

***Pangium edule* (Achariaceae) drift endocarps: first records from Britain and Bermuda and a review of NW European records**

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Abstract

During 2015, two drift endocarps of *Pangium edule* were found stranded in southern British waters, the first from Dungeness, Kent (25/09/2015) and the second from Loe Bay Beach, Cornwall (13/11/2015). The specimens represent the first records of *P. edule* drift endocarps from British waters. Four specimens have previously been recorded from Dutch (3) and Danish (1) waters. A first record of *P. edule* from Bermuda (NW Atlantic) in mid-December 2015 is also reported.

Keywords: seed dispersal; buoyancy; ocean currents; ethnobotany

Introduction

Pangium edule Reinwardt (Achariaceae) is considered to be a monotypic species but its taxonomic position is currently uncertain (Chase *et al.*, 2002; Rana & Ranade, 2009; Wurdack & Davis, 2009). *P. edule* is native to Malesia (Indonesia, Malaysia, Philippines), Melanesia (Papua New Guinea, Fiji), and Micronesia (Hemsley, 1885; Merrill, 1918; Bourke, 1996; Walter & Sam, 1996; Costion & Lorence, 2012). Although the species has a localised distribution in the clayey foothill region of Laful Forest, Great Nicobar Island, in the eastern Indian Ocean (Hore *et al.*, 1985), it does not occur in mainland India (Chakrabarty *pers. comm.*). *P. edule* was deliberately introduced into Australia during 1972 by the Commonwealth Introduction Service (Randall, 2007).

P. edule is a tall tree reaching up to 45 m in height commonly found in coastal and lowland interior forests along river banks (Ridley, 1930; Smith, 1999; Anon, 2014). The tree produces large (16-24 by 12-16 cm) green pendulous 'football-shaped' cylindrical-globose fruits, each containing 13-40 hard stony, reticulated, ribbed, triangular-ovoid seeds (3.5-6.0 cm), embedded in a pungent mesocarp (Van Heel, 1974; Hore *et al.*, 1985; Faridah-Hanum, 1996). Each seed has a conspicuously prominent (3-6 cm long, and up to 1.5 cm wide) 'lip-like' hilum (Gunn & Dennis, 1999; Nelson, 2000; Perry & Dennis, 2010). Some seeds inevitably find their way into rivers and eventually float out to sea where they are widely dispersed by oceanic currents.

Although the fruits and seeds of *P. edule* contain poisonous cyanogenic glycosides (Vetter, 2000), they form part of the natural diet of *Babyrousa babyrussa* (L.), a wild pig native to the Togeian Islands, Sulawesi, Indonesia (Akbar *et al.*, 2007). Nevertheless, following boiling, roasting and/or fermentation, the onion-

flavoured fruits and seeds of both wild and cultivated *P. edule* are widely used in the preparation of various culinary dishes and as a food preservative throughout south-east Asia (Hore *et al.*, 1985; Bourke, 1996; Faridah-Hanum, 1996; Walter & Sam, 1996; Smith, 1999; Chakrabarty & Balarkishnan, 2003; Blench, 2004; Salma *et al.*, 2006; Kasim & David, 2013).

The seeds and bark of *P. edule* are also used for various medicinal purposes and as a fish poison by some native tribes in the Asia-Pacific region (Sharief & Rao, 2007; Hariyadi & Ticktin, 2012; Lim, 2013; Rai, 2013). The seeds contain large amounts of oil which is used for cooking, as an electrolyte, in the manufacture of soap and fuel for lamps, and as a potential source of biodiesel (Cadée, 1988; Nelson, 2000; Nofiarli & Nurdin, 2013). Smith (1999) and Hopkins (2000) noted that hollow seeds are used in making handicrafts, such as necklaces and wind chimes. A number of musical instruments originating from Indonesia and New Guinea housed in the ethnobotanical collections of Kew Gardens (London) utilized hollow *P. edule* seeds as 'shakers' (Catalogue Nos: 97873-75) and as a decoration on a drum (Catalogue No. 66999).

