A device used and some methods practised by Tamil mariners in the mid-19th century: notes of Harry Congreve, Madras Infantry, 1850

Anantanarayanan Raman

An article entitled 'A brief notice of some contrivances practiced by the native mariners of the Coromandel coast, in navigating, sailing, and repairing vessels' by a Madras-based British military engineer Harry Congreve is available in the Madras Journal of Literature and Science (1850). In this article, Congreve refers to 'ra-p-palakai' a miniature version of the device known as 'kamãl' and 'al-ḳaśãbã' (Arabic) and 'tábua da Índia' and 'tavoleta náuticas' (Portuguese), which was introduced by Arab mariners into southern India in the 9th–10th centuries. Congreve qualifies the ra-p-palakai as 'ingenious', probably because of its smallness and simplicity in relation to the kamãl of the Arabs. Additionally, he briefly speaks of the methods employed by Tamil mariners of the Coromandel coast to measure the rate of sailing, assess the direction of the ocean-surface currents, evaluate sites suitable for docking a vessel and how the vessel was undocked. Except for the assessment of the direction of the surface currents using a moist ball of ash, the other methods seem to have been transmitted by European mariners who came to the Coromandel coast. Congreve's article offers interesting peeks into some of the creative practices – although of rudimentary science – of the Tamil mariners in the 1840s.

Marine fishing was widely practiced along the *c.* 1000 km long Coromandel coast in the past (note 1): from Pazhavérkãdû (Pûlicãt, 13°42′N, 80°32′E) to Kanyãkumãri (Cape Comorin, 8°08′N, 77°55′E) of the erstwhile Madras presidency[1]. Kôrkai (8°38′N, 78°4′E, Thôthû-k-kûdi district), for example, was a busy pearl- and chank-fishing centre and a commercial port during the reign of the Pãndiyã kings of the Sangam period (3rd century BC – 3rd century AD)[2]. Catamarans were commonly used on the Coromandel coast for marine fishing in ancient times (note 2; Figure 1). Open boats, also known as 'sewn-plank boats' and masûlã-s, well-suited to the rough surf of the Bay of Bengal, are known to have been in use for the past 300 years[3] (note 2; Figure 1).

With Madras (Chennai, 13°04′N, 80°16′E) growing as a vibrant city in the 18th and 19th centuries, the English East-India Company (EEIC) found it hard to bring ships transporting humans and cargo to Madras because of shallow waters and rough coastal surf. The incoming and outgoing ships were, therefore, parked nearly a mile (1.6 km) away. Humans and cargo were moved to and from the shore in the masûlã-s[4]. For detailed remarks on masûlã-s, referred as 'ôdam' (Tamil, Malayalam), see Varadarajan[5].

Figure 1. Catamarans and masula boats on the Madras beach. India-ink artwork by George Chinnery (*c.* 1810) (source: http://collections.rmg.co.uk/collections/objects/113126.html; accessed on 10 November 2020).

James Hornell (Director of Fisheries, Government of Madras, 1920s) refers to catamarans and masûlã-s in the Coromandel in the 1920s (ref. 6, p. 8):

> 'Northward of Point Calimere (Kôdiakkarai, 10°17′N, 79°51′E) is the real home of the catamaran, a truly Indian type, specialized for use upon the surf-beaten Coromandel and northern Telugu coasts where the catamaran and masula boat must continue to hold their own wherever there be no harbours of refuge, such as Madras and Cocanada (Kãkinãdã, 16°57′N, 82°15′E).'

Mapping the Coromandel, 16th–17th centuries

Today we use sophisticated GIS, e.g. the Electronic Chart Display and Information System (ECDIS), to obtain accurate details of seascapes and landscapes (International Maritime Organization, London, UK; https://www.imo.org/en/OurWork/Safety/Navigation/Pages/Charts.aspx, accessed on 28 February 2021). However, equipped with relatively primitive devices, e.g. lead line, quadrant, sextant and astrolabe, admirable cartography of the world was achieved as early as the 16th century. Near-accurate maps of the East Indies (note 3) became available in the 16th century, coinciding with many European nations colonizing parts of South and Southeast Asia. António Galvão (Antonio Galvãno, 1490–1557), a Portuguese soldier and administrator of the Maluku Islands (the Moluccas), has made

Figure 2. India by Philipp Clüver in *Indiae Orientalis et Insularum Adiacentium Antiqua et Nova Descriptio* (*Antique and New Descriptions of the East Indies and Adjacent Islands*) (source: ref. 20). Pulicate (Pûlicãt, Pazhavérkãdû) north of the present Chennai, 'Meliapore' (Mylapore) and S Thome (Santhomé) in the present Chennai are indicated on the Coromandel coast.

several maps of the East Indies[7]. A map of peninsular India by Hendricus Hondius in the *Atlas Sive Cosmographicae Meditationes de Fabrica Mundi et Fabricati Figura* is an elegant example[8]. A map of the Coromandel of the mid-17th century by Philipp Clüver includes some of the key landmarks, such as Mylapore (indicated as Meliapore), Pulicat (Pulicãte) and Santhomé (S Thome) of modern Madras[9] (Figure 2). A map of the Coromandel by the French cartographer Jean Baptiste Bourguignon d'Anville (1697–1782), published in 1788, is yet another marvellous example (Figure 3).

