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A study on some archaeological sites in the perspective of plant invasion in India

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Abstract
Different elements of nature, inclusive of plants, have been worshipped by our ancients since pre-historic times. In doing so, his sense of gratitude has gone to the extent of bestowing godhood of such plants. Gradually, temples, cave-temples and even monuments like religious stupas, etc. ware elaborately raised to appease deities. He also carved or painted plants interwoven with his faith, beliefs and customs on these edifices. India, being rich culturally, has a large number of temples, caves, etc., Plants are depicted on them. The present author assessed only their exotic status to reveal plant invasion in India in ancient past. This paper included information of such species. As many as 28 exotic species belonging to 28 genera and 244 families are gleaned from them. Their nativity is deciphered consulting relevant taxonomic literature. Maximum species are shared by the distant American continent. Belief or customs associated with them are focussed for some of them. These ancient monuments or edifices are proved informative for bio invasion in India during long past. It also appeared worth to extend investigation on rest other such important temples, caves, etc. to shed more light on bio invasion in Indian territory.

Keywords: India, temples, caves, plant invasion

Introduction
India is not simply a land mass. It is a vibrant and spiritually charged mass of land. It is also thought to be a land of sacrifice (Tyag Bhoomi), yoga (Yog Bhoomi) and action (Karma Bhoomi). Every component of nature is worshipped by Indian community. Plants, as we are aware, have practically entered in every field and human-life. Plants or trees are regarded abodes of deities (Pande, 1964; Sen Gupta, 1965) [23, 36]. Temples, caves and such other edifices in India were built or carved since ancient times in fulfilment of some observance to accumulate 'punya' (merit) for others or oneself.

India is a highly bio diverse country. It is also rich in culture and spiritual values. These all diverse factors are manifested in its action like raising temples, carving or painting of caves, building of stepped wells, etc. While doing so, ancient Indians incorporated their religious feelings, knowledge about greenary and its conservation. It is, therefore, several iconic plant species heritage of India, have been depicted on walls, entrances or pillers of temples, caves, etc. Whatever plant species were initially present or established well after their introduction on Indian landmass have been depicted on such ancient and historical edifices. These species are very informative about Indian wisdom, faith, beliefs and myths (Patil, 2020) [28]. Although these Indian monuments have been studied in past on different facets, the present author intended to focus them from the scientific point of view, and these plant species depicted in long past are useful to unfold plant invasion in India and therefore their exotic status is determined consulting relevant taxonomic literary sources. The results of this investigation on the said line are being presented in this endeavor.

Methodology
Various literary sources related to ancient temples, caves and such other edifices have been consulted. These are presented against each plant species in the Table-I. Their exotic status is also deciphered consulting relevant taxonomic literature. This table also incorporates place of each edifice, probable of period their raising and respective literary sources. The information accrued is discussed in the perspective of bio invasion on Indian landmass.

Results and Discussion
India is a country of sacred deities, lakes, animals and plants. These are many times enshrined by some temples, caves, historical monuments, stepped-wells, etc. The plants or animals are supposed to be under the protection of the reigning deity of the edifice. It is also believed that some deities have abodes in them (Khare *et al*., Vartak and Gadgil, 1981) [17, 46]. The faith of mankind on the deities is also intimately associated with such plants. The edifices *viz*., temples, caves, monuments, etc. are depicted with some species also. This depiction may be in the form of carving or painting on the gateways, pillars, walls, tombs, etc. These depictions are very informative with respect to beliefs, faith, customs, rituals, worships, wisdom about nature, history, etc. Such traditions are helpful to conserve biota of a region, nay these are our rich biological heritage preserved through the ages because of wealth of conservation-oriented cultural and religion traditions. Man-plant interaction is quite ancient sine man's appearance of the Blue Planet. This interaction is expressed in different forms such as the edifices or monuments. These are not mere structures or abodes of bricks and stones. They en tell happenstances of the past. The present author analysed elements of biodiversity in aforesaid edifices or monuments in view of bio invasion in Indian territory in ancient times. Over the ages, indigenous people have developed several monuments and technologies. Their cultures, economies and identities are inextricably tied to their traditional land and bio resources. India is a 'very fertile' land interwoven with traditions because of rich floral diversity and distinctive cultures depending largely on bio resources.

