BRAZIL NUTS *BERTHOLLETIA EXCELSA* HUMBOLT & BONPLAND (LECYTHIDACEAE) STRANDED ON IRISH, NW EUROPEAN AND WESTERN NORTH ATLANTIC MARITIME SHORES

*Declan T. G. Quigley[1], Dan Minchin[2], Tracey Williams[3] and Paul A. Gainey[4]
[1]*Sea Fisheries Protection Authority, Eastern Region, West Pier, Howth, Co. Dublin, Ireland.*
[2]*Marine Organism Investigations, Ballina, Killaloe, Co. Clare, Ireland.*
[3]*Old Bridge House, Porth Bean Road, Newquay, TR7 3LU, Cornwall, U.K.*
[4]*84 Polwithen Road, Penryn, Cornwall, TR10 8QT, U.K.*
*Corresponding author e-mail: <declan.quigley@sfpa.ie>

Abstract

Although stranded Brazil Nuts *Bertholletia excelsa* have occasionally been recorded from Irish, NW European, and western North Atlantic maritime shores, they are generally regarded as local refuse. During the early 1990s, four specimens of stranded Brazil Nuts were discovered on Irish maritime shores, and two more in Cornwall, U.K. during 2014. The occurrence and potential provenance of stranded Brazil Nuts on Irish, NW European, and western North Atlantic maritime shores is reviewed. It is possible that at least some of the NW European specimens may represent true trans-Atlantic peregrine drifters.

Key words: Brazil Nut, *Bertholletia excelsa*, stranded, Ireland, NW Europe, North Atlantic.

Introduction

Although the Brazil Nut *Bertholletia excelsa* Humbolt & Bonpland belongs to a large pantropical family of trees (Lecythidaceae) that includes approximately 234 species in the Neotropics, it is the only species within the monotypic genus *Bertholletia* (Mori and Prance, 1990; Huang *et al*., 2015; Cabral *et al*., 2017; Thomson *et al*., 2018).

B. excelsa is an exceptionally large, slow-growing, late-maturing, and long-lived pioneering canopy tree, which reaches a height of up to 60m, attains reproductive maturity at >120 years of age, and may survive for up to 1600 years. (Mori and Prance, 1990; Peres and Baider, 1997; Zuidema *et al*., 2002; Shepard and Ramirez, 2010; Thomas *et al*., 2014).

B. excelsa is native to Bolivia, Brazil, Columbia, Guiana, Peru, Surinam and Venezuela, where it is considered to be a light-dependent gap specialist, growing in widely scattered stands of 50-100 individuals (colloquially known as “manchales”, “castanales” and “castanhais”) on well-drained non-flooded (*terra firme*) nutrient-poor oxysol and utisol soils in lowland rainforests within hydrometric catchments of the Amazon, Orinoco, Rio Negro and Tapajos Rivers (Van Roosmalen, 1985; Mori and Prance, 1990; Peres and Baider, 1997). Brazil Nuts

have been introduced to Cuba, Trinidad, West Africa (Côte d'Ivoire, Gambia, Ghana, Morocco), and Malaysia where they are cultivated, albeit apparently with different levels of commercial success (Mori and Prance, 1990; Anon, 2019).

Although stranded Brazil Nuts have occasionally been recorded from Irish, NW European, and western North Atlantic maritime shores, they are generally regarded as local refuse (Nelson, 1978, 1990, 2000; Cadée, 1997; Brochard and Cadée, 2005). However, the current review considers the possibility that at least some of the NW European records may have been true trans-Atlantic peregrine drifters.

Ecology of *Bertholletia excelsa*

The Brazil Nut fruit is unique among the Lecythidaceae in that the seeds remain encased after the fruit fall. The large dark brown mesocarp is an extremely hard, globose, woody capsule (pyxidium), measuring up to 150mm in diameter and weighing up to 2.2kg, which drops to the ground after a maturation period of *c.*15 months. The pyxidium is functionally indehiscent, and the mature seeds (7-29 per fruit), remain trapped inside the thick pericarps of fruits on the ground unless opened by a vertebrate seed predator, particularly by scatter-hoarding cavimorph rodents such as Agoutis *Dasyprocta* sp. and Acouchis *Myoprocta* sp., which are capable of gnawing through the thick pericarp wall of newly fallen fruits to access the seeds inside. The Brazil Nut tree therefore relies almost entirely on these mutualistic large terrestrial rodents for the natural release and dispersal of their well-protected seeds (Van Roosmalen, 1985; Mori and Prance, 1990; Peres and Baider, 1997; Tuck Haugaasen *et al*., 2010). Native Amerindians have exploited Brazil Nuts since at least *c.*11, 000 BP, and may have contributed to the geographical dispersal of *B. excelsa*, particularly in central and eastern Amazonia (Shepard and Ramirez, 2011; Thomas *et al*., 2014, 2015).