In such a captivating maritime context of the southern segments of the Coromandel, an article by Harry Congreve[10] entitled 'A brief notice of some contrivances practiced by the native mariners of the Coromandel coast, in navigating, sailing, and repairing vessels' impresses. The present note refers to his article published in the *Madras Journal of Literature and Science* (*MJLS*) in 1850, which refers to a device used and a few methods practised by Tamil sailors in the 1840s.

Congreve's notes

The little we know of Congreve (note 4) was that he joined the Madras Army (Artillery, Infantry Division) as a Second Lieutenant in 1830 and was promoted to Full Lieutenant in April 1834 (ref. 11). He was brevetted as Lieutenant Colonel in the 1860s. He published a few papers in engineering, further to the one discussed here. In later years, he explored the anthropology and antiquaries of the Nilgiris (11°4′N, 76°7′E). Possibly he lived in the Nilgiris for some time before he returned to Britain. Congreve seems to have published a paper entitled 'The cairns of the Nilgiris', which is not traceable. A partial list of his publications could be mustered:

Congreve, H.

1843. Improved chain shot. *Art. Rec.*, **7**, 507–508.
1843. New Martello tower. *Art. Rec.*, **7**, 508–509.
1844. Some observations on a remarkable cromlech near Pullicondah in the Carnatic. *MJLS*, **13**, 47–51.
1847. The antiquity of the Neilgherry Hills, including an inquiry into the descent of the Thautawars or Todas. *MJLS*, **14**, 77–146.

1861. Remarks on the druidic antiquities of the south of India. *MJLS* (*New Ser.*), **12**, 205–212.

In the *MJLS* paper[10], Congreve refers to a device used by the Coromandel mariners to ascertain latitudes, while being off coast. He qualifies it as 'ingenious'. He also describes how the Tamil mariners ensured the rate of sailing, assessed the direction of the ocean-surface current, evaluated the sites suitable for docking a vessel and considered undocking a vessel.

An 'ingenious' device to ascertain latitudes

Congreve[10] mentions a device used by the Coromandel mariners when they were out of soundings (Figure 4; note 5). This device was a 3″ × 1½″ (7.62 × 3.81 cm) wooden board with an 18″ (45.72 cm)-long string hanging from its midpoint. The string included knots that referred to the previously observed and recorded locations (ports) along the Coromandel coast. The person using this device held the board with the longer side upward in his left hand. The board was then adjusted by moving forward and backward, to align with the vision of the person using the board 'until its upright length corresponded with or covered the space between the polar star and the horizon' (ref. 10, p. 102). With the right hand, the person holding the board brought the string close to his nose and knotted it at that point. At this point, Congreve (ref. 10, p. 120) mentions:

> 'If he (the person using the board) then was close to Point Palmiras (Point Palmyras; see Box 1 for details), an undeviating index is afforded, which, in future, would show that person whenever he was off that point. The North Star's elevation being always fixed, and therefore, all the parts of the triangle formed his line of sight, the string, and the distance between the polar star and the horizon, and or the length of the board, equally as constant.'

The knots on the string determining every identified location enabled a future mariner to ascertain that location with reasonable accuracy anywhere between Calcutta and south-point of Ceylon (Sri Lanka) (Box 1).

Figure. 3. The Coromandel by Jean Baptiste Bourguignon d'Anville (1788) pitched on the meridian of Pondichéry (at 48 × 34 cm crossover). (Source: https://earthworks.stanford.edu/catalog/70cd4aab-4f1a-416b-807c-e998a7e142ad, accessed on 17 October 2020.)

Methods to assess the speed of sailing, direction of water current, docking and undocking

The rate of speed of sailing was measured by flinging a piece of wood into the sea. The mariner who flung the piece of wood would walk towards the ship's stern, keeping pace with the floating wood. The speed of the vessel was deemed equal to the mariner's rate of walking.

The direction of the current was assessed by flinging a ball of ash kneaded with water. As this ash ball sank, it disintegrated and wafted in the water, leaving a long and broad trail. This trail was observed by the sailor on the deck of the ship and the direction of the current was inferred.

When a vessel was to be docked, she was floated into a wet dock, referred to as a 'basin' (note 5). Once docked, the entrance to the basin was manually closed with a mud embankment. Water level in the dock harbouring the vessel was raised until the vessel was at a considerably greater level than the level of the sea or the passage through which the vessel entered the wet dock. After stabilizing the vessel, water was drained and two large wooden beams were placed under the vessel in such a way that they rested on the drained bottom. Long mud shores were quickly laid parallel to the parked vessel, enabling disembarkation of the occupants.

To undock a vessel four thick ropes, each coiled like a cone were used. One cone of rope was placed under the starboard bilge (spelt as 'bulge' by Congreve, note 5) forward and another under the starboard bilge aft. The third and the fourth were placed at corresponding positions on the larboard side. These four rope cones were intended to support the ship, which was

Box 1. Ports listed in the article by Harry Congreve (Figure 4 *b*) and their present details.