NW European & Bermuda records of *Pangium edule*

On 25 September 2015, AD discovered a drift endocarp of *P. edule* stranded at Dungeness (TR006177; 50.9193°N, 0.9653°E), Kent (Fig. 1). The maximum dimensions of the endocarp were 43 mm wide, 23 mm deep, and the hilum length was 39 mm. The remains of mesocarp pulp were still adhering to the endocarp.



Figure 1. Drift endocarp of *Pangium edule* from Kent, September 2015

On 13 November 2015, a second *P. edule* drift endocarp was discovered by PAG stranded on Loe Bar Beach (SW643242; 50.07°N, 5.2945°W), near Helston, Lizard, Cornwall (Fig. 2). The maximum dimensions of the endocarp were 42 mm wide, 28 mm deep, and the hilum length was 39 mm. There were no remains of any mesocarp pulp adhering to the endocarp. The current specimens represent the first records of *P. edule* drift endocarps from British waters.



Figure 2. Drift endocarp of *Pangium edule* from Cornwall, November 2015

Details of all known NW European records of *P. edule* drift endocarps are summarised in Table 1. Since 1971, a total of six specimens have been recorded, including three from the Dutch coast, one from Denmark, and two from Britain.

Table 1. North-West European records of *Pangium edule* drift endocarps

| Date | Location | Coordinates | Collector | Refs. |
|-------------|---|-------------------------|-----------------------------------|----------------------------|
| 13/07/1971 | Shouwen, Burghsluis, Netherlands | 51.6750° N 3.7526° E | J. Viergever | Cadée (1986) |
| 1974 | Ho Bugt, near Esbjerg, Denmark | 55.4703° N 8.4518° E | Bertil Hansen | Nelson (2000) |
| 03/06/1992 | Texel, Netherlands | 53.0548° N 4.7977° E | G. Frederiks | Cadée (1995) |
| 2004 | Terschelling, Netherlands | 53.3979° N 5.3467° E | G.H. Feenstra G. Doeksen | Brochard & Cadée (2005) |
| 25/09/2015 | Dungeness (TR006177), Kent, UK | 50.9193° N 0.9653° E | Andy Dinsdale | This paper |
| 13/11/2015 | Loe Bar Beach (SW643242) , near Helston, Cornwall, UK | 50.0700° N 5.2945° W | Paul A. Gainey | This paper |

During mid-December 2015, a specimen of *P. edule* measuring 41 mm in length, 38 mm in width and 21 mm in depth, was discovered by Roger "Grassy" Simmons on Natural Arches Beach, St. George's, Bermuda (32.3328°N, 64.6881°W), NW Atlantic (BAMZ 2016 296 006, Liza Green, *pers. comm.*). There were no remains of any mesocarp pulp adhering to the endocarp. The specimen (Fig. 3) represents the first record of a *P. edule* drift endocarp from Bermuda.



Figure 3. Drift endocarp of *Pangium edule* from Bermuda, December 2015

There was no evidence of marine bio-fouling epibionts on the external surface of either the NW European or Bermuda endocarps of *P. edule*. The presence of epibionts would suggest that the endocarps had been drifting for a significant period of time at sea prior to stranding. However, it is possible that cyanogenic toxins within *P. edule* endocarps may inhibit the growth of potential epibionts. It is interesting to note that all three specimens were discovered during the autumn and winter of 2015.

Discussion

Nelson (2000) and Thiel & Gutow (2005) stated that *P. edule* seeds are capable of floating for at least 19 years, whereas Perry & Dennis (2010) remarked that they can float for 30 years. Van Heel (1974) noted that the seeds appear to be hollow and that this possibly accounts for their floating capacity. Ridley (1930) remarked that although the seeds can float easily for a long time, they do not survive the action of sea water, and never seem to have reached any oceanic island alive. Gunn & Dennis (1999) noted that while the intact seed coat provides excellent buoyancy and may drift for great distances, the embryo in these drift seeds is usually absent or nearly so. In Australia, Smith (1999) noted that stranded seeds are usually hollow although sometimes still containing a malodorous rotting kernel.

