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Short Communication

Collection, characterization and olfactory evaluation of *Pandanus* species in Southern India

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Abstract
A detailed survey along the coastal regions of Southern India revealed the occurrence of seven *Pandanus* species, viz. *P. kaida* Kurz., *P. odorifer* (Forssk.) Kuntz., *P. canaranus* Warb., *P. furcatus* Roxb., *P. thwaitesii* Mart., *P. foetidus* Roxb and a new species *P. palakkadensis* Nadaf, Zanan & Wakte. The fragrance of staminate inflorescences of these species was compared with the fragrance of commercial staminate inflorescences of *P. odorifer*. *P. thwaitesii, P. kaida* and *P. palakkadensis* recorded comparable fragrance with that of *P. odorifer*. The study reveals the fragrance potential of these species, which could be exploited commercially for extraction of essential oil.

Keywords: fragrance; *Pandanus* species; South India

Experiment

Collection and identification of Pandanus *species*

From October 2007 to May 2009, a detailed survey was carried out along the Maharashtra, Goa, Karnataka and Kerala states of Southern India and male spadices and female fruits of seven *Pandanus* species (*P. kaida, P. odorifer, P. canaranus, P. furcatus, P. palakkadensis, P. thwaitesii* and *P. foetidus*) were collected. The geographical details (latitude, longitude and altitude) of each locality were recorded using global positioning system (Magellan GPS 315) (Supplementary Table S1, available online only at http://journals.cambridge.org). The collected species were assigned a collection number and morphological characters were recorded (Table 1). In addition, habitat and frequency of occurrence of each species were recorded. Based on the morphological characters, the collections were identified using regional, state and district floras and other literature (Stone, 1976; Yoganarsimhan *et al*., 1981; Henry *et al*., 1989; Bhat, 1992; Sharma *et al*., 1996). Authentication of each collected species was done at Botanical Survey of India (BSI), Western Circle, Pune, and type specimens were deposited therein. In addition, information regarding the traditional uses of *Pandanus* species was collected from local people, farmers and tribal people (Supplementary Table S3, available online only at http://journals.cambridge.org).

Characterization and sensory evaluation of male spadices of Pandanus *species*

Mature male spadices (five to ten) of each species were characterized with respect to bract number and fresh weight per inflorescence, and bract length and colour. Sensory evaluation for intensity of fragrance was performed by placing cut pieces of bloomed male spadices of *Pandanus* spp. in glass vials and sniffing

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Table 1. Staminate inflorescence characteristics of *Pandanus* species from Southern India

Species	Mean bracts/ inflorescence (± SE)	Bract length (cm)	Mean bract fresh weight/ inflorescence (± SE) (g)	Bract colour	Fragrance score
P. kaida	11.4 ± 0.40	20–70	476.0 ± 26.38	Yellow	+++
P. odorifer	11.6 ± 0.25	20–60	455.8 ± 18.53	Yellow	+++
P. canaranus	7.4 ± 0.40	20–50	344.0 ± 14.78	White	+
P. furcatus	9.2 ± 0.49	20–50	356.8 ± 18.87	White	+
P. palakkadensis	9.4 ± 0.25	15–60	438.2 ± 9.69	Cream	++
P. thwaitesii	9.2 ± 0.49	10–30	283.2 ± 15.68	Yellow	+++

+++, high; ++, moderate; +, low; values are means of five replicates.

the fragrance against the male spadix of *P. odorifer* as the standard. The intensity of fragrance was scored based on a three-point scale as high, moderate and low.

Discussion

All *Pandanus* species were found endemic to their localities and distributed along the coastal (*P. odorifer*) and intercoastal regions (*P. furcatus, P. canaranus* and *P. palakkadensis*) (Fig. 1). *P. thwaitesii* and *P. foetidus* were found located in the forest areas under the tree canopy. *P. odorifer, P. canaranus* and *P. thwaitesii* were recorded in all four states, whereas *P. kaida* and *P. foetidus* were recorded in all states except Maharashtra. *P. palakkadensis* had been found to occur only at a few places in the Palakkad district of Kerala state (Nadaf *et al*., 2011). *P. canaranus* and *P. furcatus* had the largest distribution of the species collected and *P. palakkadensis* the smallest (Fig. 1).