Point Palmiras:	Palmyras Point (Point Palmyras, 20°45′N, 87°05′E), Brahmani River mouth, Kendrapara district, Odisha.
Ganjam Palloor:	Palur (12°76′N, 79°91′E) near the Ruśikulya River, Ganjam district, Odisha. A popular port since the 2nd century AD.
Chintapilly:	Chintapalli (18°07′N, 83°65′E), Visakãpatnam district, Andhra Pradesh. Houses the Sanatapalli lighthouse.
Godavery Coringa:	Kôrangi island (previously Hope Island, 16°48′N, 82°14′E), East Godavari district, Andhra Pradesh. Presently the popular Coringa Mangrove and Wildlife Sanctuary, well known for populations of *Prionailurus viverrinus* (Carnivora: Felidae; fishing cat), *Canis aureus* (Carnivora: Canidae; golden jackal), *Lepidochelys olivacea* (Reptilia: Cheloniidae; Olive Ridley turtle), and *Crocodylus porosus* (Reptilia: Crocadyliidae, salt-water crocodile).
Narsapore Point:	Narsapûram, Narsapûr (16°43′N, 81°70′E), West Godavari district, Andhra Pradesh. The Portuguese established a factory (trading post) here in the 16th century. The Dutch arrived here in 1626. Timber (e.g. teak, *Tectona grandis*, Lamiaceae) and chintz (fine-quality cotton fabric) were exported from here.
Chippullany Point Devi:	False Divi Point (15°46′N, 81°0′E), Krishna river mouth, Machilipatnam district, Andhra Pradesh.
Ramapattam:	Rãmayyapatnam (15°05′N, 80°04′E), Prakãsam district, Andhra Pradesh.
Pannar:	Pennã river mouth (14°58′N, 80°14′E), closest village is Ûtûkûrû, Nellore district, Andhra Pradesh.
Madras:	Chennai (13°04′N, 80°16′E), artificial port, Chennai district, Tamil Nadu.
Pondicherry:	Pûdûchérry (11°55′N, 79°49′E), the headquarters where the Governor-General of France resided during the French colony days.
Nagapatam:	Nãgapattinam (10°77′N, 79°83′E), Nãgapattinam district, Tamil Nadu.
Point Calymere:	Point Calimere, Kôdia-k-karai (10°29′N, 79°87′E), Nãgapattinam district, Tamil Nadu.
Trincomalee:	Trikûṇāmaḷaya (8°59′N, 81°20′E), Trincomalee district, Eastern Province, Sri Lanka. Tamils maintained cultural and trade relations by entering Sri Lanka via Trincomalee, known as Go-kanna, in the 6th–13th centuries.

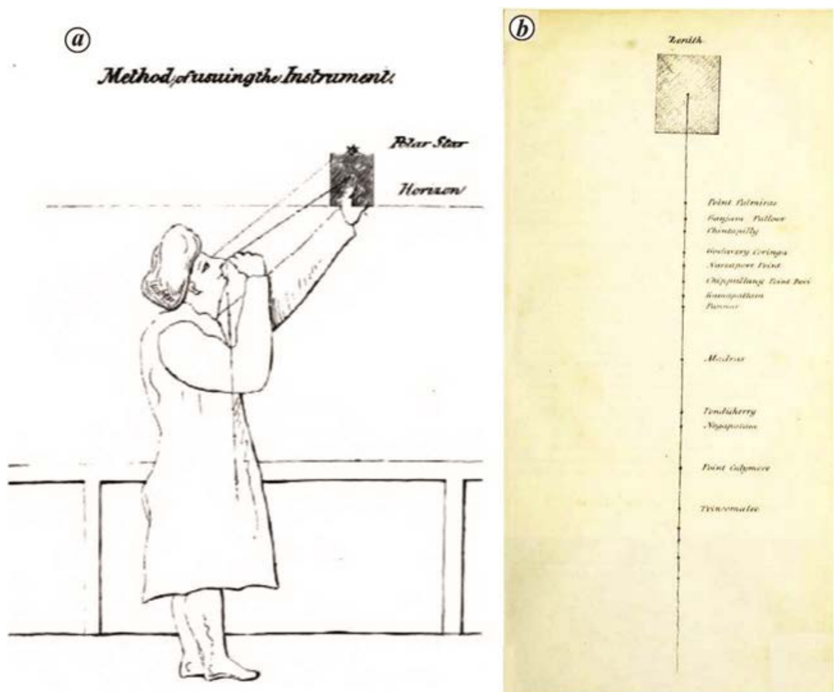

Figure 4. ***a***, Illustration in the article by Harry Congreve[10] depicting the use of an ingenious device by a Coromandel mariner to measure latitudes. ***b***, Knots on the cord matching with ports along the Coromandel coast. Box 1 provides the current names of the identified ports and their respective coordinates.

then gradually lowered by withdrawing the rope.

