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A drift log from Cape York Peninsula, Australia identified as *Vatica* (Dipterocarpaceae), and the use of botanical, zoological, geological and ethnographic data in interpreting the direction of oceanic drift

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ABSTRACT

Information on oceanic currents along with botanical, zoological, geological data and ethnographic records are used to interpret drift patterns in north eastern Australia. A log of *Vatica* sp. (Dipterocarpaceae), other botanical disseminules, and ethnographic objects, such as indigenous canoes and plastic bottles, found in north eastern Queensland are interpreted as coming from New Guinea. The southerly drift of these objects from New Guinea is facilitated, in part, by the Gulf of Papua Current and/or seasonal south westerly directed winds from October through to March. The identification of source areas for geological (pumice), zoological (*Nautilus*) and some anthropological items demonstrates predominantly westerly drift due to the South Equatorial Current and south eastern trade winds from April to October. Thus, seasonal factors determine, in part, the direction of drift in parts of north east Queensland. □ *Dipterocarpaceae*, *Vatica*, wood anatomy, Cape York Peninsula, New Guinea, drift trajectory, long-distance dispersal, Gulf of Papua Current (GPC), South Equatorial Current (SEC).

The action, prevailing direction and interplay of oceanic currents and wind lead to the translocation and accumulation of drift material from disparate source areas onto oceanic beaches. In many cases the origins of these drift objects

can only be speculated upon, but occasionally, as in this study, the sources of different classes of drift objects, i.e. zoological, botanical, geological and ethnographic, can be identified with some certainty and it is therefore possible

to infer the direction of drift of these objects in relation to the predominant oceanic currents and winds in the region.

A modern tree trunk was found by one of us (D. Wicks) washed up on the eastern coast of Cape York Peninsula, north eastern Queensland. Its wood anatomy is described, and it is shown to be referable to the Malesian genus, *Vatica* (Dipterocarpaceae). Based upon the prevailing oceanic currents in this part of north east Queensland, and knowledge as to where the Dipterocarpaceae currently occur, the likely drift trajectory of the *Vatica* log can be proposed. This trajectory is compared with that seen for different classes of drift objects in this region, and we examine the extent to which these patterns can be correlated with information on oceanic currents and wind direction (see Schiller *et al.* 2008, SPICE community). From this combined data we can identify generalised patterns for the oceanic drift of objects and the potential for oceanic dispersal of fauna and flora throughout this region.

MATERIALS AND METHODS

This study is largely based upon a log which was found at the mouth of the Nesbit River (13° 33'S 143° 33'E), Cape York Peninsula, Australia that had a diameter of 40-50 cm, and over two metres in length. While much of the outer wood is weathered and partially decomposed (Fig. 1A-B), samples from the centre of the trunk were sufficiently well preserved to allow identification (Fig. 1C-E). Transverse, radial and tangential sections were prepared, stained with methyl violet and examined under a Nikon MKII (Fig. 1C-E). The standard procedures for wood identification were carried out by the last author, a wood anatomist, based on an examination of the wood anatomical characteristics (features) of the unknown specimen. Its features were compared with authentic specimens and slides of *Vatica* according to accepted IAWA (International Association of Wood Anatomists) procedures (Wheeler *et al.* 1989). The identification is only feasible to generic level, and was conferred through reference to the systematic descriptions in PROSEA (Sosef *et al.* 1993). The critical features for *Vatica* include the

presence of diffuse axial gum canals, vessel size and frequency, nature of the inter-vessel pitting and absence of silica inclusions as summarised below in 'Description of the wood anatomy'. A sample of the wood (AQ798211) has been donated to the Queensland Herbarium (BRI).

Published papers and ethnographic records from the Cultural Heritage section of the Queensland Museum, recording the occurrence of dugout canoes in eastern Australia were assessed. Papers dealing with the geochemical analysis of pumice samples and with botanical and zoological records of drift items from the region were also reviewed. The data from these different object classes was examined to see what patterns exist.

The different oceanic currents in the Coral Sea are described in terms of their prevailing wind direction, so the northerly-directed winds from October through to March result in a south-westerly drift; similarly the south easterly trade winds that drive the South Equatorial Current result in a predominantly westerly drift.

Records in the Atlas of Living Australia website (<http://www.ala.org.au>) were assessed to determine the distribution of *Vatica* in New Guinea and *Nautilus* in eastern Australia. Authorities to extant plant taxa are available at the International Plant Names Index website: <http://www.ipni.org>, and to animal names: <http://www.organismnames.com>.

