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ACKNOWLEDGEMENTS. We thank Institute of Nuclear Energy Research at Atomic Energy Council for ^{15}N analysis; Laboratory of Soil Environmental Chemistry Department Soil and Environmental Sciences at National Chung Hsing University for FTIR analysis; Precision Instruments Center, National Chung Hsing University for C-13 NMR, EPR and elemental analysis. We also thank L. S. Young and the anonymous reviewer for helpful and constructive suggestions. This research project is supported by National Science Council, Taiwan R.O.C.

Received 27 October 2003; revised accepted 19 August 2004

The status of the baobab (*Adansonia digitata* L.) in Mannar Island, Sri Lanka

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The baobab (*Adansonia digitata)* is not native to Sri Lanka, but was introduced centuries ago, perhaps by Arab traders. Today about 40 trees survive in Sri Lanka, of which 34 have been identified and measured in the island of Mannar. The most abundant size class was between 5 and 9.9 m (girth at breast height), which accounted for more than 50% of the trees. About 40% of the trees in Mannar are between 300 and 400 years old. The oldest tree is estimated to be about 723 years of age. Despite the baobab being an introduced species, it is protected in Sri Lanka given its rarity and antiquity. Mannar Island appears to be the last bastion for the baobab in Sri Lanka. That the baobab still survives in the island is largely due to its status as a 'zero-cost species'. A potential threat for the future may come from the aspirations of the people for a better quality of life, and through ill-conceived and over-ambitious tourism development projects.

THE baobab (*Adansonia digitata* L.) belongs to the family Bombacaceae. It is unmistakable in the field, given its strange appearance and barrel-like enormous trunk, which tapers into branches. It is a deciduous tree whose rounded crown is bare during the dry season. When the leaves are shed, the tree gives the impression that it had been planted upside down. According to an Arabian legend, the baobab's strange appearance is due to the devil plucking the tree up, thrusting its branches into the earth, and leaving its roots in the air. In mature trees, the extensive lateral roots rarely extend beyond 2 m, which is why they are often toppled in old age. The large, dark-green leaves are like the fingers of the human hand, with five (seldom seven) oblong blades; hence the specific name *digitata*[1]. It was the dark-green foliage of the baobab that led the early mariners refer to Africa's western bulge as the Cape Verde (French for green). The flowers which are pendulous, white, large and solitary are seen mostly when the leaves have been shed. They open at night and emit a scent attractive to bats which pollinate them[2]. The sour scent also attracts certain flies and moths at night. The large, white, oval fruits are provided with a dense coat of velvety hairs, and are gourd-shaped, spongy, acidic and farinaceous[3]. The fruit is edible and contains a pleasant, cool-tasting mucilaginous pulp in which seeds are buried, and each fruit hangs from a thick stalk. The seed coat is hard and drought-resistant.

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The name baobab comes from the Arabic plant name Buhibab, while the generic name is after the French botanist, M. Adanson (1727–1806). The tree is known more for its girth than height: trunks attain a diameter of 9 m in some cases, and are hollow in the centre. The bark is rough and greyish, and since it resembles the hide of an elephant, the tree is popularly known in Sri Lanka as 'aliya-gaha' by the Sinhalese (aliya means elephant; gaha means tree); but the Tamils refer to it as 'Perukka'. To the Catholics in the island of Mannar, the baobab fruit is known as the 'Judas Bag' given the 30 seeds it contains. Monkeys love the fruit and hence the tree is sometimes known as the monkey-bread tree. Alexander von Humbolt called the baobab, 'the oldest organic monument of our planet'. It is truly a wonder of nature.

