo, conjunctivitis, epilepsy, ear ache, head ache and throat problems etc. The Kewda oil is stimulant, purgative, antispasmodic, aphrodisiac and anti-rheumatic. Similarly, the various uses of its *Attar* and water are reflected in the text. Chemical studies of Kewda were undertaken that establishes the chemo profile of the plant consisting of more than 44 chemical constituents, out of which 11 are important and 2 constituents determine the quality of the perfume. The chemical composition changes with the change of eco-physical condition of the plant. Chromosomal studies established its morpho types. The plant enjoys a chromosome number of 2n=60. A variation of 2n number 56 – 64 is related to morphotype of the plant.

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INTRODUCTION

Certain geographical regions of the world are bestowed with the bounty of nature and enriched with a specific biodiversity of its own kind. The coastal area of Odisha state is en-

dowed with such specialized plants and animals with unique ecological importance. Among the plants *Anacardium occidentale* (Kaju), *Casuarina equisetifolia* (Jhaun), *Cocus nucifera* (Coconut) and *Pandanus fasicularis* (Kewda) significantly dominate the Phytodiversity. The Vedic age animal *Antelope cervicapra* (Black Buck) is found in three places of Odisha, out of which two are restricted to other coastal regions *i.e.*at Bhitara Kanika of Cuttack and Balukhand of Puri districts respectively (Padhy et al. 1997). Similarly, the Ganjam district coast is the most favourable place for the lay down of eggs by marine turtles Olive ridley (*Lepidochelys olivacea*), an ear marked area in the global geography. Chilka, the biggest salt water lake of Asia is famous for its migratory and resident birds, fish population, wild life and variegated flora is a Divine Gift of nature to Odisha coastal ecology (Patro 1988). One can enjoy the bountiful natural beauty of Chilka while on a trip in East Coast railway.

Amidst the above natural resources, the plant *Pandanus fasicularis* has a special reference for its Ethno-Ecological existence. It adds fragrance for the higher society and as well supply bread to the rural poor in Ganjam hinterland regions of Odisha state. This communication is devoted to explore the diversity, ethnic utility, genetics, biochemistry and economic prospects of *Pandanus fasicularis* Lamk.

THE KEWDA PLANT

Distribution

Pandanus fasicularis Lamk., with an English name Screw pine (popularly the umbrella tree) has different vernacular/ local names like Ketakee, Gandha pushpa, Sthira gandha, Indu Kalika, Jambala (in Sanskrit); Kewra, Keora, Kewda, Gagandhul (Hindi); Kedgi, Kevda, Keora (Marathi); Kewoda (Gujarati); Kiya, Ketakee (Odia); Keya, Kedki, Keori (Bengali); Thazhai, Thalay, Thazhampoo (Tamil); Mogali, Gajangi (Telugu); and Kaitha, Kaida, Thala (Malayalam). The genus *Pandanus* has over 500 species of which 36 are recorded in India. *Pandanus* has tropical distribution extending from Western Africa in the west to the Polynesian island in the east. The plant grows wide in the riversides of sea coast of the Indian peninsula and the Andaman. Other than India it occurs in the coastal regions of Iran, Malaysia, Mauritius, Myanmar, Java, China, Taiwan and south islands of Japan.

The distribution of the plant in India is mostly in coastal districts of Odisha, Andhra Pradesh, Tamil Nadu, Kerala and Gujarat. To a little extent, it is also found in Badaun, Balia and Ghazipur districts of Uttar Pradesh. Though, the Plant is found in different parts of India, its growth in Odisha, especially in districts like Ganjam, Balasore, Cuttack and Puri is luxuriant. Above all, the South-East coast of Odisha to a stretch of merely 4 km coastal line of Ganjam district from the river Rrushikulya to the boarders of Odisha and Andhra Pradesh, the distribution of the Kewda mostly within a narrow range of 8-10 KM from the sea, is unique. Nowhere else, one can find such luxurious growth of the species so abundantly acclimatizing to the environmental conditions as is observed here. This is the main reason for the extensive research on *Pandanus fasicularis* by the scientific hubs of this area and all such facts are conglomerated and reviewed in this communication.

Conditions of Growth

Kewda is an ornamental, showy, densely branched shrub, growing to 6m high with spiniscent leaves arises alternately spire; tightly embracing the trunk. Leaf linearly oblong, measures up to 1.5 m long and 5-6 cm breadth, acuminate, coriaceous, midrib and margins with thorny spines; trunks not strong enough to stand erect with foliar branches. The profusely developed leafy canopies sustain on adventitious stilt root tangentially arose from stems with a pseudo appearance of 'walking plants' (Fig. 1).

In wild state, *Pandanus* grows along the sea coastal line resulting thick impervious; rather impenetrable vegetation. Normally it is found growing on banks of rivers, canals, ponds and fields nearer to water bodies of coastal region. It constitutes a tropical species, hardly is drought or frost resistant. The plant requires reasonably high rainfall. It prefers sandy, saline, marshy and waste lands, with edaphic conditions of pH 7.5 - 8.9, organic carbon 0.63 – 1.24 percent, soil moisture 16.53 – 24.16 percent, water holding capacity 23 – 40 percent, soil temperature 18^0C – 32^0C and soil texture salty sandy to clay loam, mostly available in Ganjam hinterland regions of Odisha state (Rao 2007).

The physiological and biochemical parameters, influencing on flowering in plant are well

Fig. 1. Avenue Kewda vegetation and Kewda Plant in full blossom (Electric Pole indicates its relative height)

established. During flowering season (rainy) the pigment content of the leaves are high as compared to non-flowering seasons. Similarly, it has also been reported that total carbohydrate, protein and lipid content of leaves enhances during the flowering season. Changes are recorded in the relative growth rate, leaf area density and harvest index of leaves in *Pandanus* in different seasons of a year. The plants growing in shade shows decrease growth in shoot and root length but higher in leaf number and leaf area compared to the plant grows in sunlight. However, these plants show decrease in chlorophyll content and chlorophyll a/b ratio in comparison with the plants grow in light condition (Das 2008; Das et al. 2003, 2004, 2008).