Census of taxa

Floristic analysis of the species enlisted in the Table-1 as depicted on temples, caves, stupas and stepped-well belong to 28 species, 28 genera and 24 families of angiosperms. Of these, 06 species, 06 genera and 06 families are monocotyledonous. The dicotyledonous taxa are depicted maximum. They belong to 22 species, 22 genera and 18 families.

Out of 28 species, 26 species are found exclusively under cultivation. Only one is wild (*Datura metel* L.) and another one is either cultigen or runs wild (*Annona squamosa* L.)

Table 1: Exotic plants and archaeology

Sr. No. (1)	Plant Species & Family (2)	Cave/Temple/ Monument (3)	Plant or Part Depicted (4)	Period (5)	Reference (6)	Nativity(7)
1.	*Acanthus mollis* L. Acanthaceae	Tajmahal, Agra, Uttar Pradesh.	Plant with flowers	1632-1652	Giraldo-Canas, 2013 [10].	Mediterranean Region: Janick *et al*., 2010 [13].
2.	*Anacardium occidentale* L. Anacardiaceae	i) Jambukeshwara Temple, Tiruchirapali, Tamil Nadu. ii) Bharut Stupa, Madhya Pradesh	i) Complete plant, flowers & fruits. ii) Fruits (Nut)	i) 2500 year back ii) 2nd Century BC.	i) Gupta, 1996 [11]. ii) Cunnin-gham, 1879 [7].	Tropical America: Yadav & Sardesai, 2002; Patil, 1995 [49, 24]. America: Panda & Das, 2004 [22,].
3.	*Ananas comosus* (Linn.) Merill Bromeliaceae	i) Bharut Stupa, Balustrude, Belief. ii) Udaigiri Temple, Madhya Pradesh	i) Fruit ii) Fruit	i) 2nd Century, BC. ii) 5th Century BC.	i) Gupta, 1996 [11] ii) Gupta, 1996 [11]	Tropical America, Sharma *et al*., 1996 [38].
4.	*Annona squamosa* L. Annonaceae	i) Gateways at Sanchi, Madhya Pradesh ii) Ajanta Caves, Maharashtra iii) Bharut and Sanchi Bas-reliefs iv) Durga Temple, Aihole, Karnataka v) Hands of Karttikeya (Murugan), Madhukesvara Temple, Mukhalingam. Andhra Pradesh vi) Hands of Kubera Hoyasaleshvara Temple, Karnataka	i) Fruit ii) Fruit iii) Leaves, Fruit iv) Fruit v) Fruit vi) Fruit	i) End of 2nd Century BC. — iii) C. 2nd Century BC iv) 10th Century BC v) 8th Century vi) 8th Century	i) Gupta, 1996[11]. ii) Watt, 1889 [48] iii) Marshall *et al*., 1940; Brown, 1949 [20, 3]. iv) Pokharia *et al*., 2009 [29]. vi) Gupta, 1996 [11]. vii) Bussagli & Sivaramamurty,	Tropical America: Patil, 2003 [25]. Tropical America & West Indies: Shetty & Singh, 1987 [39].
(1)	(2)	(3)	(4)	(5)	(6)	(7)
		vii) Varuna (Lord of waters) and his consort on a Makara monster with fruit in hand.	vii)Fruit	vii) 8th Century	1978 [2].	
5.	*Borassus flabellifer* L. Arecaceae	Kailas Temple, Near Ram & Harivamsa, Ellora Caves, Maharashtra	Entire Plant	11th Century AD.	Chafekar, 2007 [5].	Tropical Africa: Reddy, 2008; Chandra Sekar, 2012 [33, 6].
6.	*Campanula lactiflora* M.Bieb. Campanulaceae	Tajmahal, Agra, Uttar Pradesh.	Plant with flowers	1632-1652	Giraldo-Canas, 2013; Janick *et al*., 2010 [10, 13].	Turkey & Caucasus: Giraldo-Canas, 2013 [10].
7.	*Capsicum annuum* Linn. Solanaceae	i) Temple of Shiva, Tiruchirapalli, Tamil Nadu	i) Entire Plant bearing fruits	i) 6th to 8th century AD.	i) Gupta, 1996 [11]	Tropical America: Singh *et al*., 2000 [42]; Patil, 2003 [25].
8.	*Chrysantheum indicum* L. Asteraceae	Tajmahal, Agra, Uttar Pradesh.	Plant with flowers	1632-1652	Giraldo-Canas, 2013; Janick *et al*., 2010 [10, 13].	China & Japan: Jadhav, 2012 [12].
9.	*Citrus medica* L. Rutaceae	i) Vishnu (24 armed), fruit in hand, Wall of Rani-Ki-Vav, Patan, Gujarat ii) Hand of Balarama (an incarnation of Vishnu) with fruit, Wall of Rani-Ki-vav, Patan, Gujarat	i) Fruit ii) Fruit	Last Decades of 11th Century AD.	Kirit Mankodi, 2012. Kirit Mankodi, 2012.	China: Roxburgh, 1814 [35].
10.	*Couroupita guianensis* Aubl. Lecythidaceae	Shivaite Temple Carving Tamil Nadu, Karnataka	Flower	Medieval Age	Gupta, 1996 [11].	Guinea & South America: Verma, 1973 [47]. Trininad & South-East America: Singh