Among the eight species of baobab known to be extant, one occurs in Africa, and another in the northwest Australia's remote Kimberley region, while six are found in Madagascar. Hence Flannery[4] identifies Madagascar as the natal home of the baobab, but Macmillan[3] considers it native to Africa, where it thrives naturally in almost desert areas. The baobab is one of the longest-lived trees in the world. The French botanist Adanson contended that some specimens of the baobab were as much as 5000 years old. In Senegal (West Africa), it is reputed to live to an age of 5000 years[5]. In Sri Lanka, the oldest tree found in Mannar is estimated to be about 800 years old[1]. The baobab has also been recorded from Jaffna in the past, and another from Puttalam which was destroyed later[6]. One tree still stands at Eruvettan in the Mannar District, while another in Wilpattu National Park, near Kala oya. According to a letter written by General Hay Macdowall in 1802, there were many baobabs at Mantai (on the mainland, opposite Mannar), some of which were nearly 15 m in circumference. Today only one tree survives here. Even when Henry Trimen visited Mantai in 1890, only a few of them were left, the largest near the Thiruketheesvaram Hindu temple measuring 14.6 m in circumference at a height of 1.8 m above ground. At one time, there were at least 60 trees in Mannar and Jaffna, but today perhaps no more than 40 survive, and none in Jaffna. Given its rarity, the baobab is one of the protected trees in Sri Lanka. The present study on the current status of the baobab was carried out in Mannar, given the lack of any previous study in the island, despite the rarity and antiquity of the species.

Mannar (area 117 km^2) lies in the shallow sea known as the Palk Strait opposite the northwestern coast of Sri Lanka bounded by 8°30′ N lat and 80°30′ E long (Figure 1). It links Sri Lanka with southern India along a shallow sand bank known as the Adam's Bridge. The name is derived from the Arab belief that Adam and Eve entered Sri Lanka through it. Many centuries ago, the island of Mannar and the city of Mantota on the mainland opposite were important sea ports, where merchants came from both the Orient as well as the Occident to trade in pearls, shanks, ivory and elephants. Brohier[7] refers to the coastal region of Mannar as 'a great commercial emporium' from where Cleopatra is reported to have obtained her pearls. Today, Mannar is one of the bleakest places in Sri Lanka, with much of the land being sterile and repulsive, covered by a stunted growth of umbrella trees and buffalo thorns. The

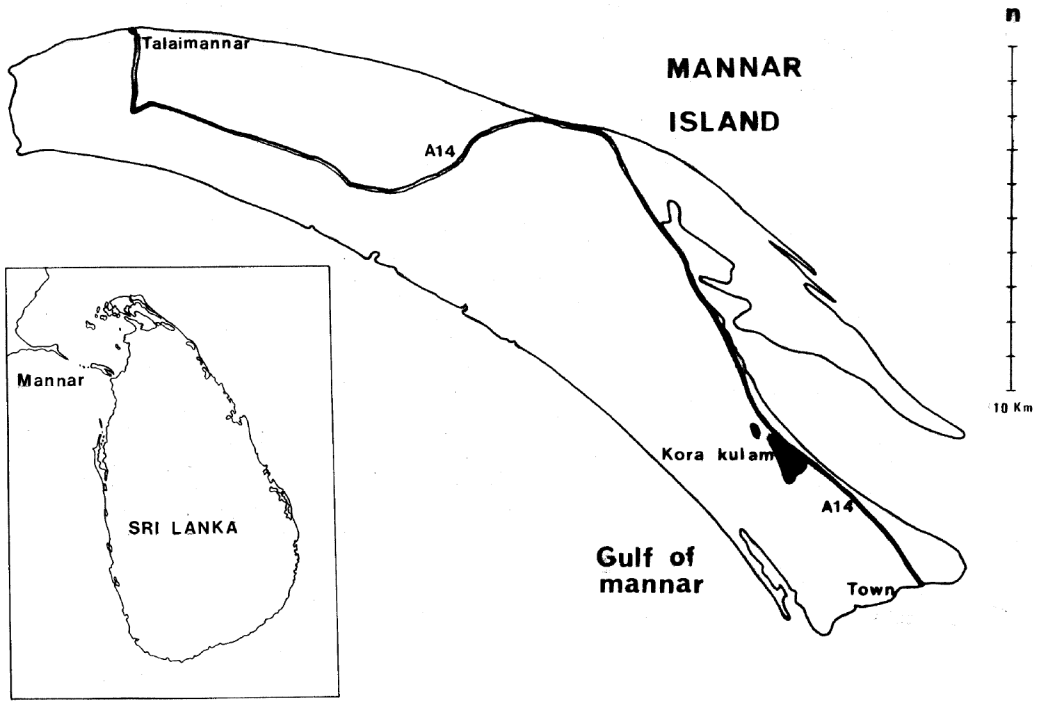

Figure 1. Map of Sri Lanka (inset) with the island of Mannar along its northwestern coast.

annual rainfall ranges between 890 and 1270 mm, most of which is precipitated in the northeast monsoon from December to February, followed by a long period of drought[8].