Screw pine multiplies by vegetative method. The plant is propagated through vegetative branches and aerial (stilt) adventitious roots. The division of suckers and cuttings about 60-80 cm long and 8-10 cm thick, made from non-flowering stumps transplanted in rainy season maintaining each 3 -7 meters apart. The rapid cloned propagation of the plant at the laboratory is standardized using different tissue culture media. MS medium supplemented with Auxin (2,4-D) is found to be suitable for callus formation. Indole Acetic Acid (IAA) promotes the root initiation rapidly *in vitro* as compared to other Auxins (Das and Behera 2008).

Flowering Pattern

Kewda is dioecious; flowers unisexual; staminate inflorescence alone valued for fragrance emitted from androecia and tender white spathus bracts subtended there in. The male inflorescence (spadix) totally act as source of valuable essential oil, hence deemed to be economically most vibrant. The male spadix (25-50 cm long), with numerous sub sessile cylindrical spikes (5-10 cm long) are enclosed in long creamy white spathes (Fig.1). In the female inflorescence the spadix is solitary, 5 cm diameter, represented by gynoecia consists of several carpels without perianth; fruit multiple drupaceous sorosis, oblong/globose, 15-25 cm diameter, green and turned to yellow/red when ripened without any characteristic odour.

Vegetative maturity of Kewda plant normally takes 4-5 years after plantation when flowering commences. A healthy plant remains viable up to 40-45 years. A five year old plant attains an average height of 170 cm with a stem circumference of about 50cm with 20-25 aerial roots and bears 4 flowers per month initially which normally increases. There occurs two main seasons of flowering, peak period being the May-June lasts up to September-October. About 70 percent of the flowers emerged in this season. The rest 30 percent are scattered during the month of November to April. Annually each plant pro-

duces 56-60 inflorescences in the 5th year of plantation. However, from the 10th year onwards 100-120 inflorescences are bloomed up to 40 years age of the Plant.

Generally warm and moist weather is conducive for flower production. The flowers are harvested manually after breaking the stalk with the help of stick fitted with a hook. Knives are avoided as it damages the flower buds. The best time moderated for collection of flowers is the morning with immediately transported to distillation units by 08 AM. The flowering depends on the branching, rain fall and nearness of the bush to water resource.

Kewda plant is highly polymorphic. Six morphotypes have been identified on the basis of pigmentation, leaf size, presence/absence of prickled margin etc. The dark green spiny type is considered as economically good trait on the basis of average flower production. The other dwarf variety 'Mala type' has low flower yield (Beura et al. 1996). However, here and there some Kewda bushes are seen with thorn less leaves. Genetic research will throw more light on such morphological variations. The local people as well, the scientific community has strong belief (Mohanty 2014) that the climatic conditions, environmental status and edaphic composition are responsible for huge flowering with high commercial scent value of the Ganjam hinterlands. This fact is also established (Purohit et al. 2007) which is reflected later.

MICRO FLORA AND MACRO FAUNA OF SCREW PINE

The plant is generally not affected by any pest or disease of serious nature. However, leaf-blight caused by *Alternaria tenuis* and *Botrydiplodia theobromae* has been reported. An extensive study was carried out for two years to record the atmospheric flora and of phylloplane flora of *Pandanus fasicularis*. A large number of micro-flora are harvested over the leaf platform, many of them are residential ones, which considerably protects Kewda from the pathogens at their first step of interaction with the host. Probably, this may be one of the reasons for the healthy growth of *Pandanus fasicularis.* However, air pollution due to chlorine gas has got varying effects on composition and frequency of concentration of micro flora as a whole and also individual residential ones growing on leaf surfaces (Behera 2007). There are preliminary reports on anti-microbial and anthelmintic activity of Kewda leaf extracts (Pradhan 2012), which need further conformation to support the observations of Behera (2007).

Further, the antimicrobial activity of the Kewda *Rooh* was tested against Gram +ve and Gram -ve bacteria like *Escherichia coli*, *Staphylococcus aureus*, *Proteus vulgaris*, *Pseudomonas aeruginosa, Klebsiella pneumonia*; Fungi - *Aspergillus niger* and *Neurospora crassa*, was proved positive in laboratory experiments, while the Kewda water comparatively with diluted fragrance was less effective to bacterial strains (Malana 2012). Most probably, the aromatic odour of the plant is antibacterial. Coincidently in nature, the natural spreading of the odour from the flowers protects the whole plant from pests and diseases as reported by Behera (2007).

The densely grown impenetrable vegetation of Kewda forms itself a biotope. It forms an arboretum for aerial, arboreal and bottom dwelling animals those constitute the macro-fauna of unique niche. The ever available shade, sunshine-shade mosaic during hotter part of days, semi-aquatic or sandy-mud soil condition, water holes, vegetable rubbish and privacy due to stilt root ramifications around Kewda bush acts as repository for variety of lives , forming food-webs at par with any eco-system (Pandit and Maharana 2007). The important animals to be usually encountered there are:

Mollusca: Snail (*Pila globosa*), Unio (*Lamellidens marginalis*), Cerithedia (*Cerithium morus*), Cone Shells (*Telescopium telescopium*).

Insecta: Leaf hopper (*Schistocera*), Spiders (*Arachnida*), Mosquitoes (*Anopheles* and *Culex*), Ants (*Hymenoptera*), Plant lice (*Aphids*), Dragon fly (*Odonata*) and Mantis (*Orthoptera*).

Pieces: Channa, Anabas and *Clarias.*

Amphibians: Hyla and *Rana tigrina*

Reptiles: Mud turtle (*Lissemys punctata*), Garden lizard (*Calotes versicolor*), Land monitor *Varanus bengalensis*), Snake skink (*Riopa punctata*), Water snake (*Natrix piscator*), Rat snake (*Ptyas mucosus*), Monocled cobra (*Naja kauthia*), Spectacled cobra (*Naja naja*), King cobra (*Ophiophagous hannah*), Common krait (*Bngarus caeruleus*) and Russel's viper (*Vipera russeli*).

Aves: White breasted water hen (*Amaurormis phoenicurus*), Cotton teal (*Nettapus coromondelianus*) Spotted dove (*Streptopelia chinensis*), Little cormorant (*Phalacrocorax niger*) and Crow pheasant (*Centropus sinensis*).

Mammals: Rat (*Rattus rattus*), Rhesus macaque (*Macaca mullata*) and Jackal (*Canis aureus*).

Activities of flower pluckers are a sustained disturbance to this open ended ecosystem. The material discarded by the flower pluckers is liable to land on the animals there in and obviously there are reports of snake bites in defense for intrusion to the territory. Traditional plucking of flowers at dawn accounts for rarity of snake bite.

