I
BRIEF HISTORY

A little over five hundred years ago, Vasco da Gama, having rounded the cape, was creeping along the African coast, full of imaginary fears about the motives behind traditional African hospitality. Equally, he was afraid to strike out across the "uncharted" deep sea. Ultimately he accepted the advice to do just that if he wanted to proceed towards the land of spices. But he needed a pilot to bring him from Africa to India so that he could "discover" India. There is a controversy whether the pilot who brought Vasco da Gama from Melinde to Kozikhode (Calicut) was an Arab (the legendary Ibn Mājid) or a "Guzerati Moor", Malemo Cana, as earlier accounts called him.[1] (Vasco da Gama himself did not mention any nationality, for the obvious reason that he was unaware of Gujarat, and simply thought of all Muslims as Moors.) Tibbets[2] believes the latter is likely since Indians lack any sense of national identity. While agreeing with Tibbets' conclusion, and without needing to deny his irrelevant observation (which applies equally to Europeans), the connection between observation and conclusion is nevertheless far fetched, for the Arabs then tended to regard the Portuguese as barbarians. As is amply clear from the organized arrangements for traders that Vasco da Gama encountered in Calicut, sea trade between India, Arabs, Africa, and China was at that time carried out in a peaceful and honourable way.

In any case, everyone agrees that the pilot[3] (*Muālīm*, or *Mālmī*, or "Malemo") of that fateful voyage used the *kamāl*, a copy of which the mystified Vasco da Gama carried back with him. Vasco da Gama thought the pilot told the distance with his teeth! How did the pilot manage to do that?

Kamāl means complete, so *kamāl* denotes a complete instrument. *Rā* means night as in *rātri*, while *palagai* (usually spelt *palaka*) means a block of wood or instrument, so that *rāpalagai* means a night instrument.

It is now generally agreed that, during Vasco da Gama's time, the boat-building and navigational techniques existing in the Arabian Sea and the Indian Ocean were superior to those possessed by the Europeans. The Arabs then ridiculed the European method of using charts.[4] But things changed. According to Tibbets, by the mid-nineteenth century, pilots in the Arabian sea had abandoned the *kamāl* for the sextant. However, the navigational needs of the Lakshadweep islanders (excluding Minicoy) were limited to travel to the mainland and back. They travelled for barter, and not for commerce or adventure. So the Lakshadweep islanders continued using the *kamāl*, and shifted to the *kamān* (sextant) later.

In 1923, R. H. Ellis, a British officer, inspected the islands. He recommended[5] that schools should teach a course on modern navigation. The recommendation was intended to make the British government and its institutions more popular with the islanders. Eventually, a textbook called *Nāvik Shāstram* written in Malayalam, was published in 1939, and teaching of modern navigational techniques commenced at Amini. Today, no Amini islander recollects seeing the *rāpalagai* in use. I spoke to two of the oldest Amini-based navigators, Syed Bukhari (b. 1929), and Ahmed Pallechetta (also around 70 years at that time), who too learnt from Syed Bukhari's father; both used *Nāvik Shāstram* and "Noorie tables".

As regards the Arabic-sounding "Noorie", it should be clarified that the reference is to *Norie's Nautical Tables*, a book first published by Capt. James Norie, in 1803, which has remained in print continuously since then, though it has undergone numerous revisions. The enormous success of the book presumably enabled Capt. Norie to acquire a stake in a publishing company, which now publishes the tables. The Norie tables in the present *Rehmani* of Kunhi Kunhi Maestry of Kavaratti refer to the declination tables for the sun from the 1864 edition of *Norie's Tables*, which he consulted from the Kavaratti library. However, the idea of using solar altitude and declination to determine latitude is detailed in numerous Indian and Arabic astronomy books from the 5th century CE onwards. So this idea was already very much a part of the navigational traditions prevalent in the Indian ocean—but the sources have changed.

Contrary to what one might expect, *a priori*, the navigational traditions vary substantially between the islands: a knowledgeable navigator at Kavaratti may be quite unable to explain an instrument such as the *kolpalagai* used in Bitra. Similarly, though the Amini *mālmi*-s were quite unfamiliar with the *rāpalagai*, it was the Kiltan *mālmi*-s who were most knowledgeable about it. (The distance between Kiltan and Amini is around 30 km: Amini is adjacent to Kadmath, and there is a point in the sea between Kiltan and Kadmath from which one can simultaneously see both islands. Mr Abdullah Koya of Kiltan was able to supply us with a copy of the Arabic literature on the construction of the *kolpalagai*.)

Mr Ali Koya of Kiltan had a *kamāl* which he discarded for he had no use for it. Mr Harris, also of Kiltan, kindly constructed a model, but could not explain how the instrument was calibrated. The most knowledgeable person was Kazi Sirāj Koya of Kiltan. He could not offhand recollect the calculations used to calibrate the instrument, but referred to a book containing the calculations. Though Dr C. H. Koya had a copy of the book in Arabic-Malayalam he was unable to translate it for us.

Ultimately, a model of the *kamāl* was obtained from Mr Aboo Backer of Kavaratti, who had preserved it along with the *kamān* used by his father Mr Ahmed Malmi of Kavaratti.

The *rāpalagai* is clearly a lost tradition. None of the *malmī*-s I talked to, in the various islands, was able to explain the construction or use of the *rāpalagai*. One took the smaller piece in his mouth, and raised the knots above the block, as one might do with finger measurements. One divided the string into eight equal parts, but was unable to explain how to add five more equal parts he thought would be needed for Kavaratti at a lower latitude. One thought that the instrument was used to measure the speed of the boat in knots. One remembered only snatches of some mnemonic verses related to the *rāpalagai*.