						et al., 2001 [43].
(1)	(2)	(3)	(4)	(5)	(6)	(7)
11.	*Datura metel* L. Solanaceae	i) Head-dress of Shiva, Vishapaharana, Thanjavur District, Tamil Nadu. ii) Nataraja's Head-dress, Kunniyar, Thiruvarur, District, Tamil Nadu. iii) Stone sculpture of Uma Maheshwara, Nolambas, Hemavati, Anantpur District, Andhra Pradesh	i) Flower ii) Flower iii) Flower	i) 9th-10th Century CE. ii) 12th Century CE. iii) 11th Century CE.	i) Geeta & Waleed, 2008. ii) Geeta & Waleed, 2008. iii) Geeta & Waleed, 2008.	Tropical America: Chandra Sekar, 2012; Patil, 2017 [6, 27].
12.	*Durio zeibethinus* Linn. Bombacaceae	Floral motif, Bharut, Madhya Pradesh.	Fruit	2nd Century, BC.	Gupta, 1996 [11].	Borneo, Sumatra & Peninsular Malaysia: Morton, 1987 [21]; Bumrungsri *et al*., 2002.
13.	*Fuchsia venusta* Kunth Onagrceae	Tajmahal, Agra, Uttar Pradesh.	Plant with flowers	1632-1652	Giraldo-Canas, 2013 [10].	Tropical America: Giraldo-Canas, 2013 [13].
14.	*Helianthus annuus* L. Asteraceae	i) Rani Gumpha Cave, Udaiagiri, Madhya Pradesh	Flowering Head	2nd Century BC.	Johannesan, 1998	Western USA: Singh *et al*., 2001; Patil, 2003 [43, 25].
15.	Iris germanica L. Iridaceae	Tajmahal, Agra, Uttar Pradesh.	Plant with Flowers	1632-1652	Giraldo-Canas, 2013 [10].	Europe: Giraldo-Canas, 2013 [10].
16.	*Lilium martagon* L. Liliaceae	Tajmahal, Agra, Uttar Pradesh.	Plant with flowers	1632-1652	Giraldo-Canas, 2013; Janick *et al*., 2010 [10, 13].	Asia Minor & Mongoloa: Giraldo-Canas, 2013 [10].
17.	*Lonicera henryi* Hemsl. Caprifoliaceae	Tajmahal, Agra, Uttar Pradesh.	Plant with flowers	1632-1652	Giraldo-Canas, 2013 [10].	China: Giraldo-Canas, 2013 [10].
18.	*Luffa cylindrica* M.Roem Cucurbitaceae	Tajmahal, Agra, Uttar Pradesh.	Plant with flowers	1632-1652	Giraldo-Canas, 2013; Janick *et al*., 2010 [10, 13].	Egypt: John, 1891 [15].