The findings are too preliminary for any blanket recommendation except an insurance cover for snake bite and leg wear for flower pluckers. Detailed site specific studies would throw light on the lesser known aspects of the biology of the conservation. Virtually Screw Pine ecosystem is a bonus for conservation of wild life at no extra cost has gone unnoticed. Nesting habits of birds and snakes, prey-predator context among insect-frog-rat-bird-snake population, synchronization of non-flowering season with breading of animals sheltered in the thickets of Screw Pine offer immense scope for future research.

ETHNIC UTILITIES OF KEWDA

A conservatory approach to Kewda vegetation is so much occupied in the minds of the locals that unless there is in-depth need someone hesitates to spoil a leaf even (Padhy et al. 1997). The general concept with the locals is that two varieties of Kewda are prevalent under common names 'Kia' and 'Ketakee'. Ketakee bears yellow flowers, available with sporadic frequency, has got comparatively less ecological coverage and its flowers used for worshipping once in a year during; Mahaa Ssivaraatri' festival. The cost of a single flower during the festival reaches Rs. 500 to Rs 700.

The Kewda flower is widely quoted in different Sanskrit compendia like *Ssrrungaar Ssatakam* (Poet-Bhratruhari), *Rrutu Sanghaaram* (Kalidas), *Ramayana* (Baalmikee) and in a collection of '*Neeti Sslokas*.' In Odia literature the flower is referred in *Baidehisa Bilaasa* (Upendra Bhanja), *Chandrabhaagaa; Chilikaa* (Radhanatha), *Mathuraa Mangala* (Bhakta Charan) and many others. In most of the Odia literature the ethno botanical, ecological, horticultural, therapeutic, aphrodisiac, fodder value and agro climatic suitability of Kewda plant are expressed in poetic and folk lore form. This tracks the phyto-sociological link between Kewda and the people of Odisha since long. An exemplary ethno-agricultural lore in Odia language is referred here as:

Jyeshthe Kadalee Aashaadhe Keyaa,
Pota na pota Hoeba Thiaa. (Khanna Bachana)

Meaning: *Kadalee* (Banana- *Musa sp*) and *Keyaa* (P*andanus fasicularis*) irrespective of any care their superficial subjection in the field during the month of 'Jyeshtha' and 'Aashaadha' would grow erect of their own. It is an agricultural tip in lore form (Dash et al. 1997; Bharati 2007; Dash 2007).

Ethno-ecological, Therapeutic and Cottage Industrial Value

Whole Plant: Forms a live green wall, avenue tree, hedge value, rest shed for travelers and domesticate animals under the canopy, horticultural value, Phyto-sociological, fuel and fodder values. The crop fields are often fenced with the plants since the farmer finds it as a cheap and useful role of protection from the herbivores due to spiniscent leaves and thicket growth. Besides this, the leaves are bad to taste, irritant and not relished by the herbivores. Moreover, every part of the plant is used as fuel by the poor. In terms of environmental protection, the plant has a major role (Behera and Behera 2007).

Rhizome: used as means of vegetative propagation; with nutrient value; coir extracted from it used for production of cushion, manufacturing of musical instruments like 'Mridunga', good raw material for paper industry.

Stilt Root: Thin strips prepared from it are used as fibrous strips like raw materials for repairing of baskets made of bamboo strips, a source of livelihood by a nomadic community 'Naloe'. A type of local painting brush is made by cutting the roots into lengths and then pounding them out forming a coarse painting surface. Long aerial roots contain very strong fibers, which are used for making ropes and baskets. The fibers are useful for making high quality handmade papers.

Root: Local people use the roots as tooth brush. Because of fibrous nature, it works best with medicinal property. Roots are used as source of medicine to treat leprosy, wounds, ulcers, diabetes, sterility, general debility and to check spontaneous abortion. Macerated roots in cow milk taken internally prevent abortion by check-

ing menstrual discharge. Ash from the dried roots mixed with Til (*Sesamun indicum*) oil made to pills for internal use cures tumors and rheumatic colic (Tripathy 1953). The fibrous nature of the roots finds a place in basket making and binder capacity. Moreover, the root system of the plant has major role for environmental protection. The extensive root system serves to bind the soil and this precious locality is not washed away in to the sea, a natural means to check soil erosion.

Leaf: It is a good raw material for paper industry. Fancy materials like hats, bags, baskets, cordage, mates are prepared from leaves. Poor people use the leaves for thatching purpose of their roof huts. Therapeutically, the leaves are very much valuable in the treatment of leprosy, syphilis, small-pox, scabies and leucoderma. Tender leaves are good source of medicines for diseases of the heart, brain and blood disorders. Ash from the burnt leaves used as detergent by local washer men.

Inflorescence

- Spathe is used for hair dressing that removes bad odour with anti-dandruff value.
- The tender buds (male flowers) are sometimes eaten raw or in cooked form.
- Juice of the inflorescence peduncle is used as a veterinary medicine against rheumatic arthritis.
- Peduncles as waste product from distilleries are used as fodder and green manure.
- Anthers from male flowers are considered for curing diseases of blood.
- Flower is considered as source of medicine for ailments like debility, swooning, vertigo and conjunctivitis.
- Powdered anthers along with the bract tips used a snuff against epilepsy.
- Anthers are useful for treatment of ear ache and headache.
- Smoke inhaled from Cigarette made from anthers cures sore throat and other throat problems.
- The inflorescence is the main source for production of kewda oil/attar/water.

Kewda Oil: The oil extract is used as a stimulant, purgative, antispasmodic, aphrodisiac and anti rheumatic. It is used as ear drop against ache and also applied externally to relief head ache.

Kewda Attar: It blends with all types of perfumes; used for scenting clothes, bouquets, lotions, cosmetics, soaps, hair oils, tobacco, Pan Masala and Agarbati (inscence stick) etc.

Kewda Water: Used for flavouring sweets, syrups, soft drinks and various food etc.

Fruits: Used for preparation of Ayurvedic formulations, on internal use cure leucorrhoea, spermatorrhoea and rheumatism. Seeds have edible value. More discussion in detail, regarding the medicinal value of Kewda is beyond the scope of this communication.