Remarks

Coromandel mariners' seafaring activity, 1700s–1900s

The EEIC administration in the Madras Presidency saw the services of local masûlã-s as vital because no harbour existed in Madras until the later years of the 1850s (note 6). Native boatmen were valued for their navigation skills by the incoming foreign sailors, especially as the latter approached Madras. The British administrators in Madras used the services of the Indian boatmen as pilots to guide and navigate their large ships, the *East Indiamen*, for instance (ref. 12, pp. 38, 39):

> 'They (British seamen) did the best they could with their astrolabes and cross-staffs, but they lacked the perfection of the modern sextant. The most they could hope for was to make a land-fall not too distant from where

they wanted to get, and then, having picked up the land, keep it aboard as far as possible. Thus they would approach their destined port, by means of parleying with one of the native craft, they might persuade one of the crew to come aboard and so pilot them in.'

The masûlã-s were used to bring the newly arriving foreign passengers into town, and to move cargo (e.g. saltpetre, opium, indigo, textiles, cotton and grains). These were also useful in moving troops and horses to larger vessels that transported them from one town to another along the coast. By sheer acquaintance, the local boatmen knew the patterns and behaviours of the Bay of Bengal well. Trading privileges and custom-duty exemptions liberally offered to Muslim, Parsi, Jew and Armenian merchants by the British in Madras, Bombay, Calcutta, French in Pondichéry, and the Dutch in Pûlicât and Nãgapattinam, enticed the merchants to migrate and settle in those towns. They exported goods to and imported from overseas, such as Borneo, Sulawesi, and Java islands of the Indonesian Archipelago. Several of those merchants owned large boats and vessels, manned by Indian crew (Figure 5). In their vessels, the Coromandel merchants usually transported merchandise, and occasionally humans, from one coastal town to another (e.g. from Madras to Machilipatnam)[13]. Porto Novo (Parangipéttai, 11°29′N, 79°46′E), for instance, was a busy port, exporting and importing commodities to and from Calcutta and overseas locations such as Acéh (Indonesia), Kédãh, Mélãccã (Malaysia) and Lisbon (Portugal) in 1729–1740 (ref. 14). Native merchant vessels sailed from the Coromandel ports to overseas destinations, touching ports on the Coromandel coast en route (ref. 14, p. 109):

'A ship owner at Madras would have his vessel sailing from San Thome to Malacca via Porto Novo. Similarly, the Achnese merchant Baba Talim's (…) Coromandel bound ship would first sail to Ganjam, from where it would come to Porto Novo (Parangipettai). While sailing back, it would go via Pondicherry and thus make a round trip. … Another ship, belonging to the French private merchant Dutertre, coming from Batavia (Jakarta), came first to Nagore, then to Tranquebar (Tarangampadi) and then to Porto Novo. It sailed back via Pondicherry.'

Figure 5. Large boats with rolled sails and a catamaran (right) manned by southern Indians to transport cargo and occasionally passengers in the Bay of Bengal. Artwork captioned 'Küstenfahrer bei Koromandel, Indien, 19 Jahrhundert' (the Boatmen in the Coromandel, India, 1900s) by the German artist and explorer Christopher Rave (1910). (Source: https://www.Ansichtskarten-versand.com/ak/index, accessed 1 February 2021.)

An ingenious device to determine the latitudes – the Kamãl

The 'ingenious' device used by the Coromandel mariners to determine latitudes arouses curiosity. By its function, but not by its appearance and design (note 7), this device reminds us of quadrants used by European mariners from the 15th century. The device referred to by Congreve was the kamãl, which the Arab mariners used from the medieval period[15] (Figure 6; note 8). Ahmad ibn-Mãjid (1432–1500), a navigator–sailor of the Omani kingdom and his Yéméni protégé Sidi-Ali al-Mãhri (1480–1550) were acquainted with using the kamãl decades before Vasco da Gama (Portuguese explorer, sailor, 1460–1524) travelled to Kôzhikôde (11°25′N, 75°77′E)[16]. In some of the older publications 'al-ķaśãbã' (Arabic, a wooden board) meant the kamãl[17]. The Portuguese, while in India at the end of the 15th century, called this device tábua da Índia (tablet of India) and tavoleta náuticas (navigation tablet)[18]. In the Tamil and Malayalam segments of the 16th century-India, kamãl was referred as rã-p-palakai (note 9)[19,20]. Vasco da Gama, during his first trip to India in 1497–1499, stopped at Melinde (presently, Malindi, 3°13′S, 40°7′E). The ruler of Melinde provided the services of ibn-Madjid – a Malindian navigator proficient in using the kamãl – to Vasco da Gama, enabling him to reach India[21] (note 10).

Figure 6. Kamãl used by Arab mariners until the 1900s. The cross-staff evolved from this (source: https://exploration.marinersmuseum.org/object/kamal/, accessed on 10 January 2021).