A survey of the baobab trees in the island of Mannar was carried out in August 2003 during the dry season. The exact geographic location of every tree seen was established using the GARMIN eTrex Summit Geographic Position System (GPS). At each tree, the girth at breast height (GBH) was measured. Among the 34 trees that were located, one (tree # 5) could not be measured since it had fallen to the ground, and was horizontal. In another case (tree # 19), the coordinates could not be obtained due to the lack of signals to the GPS. The trees were assigned to four size classes (i): 0–4.9 m, (ii): 5–9.9 m, (iii): 10–14.9 m and (iv): 15–19.9 m. No records exist as to when precisely the tree was introduced to Mannar by the Arab traders. In one case, a sapling that was planted within the premises of the Kachcheri had a plaque erected by the British besides it bearing the date of planting as 21 March 1922. All that can be inferred from this information is that the tree is at least 80 years old, but it is probably much older. The trunk does not begin to swell in baobab saplings until it is about 30–40 years old. In the absence of reliable data on the age of the baobabs in Mannar, an attempt was made to estimate the age following the method adopted by Barnes[11].

The size classes of the baobab trees based on GBH are given in Figure 2 *a*, the relationship between girth and age is shown in Figure 2 *b*, the estimated age distribution of the baobab is given in Figure 2 *c*.

The size of baobab on the basis of GBH ranges from 1.9 to 19.4 m, with an average of 9.5 m. Unlike in Africa, where baobab trees are known to reach heights between 18 and 25 m, almost all the trees in Mannar are less than 9 m tall. The most abundant size class was 5–9.9 m which accounts for more than 50% of the trees, while 24.2% of the trees belong to the size class 10–14.9 m, and the size classes 0–4.9 m and 15–19.9 m each makes up 12.1% (Figure 2 *a*).

In the past, since it was never established that the baobab produces annual rings, all estimates of the age of baobabs were considered mere guesswork. But Swart[12] was able to show that the baobab does indeed produce annual rings and that the trees increase in radius more slowly during the latter half of their lives. He concluded that there was no reason why some of the really large baobabs in Africa should not be several thousand years old.

Adapting the method used by Barnes[11] in estimating the ages of the baobab trees in Africa (Figure 2 *b*), we find that the age of the baobabs in Mannar ranges between 101 and 723 years. This is on the assumption that growth rates of the baobab trees in Mannar (Sri Lanka) are similar to those in Ruaha (Tanzania). We understand well that conditions in Africa are quite different to those in the arid zone of Sri Lanka and so such a method may not be accurate. The assumption will be influenced by differences between Mannar and Ruaha in soil type, temperature and rainfall (Richard Barnes, pers. commun.). Both Mannar and Ruaha get pretty hot in the late dry season, with temperatures exceeding 30°C, and have unimodal pattern of rainfall. But given that Ruaha receives a much lower rainfall (580 mm) per annum compared to Mannar, its climate may be even harsher. Although the assumption is not substantiated, as an index of age, it gives us some idea of the relative antiquity of the baobab in Mannar. Furthermore, according to Popham[1], the oldest tree at Palimunai (#20 near Mannar town) is supposed to be about 800 years. The fact that our estimate of 723 years as the age for this tree is reasonably close, suggests that the assumption is not far out. It may lend some credibility to the pattern of age distribution of the baobab in Mannar, as seen in Figure 2 *c*. When Henry Trimen[13] measured the tree at Palimunai in 1890, it had a GBH of 18.6 m. Today, it has a GBH of 19.4 m. It shows that during the interval of 113 years, the increase in girth had been slow: at the rate of 7.1 cm per year.

The introduction of the baobab to Sri Lanka from Africa still remains a mystery. The Portuguese could not have introduced the tree to Sri Lanka given the fact that they first appeared only in 1505 in the coastal waters of Sri Lanka[14], about 498 years ago, but some of the baobabs in Mannar are more than 500 years old. Among the 33 trees that were measured, 23 (almost 70%) are less than 400 years old, while the rest are older. It is not clear whether these trees were deliberately planted by people or naturally propagated. All evidence points to the Arab traders who predated the Portuguese as the source of the baobab. These early mariners who brought the coffee-tree to Arabia, and the cinnamon to Malabar (India) must have introduced the baobab to Sri Lanka in the distant past, where it survives today in Mannar. Although the baobab cannot be identified in any ancient Sanskrit writings[15], its presence points to a remote occupation of the area by Arab traders from the Red Sea, who came probably attracted by the pearl and shank fisheries[5].