Any village system in India depends on the surrounding ecosystem for many of the daily needs. In this regard, the energy flow model developed to explore the biomass and energy dynamics in a village ecosystem is significant (Nayak and Misra 1991; Nayak et al. 1993). An ecological study was initiated during 1993-94 to investigate the role of Kewda plantations in the village eco-complex functioning along with other socio economic factors (Sahoo and Misra 1992, 1994, 2007). A cluster of three villages situated near Gopalpur-on-sea ($84^0$53' E, $19^0$16' N) were adopted for the purpose. It is observed that 66.7 percent households dependent on the village common property resource lands for collection of Kewda flowers. The average time spent for collection of flowers was 4h per day. This is significant while considering the average time spent for other activities like collection of fire wood for household fuel (4.9h) and collection of bivalves (*Ssamukaa*) for 2.1h. The bivalves are exported to lime industries and Kewda to distillation centres. Though considered as low pay off activity, the land less poor and small farm households, with their surplus labour and low opportunity cost readily accept this activity. However, for the fishing households, flower and bivalve collection serves as supplementary source of income. It is important to note that, economic return from agriculture and animal husbandry in these villages are very low. This is how Kewda stands as the bread of the rural poor in the Ganjam district of Odisha state.

GENETIC DIVERSITY OF *PANDANUS FASICULARIS*

The vegetation of *Pandanus fasicularis* is distributed throughout the east and west coast of India. But, remarkably, the economic activity relating to perfume extraction from the male inflorescence is confined to Ganjam district of Odisha. DNA and Protein molecular marker as-

sisted genetic variation among the populations of *Pandanus fasicularis* was investigated to find out the eco-geographic and genetic attributes underlying the bio-resource potential of the specific species (Panda et al. 2000, 2007).

A survey along the coast line of Odisha and the adjoining Andhra Pradesh were undertaken covering a distance of 600km from Srikakulam to Balasore through Ganjam coast and Paradeep. Plant samples from seven different populations I-VII along the east coast line were collected (Fig. 2), transplanted and maintained in earthen pots at Berhampur University campus. Periodically fresh root samples were collected for chromosome number analysis and 4C- nuclear DNA content was performed. DNA and protein extracted from leaf tissue are used for analysis. The results are depicted as follows.

Chromosome Analysis

Metaphase analysis reveals that the chromosome numbers irrespective of the population varied between 2n = 56 and 64. In 50 metaphase spreads analyzed for each population or morphotypes a majority of them showed 2n = 60. A representative monograph of a metaphase spread showing chromosomes (2n = 60) is presented in Figure 3. The basic chromosome number was therefore determined to be n = 30. Chromosomal mosaicism indicating hypo- or hyperploidy observed in the study indicated genetic instability attributed to the vegetative propagation of the plant populations.

Based on the DNA cytophotometry the 4C-DNA amount determined for the seven populations I-VII ranged from 4.6 ± 1.7 to 5.65 ± 1.6 pg. The DNA amount between the populations did not differ significantly (Fig. 4). 4C- DNA in *Pandanus veitchii* (4C-DNA=3.4 pg) is the only other species of *Pandanus* for which information C-value is currently available. The average 2C-genomic DNA for *P. fasicularis* was thus calculated to be 2.55 pg (~=2458.6 Mbp). Incidentally, this is the first report on the genomic DNA of *P. fasicularis*.

Fig. 2. Sites from where the population of *Pandanus fasicularis* obtained from different sampling sites along the coast of Odisha for investigation.

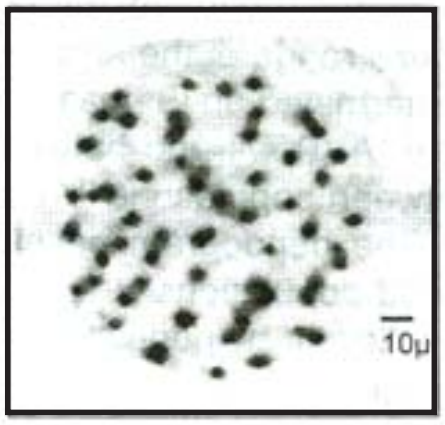

Fig. 3. A metaphase spread of *P. fasicularis* showing 2n=60 chromosomes

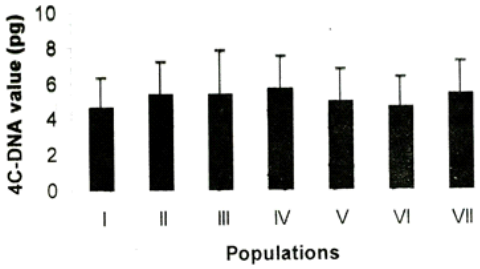

Fig. 4. Populations of *P. fasicularis* showing nuclear 4C-DNA content

RAPD analysis of seven populations (I-VII) of *P. fasicularis* showed DNA amplification with 14 primers out of 21 primers tested. A total of 461 amplified products were obtained out of which 180 were polymorphic, 18 were monomorphic and 13 were unique. The polymorphic percentage varied from 23.33 percent with OPD 02 to 54.54 percent with OPD 12. The size range of the amplified products varied from 300bp to 900bp. Similarity indices determined on the basis of PCR amplified products were high between populations V to VI (0.77) and between populations II and III (0.76). Similarity indices were low between populations IV and VII (0.35) as well as between populations I and IV (0.35). The dendrogram developed on the basis of RAPD data showed the five clusters that placed populations V to VI in one cluster and populations IV and VII in the next vicinity followed by populations VII, I and IV in that order; each representing a separate cluster (Fig. 5).

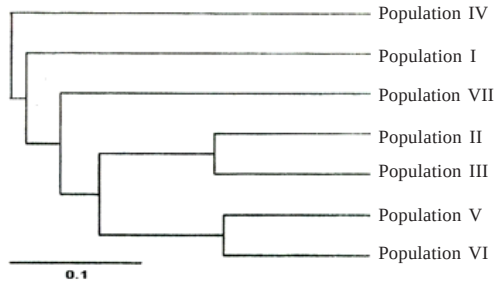

Fig. 5. Dendrogram based on RAPD analysis of populations of *P. fasicularis*

Protein Profile Analysis

All the protein profiles of the seven populations (I-VII) generated total 96 bands, of which 30 bands were polymorphic. The dendrogram generated by UPGAM analysis placed the seven populations of *P. fasicularis* under two major clusters having population I-IV in one and populations V-VII in the second (Fig. 6). In the first cluster populations I, II and III having the same similarity index 1 are grouped together and population IV sharing similarity index 0.73 with populations' I-III are placed separately. Interestingly, a unique protein marker band of 67 kδ was common to this cluster comprising of population I-IV. The second cluster comprised of populations V-VII; populations VI and VII with similarity index of 0.94 for population VI and 0.88 for population VII.