DESCRIPTION OF WOOD SAMPLE

Dipterocarpaceae Blume (1825)

Vatica L.

Description of wood anatomy. Wood reddish-brown with streaks of pale-coloured decay and resinous deposits with a faint odour. Growth rings indistinct. Vessels small, numerous, mostly solitary and heavily tylosed, approximately 100-120µm in diameter. Rays appear to be of two types, 1, 4-7 cells wide, narrow and medium width with occasional sheath cells, - the latter almost as wide as the vessels. Vertical canals diffuse and difficult to detect, appear

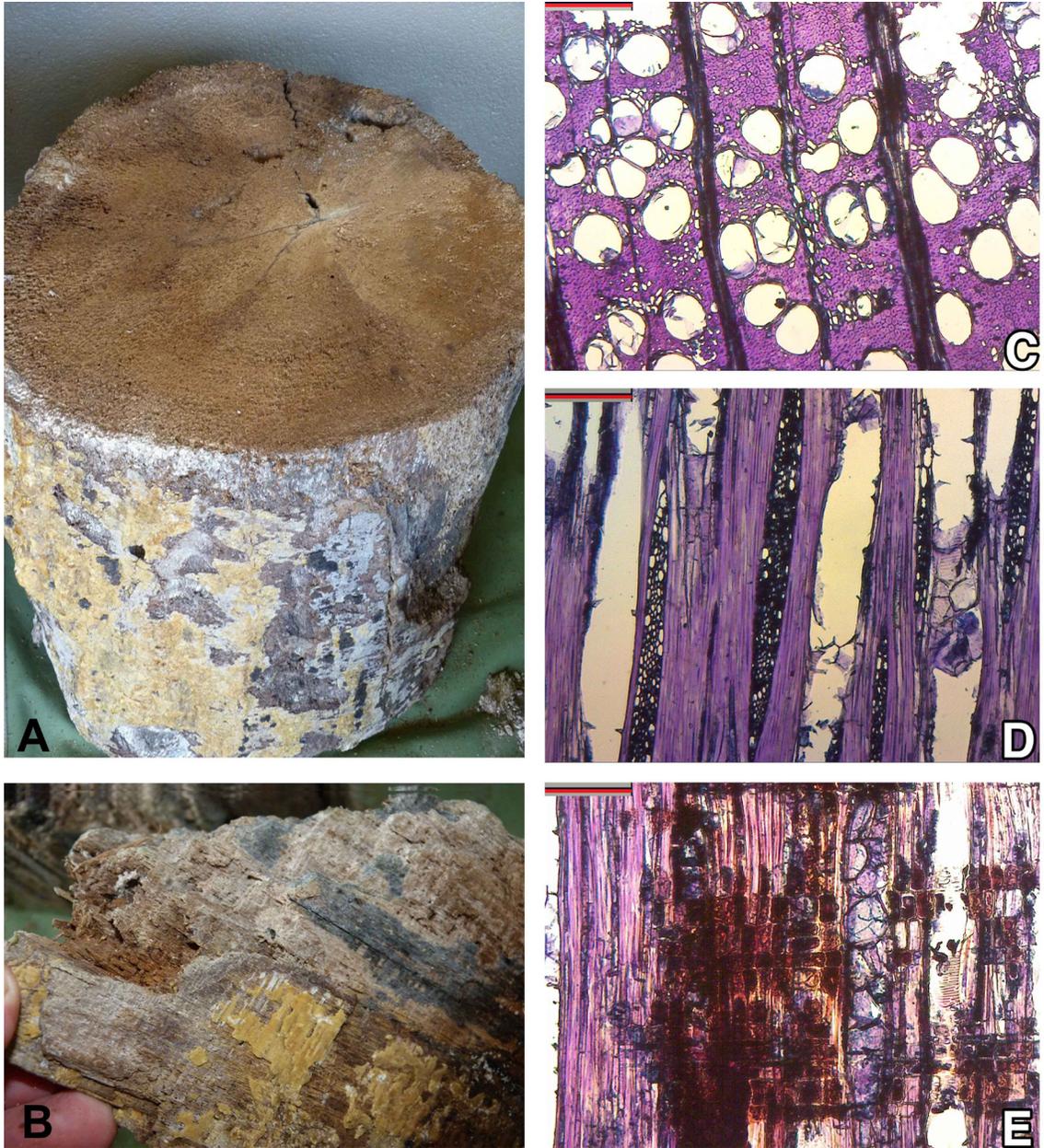


FIG. 1. A-E. *Vatica* wood. A, View of log showing the resin on the outside of the trunk; B, detail showing resin; C, Transverse Section; D, Longitudinal Section; E, Radial Section. Scale bar = 200µm.