Brazil Nut seeds measuring up to 50mm in length and 25mm in width, are triangular in cross-section (triquetrous), finely transversely ribbed (costate), with three longitudinal furrows. The external hard lignified testa (shell) protects a large embryo measuring on average 40mm in length, 20mm in width, and weighing up to 6.7g. The edible embryo is highly attractive to seed predators and contains 17-25% protein and 70-72% lipids (Van Roosmalen, 1985; Mori and Prance, 1990; Peres and Baider, 1997; Tuck Haugaasen *et al*., 2010; Sonego *et al*., 2019.

Commercial harvesting of Brazil Nuts (*Bertholletia excelsa*)

Brazil Nuts were first introduced to Europe by Dutch traders during the late 18th century with trade increasing greatly during the late 19th century. The nuts now represent Amazonia's most socio-economically important non-timber forest product, and the only globally-traded seed crop predominantly collected from natural forests (Mori and Prance, 1990; Shepard and Ramirez,

2011). During 2018, the total global volume of unshelled Brazil Nuts was 94,437 tonnes, produced by four countries: Brazil (39.1%), Bolivia (32.9%), Côte d'Ivoire (21.4%) and Peru (6.6%) (Anon., 2019).

After the fruits are collected, they are split open with a machete or an axe and the seeds are removed. The seeds are placed in water to clean them of mud and to determine which are bad. Seeds that sink are classified as good while those that float to the surface are culled out. Due to their high polyunsaturated fat content (32%), primarily omega-6 fatty acids, shelled Brazil Nuts may quickly become rancid and are extremely susceptible to fungal attack (De Almeida, 1963; De Souza, 1963; Mori and Prance, 1990).

Brazil Nuts (*Bertholletia excelsa*) stranded on Irish and NW European maritime shores

On 16 June 1990, DM discovered an intact Brazil Nut measuring 41mm in length and 26mm in diameter stranded on Tramore Beach (52.1585 ^{o}N, 7.1444 ^{o}W), County Waterford, on the SE coast of Ireland. On 14 May 1991, DM discovered a damaged Brazil Nut measuring 39mm in length and 25mm in diameter, along with a specimen of the tropical Horse-Eye Bean *Mucuna sloanei* Fawcett & Rendle, 1917 stranded on Ballydonegan Beach (51.6323 ^{o}N, 10.0583 ^{o}W), Allihies, County Cork, on the SW coast of Ireland. Two more stranded specimens were discovered by DM at unknown locations on the Irish coast during 1990-1991 (Plate 1). The specimens, which represent the first published records of stranded *Bertholletia excelsa* seeds from Irish waters, were donated to the National Herbarium, Dublin (DBN: 2020).

Details of all known records of Brazil Nuts stranded on NW European maritime shores are summarized in Table 1, including at least 29 from Ireland, 7 from the UK, and 3 from the Netherlands. During the early 1960s, hundreds of Brazil Nuts were reported from various beaches on the Dingle Peninsula, County Kerry, on the south-west coast of Ireland (Nelson, 1986, 1990, 2000). Based on the maximum known flotation ability of Brazil Nuts at that time (3 months), Nelson (1990) concluded that these nuts were clearly the result of cargo-loss from a ship. The U.K. specimens included 4 recorded from the Isle of Barra (Outer Hebrides), on west coast Scotland during the early 1900s (Nelson, 1986, 1990, 2000), one from Wales (Cardigan Bay) prior to 1998 (Chater, 1998), and 2 from Cornwall during 2014 (Plate 2). Chater (1998) considered that the Welsh specimen was refuse of human origin. Apart from one specimen recorded at Zandvoort (Holland) during 2002 (Anon., 2003), Brochard and Cadée (2005) remarked that specimens were regularly washed up on the Island of Texel. Cadée (1997) considered that the Dutch specimens were probably locally discarded.