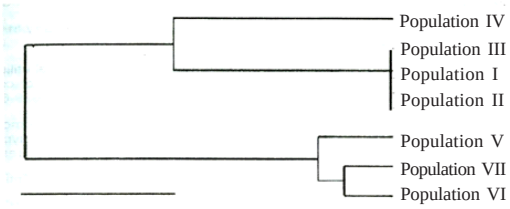

Fig. 6. Dendrogram based on protein polymorphism of populations of *Pandanus fasicularis*

Whereas, no remarkable inter- population variation was observed with respect to chromosome number or genomic DNA content; RAPD and protein profiles revealed distinct inter-pop-

ulation variations. The dendrogram based RAPD placed populations II and III placed in close proximity (Fig. 5). The same plotted on the basis of protein profile placed populations I II and III showing a unique 67 k δ protein marker in a single cluster. On the basis of both RAPD and protein profiles the populations of *P. fasicularis* belonging to Ganjam coast were thus distinct from rest of the populations, which perhaps could be attributed to the eco-geography of the region.

TRADITIONAL TECHNOLOGY OF KEWDA PERFUME INDUSTRY

History on Indian Context

India has a perfumery tradition that dates back to over 5000 years to the Indus valley civilization. In excavations at Harappa and Mohenjo-Daro, a water distillation still and receiver have been recovered which are similar to the present day Deg and Bhabka type of traditional distillation units.

During the days of Roman trades with India, Indian Sandal woods, Kashmiri saffron, Assami Black agar, Himalayan Kasturi, different floral Attars and essential herbal oils were regarded as essential commodities of business. During 606 to 647 AD the perfume industry took a firm footing in Indian trade during the reign of King Harshabardhana. The essential oils and fragrances from India entered to Europe through Egypt under the name Arabian perfumes. Mostly Babylon, Greece, Roam, Persia and Iran were the exporters of these perfume items to earn foreign exchange. By that time Kanauj, Kumbakonam, Pataliputra, Pandharpur, Poona and Bangalore were the famous centers of essential oil industries in India. Interestingly, Harshabardhana introduced a business tax on perfume products, taking the advantage of the flourishing trade.

The Mughal emperors were great lovers of exotic perfumes. This has reflected in the Ain-e-Akabari (1547-1605) written by Abul Fazl. During the Mogul period Lucknow, Aligarh, Jaunpur, Ghazipur, Delhi and Jaipur were centres of perfume and floral extracts.

Perfume Industry in Ganjam, Odisha

Some time before during the Mughal period Kewda extraction was started by a Muslim personal in the village 'Agraharam' near Chatrapur (present head quarter of Ganjam district), Odisha. In course of time the business spread up and traders from Kanpur, Kanauj, Lucknow and other places rushed to various places of Ganjam district for extraction of Kewda. Of late, the local business people entered in to the field of extraction and trade (Patra et al. 1999). Interestingly, a market in Delhi named 'Agraharam' was developed as the place of perfume business, at present devoted for Ayurvedic treatment and other business.

The activity of the Kewda perfume industry starts with the primary event of flower collection. Normally the flowers are collected early in the morning by the local people with the help of a plucking stick. It is found that the morning sun rays diminish the smell of the flowers and deteriorates its importance in business with a decreased commercial value (Mohanty 2014). The flowers are brought to the industrial site, screened and processed by removing the outer spinulose spaths. The pointed tips of other spaths are manually removed. Floral lots like 500, 1000, 1500 are made and used depending on the capacity of the distillation tank.

Kewda distilleries yield normally three major products namely Kewda essential oil ('*Rooh*'), Kewda *Attar* and Kewda Water. Specially designed furnace ('*Chula'*) is used for the extraction procedure. The jacket of the furnace is made of bricks aligned with mud and outside being cemented. Generally the furnace is constructed as per the direction of the wind to increase the burning efficiency. A person at the inlet continuously monitors the supply of fire wood and fuel (Fig. 7 and 8).

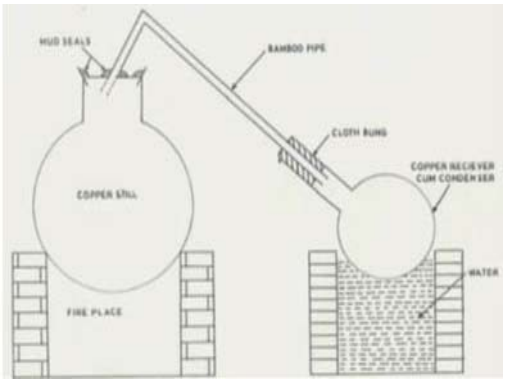

Fig. 8. Traditional Kewda extraction site

Fig. 7. Schematic representation of Kewda extraction

The flower distillation is carried out using big cupper stills (capacity of 300 ltr) locally known as '*Degs*.' Each *deg* is closely fitted to the furnace with the help of bricks and mud. The *degs* are connected to another small copper still '*Bhabka'* (capacity of 65 ltr) that is the receiver vessel through a connector called '*Chunga'* made of bend bamboo piece tightly bounded with coir rope thus jacketed outside. The *bhabka* is placed inside the water bath. A lid made of copper covers over the *deg* with a hole for the connection of the *Chunga*. The lid region is sealed with the help of a paste made of special clay entitled '*Multan mitti*'. Other parts of the system are tightly filled with the help of polythene. On heating, the steam along with vapour of Kewda product flows through the *Chunga* to the receiver vessel *Bhabka*, where it is condensed being cooled. The whole procedure of distillation is same for extraction of Kewda oil, Attar or Water with certain basic differences which can be discussed separately.

Kewda Oil: It is the essential oil from Kewda flowers, obtained by hydro-distillation process. The oil is commercially known as '*Rooh*' .Due to relatively high solubility of *Rooh* in water the distillation of this genuine essential oil is difficult. Extraction of Kewda oil is not done in large quantity. The same age-old *Deg-Bhabka* technology is followed to extract the oil by controlling fire, quantity and rate of distillation. The rate of distillation is controlled by highly experienced hands for monitoring the whole process. The technique involves repeated distillation of flowers and the receiver vessel does not contain any base oil. Generally *Rooh* is produced during the peak flowering rainy season when the ambient temperature is comparatively low and the oil recovery is proportionately better. Hot days are reported unsatisfactory and uneconomical. Altogether, the production of *Rooh* is considered to be tricky job for better quantity and quality yield. This secret ethno-technology is restricted among the distillatory, not revealed to out sides. The *Rooh* yield ranges from 25-35 g / 1000 flowers, which varies from season to season and site to site as well.