(1)	(2)	(3)	(4)	(5)	(6)	(7)
19.	*Nicotiana tabacum* L. Solanaceae	i) 'Hooka' (a water-cooled smoking device) Temple in Himachal Pradesh	i) Hoka (a smoking device)	1422-1424 AD.	Singh, 2016 [41]	Tropical America: Patil, 2003; Gaikwad & Garad, 2015 [25, 8].
20.	*Papaver orientale* L. Papaveraceae	Tajmahal, Agra, Uttar Pradesh.	Plant with flowers	1632-1652	Giraldo-Canas, 2013; Janick *et al*., 2010 [10, 13].	South-Western Asia: Reznick *et al*., 2011 [34]. Levant: John, 1891 [15].
21.	*Primula sinopurpurea* Balf. *f*. ex Hutch. Primulaceae	Tajmahal, Agra, Uttar Pradesh.	Plant with flowers	1632-1652	Giraldo-Canas, 2013; Janick *et al*., 2010 [10, 13].	China: Giraldo-Canas, 2013 [15].
22.	*Punica granatum* L. Punicaceae	Tajmahal, Agra, Uttar Pradesh.	Plant with flowers	1632-1652	Giraldo-Canas, 2013; Janick *et al*., 2010 [10, 13].	South Asia: Gaikwad & Garad, 2015 [8]. Afghanisthan, Baluchistan & Persia: Patil, 2003; Shetty & Singh, 1987 [25, 39].
23.	*Raphanus sativus* L. Brassicaceae	Ganesha holding Raphanus root in hand, Temple at Kanpur, Bhadrak District, Orissa	Root	8th-14th Century AD.	Gupta, 1996 [41]	Western Asia: Purseglove, 1968 [30]. Europe & Temperate Asia: Singh *et al*., 1991; Patil, 1995 [44, 24].
24.	*Ravenala madagasca-riensis* J.F. Gmel Musaceae	Hoyasaleshvara Temple, Karnataka	Entire plant	12th Century AD.	Gupta, 1996 [41]	Madagascar, Cuba & Brazil; Bailey, 1949; Gaikwad & Garad, 2015 [1, 8]
25.	*Solanum melongena* Solanaceae	i) Nataraja Temple, Chidambaram, Tamil Nadu ii) Jambakashvara Temple, Tiruchirapalli, Tamil Nadu (Both Shiva Temples)	Fruit	i) 10th Century, AD. ii) 2500 year back	Gupta, 1996 [41].	East Indies: Singh *et al*., 2001. America: Gaikwad & Garad, 2015 [43, 8].
(1)	(2)	(3)	(4)	(5)	(6)	(7)