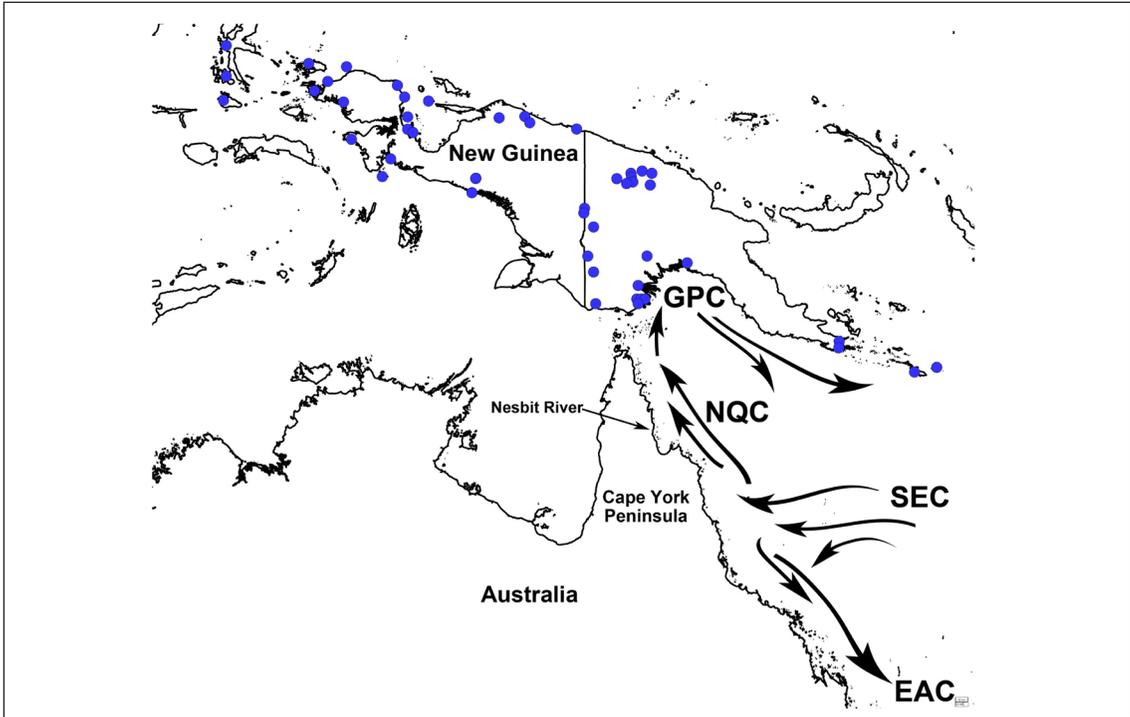


FIG. 2. Map showing distribution of *Vatica* spp. (in circles) records in New Guinea from the Atlas of Living Australia (ala.org.au), 22 January 2013. The location, Nesbit River, where the log was found, is highlighted and the generalised oceanic currents in this region, i.e. SEC South Equatorial Current; EAC East Australian Current, NQC North Queensland Current, GPC Gulf of Papua Current, based upon Ridgway & Hill (2009) are shown.

smaller in diameter than the vessels. Rays weakly heterocellular with 1–3 rows of square to upright marginal cells. Parenchyma apotracheal – diffuse and paratracheal – vessels partially surrounded by parenchyma cells. Intercellular canals surrounded by parenchyma cells. Perforation plates simple. Pits to vessels rare, opposite to scalariform. Vessel-ray pits simple, large, rounded to elongated. Fibres thick walled, non-septate. Silica and crystals absent.