Kewda Attar: The *attars* are made by absorbing the vapours of perfumes directly in to a base oil, the Sandal wood (*Santalum album*) oil. Sometimes, liquid paraffin (White Oil) or Dioctyl Phthalate is used as base oil when cheaper grade attars are made. About 5 Kg of base oil is taken in the receiver vessel during attar preparation.

When 10,000 flowers are distilled in 5Kg of Sandal wood oil it is called *Dus Hazara*. The 1st distillation is called '*Agadi* 'and is absorbed by the base oil, while the 2nd and 3rd distillations are called '*pichadi' and 'tichadi'* respectively. Where base oil is not taken and the water is only collected. This water is again recharged in next distillation. The concentration of *attar* is determined by the number of flowers used. *Attar* making is practiced throughout the year; even when, the quality of flowers is not good. However, the quality of *attar* depends on several factors; such as: season, ambient temperature, time of plucking, time between collection and distillation and so on.

Kewda Water: Kewda water is prepared by distilling the flowers with water in the similar manner and collecting the distillate in an empty receiver vessel. Distillation of 1000 flowers yields about 10-18 ltr of Kewda water. This is known as *Ek Hazara*. Kewda *attar* and water is packed in air tight galvanized iron drums and transported to Kunnaj, Lucknow and other places of perfumery industry in north India for blending and manufacture of various types of preparations. Final processing of Kewda Perfume is trade secret (Sahu and Misra 2007).

MOLECULAR COMPOSITION OF KEWDA OIL

Gas- chromatographic analysis reveals that the Kewda oil contains (Table 1) more than 44 components (Rao 2007). The major constituents are:

Table 1. Chemical composition of Kewda oil

S. No.	*Chemical component*	*Percentage fraction*
1.	â-Phenyl ethyl methyl ether	65-80
2.	Terpinen-4 ol	10-20
3.	á- Thujene	04
4.	Þ-Cymene	0.3-3.3
5.	á-pinene	0.2-0.6
6.	â- pinene	0.05-1.8
7.	y-Terpinene	0.05-2.5
8.	â-phenethyl alcohol	0.1-1.0
9.	á-Terpineol	1.1-3.2
10.	Limonene	0.2-0.4
11.	1,8 Cineole	0.1-0.2

A comparative study of chemical composition of the Kewda oil extracts of different locality reveals that, better odour of the samples might be due to differences in availability of soil nutrient and age of plantation. However, the enriched composition of rare earth in the coastal region of this area may be an additional factor for this luxuriant growth of the biodiversity of Kewda and their chemical composition. Moreover, the component number 1 and 2 of the Table, indicate the quality of the oil (Purohit et al. 2007). Recent studies also focus on the economic importance of essential oils of Kewda (Das and Patra 2015).

ECONOMICS OF KEWDA

Pandanus fasicularis though found scattered over the coastal regions of India, its luxuriant and gregarious growth concentrated along the coast of Ganjam district of Odisha state is unique. The challenging contributions of the plant to monitor the economy of the rural poor and its socio-ecological complements cannot be believed unless and until someone witness personally. The plant is honoured as the 'Bulga species' in this area (Dash 2007), compared with the Reindeer (*Rangifer tarandus*- Bulga Harina-Odia) of Eskimos in Tundra regions on the globe. No body part of the plant left unused by people of this area as that of the Reindeer relates to Eskimos. This gifted species *Pandanus*, which has been conserved by the rural communities, impenetrable for invaders, thus constitutes a sacred groove for the species in the entire Ganjam Hinterlands.

The Kewda flower distillation industry in Ganjam district (Odisha) accounts nearly 90 percent of the production of commercially important perfumes in the country and 50 percent of that of the world. According to a recent NABARD report, the Kewda industry provides a total turnover of Rs. 50 crores with Ganjam district (2007 data base) accounting for eighty five percent of the production. It is estimated that about 300 to 400 thousand trees producing nearly 10 million of inflorescences (spadices) annually for the production of this perfume in this district (Rao 2007).

In Ganjam coast Kewda plant is wildly grown in an area of approximately 5000 hectares in 4blocks namely: Rangailunda, Gopalpur, Chatrapur and to a small extent in Chikiti block. There are about more than 300 distillation units spread over these four blocks comprising of 44 Gram Panchayats, 230 villages with a population of

more than 0.3 million. It is estimated that about 4 crore of flowers are processed in 300 distillation units (*Bhatti*). It is thus seen that the 100 and odd Kewda villages and hamlets, where either flower collection or processing or both take place, enjoy money inflow of at least 20 crore per annum, supplementing to their normal agricultural income. The pickings of flowers, their transport to *Bhattis* are generally carried out by the women folk, land less/ marginal farmers and that the activity is limited to the early hours in the morning, des not hamper their day schedule. It is important to note that the method of manufacture is traditional *Deg-Bhabka* method and until today any modernization of the processing (distillation) technique is being strongly resisted by the so called perfumers, who happen to be the sole buyers. It is claimed that, modernized distillation techniques reduce the quality of the perfume properties of the products.

The price that a flower fetched in 1984 was Rs. 0.60 Ps; Rs. 4.25 Ps in 1994 and Rs. 5.00 in 1995. The price of a flower officially remains the same throughout the year; it rises to the extent of Rs. 11.00 to Rs. 13.00 at certain places at the peak of the rainy season. The peak season lasts for about 20 to 30 days, when all the distillation vessels (*Deg*) in each and every *bhatti* run in full swing. The rest of the year, the *bhatti*s run to their under capacities. The rise in the cost of flowers during the peak season is that the distillers rush to buy flowers, even at a higher cost to fulfill their commitment to supply *Rooh* to the traders. The present cost of the flower is ±Rs. 10.00 in 2015 (Table 2).