Gunn & Dennis (1999) noted that when fresh *P. edule* seeds are freed from the decaying fruit, they are covered with a white fleshy aril which is soon eroded. It is interesting to note that the remains of mesocarp pulp were still adhering to the Dungeness endocarp which strongly suggests that the specimen was recently discarded. Many NW European cities are home to large ethnic populations with an ancestral knowledge of the poisonous, medicinal and culinary properties of *P. edule*, and unknown quantities may be imported into Europe either for commercial and/or personal use, and some may be locally discarded. Indeed, *P. edule* seeds are currently marketed internationally on various websites.

Drift endocarps of *P. edule* have been recorded from a wide geographical area within the Indo-Asian-Pacific region, including the Cocos-Keeling Islands (Guppy, 1890) and Christmas Island (Ridley, 1930; Green, 1999) [eastern Indian Ocean], Australia (Kenneally, 1972; Hacker, 1990; Smith, 1994, 1999; Smith *et al.*, 1990;

Pike & Leach, 1997), Malaysia (Ridley, 1930), Java (Ridley, 1930), Taiwan (Anon, 2016), and Japan (Longhorn, 2004; Nakanishi, 2011). However, despite their known long-term floatation capacity, there are no confirmed strandings from either the central or eastern Pacific Ocean (Flynn & Van der Burgt, *pers. comm.*), western Indian Ocean, including SE Africa (Muir, 1937; Hosten-Willems, 2005; Burrows, *pers. comm.*), South Atlantic Ocean, including NW Africa (Van der Burgt, 1997, 1998), and only rarely from the NW and NE Atlantic Ocean (Gunn & Dennis, 1999; Perry & Dennis, 2010; this paper).

In the NW Atlantic, Perry & Dennis (2010) noted that there were no records of *P. edule* drift endocarps from Yucatan, Gulf Coast or Carolina shores, and that the seeds are a rarity on the east coast beaches of Florida. Indeed, Perry (*pers. comm.*) remarked that he was only aware of two definitive records of *P. edule* drift endocarps from the NW Atlantic, both from Melbourne Beach, Florida (28.0683°N, 80.5603°W), one during the 1970s, and another during the 1990s.

It has frequently been suggested that the endocarps of *P. edule* found stranded on NW European coasts were unlikely to be true peregrine drifters, and were most likely transported and discarded there by man on the basis that no ocean current could be envisaged that transports seeds from the Indo-Asian-Pacific region to NW Europe (Cadée, 1986, 1988, 1995, 1997; Nelson, 2000; Cadée & Nijhuis, 2001; Brochard & Cadée, 2005). Although the rarity of stranded *P. edule* specimens in the North Atlantic Ocean and the absence of records from the South Atlantic and western Indian Ocean lend support this hypothesis, it is conceivable that some endocarps may have drifted from the Indo-Asian-Pacific region.

Gunn & Dennis (1999) noted that the Malayan region (including Indonesia) is a major epicentre for drift disseminules. Currents passing this region carry disseminules both eastwards into the Pacific and westwards across the Indian Ocean. Although the continent of Africa effectively blocks most movement westwards beyond the Indian Ocean, a few species have successfully rounded the Cape of Good Hope via the Agulhas Current into the Atlantic and have achieved a pantropical distribution (Steinke & Ward, 2003; Schaefer *et al.*, 2009; Michalak *et al.*, 2010; Thomas *et al.*, 2015).