Remarks. The log found at the mouth of the Nesbit River is from a species of *Vatica* L. (Dipterocarpaceae). The family includes 17 genera and about 500 species and is most diverse in the South East Asian region; with a few additional taxa occurring in Africa and South America (Ashton 2003). Most genera in South East Asia are restricted to the western side of Wallace’s line. Only *Anisoptera*, *Hopea*

and *Vatica*, with a combined total of 15 species, are found in New Guinea (Ashton 1982: fig. 3). The Dipterocarpaceae reach their eastern limit in New Guinea in the Louisiade Archipelago (Frodin 2001: 501). The family does not occur in Australia (Hoogland 1972) and neither is there any fossil record in this continent (Mary Dettmann pers. comm. 2013), so we can conclude that the log came from outside Australia.

There is only has a single species of *Vatica* in New Guinea, and *V. rassak* is widespread across the Island (Fig. 2). It does not occur in the Solomon Islands, Vanuatu or New Caledonia. As *Vatica* is found throughout New Guinea, it seems probable that this island was the source of the tree trunk implying a southerly drift trajectory, although drift from islands west of New Guinea is also a possibility.

OCEANIC CURRENTS IN NORTH EASTERN AUSTRALIA

Based upon current oceanographic models we can predict the direction in which oceanic currents and winds move objects in this region (Schiller *et al.* 2008; SPICE community). While surface currents vary throughout the year (Anonymous 1973), the predominant current affecting north eastern Queensland is the South Equatorial Current (SEC), which is the prevailing westerly directed current in this area (Schiller *et al.* 2008; SPICE community) (Fig. 2). The SEC bifurcates on reaching the Australian coast, generating the East Australian Current (EAC) that flows south along the Queensland coast and the North Queensland Current (NQC) flows north towards New Guinea. The surface currents in north-eastern Australia and southern Papua New Guinea, from March through to October, have a predominantly north westerly direction, which is driven by the south easterly trade winds. We would therefore anticipate that the SEC and south east trade winds are important for determining the drift trajectory of objects onto eastern Australia at this time of year.

The Gulf of Papua Current (GPC) (SPICE Community) which runs along the southern coast of Papua New Guinea is associated with the Coral Sea Gyre which is a strong and dominating feature in oceanic circulation between north-eastern Australia and Papua New Guinea. From October through to February the surface currents have a predominantly south westerly direction and are driven by northerly to north westerly winds (Anonymous 1973), that are referred to colloquially as the “northerlies” in north Queensland. At this time of year, these surface currents and winds are responsible for moving drift objects away from New Guinea and towards the north east coast of Australia. Where the southern arm of Gulf of Papua Current intersects the prevailing South Equatorial Current (Ridgway & Hill 2009), the trajectory for drift objects is westerly, which may also result in them washing up on the northern coast of Australia (Schiller *et al.* 2008). Large tropical (cyclonic) storms, between September and April are also likely to affect the drift trajectory of objects in this region

(Gillespie *et al.* 2012; Bryan *et al.* 2012); and floods from the Fly River are also responsible for moving flood debris, including vegetation, into the Gulf of Papua (Jeffries 2015).

EVIDENCE OF DRIFT TRAJECTORY IN NORTH EASTERN AUSTRALIA

To infer the trajectory of a drift object, the item must (a) have a restricted distribution, and be endemic to a particular geographical area and/or (b) have a source that can be identified with certainty, e.g. through analysis of geochemical data (for pumice), or molecular data (for animals and plants). Objects, or species, with widespread or cosmopolitan distributions will be therefore largely uninformative in determining drift patterns. The underlying assumption is that objects are likely to respond to oceanic currents in similar ways, and it should therefore be possible to identify generalised patterns of drift through the study of different classes of objects and whether these patterns are consistent with oceanic currents in north east Queensland, and whether they can explain the occurrence of a *Vatica* log on the east coast of Cape York Peninsula.

Geological evidence

The source of pumice can be identified using geochemistry and it is therefore possible to infer the drift trajectory of samples that have washed up on beaches in Australia. The geochemical signatures of pumice from north eastern Queensland show diverse origins although most specimens on the east Australian Coast are from the Tongan – Kermadec Island arc, in the western Pacific, and therefore demonstrate a predominantly western drift trajectory on the South Equatorial current (Stanton 1992; Sutherland & Barron 1998; Bryan *et al.* 2012). However, while the majority of pumice samples indicate a West Pacific origin, consistent with drift on the SEC, two samples, found on beaches between Cardwell and Cape Upstart in North Queensland, have been identified as coming from Indonesia; suggesting that easterly drift from the Indian Ocean also occurs (Stanton 1992). Judd (in Symonds 1888) also noted that a pumice sample collected at Cape York Peninsula was

from the 1883 eruption of Krakatoa (Indonesia) and geochemical analysis confirmed this origin (Frick & Kent 1984).