26.	*Spathodea campanulata* P.Beauv. Bignoniaceae	Sanchi Stupa (Graphically Sculpted), Madhya Pradesh	Flower	2nd Century BC.	Gupta, 1996 [41].	Tropical Africa: Singh *et al*., 2001; Bailey, 1949 [13].
27.	*Vitis vinifera* L. Vitaceae	Tajmahal, Agra, Uttar Pradesh.	Plant with flowers	1632-1652	Giraldo-Canas, 2013; Janick *et al*., 2010 [10, 13].	Mediterranean Region: Giraldo-Canas, 2013 [10].
28.	*Zea mays* L. Poaceae	i) Stone carvings, Hoysala Stone, Block Temple (Near Mysore) Karnataka ii) 8-armed Dancing Vishnu in female form Mohini, Lakshmi Narasimha Temple, Nugehalli, Karnataka	i) Ear ii) Ear in left hand	i) 12th & 13th Century AD. ii) 12th-13th Century AD.	Johannessen & Parker, 1989 [14].	Central America: Purseglove, 1972 [31]. South America: Stewart, 1972 [45].

Nativity

These taxa are generally valued as shade, ornamental, edible fruits and nuts, cereals, oil yielder, spice, narcotic, vegetable and medicines. Their nativity is deciphered consulting relevant taxonomic literature. They turned out belonging to different 17 continents, countries, islands or geographical regions of the both New and Old Worlds. It is interesting to note that maximum species [11] are hailed from distant American continent. Other continents *viz*. Africa and Asia (Excl. India) share only three species each, while Europe and Mediterranean region contributed for just two species each. The adjacent country China shared total four species. Other countries or islands contributed a single species each e.g. Borneo, Sumatra, Malaysia, Madagascar, Cuba, Brazil, East Indies, Mongolia, Turkey, Caucasus, Afghanistan, Baluchistan, Persia, Japan and Egypt.

The information revealed from the various texts about the external and internal walls, gateways, pillars, domes, etc. is of historical and socio-religious significance. These are ornamented by various exotic plant species and amalgamated by different traditions and cultures. This paper opened up trends of plant invasion in ancient past. These exotic and species are deeply associated with the faith, beliefs, customs, rituals, etc. developed over long part in India. It appears relevant to throw light on socio-religious aspects of the plant species as well as monuments studied. Depending upon the religion and cult, their significance vary from temple to temple or such edifices. For instance, (i) Citron (*Citrus medica* L.) and maize (*Zea mays* L.) are depicted on temples associated with Lord Vishnu, a deity of Hindus. It is so because fruits or ears of the plant species are yellow in colour, which is held sacred to Lord Vishnu by Hindu. Lord Vishnu wears yellow attires and this colour symbolizes purity, victory and chastity (Rao, 2010) [32]. (ii) Flowers of Cannon ball tree (*Couroupita guianensis* Aubl.) are associated with the temple of Lord Shiva, a god of Hindus. Its flowers also constitute an offering to Shiva. These trees are also grown near the temples Shiva. This is so because the stamens of this flower appear as a hood of cobra, which is always associated with this deity (Krishna and Amirthalingam, 2014) [18]. (iii) Similarly, flower of Dhatura (*Datura metel* L.) is noted in the head-dress of Shiva or Nataraja (Khare *et al*., 2020; Patil, 2017) [17, 27]. This plant species is poisonous. During ocean churning (Samudra manthan), the emerged poison was consumed by Lord Shiva and his throat turned blue. He is, therefore, called 'Nilkantha' (Nil-blue; Kanth-throat) (Sivkishen, 2014) [40]. This poisonous species is appropriated as an offering to him. It is hence depicted in the temples of Shiva. (iv) Palmyra palm (*Borassus flabellifer* L.) is shown near Lord Roma in Hindu Kailas temple in Ellora caves (Chaphekar, 2007) [5]. A legend is mentioned in the epic Ramayana. To show his strength to Sugriva, Rama shot an arrow at seven trees (in a row) of palmyra palm. The arrow pierced through all the seven trees and also, the came back into his quiver. Sugriva then fell at the feet of Rama and helped him to fight against his elder brother Bali to regain Rama's wife Sita (Patil, 2020) [28]. (v) Taj Mahal needs no introduction, being one of the ancient seven wonders of the ancient world. It has been built with white marble and walls are decorated with beautiful plants, flowers and fruits. In doing so, some exotic species have been depicted, apart from the indigenous ones. They have added aesthetic value and beauty to this historical monument. This extravagant monument represents earthly paradise honouring a lost love, and has captured the romantic imagination of poets and public. Its architectural reputation continues to soar (Janick *et al*., 2010) [13]. (vi) Custard apple (*Annona squamosa* L.) is called 'Sitaphala' (Sita: Rama's wife). It is believed that, while in exile, Sita subsisted on its fruits (Saraswat *et al*., 2006) [35]. Ancient monuments act as a means of reaching out to our historical past *vis-a-vis* knowledge about plant invasion in a region. Present biodiversity is the result of past human activity, besides natural forces. Most of these sacred plant species also have been known for their regions. Present biodiversity is the result of past human activity, besides natural forces. Most of these sacred plant species also have been known for their various utilities since ancient times. Various religious practices and worships associated with them are meant to aid in conservating biodiversity.

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