The kamãl used by medieval Arabs was made of a rectangular wooden board (12″ × 9″ (30 × 22 cm), 1″–2″ thick (2.5–5 cm)) with a long cord passing through its midpoint. The cord included knots at intervals along its length. These knots implied the latitudes of the previously determined ports, as they were relevant to the sailor sailing in a particular landscape[21]. The cord was divided into 16 equal divisions, each an isba (note 11). As a sailor left the port, he (no female sailor was known at that point in time) usually sailed either southward or northward until he knew the latitude of the port of his destination with the help of the kamãl before changing the course, either eastward or westward. The sailor clenched one of the knots towards the free end of the cord between his teeth and held the kamãl vertically on his fully stretched arm and viewed the Pole Star through the pinhole, aligning it with the horizon (ref. 22, figure 14, p. 32). The angle between the horizon and the Pole Star was considered equal (θ). As the cord passed through the midpoint of the kamãl, the board naturally got divided into two equal parts (h). The length of the board gave the altitude of the Pole Star from the horizon. The distance of the observer's knot hold between his teeth and the board was another reckoned factor (α). Figuratively, this would form an isosceles triangle. Therefore, by applying the equation $\alpha = h \times \cot \theta$, the latitude was determined. Stepwise calculations made using this device are available in Polat[17]. Sailors usually knew the nautical distances for ports from the North to the South, by corresponding them to finger widths on the cord. By measuring the altitude of the Pole Star, they also knew the sailed distance. The kamãl, however, had drawbacks: (i) it was reliable only for measuring small angles; as the angle widened, it was less helpful; (ii) as the Pole Star became closer to the horizon in tropical longitudes, the kamãl was useless[23]. Today the kamãl is used in marine kayaking to estimate distances to land at mid-sea[24].

David Berson, an American sailor and navigation instructor, comments thus on the kamãl (https://www.oceannavigator.com/arab-navigators-used-a-kamal-to-find-latitude/2003, accessed on 11 January 2021; 2003):

> 'Since the Pole star is several degrees from the celestial pole, some correction must be made to get an accurate latitude; it isn't known how Arab navigators made this correction. Twice in each revolution, the pole star stands at the altitude of the celestial pole, and these points can be determined by noting the position of Kochab (note 12) and its fellow star at the dipper end of the little dipper (these stars were called "the guards" by Europeans). A rule based on this relationship was taught to European sailors in the late 15th century, but it's not known if Arab navigators knew of it. … Col. Warren Davis, a celestial navigator and sailor (note 12), has used many ancient tools for navigation on passages. It is his belief that the Arab navigators would have had a small collection of kamals, each one properly labeled and with its string knotted for the labeled port or headland. He questions whether the kamal was actually constructed by mathematical plan or design. "I believe", he writes, "that the mariners, in the course of their apprenticeship, visited many ports. At each port they could make a kamal and mark it to the right knotted string length by actual observation." '

Shylaja (astronomer), while reviewing the present manuscript, commented (pers. commun., 6 March 2021):

> 'Possibly the knots were specifically designed to match the latitudes of different ports along the West Coast of India. This worked well for the northern segments of the coast since the visibility of Pole Star from south of 10°N (Kerala and Tamil Nadu) is poor. This supports the observation by David Berson. I also thought of another practical application of this device. The fishermen were familiar with three bright stars on the southern horizon. These stars had no names but were recognised as the first, second, and the third. The altitudes of these stars above the horizon could be measured with this device, which incidentally provided a measure of time. For example the second (of the three) bright star Canopus or Agastyã is on the meridian at midnight in December. Therefore this star was also called Jesu natchatram (the star of Jesus).'

The Arabs frequented the coasts of present-day Kerala, Tamil Nadu and southern Andhra Pradesh, seeking spices and pearls in the 7th–11th centuries[25]. Their visits and stay in southern India enabled sharing and transmission of many aspects of their culture and technology with the southern Indians[26]. One example of a simple but brilliant technology transmitted by the Arabs to Indians is the water crane (shaduf), originally from ancient Egypt[27]. The medieval Arabs possessed high-quality navigation skills because of their brilliant understanding of the

Figure 7. A double-reflecting quadrant (DRQ) developed by John Hadley (1731), the predecessor of the modern sextant. Also known as an octant because of its 45° arc. The DRQ included mirrors to align the sun and/or other celestial objects with the horizon. It was useful in star sightings, and therefore advantageous in marine navigation. It was popular until the mid-19th century (source: ref. 49).

oceans[28]. For example, they produced 'precise' maps; they developed the él-huqqa – a magnetic compass[29]. Transmission of the skills of Arab navigation science and use of the kamãl to southern Indian seafarers, especially those in Malabar (note 13), must have occurred in the 9th–10th centuries.

Gunter's, Hadley's, Davis's and Elton's quadrants were widely used by European mariners in the 18th and early decades of the 19th centuries to determine latitudes during sailing[30]. By viewing the Pole Star through a pinhole, the quadrants enabled the determination of latitudes by measuring the angle between the horizon and the Pole Star, a technique also used in the kamãl (Figure 7). As a trained engineer, Congreve should have known of the better-performing and more-precise quadrants of that time. The use of the term 'ingenious' by Congreve could be in the context of the size of the rã-p-palakai. The kamãl used by the Arabs was large, measuring 30 × 22 cm, with a long cord, whereas the rã-p-palakai used by the Coromandel mariners in the 1850s was a smaller device, measuring 8 × 4 cm and with a much shorter cord. In terms of performance, the rã-p-palakai was as efficient as the kamãl and was widely used by the Coromandel mariners. From the 9th–10th centuries, the southern Indian mariners must have learnt to miniaturize the kamãl, while retaining its efficiency, similar to the revolution created by the miniaturized portable-radio receivers applying transistor-based circuitry in the audio industry in the 1950s (ref. 31).