Table 1 depicts the analysis of staminate inflorescences of *Pandanus* species. The average number of bracts varied from 7.4 (*P. canaranus*) to 11.6 (*P. odorifer*). The range of bract length was from 10–30 cm (*P. thwaitesii*) to 20–70 cm (*P. kaida*). The fresh weight of bracts varied from 283.2 g (*P. thwaitesii*) to 476.0 g (*P. kaida*). *P. kaida* recorded maximum number of bracts with maximum bract length and fresh weight. *P. thwaitesii* and *P. kaida* recorded the highest fragrance score compared with *P. odorifer*. An interesting positive correlation between flower colour and fragrance was observed such that the intensity of fragrance found increased with increase in yellow colour intensity of bracts. All the staminate inflorescences showed ephemeral nature with average life of 8–12 d after blooming (Supplementary Fig. S1, available online only at http://journals.cambridge.org). The flowering time of most of the species was from July to October (rainy season), except *P. thwaitesii* and *P. foetidus* that blossom from November to February (winter season) (Supplementary Table S2, available online only at http://journals.cambridge.org).

P. odorifer, which supports the local perfume industry by the perfume extracted from the male inflorescence, is cultivated in the Ganjam district of Orissa, India (Panda

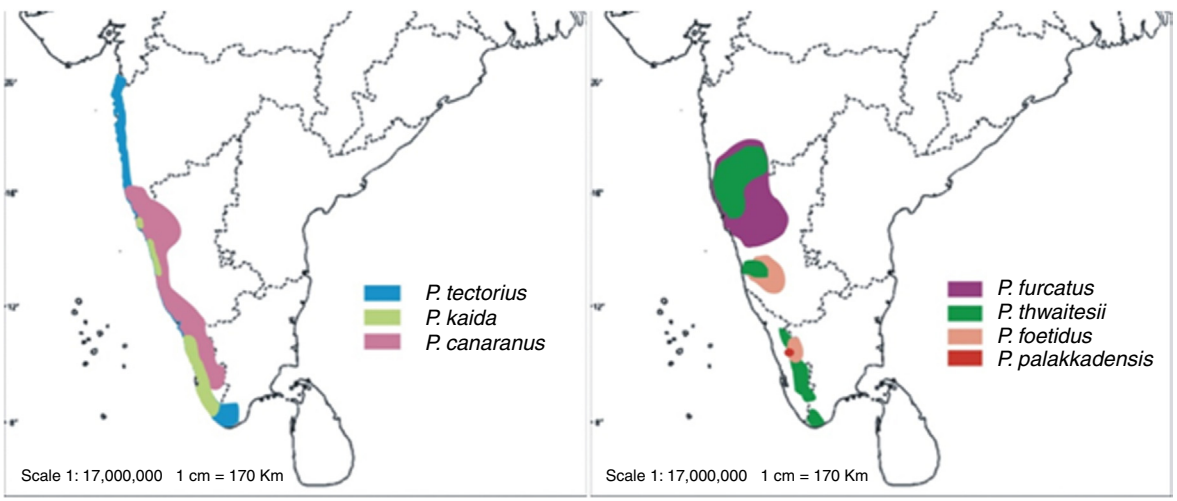

Fig. 1. Distribution and area size of *Pandanus* species in Southern India. (A colour version of this figure can be found online at http://www.journals.cambridge.org/pgr)

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et al., 2007, 2009). It is estimated that about 35 million flowers (~3500 tons) are processed annually to produce fragrance and flavour materials worth Rs. 400 million (US$ 8.9 million) (Anonymous, 1996). The peculiar sweet fragrant smell of *P. odorifer* flowers represents 85 volatile oil compounds, mainly due to the major constituents 2-phenyl ethyl methyl ether (37.7%), terpinen-4-ol (18.6%), α-terpineol (8.3%) and 2-phenyl ethyl alcohol (7.5%) (Raina *et al*., 2004). The study reveals the fragrance potential of *P. thwaitesii, P. kaida* and *P. palakkadensis*, which could be exploited commercially for extraction of essential oil.

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