Table 2: Price index of Kewda

Year	*Price per 1000 flowers in Rs.*	*Price per flower (Rs.)*
1930	30	0.03
1960	30	0.03
1970	100	0.10
1980	400	0.40
1990	750	0.75
1993	2000	2.00
1994(May)	2750	2.75
1994(Oct.)	4000	4.00
2000	6000	6.00
2006	8500	8.50
2007	10000	10.00
2013	±15000	± 15.00

Source: Kia Phula Samiti, Keluapalli, Ganjam District

This price hike was marked for three times from 1970 to 1980 and got doubled in between 1980-1990. However, there was a constant rise in price from 1994 to 2006 due to continuing rise of demand for Kewda Flowers. Also, this rise in price was further due to the involvement of local entrepreneurs, who had established direct link with the buyer parties of Kanpur, Kanauj and Lucknow for nationwide marketing of Kewda products. The change in trade policies of the foreign countries, economic reformation of our country, constraints in Research and Development of Kewda industries, monopoly and greedy attitude of outside business people preventing the locals to grow up in this line and depletion of the global economy are the various reasons responsible for the decline in Kewda business (Mohanty 2014). The selfish motivated business people showing various false reasons reject the flowers or purchase with low price and inordinate delay in payment adversely affect the poor farmers. Comparatively the price of the flower which had reached Rs. 15 to 16/- at one time, is now reduced to Rs. 5-6 /-. In this regard, the role of middle man too, cannot be ignored which are summarized as follows:

- The *Badawala* at the bottom collects Kia flowers from the farmers and the labourers who collect the flowers.
- Next is the commission agents, who advances credit to the *Badawala* and also collects the product from him and supplies it o the *Bhattiwala*.
- The *Bhattiwalas* get the supply of these flowers and make the first processing in their distillation units.
- Finally the *Galliewala i.e.* the outside Entrepreneurs collects the primary processed products from *Bhattiwalas* and export them to other states for production of the final products.

In fact, the profit is being snatched by these chains of middle men cum agents; as a result, the unfortunate farmers are deprived of these assets created by themselves at their end. As suggested by some researchers in their recent revelation that, if the middle men can be reduced through a regulated market potential envisaging direct procurement of raw material from the farmers, this hike can be checked and then only the boon bestowed by nature in this locality can be enjoyed by the real son of the soil *i.e.* the farmers (Rajguru 2007).

The Kewda processing industry entails engagements of skilled and semi skilled labourers deployed in the respective units; their works related to operation which includes sorting, counting of flowers, carrying out distillation work, wood cutting and controlled firing in furnace, clearing the stills after distillation *etc*. These operations engage two labourers /day/1000 Flowers/one unit. In other words a total of minimum 80,000 man days of labour per annum can be accounted as the total requirements (Dash 2007).

Issues for the Growth of Kewda Industry in Ganjam

1. A major financial input is towards the cost of flowers and only a part goes in processing. Therefore, the major income generation is the production of flowers. A few progressive farmers have already started planting Kewda in their paddy lands and there is plenty of scope for standardizing the agro technology of the plant. Agronomical studies of Kewda plant are scanty in literature and useful scientific research on the chemo-/geno-types is yet to be taken up fully by any organization.
2. There is hardly any distillation unit in the area which carries out true business through the bank. The registered units are either not existing or doing the business through self financing. Recently, few units have come forward to take loan from the nationalized banks, which were met by private finance before.
3. The state Government has imposed tax of 4 percent on the case of the flower, which raises big questions:

i. Who will pay tax? (a) The poor women plucking a few flowers early in the morning, or (b) the middle man who collect flowers in different localities and supplies to the distillers, or (c) the distiller himself.

ii. Generally every distillation unit has a number of distillation sets (*Degs*) for hydro distillation of flowers. Throughout the year, the sets remain idle because of over capacity and during the peak season, all the sets are utilized subject to availability of flowers to the unit. In such a case, to calculate the imposition of tax on the unit is of ridicules and certainly difficult for anybody concerned.

iii. There is no open market for *Rooh* of Kewda. The oil is costly (Rs. 2.5 to 4 lakhs per litre) and all the transactions are made clandestinely. The small distillers are sometimes getting harassed by the buyers in the name of quality, adulteration etc. To get a true picture of the total distillation made during a particular season, which in turn, will arrive at a particular tax structure, is cumbersome.

4. The district of Ganjam is famous for migration of labourers to Gujarat to work in textile industries. Incidentally, the area falling under natural vegetation of Kewda ad hence its Kewda distillation industry creates a check point to stop such migration. However, to avoid poverty and unemployment Kewda industry deserves; rather encourages a systematic study for an organized business.
5. Although the distillation of Kewda oil is reportedly more than eight decade old, no specific institution has truly come forward for modernizing the distillation process. At the instance of NABARD the Regional Research Laboratory (presently renamed as IIMT), a CSIR institute at Bhubaneswar has carried out some work on Kewda distillation process. The distillers and perfumers have out rightly rejected the same, reportedly for want of specific olfactory note that the *Deg-Bhabka* method provides.
6. Most of the Kewda grown area is inaccessible. The roads are either dilapidated or not exists at all. Transport system is still meager and demands uplift on priority basis to bring the business further to lime light (Dash 2007).

The Market Study

Odisha is full of different natural resources, considered to be one of the poorest state in the country. The district of Ganjam is held high by the outsiders, particularly in the field of fragrances and the whole country is proud of its Kewda Oil. In spite of all these, the area has poverty. Only thing missing is that of the people in the area are not aware of the economic importance of the flowers they pluck every day. The only market they (small/marginal farmers) know is the buyers from Kannauj or Locknow, who arrive at their houses to buy the oil. Another market is for

the so called big farmers, who collect advances from the potential buyers well before the onset of the flowering season and supply the oil as commitment. The export market, if any, is created and controlled by the buyers from outside (Kannauj, Lucknow, Kanpur, New Delhi and Mumbai). Here is a case of monopoly market. The aroma in flowers is unique and wonderful. It is available only in this region. Here is a burning case to study and penetrate the market depth and help the local people and their rights due (Table 3).