Measurement of sailing speed

The European mariners of the early decades of the 15th century gauged the speed of their ships by flinging a specially made wood piece – the Dutchman's log (for an illustration, see https://webspace.science.uu.nl/~gent0113/holmbox/holmbox.htm, accessed on 2 February 2021; note 14) – into the sea from the bow of the vessel. The English sailors pioneered the use of this log[32]. Time, measured either by rhythmical counting of numbers – equalling seconds of time – or by measuring with a hand-held hour glass as the vessel moved past the flung Dutchman's log over a specific distance – from the bow to the stern – enabled the mariners to measure the speed of the vessel. The use of the Dutchman's log did not factor the force of either wind or sea currents in relation to the position of the vessel. The vessel speed was calculated using the elementary formula: distance/time = speed. The Dutchman's log got improved as the chip log in the 16th century[33].

The Dutch, who colonized Pûlicãt (Pazhavérkãdû, 13°42′N, 80°32′E) in 1610, should have introduced the Dutchman's log to the Coromandel mariners, although no concrete evidence is available. Between AD 1225 and 1275, Arab traders transporting 'tin' (Sn) from Malaya stopped in Pûlicãt[34]. However, no records indicate that they either knew the Dutchman's log or introduced it to the Tamil mariners. This device was probably introduced to the southern Indian mariners by the Dutch, who controlled this region until 1825 (https://dutchindianheritage.net/pulicat-palliacatta/, accessed on 19 January 2021). Pûlicãt was a popular port in the 16th and 17th centuries. Approximately 4500 European ships had docked in Pûlicãt for commerce, including the slave trade (https://dutchindianheritage.net/2020/06/04/pulicat-dutchshipped-indian-slaves-from-here/, accessed on 19 January 2021). Similar to simplifying the kamãl, the Coromandel mariners may have simplified the science of the Dutchman's log and modified the practice using throwing a random piece of wooden board into the sea, yet maintaining the science of measuring distance from the bow to the stern of the boat by foot. The floating board used for measuring speed in the Tamil-speaking segments of the Coromandel was known as Mitappû-p-palakai (Ŧa-p-palakai in spoken Tamil) (K. R. A. Narasiah, pers. commun., 23 February 2021).

Assessment of surface water movements and currents

Ocean currents – however mild their effect would be at the surface – and trade winds were the key elements factored in by the mariners, especially in sail-bearing ships. In the later decades of the 20th century, mechanical sensors came into use. Presently, we have progressed to using electromagnetic, acoustic and optical sensors. However, in the 18th and 19th centuries, Indian traders sailed to Africa exploiting the northeast monsoon winds in cool and dry winter months and returned availing the southwest monsoon in the hot and wet summer months[35]. The sailors operating sail-bearing ships knew how to evaluate the trade winds and ocean currents and used them to their advantage. The European sailors of the 18th and 19th centuries used tightly sealed glass bottles – the 'drift bottles' – partly filled with dry sand and floated them on the sea surface to estimate the horizontal movements of water, viz. the sea-surface currents[36] (note 15). A reliable estimate of the mid-sea surface current could be obtained from the set and drift calculated from the difference between the dead reckoning position and true position of a ship. This method was practised widely in the 1830s–1900s. By the mid-18th century, more accurate pilot charts and maps became available with the invention of the chronometer by the British horologist John Harrison in 1735, the sextant by the British naval officer John Campbell in 1757 and publication of the *Nautical Almanac and Astronomical Ephemeris* in 1766. Although the drift-bottle method was well known among the European sailors of the 18th and 19th centuries, the Coromandel sailors used a method to assess ocean-surface currents neither known to nor practised by the European and other regional mariners. The Coromandel mariners flung a ball of ash kneaded with water, and assessed the surface current based on how the ash disintegrated and dispersed on the water surface. It was an extremely crude method, yet it helped the Coromandel mariners evaluate the surface water current.

Docking and undocking

Docking ships in the Coromandel, as described by Congreve, was a well-known practice almost throughout the civilized world: generally referred to as dry-docking and the docks known as either dry or graving docks. A basin of water was necessary to float the vessel into the dock. Graving docks (note 16) usually involved the docking of small vessels (5–10 m long)[37]. Nonetheless, the Chinese are known to have docked *c.* 60 m-long vessels in the 10th century[38]. With larger vessels, because the carpenters and machinists were required to inspect the hull needing repair, construction of temporary basins for the vessels on land became a standard practice (Figure 8)[39]. The practice of launching a ship into a basin, followed by adding wooden beams to support the vessel after draining water, is supposed to have been developed by a Phoenician of the 3rd century BC Egypt[40]. Congreve's reference to the docking process in the Coromandel indicates that he was referring to ships – larger than the masûlã-s – owned and used by Tamil traders and merchants, because such boats were physically dragged onto the sandy beach (Figure 1). The process of docking, determinable as 'dry docking' practised in the Coromandel in the 1840s, must have been introduced by the Europeans. The likely reason is that no reference to a 'dockyard' occurs in medieval Tamil literature, although the term 'turai' implying a boat jetty does exist (note 17).