Several oceanographical studies have demonstrated that Indian Ocean water frequently leaks via the Agulhas Current around the southern tip of South Africa into the South Atlantic and is carried northwards along the western coast of Africa via the Benguela Current and westwards via the South Atlantic Drift to South America (Garzoli *et al.*, 1999; Boebel *et al.*, 2003; Steinke & Ward, 2003; Richardson *et al.*, 2003; Richardson, 2007; Van Sebille *et al.*, 2009; Dencausse *et al.*, 2010; Guerra *et al.*, 2018), and possibly thence via the Gulf Stream and North Atlantic Drift to NW Europe. Ebbesmeyer (2003) noted that a plastic drift card which had been released off Cape Town on 17 April 1966 was recovered 19 months later on 25 September 1968, at Stuart Beach, 80 km north of Miami, SE Florida, USA, having drifted at an average speed of c.14 km/day. He also noted that a large log of mahogany originating from a wreck in the Mozambique Channel, between the eastern coast of Africa and Madagascar (Indian Ocean), was found stranded at Cape Town, on the Atlantic coast of South Africa, and hypothesized that some of these mahogany logs could wash ashore in Britain if they remained afloat for 4 years.

Nathan (2006) recognised that long-distance dispersal (LDD) of plants poses challenges to research because it involves rare events driven by complex and highly

stochastic processes. He suggested that nonstandard mechanisms such as extreme climatic events and generalized LDD vectors seem to hold the greatest explanatory power for the drastic deviations from the mean trend, deviations that make the nearly impossible LDD a reality. Smith *et al.* (2018) acknowledged that although LDD dispersal events occur rarely, they play a fundamental role in shaping species biogeography. Indeed, they discovered that the Australian Grass-Wrack *Heterozostera nigricaulis* J. Kou had naturally dispersed across the entire Pacific (c. 14,000 km) to colonize coastal areas in Chile (South America).

Renner (2004) hypothesized that trans-Atlantic dispersal of diaspores by water probably accounted for the occurrence of at least 110 genera of plants which contain species on both sides of the tropical Atlantic (Africa and South America). Kistler *et al.* (2014) hypothesized that trans-Atlantic drift most likely accounted for the successful establishment of wild African Bottle Gourds *Lagenaria siceraria* (Molina) Standley in neo-tropical areas of the New World during the late Pleistocene. During 1998, viable propagules of the Indo-Malaysian Mangrove Palm *Nypa fruticans* Wurmb were discovered on the coast of Trinidad in the Caribbean Sea (Bacon, 2001). The propagules were thought to have drifted across the Atlantic from naturalized populations in West Africa where the species was introduced during the early 20th century (Sunderland & Morakinyo, 2002). Although specimens have occasionally been recorded from NW Europe, they are generally considered to have been imported and locally discarded (Nelson, 2000; Brochard & Cadée, 2005). However, considering the occurrence of *N. fruticans* in the Caribbean region, it is conceivable that the NW European specimens could have originated in West Africa.

A number of other disseminules of Indo-Asian-Pacific origin have been recorded, albeit rarely, from NW European waters (Nelson, 2000), including *Attalea funifera* Martius (Cadée, 1988), *Heritiera littoralis* Aiton (Cadée, 2001), and *Cerbera* sp. (Quigley & Fenwick, in press), but they are generally thought to have been imported and locally discarded rather than true peregrine drifters.

Although vast numbers of disseminules are passively dispersed by ocean currents, only a fraction of these remain buoyant, intact and potentially viable; most undoubtedly either sink, disintegrate or are stranded undetected in inhospitable areas where there can be no expectation of establishment. It is possible that *P. edule* drift endocarps and other Indo-Asian-Pacific disseminules may occur more frequently in NW European waters than the current paucity of records would suggest; their apparent rarity may simply reflect a lack of recording effort throughout most of the Atlantic region. Although it is likely that the occurrence of *P. edule* drift endocarps in NW European waters may be due to local discarding, it is also conceivable, considering their long-term buoyancy (up to 30 years), that some may have passively drifted here from the Indo-Asian Pacific region.

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