1. The Kewda plant is not looked after, but the flower is most sought after commodity in the area. It is all left to the soil, climate and the ecology of the area. There is no official intervention in the growth of the crop.
2. Distillation process is traditional and it is bound to remain so to favour the buyer/ perfumer. Slight deviation in fragrance coming through improvised devices affects acceptability in the market.
3. There is little space left for possible intervention in the traditional interlink among the farmer, the distiller and the perfumer. At the distilling unit, there is always a local manager or care taker to take care of the interest of the buyer.
4. The bonds between the perfumer and the end-user remain unknown. The respective margin of profits earned by them is no where clear. Hence, the evaluation of prices charged by the grower from the distiller or from the perfumer remains elusive, creates illusion.
5. The perfumer/buyer on the spot is the most visible broker. His powers over the growers are enormous. He bids and controls the purchase price of the flower (during season) and makes advances or immediate payments as and when necessary. There is no direct link between the distiller and the end user. Any rationalization of the price structure is therefore day dream only.
6. The sporadic fluctuations In the Kewda flower prices (during the season) are mostly remote controlled by few perfumers with their managers working in the area. There is certainly competition and profiteering as the case is a clear-cut private bidding. Any intervention by government agencies in this system is a risky proposition.
7. There has not been any socio-economic survey of the Kewda industry from the farm to the user point. Of course, there is attempt for such survey from educational point of view and the results are limited to the research papers only as presented in this review.
8. No genetic hybridization study has so far been carried out to encourage the cultivators. There are few recent reports note worthy (Panda et al. 2000, 2007).
9. The bargaining strength of the farmers and local distillers can be enhanced

Table 3: Basic information on Kewda industry in Ganjam district

1.	Area covered by Kewda Plantation	:	5, 000 Ha
2.	From sea – coast, the Kewda plantation area		
	Within 5 Km	:	80-85 percent
	Within 5-10 Km	:	15-20 percent
	More than 10 Km	:	——
3.	Total flower production in the district @ 7500 /Ha	:	375 Lakhs
4.	Cost of flowers @ Rs. 10/- per flower	:	Rs. 37.50 Crores
5.	Production per annum		

Item	*Quantity in Kg*	*Rate (Rs)*	*Value(Rs. In Lakhs)*
Kewda oil (*Rooh*)	346	2,50,000/-	865
Attar (Sandal wood oil base)	8,150	20,000/-	1630
Kewda water	1,55,000	300/-	465

Estimated data are approximate only

Source: Technology Support Centre for Kewda Industry, Berhampur 760 002, Odisha, India.

through adequate training, orientation and formation of cooperative societies.

10. Knowledge in the line of making a fragrance or flavour, though scientific, is not open to the public. There are various layers of marketing structure, some of them are visible and some in obscurity. This is the reason for which the local people are deprived of any bargaining strength (Dash 2007).

THREAT TO KEWDA VEGETATION

Natural Threat

The coastal district of Ganjam, Odisha is situated in the east coast belt of Indian subcontinent lying between 19.21^0 N and 85.03^0E. This coastal zone frequently experiences tropical cyclonic weather throughout the year. The enriched vegetations of this area dominated by plants *Cocus nucifera, Anacardium* sp, *Casuarina equisetifolia* and *Pandanus fasicularis* are frequently exposed to the coastal cyclone. The super cyclone (250 km /hr), occurred in 17th October 1999, drastically effected the hinterland ecology. The cyclonic effect on the destruction pattern of *Casuarina* was reported earlier (Padhi and Padhi 2004, Padhi et al. 2003) which is a species of social forestry and waste lands development in coastal Odisha. The vertical branches of *Pandanus fasicularis* having average girth ranging from 43.5 (±0.13) to 60 (±0.18) cm and side branches from 27.3 (±0.29) to 43.35 (±0.17) cm were not affected by the pressure of cyclonic wind. The tertiary branches with girth 15.32 (± 0.02) to 27.5(±0.17) cm, have been partially affected. The branches coming out of tertiary structures bearing less than 15 cm girth have been totally affected. Generally these branches are covered with vegetation, flower buds, flowers and mature leave at their apical regions. Comparatively these branches are subjected to certain amount of vegetative load. Such branches have been found to be with damaged structures of 95 percent blunt ends. The cyclone escaped branches have shown either partial or total desiccation. The *status quo* of the plants was under observation for one year and more. About 95 percent of secondary and tertiary branches have lost their regeneration capacity. The vertical branches and sub branches were affected severely compared to the horizontal and bushy branches. The vertical branches took one year minimum to rejuvenate normalcy. This causes 80-90 percent decrease in flower production during the year 2000-2002 and the perfume industries were put in to heavy loss. Comparatively Kewda was firm over the soil to face the super cyclone compared to the above referred hinterland plants. The flexible and fibrous tissue system of the Kewda plant adds to its resistant against the wind stress (Padhi and Padhi 2007).

Chemical Threat

The pollution effect of chlorine gas released from Jayashree Chemicals, Ganjam was discussed earlier (Behera 2007). Chemical research and production of synthetic perfumes are the greatest threat on Kewda perfume industries. It is well established that synthetic perfumes has negative impact on human health. Now, the question is when synthetic perfumes are available with the price Rs. 20 -30 thousand per kilo, why one should go for natural product – Kewda *Rooh* with the price of 4.5 lakhs per kilo? This attitude of top business people ignoring the public health is the greatest inhibiting factor for the total development of Kewda cultivation and the industry there of (Mohanty 2014).

Industry versus Industry

Development and displacement are the two sides of a coin, inseparable and insurmountable. Some degree of displacement is bound to be there in order to achieve development. Large scale industrialization is due to the evil consequences in terms of displacement costs, resource depletion cost and environmental cost of development. The proposal for establishment of indigenous steel project of Tata Steels suffered from local resistance because of encroachment of a substantial part of Kewda plantation by the Government for the establishment of an industry in this area. The Kewda economy was one of the strong reasons for the resistance to brew against the Tata project. It is true that Kewda, the nature's gift to the local poor to earn their livelihood even though for a specific season, has been just an alibi for resistance. The local people are getting good returns from Kewda vegetation without any financial investment; justified their attachment to the collection and

supply of this flower. The Kewda business of this local people is restricted in terms of extraction of its essence only. Further purification, production and marketing of costly scent in the international markets have been monopolized by outsiders. The Tata has proposed to retain this natural cover of wild growth of Kewda and it needs organized Kewda plantation. This was not taken positively by the activists, because of the ostensible fear that Kewda is not a cultivable plant (Patro 2007).

Thanks to The Divinity "Kewda vegetation, a rare phytogeography of the world was saved."

This communication is only a minimum presentation of *Pandanus fasicularis* compared to its vast contribution to the nature and humanity, as well.

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