The baobab is not indigenous to Sri Lanka. Despite being an introduced exotic species, it is protected in Sri Lanka given its rarity, antiquity and limited distribution. While it has almost disappeared from other areas where it once occurred, in Mannar it seems to take adversity in its stride and refuses to die. Thus Mannar appears to be the last bastion of the baobab in Sri Lanka. Houghton[5] was able to germinate in Mullaitivu on the northeast, the baobab seeds that he collected from Mannar. The sowed seeds were flourishing when he left the area in 1890. Given that the seeds germinated well but no young plants were seen, Trimen[13] came to the conclusion that cattle could have eaten the saplings. This led him to believe that the baobab was unable to propagate its species from its own seeds, and so it had not become naturalized either in India or Sri Lanka. Even today, given the large number of cattle, goats and donkeys that the island of Mannar supports, the vegetation is closely cropped, and it is likely that most of the

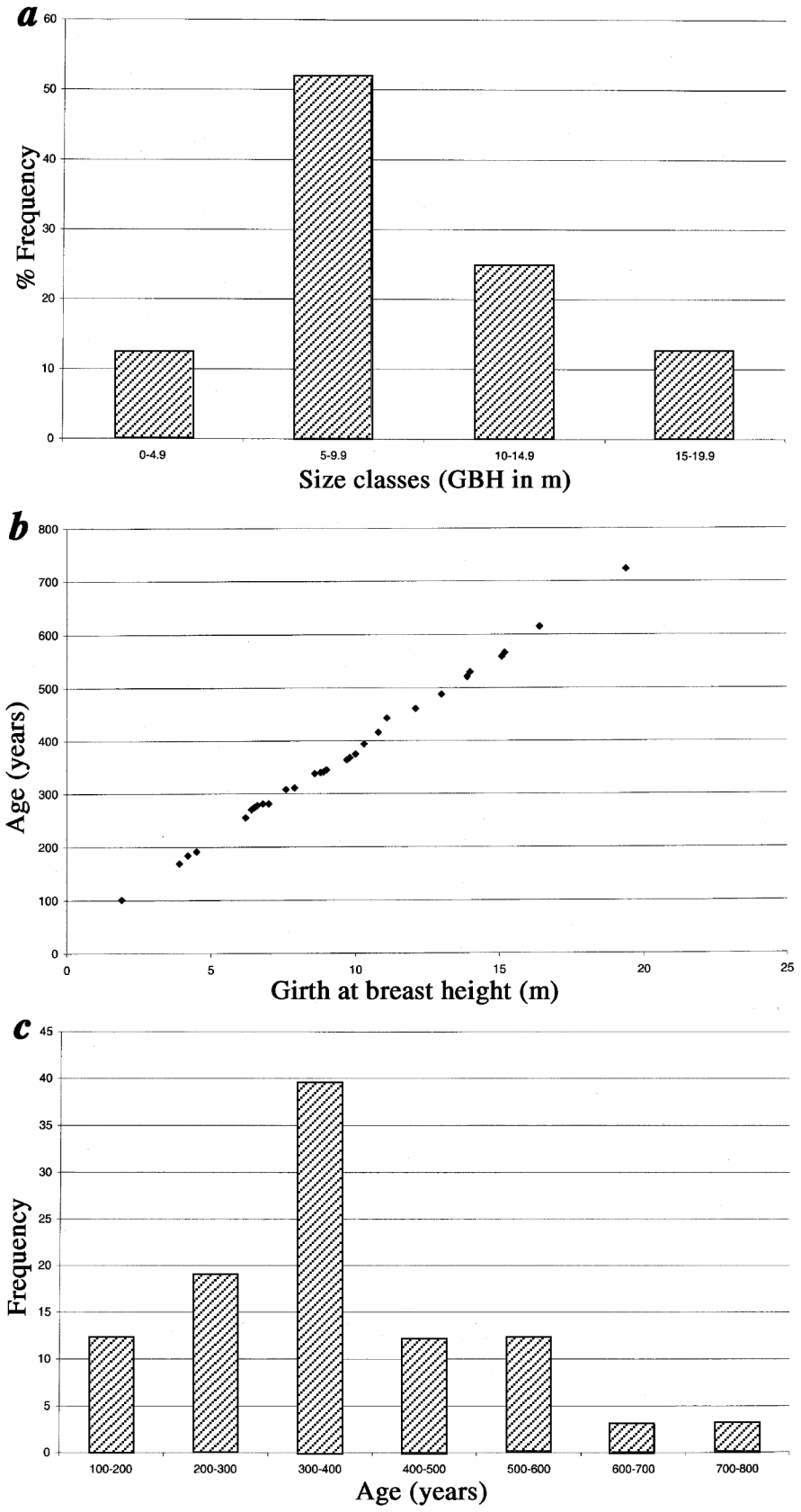

Figure 2. Frequency histogram of size classes (*a*), relationship between girth and age (*b*) and estimated age distribution (*c*) of the baobab in Mannar.

young baobab plants would not survive under such grazing pressure. In the arid climate of Mannar, many plants in the underbrush have evolved spines and thorns to protect themselves from the browsers and grazers. It is probable that these plants may also act as protective nurseries for the baobabs. Therefore, indiscriminate clearing of the scrub may expose the seedlings to grazing pressure from cattle.

There are no conservation areas in Mannar set aside especially for the protection of the baobab. That the baobab still survives in Mannar is due to its status as a 'zero-cost species' which does not compete with native species, and that the areas where it occurs today are inhabited by some of the most impoverished people who make little use of it: only their goats are fed on baobab leaves. In ancient times, the Arab traders who brought camels to Mannar fed the animals on the leaves of the baobab. A potential threat for the future may come from a rapid rise in the human population (through resettlement of refugees), the spread of settled agriculture, and the development of ill-considered and over-ambitious tourism facilities. The baobab has become a conspicuous component of the coastal biological diversity of Mannar and its ability to adapt to the harsh conditions prevalent in the island is in itself a justification for its conservation.