Botanical evidence

Smith (1994) recorded 47 species of drift disseminules in north west Coral Sea and provided an overview of their drift patterns. He identified the disseminules of a number of non-Australian species from beaches in northern Australia, including *Excoecaria indica*, *Lithocarpus* spp. and *Inocarpus fagifer*, and concluded that their occurrence were due to southward drift from New Guinea. *Lithocarpus*, like *Vatica*, has its most easterly distribution in New Guinea (Hoogland 1972; Frodin 2001), and its fruits have been recorded from beaches in the Torres Strait, north east Cape York Peninsula and eastern Australia as far south as Raine Island (George Batianoff, pers. comm. in Smith (1994)). *Excoecaria indica* and *Inocarpus fagifer* have more widespread distributions in the Malesian region, so the suggestion by Smith (1994) that disseminules of these species were from New Guinea may be incorrect, although it is still the closest, and therefore the most likely source area. Many of the other drift species recorded by Smith (1994) occur widely throughout the region, and are thus uninformative in inferring the origin of the drift material.

A log washed up at Seisia boat ramp, Cape York on 8th March 2012 was identified as *Octomeles* (Tetramelaceae) by the botanist, John Ford (James Walker pers. obs.). This genus contains a single species, *O. sumatrana*, which is a rainforest timber known as 'Erima'. It grows in Malaysia, Indonesia, Brunei, the Philippines, the Solomon Islands and Papua New Guinea but is not known from Australia. While the closest source area for this log is again New Guinea, it could conceivably have come from another part of south east Asia. Anecdotal evidence also exists of other logs washing up on northern Australian beaches (James Walker pers. obs.), but as their taxonomic affinities remain unknown, we cannot speculate on their origins.

Zoological evidence

The shells of three species of *Nautilus*, *N. pompilius*, *N. stenomphalus* and *N. macromphalus* have been found on beaches in north eastern Queensland (Bonacum *et al.* 2011). While *Nautilus pompilius* and *N. stenomphalus* occur in the seas off north eastern Australia, shells of *N. macromphalus* are due to long distance drift from New Caledonia, where this species is endemic (Bonacum *et al.* 2011). Shells of *N. macromphalus* have been found along the eastern coast of Australia, from north eastern Queensland to near Sydney (Atlas of Living Australia (ala.org.au) data retrieved Dec 2014, Queensland Museum malacology records) and their distribution is consistent with a westerly drift trajectory due to the South Equatorial Current and drift on either the East Australian Current south along the Queensland coast or the North Queensland Current towards New Guinea.

Ethnographic evidence

Ethnographic evidence can also be used to infer the direction of drift, if the source of objects can be identified with certainty. We focussed on canoes and other large wooden items as we assumed that they would respond to oceanic currents in a similar way to tree trunks. However, the origin of some canoes is not always certain (see below).

A canoe (QME2168) from Point Lookout, Stradbroke Island, South East Queensland and a Kanak door jam or *chambraule* (QME4018) from Lizard Island in north eastern Queensland, have been identified as either Vanuatuan or New Caledonian in origin (QM ethnographic records). Boyd (1999) provided an overview of the drift canoes, than known, that have washed up on the eastern Australian coast and he argued that one found in the Solitary Islands off the northern New South Wales coast was likely to be from Vanuatu. He concluded that the source of canoes, particularly those in South Eastern Queensland and northern New South Wales, was likely to be islands in the western Pacific, indicating westerly drift via the South Equatorial Current.

Many of the canoes found in northern Queensland are, however, assumed to have come from New Guinea to the north. Beaton (1978) noted that dugout canoes are common flotsam on Great Barrier Reef islands and he considered that their likely source, probably based upon geographical proximity, was the islands of the Torres Strait or New Guinea. Canoes have been recorded from the eastern side of Cape York Peninsula at Noah's Beach, Cape Tribulation; Hummock Beach, north of Starcke River, Cape Flattery; Cape Hillsborough; near Bowen; and further south but their provenance and origins are often uncertain (Boyd 1999, QM Ethnographic records).