Conclusion

Harry Congreve's four-page note on the ingenious device – the kamãl – and a few navigation practices of the Tamil mariners of the Coromandel coast in the mid-19th century offers not only an interesting read, but also unveils many dimensions of the 'science' they practised. Although the manner in which they measured latitudes while navigating ships and large boats in the Bay of Bengal appears unrefined, such practices obviously worked for them. Otherwise, Congreve – a trained British engineer – would not have referred to the latitude-assessing device, the simplified and miniaturized kamãl, as ingenious. However, what needs to be reckoned with is that the simplified and miniaturized kamãl used by the Coromandel mariners of the 1840s was known and used in southern India earlier than that time. The other methods to measure the rate of sailing and how they executed docking and undocking a vessel could have been introduced into the Tamil country either by the newly arrived Portuguese, Dutch or the Danes, who arrived in the Coromandel a little earlier than the English, because these methods show parallels with the practices of the European mariners of that time. Nevertheless, the assessment of the speed of the surface currents by flinging an ash ball kneaded with water and observing its dispersal from the deck impresses a locally developed method, however unsophisticated it could

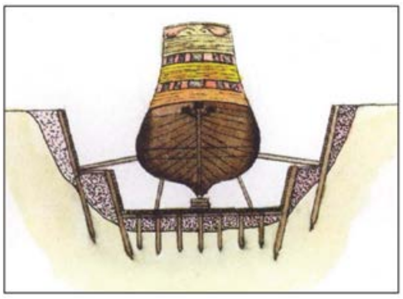

Figure 8. Dry docking, vertical sectional view. (Source: *History 1495–1690*, Portsmouth Royal Dockyard Historical Trust, UK; https://portsmouthdockyard.org.uk, accessed on 12 Februry 2021.) For details, see Barker[50].

be, compared with ocean surface current measurement methods of the then Europe.

K. R. A. Narasiah offered the following remark (pers. commun., 23 February 2021):

> 'The Tamils did not use a rudder for steering, instead they used a steering oar. This is because they never sailed across latitudes, but sailed only parallel between latitudes (parallel sailing). To effect parallel sailing, they used a drop board in the centre of the ship, which maintained the vessel sailing in a straight line. They always sailed due east–west and therefore required much steering. The only time they did rhumb-line sailing was when they were to cross the latitudes. Mostly they remained close to the coast and could reckon their bearings from visible coastal landmarks.'

The details presented by Congreve refer to the mid-19th century. Nevertheless, thinking of how the *Pallava*-s (6th–9th centuries) and *Çôlã*-s (10th–12th centuries) of the Tamil country launched and navigated their pãi-mara-k-kappal (sail boats) to foreign lands (e.g. *Gô-karnã*, presently Trincomalee, 8°34′N, 81°14′E, Sri Lanka) and Kadaram (presently Kadatuan Sriwijayã, Langkawi Archipelago, 6°21′N, 99°48′E), assessing the behaviour of the seas they crossed, indeed leaves us baffled.