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Received 23 March 2004; revised accepted 23 July 2004

Residue burning in rice–wheat cropping system: Causes and implications

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Combine harvesting technologies, which have become common in RWS (rice–wheat system) in India, leave behind large quantities of straw in the field for open burning of residue. Such burnings result in perturbations to the regional atmospheric chemistry due to emissions of trace species like CO_2, CO, CH_4, N_2O, NO_x, NMHCs and aerosols. The emissions of CH_4, CO, N_2O and NO_x have been estimated to be about 110, 2306, 2 and 84 Gg respectively, from rice and wheat straw burning in India in the year 2000. Residue burning causes nutrient and resource loss and adversely affects soil properties, thus calling for improvement in harvesting technologies and sustainable management of RWS.

RICE (*Oriza sativa*)–wheat (*Triticum aestivum*) cropping system has a long history in Asia. This cropping system has been practised[1] in Asia (China) since AD 700. In the Indian subcontinent, states like Uttar Pradesh (UP; India) have practised[1] this cropping system since 1872, and Punjab (Pakistan and India) and Bengal (India and Bangladesh) since 1920. Rice and wheat are currently grown in rotation on almost 26 million hectares (m ha) in South and East Asia[1]. Rice–wheat system (RWS) occupies nearly one-fifth of the total area under these crops[2,3]. The RWS is one of the widely practised cropping systems in India and covers about 9.5 m ha, about 90% of this area is concentrated in the Indo-Gangetic Plains (IGP)[4]. The RWS in the IGP spans from the Swat valley in Pakistan through the States of Punjab, Haryana, UP, Bihar and West Bengal in India, and into Nepal and Bangladesh. The IGP occupies one-sixth of South Asia's geographical area, holds nearly 42% of its total population and produces more than 45% of its food[4]. Nearly 85% of the RWS of South Asia is located in the IGP. Other parts of the RWS outside IGP lie in Madhya Pradesh (MP), Himachal Pradesh (HP), Brahmaputra flood plains of Assam and southwestern parts of India and Bangladesh. The total area under RWS in India is roughly around 20 m ha. Almost 90–95% of the rice area in Punjab, Haryana and western UP is used under intensive RWS[3].

Widespread adoption of Green Revolution technologies resulted in expansion in area under RWS, and subsequent

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