Dugout canoes are thought to have been introduced from New Guinea through the Torres Strait Aboriginal groups to Cape York communities (Haddon 1913; Thomson 1934; Clarke 2012). Canoes identified as "New Guinean" have also been collected, or noted, from the western side of Cape York Peninsula at Weipa, Kowanyama and Crabbe Island, near the mouth of the Jardine River (Cameron & Cogger 1992; QM Ethnographic records; Patrick Couper pers. comm. 2013). These are more likely to have come from communities either in the Torres Strait Islands or the southern coast of New Guinea. Roth (1910) also claimed that pre 1910, Torres Strait islanders, would travel south down the Great Barrier Reef during the monsoon in summer (November-February) due to the prevailing south westerly winds and return with the south east trade winds during the dry season (April-September). So the occurrence of these water craft in parts of the Torres Strait and northern Cape York may be through drift on oceanic currents but could equally be the result of trade and the movement of people between communities. Identifying the provenance of some dugout canoes can be difficult. Michael Quinnell, Senior Curator of Anthropology, at the Queensland Museum pointed out, in a letter to Mr W Fisher (6 April 1990), Regional Director of the Department of Environment and Heritage that these drift canoes resemble coastal canoes from areas as far apart as Melakula in Vanuatu and the Fly River in Papua New Guinea.

While there are problems in using these ethnographic records, uncritically, the overall evidence suggests a southerly movement of at least some canoes in northern Australia. Evidence of this movement also comes from KKK bleach bottles, identified as originating from New Guinea, which washed up at Archer Point, near Cooktown, in north eastern Queensland (Hinchcliffe & Howley 2009).

DISCUSSION

Evidence for the direction of movement of drift objects washed up on north Queensland beaches comes from: (a) direct observations of their movement by oceanic currents and (b) indirectly through determining, or knowing, the source of geological, zoological, ethnographic and botanical objects. The ability to determine the direction of drift requires that we know both their source and that we apply the principle of Occam's Razor that we use the simplest explanation for the movement of a drift object in preference to a more complex scenario. It is also evident, particularly from ethnographic and geological samples that assumptions about the origins of objects need to be examined critically.

This study demonstrates that where their source can be identified drift objects found on in Cape York Peninsula, have come from several diverse areas including islands in the western Pacific to the east, from New Guinea to the north, and from Indonesia to the west. However, the predominant current affecting north eastern Queensland is the South Equatorial Current which moves in a prevailing westerly direction (Ridgway & Hill 2009). Most of the drift records of pumice and its associated epifauna (Bryan *et al.* 2012), drift shells of *Nautilus macromphalus* and some ethnographic drift objects show western Pacific origins.

The occurrence of a log of *Vatica* sp. (Dipterocarpaceae) in north eastern Australia is interesting because the family is unknown from Australia, New Guinea being the most easterly distribution of this family and therefore the most likely source area. New Guinea also represents the most easterly distribution for other genera, such as *Lithocarpus*. We speculate that the *Vatica*

sp. log came from New Guinea, which is the closest source area for these trees. Anecdotal records indicate that large (unidentified) trees, are washed down the Fly River and have been recorded 30 km, out to sea, at Bramble Cay, south of the river's delta (Jeffries 2015). This supports Smith's (1994) suggestion that disseminules of *Lithocarpus* spp., and probably *Inocarpus fagifer* and *Excoecaria indica*, are from the Fly and other large rivers flowing into the Gulf of Papua. These disseminules are washed into the Gulf of Papua Current and surface currents and seasonal south westerly winds move them away from New Guinea, towards Australia. The prevailing Southern Equatorial Current may also have led to the log being washed onto the northern coast of Australia (Schiller et al. 2008). A similar southerly drift trajectory is also evident for ethnographic objects such as canoes and bleach bottles.

Drift logs occur commonly on the North Queensland coast are also important as a raft and habitat for other species. For instance, living colonies of non-Australian termites (Isoptera: Blattodea) have been found in beach-washed logs on Cape York Peninsula (James Walker pers. obs. 2014). The likely origin of these termites is yet to be determined and they may have come from the Pacific Islands to the east, or New Guinea to the north but they have not yet become established in Australia (James Walker pers. obs. 2014).

We suggest that seasonal factors, determine, in part the patterns of drift and therefore the movement of objects onto this part of the Queensland Coast. Understanding drift patterns is important because the drift of animals or plant disseminules have the potential to result in dispersal events and hence the colonisation of new geographic localities. While the *Vatica* log does not demonstrate successful colonisation, it, along with *Lithocarpus* fruits does provide evidence of a southerly drift of objects between New Guinea and north east Queensland.

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