In 1998, the European Community (EC) enacted a regulation (Regulation 1525-98 EC; Anon., 1998) reducing the maximum acceptable level of aflatoxins, carcinogenic chemicals produced by moulds that grow on protein-rich foods such as Brazil Nuts, from 20 ppb to 4 ppb.

This regulation appears to have resulted in a major reduction in the quantity of whole in-shell Brazil Nuts subsequently imported into EU countries (Newing and Harrop, 2000; Anon., 2005). Whole in-shell Brazil Nuts were traditionally regarded as a favourite nut-cracker's fare, particularly at Halloween (31 October), but they now appear to be a rarity. Indeed, during the month running up to Halloween 2020, DQ failed to find any whole in-shell Brazil Nuts on sale in several major supermarkets, specialist fruit and vegetable shops and ethnic stores in Counties Dublin and Wicklow. However, shelled Brazil Nuts were widely available in many retail outlets. It is possible that this EU regulation may also partly account for apparent paucity of stranded whole in-shell Brazil Nuts on NW European maritime shores since the late 1990s.

Brazil Nuts (*Bertholletia excelsa*) stranded on western North Atlantic maritime shores

Stranded Brazil Nuts have been reported on various beaches in the western North Atlantic (Gulf of Mexico) ranging from Mexico (Yucatan Peninsula), Texas (Padre Island) and the east coast of Florida (Gunn, 1968; Gunn and Dennis, 1973; Gunn *et al*., 1984; Sullivan, 2003) Although Perry and Dennis (2010) considered that most of these nuts were probably left behind by local picnickers or were derived from shipping refuse, they suggested the possibility, based on subsequently recorded maximum flotation abilities of up to one year, that some nuts may have arrived by way of ocean currents from northern South America.

Discussion

The maximum recorded flotation ability of Brazil Nuts in seawater under test conditions (one year) would suggest that it is unlikely that they could drift across the Atlantic *via* the Gulf Stream and North Atlantic Drift and strand on NW European maritime shores within the estimated minimum time interval of 14 to 18 months for passively drifting objects (Quigley *et al*., 2016).

However, it is possible, under certain conditions, that some nuts may remain afloat long enough to achieve a passive trans-Atlantic crossing. For example, long-term immersion in water (either fresh or seawater), particularly in anoxic benthic environments, is likely to lead to gradual bacterial decay of the endosperm and the release of gases which might result in some level of temporary buoyancy. Indeed, empty and/or partially empty Brazil Nuts (which float), are commercially sorted and discarded from whole nuts (which sink) on the basis of their flotation properties (De Almeida, 1963; De Souza, 1963; Müller, 1981; Mori, 1992; Martins *et al*., 2018). It is possible that some of these commercially discarded 'floaters' are carried down Amazonian rivers into Caribbean Sea and continue floating in ocean currents until they eventually sink or strand on maritime shores, in some cases, perhaps many thousands of miles from where they were originally harvested and sorted.

It is interesting to note that after three decades in dry storage, three of the intact, albeit empty Brazil Nuts stranded on the Irish coast during 1990-91 remained afloat for at least two months in freshwater, whereas the damaged specimen immediately sank like a stone. Although both of the Cornish specimens collected during 2014 remained afloat during short-term seawater tests, longer-term flotation tests (>14 months) are required in order to determine if these NW European stranded nuts might represent true peregrine trans-Atlantic drifters.

The co-occurrence of stranded Brazil Nuts along with other tropical seeds suggests that these disseminules may have originated from the same general region in the western tropical Atlantic and probably arrived in NW Europe simultaneously. For example, the relatively large number of Brazil Nuts recorded on various beaches in County Kerry during 1965 coincided with the stranding of a Sea Purse *Dioclea reflexa* Hook. f. and Sea Heart *Entada gigas* (L.) Fawcett & Rendell in the same area (Nelson, 1986). During May 1991, a Horse-Eye Bean (*Mucuna sloanei*) was found stranded along with a Brazil Nut on Ballydonegan Beach, County Cork. *D. reflexa*, *E. entada*, and *M. sloanei* are endemic to tropical America and specimens stranded on NW European maritime shores are considered to be true long-distance drift-seeds (Nelson, 2000).