Notes

1. The term 'Coromandel' is a Portuguese corruption of the Tamil term 'Çôla Mandalam' (≈ Çôlã-s' landscape). The Portuguese first established a 'factory' (≈ a trading post) in Pûlicãt (*c*. 50 km north of Madras) in the Coromandel in 1502.
2. The term 'kattu-maram' [Tamil] meant wooden rafts tethered with a rope. Large-power transport yachts are presently known as 'catamarans', an English corruption of 'kattu-maram' (shortened as 'cats'). *Masûlã* boats, 8–9 m long, have been used by the Tamil fisherfolk for well over the past 300 years. Masûlã in some of the old literature is spelt 'masûlãh' and 'masoolã(h)'. The origin of masûlã is possibly in the late 17th century; the on-line UK dictionary *Lexico* explains that the origin of the term 'masûlã' is uncertain and has arisen perhaps from mãslī (Marathi, Konkani), which means fish via Telugu and Tamil pronunciations (https://www.lexico.com/definition/masula, powered by the Oxford University Press, accessed on 28 April 2022). Another possibility is that such boats in the early days were built using the wood of *Chloroxylon swietenia* (Rutaceae), which was called masûlã in Kannada (see 'Plants for a future'; https://pfaf.org/user/Plant.aspx?LatinName=Chloroxylon+swietenia, accessed on 28 April 2022). In the Coromandel coast, a masûlã boat is built using mango-tree planks sewn together with coir ropes, but prominently with no ribs. Masûlã-s serviced the areas with neither harbours nor boat jetties. Similar boats were used in the other parts of the Coromandel: the padava in the Telugu-speaking parts and 'bar' boats in the Oriya-speaking parts[5]. A masûlã could transport 40–60 tonnes of load. Identically constructed marine-capable boats were used by the medieval-period Persians and Arabs (ref. 41, p. 165, figures 46 and 47).
3. 'East Indies': India, Indonesian Islands, Malay Archipelago, and mainland Southeast Asia.
4. That the Lieutenant Colonel (Brev.) Congreve was 'Harry Congreve' (vide *The Edinburgh Gazette*, 27 June 1872, p. 1114) and not 'Henry Congreve' as cited in many old publications.
5. Out of soundings: The offshore area beyond the 100-fathom line, usually too deep to be fathomed by a hand sounding line[42]. Basin: A wet dock; also applied to a portion of a tide-harbour. Usually characterized by a narrow entrance forming an inner sheltered harbour. Bilge: A part of a vessel's bottom, which begins to round upwards at the point where the floors and second futtocks unite, and whereon the ship would rest if laid on the ground. Aft: The rear of the stern of a vessel. Starboard: The right side of a vessel as one looks towards the bow. Larboard: The left side of a vessel as one looks towards the bow.
6. The Madras harbour was developed in the 1850s. One pier to berth vessels was constructed upon request made by the Madras Chamber of Commerce and Industry[43]. Today the Madras port (Chennai port) is the second largest and busiest port in India, equipped with 24 deep-drafted berths (https://www.chennaiport.gov.in/content/milestones, accessed on 3 January 2021). Most of the ships were built in India in Hooghly in the 19th century. Madras was not a popular ship-building dockyard[44].
7. Compare Figures 4 *a* and 7.
8. The Mãppilã Mûslims (Môplãh-s) of Malappuram district (11°04′N, 76°08′E), Kerala, are considered the descendants of Medieval Arabs[45]. The marakkãr-s of Kerala and marakkãyar-s of Tamil Nadu are committed sailors and boat-builders[46]. A feature film 'Marakkãr – Arabikadalinté Simham' (Marakkãr – the Lion of the Arabian Sea) by Priyadarshan Soman Nair celebrates the life of the heroic Malayalee sailor Mohammad Ali Kûnjãli Marakkãr of the 16th century.
9. Rã-p-palakai: Rã – 'wee hours' of the day, when Venus would be visible; palakai – a wooden board (currently implies any display board). Etymologically here 'ra' implies its use in present-day Malayalam, wherein it means early morning. 'Ra' presently means night (iravû) in Tamil.
10. D. P. Agrawal (n.d.) indicates that Vasco da Gama used the services of an Indian ship-pilot Kanhã, who was versatile in using the kamãl to reach India (http://www.indianscience.org/essays/15-%20E-Navigation%-20&%20Math.pdf, accessed on 6 February 2021).
11. Medieval Arab navigators divided the circumference of a circle into 224 isba-s, in such a way that each compass point measured seven isba-s, whereas the European equivalent was 11¼°. One isba therefore was 1°36′25″ in European measurement; 5 isba-s = 8 degrees[47].
12. Kochab – *Beta Ursae Minoris*. The brightest star in the bowl of the Little Dipper asterism. The use of kochab for obtaining the latitude was popular in northern latitudes, demonstrated by a device known as the *ḍruvabharama yantrã*. Since the visibility of the pole star itself becomes poor, its upper culmination and alignment with kochab is practically irrelevant in the south (B. S. Shylaja, pers. commun., 6 March 2021). Warren P. Davis (1915–2003) was an American soldier who taught navigation after retiring from the US Army.
13. Malabar: The southwestern coastline and the adjacent inland area of peninsular India stretching from Kôdagû (12°25′N, 75°44′E) to Calicut (Kôzhikôde, 11°15′N, 75°46′E).
14. Dutchman's log was also known as the 'tobacco box' since it was also used to store tobacco[48].
15. Release of 2000 drift bottles into the sea by C. Hunter Brown in 1914 was a trailblazing experiment. Also, the work of Edward C. Carmack, Canadian oceanographer (https://www.dfompo.gc.ca/science/data-donnees/driftbottles-bouteillesflottantes/index-eng.html, accessed on 10 February 2021) is pertinent here.
16. 'Graving' means cleaning of the hull, viz. removal of barnacles and rust and, if necessary, repainting the hull. Modern graving docks include a narrow basin constructed with concrete beams and are closed with either gates or a caisson. When open, a vessel is floated in and the water pumped out, leaving the vessel standing on concrete beams. A graving dock is one form of a dry dock, practised even today, e.g. Hughes and Merewether dry docks in Mumbai.
17. From 'turai' (Tamil) the term 'turaimûgam' referring to a harbour evolved in later years. Venkatesan Prakash (l'Institut Française de Pondichéry, Puducherry) clarified that the term 'mûgam' means a 'place', 'location' and not as in 'mûkam' (Sanskrit) meaning 'face'; the term 'turaimûgam' occurs in the *Silap-p-adikãram* commentary made by Adiyãrkû-Nallãr (12th or 13th century AD).

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Anantanarayanan Raman is in CSIRO, Underwood Avenue, Floreat Park, WA 6014 and Charles Sturt University, PO Box 883, Orange, NSW 2800, Australia.
e-mail: Anantanarayanan.Raman@csiro.au; *araman@csu.edu.au*

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