Although some of the Brazil Nuts stranded on NW European maritime shores may have been locally discarded or derived from lost ship cargo, perhaps others may represent true peregrine trans-Atlantic drifters, possibly commercial discards ('floaters') from the Amazonian region which currently accounts for almost 80% of global production.

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TABLE 1. NW European records of stranded Brazil Nuts *Bertholletia excelsa.*

Date	Location	Latitude	Longitude	TL (mm)	Width (mm)	Recorder	Voucher	Reference	Notes
early 1900s	West Sand, Eoligarry, Isle of Barra, Outer Hebrides, NW Scotland	57.0393	-7.4321			William L. MacGillivray	King's Museum, Aberdeen (ABDUZ: 50086.1)	Nelson (1986, 1990, 2000)	
early 1900s	West Sand, Eoligarry, Isle of Barra, Outer Hebrides, NW Scotland	57.0393	-7.4321			William L. MacGillivray	King's Museum, Aberdeen (ABDUZ: 50086.2)	Nelson (1986, 1990, 2000)	missing 26.11.1975 S.S.
early 1900s	Cliaid Shore, Isle of Barra, Outer Hebrides, NW Scotland	57.0119	-7.4904			William L. MacGillivray	King's Museum, Aberdeen (ABDUZ: 50086.3)	Nelson (1986, 1990, 2000)	
early 1900s	Isle of Barra, Outer Hebrides, NW Scotland	57.0393	-7.4321			William L. MacGillivray	Royal Scottish Museum (RSM)	Nelson (1986, 1990, 2000)	
1964	Slea Head, Co Kerry, SW Ireland	52.0964	-10.4592			Michael Long		Nelson (1986, 1990, 2000)	
24/03/1965	Slea Head, Co Kerry, SW Ireland	52.0964	-10.4592			Michael Long		Nelson (1986, 1990, 2000)	3 seeds
26/03/1965	Inch, Co Kerry, SW Ireland	52.1427	-9.9810			Michael Long		Nelson (1986, 1990, 2000)	17 seeds
02/05/1965	Ventry, Co Kerry, SW Ireland	52.1327	-10.3632			Michael Long		Nelson (1986, 1990, 2000)	
20/05/1965	Dingle, Co Kerry, SW Ireland	52.1408	-10.2880			Michael Long		Nelson (1986, 1990, 2000)	
20/05/1965	Kinard, Co Kerry, SW Ireland	52.1209	-10.2063			Michael Long		Nelson (1986, 1990, 2000)	
1966	Ventry, Co Kerry, SW Ireland	52.1327	-10.3632			Michael Long		Nelson (1986, 1990, 2000)	
06/06/1990	Tramore Beach, Co Waterford	52.1585	-7.1444	41	26	Dan Minchin	DBN 2020	This paper	
14/05/1991	Ballydonegan Beach, Allihies, Co Cork	51.6323	-10.0383	39	25	Dan Minchin	DBN 2020	This paper	broken shell
1990-91	Irish coast			44	23	Dan Minchin	DBN 2020	This paper	
1990-91	Irish coast			39	22	Dan Minchin	DBN 2020	This paper	
prior to 1997	Dutch Coast							Cadée (1997)	refuse of human origin
prior to 1998	Cardigan Bay, Cardiganshire (VC46), Wales, UK	52.5000	-4.4167					Chater (1998)	refuse of human origin
08/11/2002	Zandvoort, Holland	52.3711	4.5334			Wim Kruiswijk		Anon (2003)	
prior to 2003	Texel, Holland	53.0548	4.7977					Brochard & Cadée (2005)	regularly wash up on Texel
01/04/2014	Perranporth, N Cornwall, UK	50.349	5.1569	45	30	Tracey Williams		This paper	
01/04/2014	Perranporth, N Cornwall, UK	50.349	5.1569	49	31	Tracey Williams		This paper	

PLATE 1. Stranded Brazil Nuts (*Bertholletia excelsa*) from Irish waters. Photograph © Declan Quigley.

PLATE 2. Stranded Brazil Nuts (*Bertholletia excelsa*) from Cornwall, U.K. Photograph © Tracey Williams.