The Accuracy of the Kamāl

> I certainly imagined that nothing could be more primitive than my Maldive friend's *kamāl*..., when lo! here is something even less advanced in ingenuity!
>
> James Prinsep[9]

To express this accuracy in modern terms, we proceed as follows. A glance at Table 5.1 and Fig. 5.2 shows that the bigger piece has a range from

$$\tan^{-1}\frac{36.5}{21.9375 \times 25.4} = 3.747^\circ \tag{5.12}$$

to

$$\tan^{-1}\frac{36.5}{6.0 \times 25.4} = 13.45^\circ. \tag{5.13}$$

A 90° increase in the elevation of the pole star corresponds to the distance from the equator to the pole, i.e., $\frac{1}{4}$ of the earth's circumference, calculated using the polar radius. Thus, a 1° increase in the angular elevation of the pole star corresponds to $\frac{1}{360}$ of the polar circumference of the earth. This differs very slightly from the equatorial circumference, and using either gives us a figure of approximately around 69 English miles. This gives a total range of around 670 miles. Since this range has been divided into 12 equal parts, each knot of the *kamāl* corresponds to an average distance of around 55 miles. Thus, each knot of the *kamāl* represented approximately half a finger increase in the elevation of the pole star, so that the constant F_0, used earlier, corresponds approximately to 4 fingers. The larger piece was, thus, suitable for travel from Mahaladwipa (Maldives) to Mangalore.

The larger piece of the *kamāl* is also extremely precise at the local level. Thus, using the two scales together with the larger piece gives an accuracy which is five times better, so that the *kamāl* could actually be used to measure distances as small as some 11 miles, or better than one *shāmam* which is quite extraordinary. In practical terms, this accuracy meant that the *kamāl* could be used to navigate to a point within sighting distance of the target.

Such a level of accuracy was indeed needed to sail to small islands. Thus, 19th c. CE English sailing manuals mention the difficulty in navigating to small islands, and suggest that a good way to this would be to run into the latitude, and then adopt a course due east or west. If this sort of thing were to be done, an accuracy of better than one *shāmam* (the distance to the horizon) would be needed to ensure that one did not sail past the island without spotting it.

In terms of angular measure, if we regard the range of around 9.7° as divided into 12 equal parts, each knot measures an angle of around 0.8° or 48′. If the two scales are used together, the precision is improved by a factor of 5, so that the precision is around 10′ of the arc.

Similar considerations apply to the smaller piece which covers a range from

$$\tan^{-1}\frac{32.7}{2.625\times 25.4} = 26.168^\circ \tag{5.14}$$

to

$$\tan^{-1}\frac{32.7}{17.375\times 25.4} = 4.237^\circ \tag{5.15}$$

divided into 8 knots, with each knot corresponding to 2.75° or around 189 (English) miles. The use of both scales would enable this instrument to do 5 times better and measure distances of around 40 miles. (If we use the figure $\frac{5}{24}$, the two scales together could do only 3 times better, so that last figure would be only around 63 miles.)

Note that the total range of the instrument is a little above 1500 miles north–south. The upper end of this scale corresponds to the latitude of Karachi. Thus, the instrument reflects the fact that at higher latitudes (after crossing the latitude of Mangalore, say), a very high level of accuracy was no longer critical since the coastline was near. This applied also to the eastern side, where sailors from Minicoy typically travelled as far as Singapore.

Thus, in totality, the *kamāl* is a remarkable instrument with a huge overall range of 1500 miles, together with a striking accuracy of 11 miles at the lower end of the range. The construction of the *kamāl* also shows how instruments can be built from simple materials to measure angles with an accuracy of 10′.

Clearly, it was James Prinsep who lacked the ingenuity needed to understand the construction of the instrument. Moreover, carried away by his sense of racist superiority he failed to exercise common sense and ask how the island-based navigators could have routinely managed to sail back to small islands with inaccurate techniques of navigation. It is also noticeable that since Prinsep's article was first published in 1836,[10] Western histories of the subject have simply repeated his account.

The Two-Scale Principle and the Size of the Earth

The use of the two-scale principle suggests how al Bīrūnī could well have constructed an accurate instrument for measuring angles, to measure the dip of the horizon, and hence estimate the size of the globe, as he recorded. This answers a question, raised by S. S. H. Rizvi,[11] as to the accuracy of al Bīrūnī's hand-made instrument. Rizvi speculated that al Bīrūnī's hand-made instrument could well have had an accuracy of 1° for him to have arrived at as accurate an estimate as he did. The *kamāl* shows how higher precision *by nearly an order of magnitude* is easily possible for a hand-made instrument. The reason for Rizvi's extra-conservative estimate is obviously a false history of science which wrongly suggests to us that this two-scale technique was invented by Vernier, though it has been known to Europe from at least the times of Pedro Nunes (who also used it in an instrument to measure angles).

Instrumental Accuracy and the Accuracy of Trigonometric Values

Such accurate instruments for angle measurements probably first came into widespread use with the rise of Arabic navigation, sometime between Brahmagupta and Vaṭeśvara, and that would explain very clearly why Vaṭeśvara found Brahmagupta's sine table very gross, and needed to alter it to a more precise sine table with stored values at intervals of $56' 15''$, together with a second-order procedure for interpolation. In fact, since the accuracy of the instrument is about ten times better, this would also explain very clearly why even Vaṭeśvara's sine values would have been found to be "too gross" by later authors, who would have needed even more accurate sine values, together with higher order interpolation procedures.

By the end of the 18th c. Europeans had picked up a lead in navigation. Just as the Arabs had earlier made fun of the European method of navigating by charts, the European now started ridiculing the "little pieces of wood and string" used by the Arabs. We see that "little pieces of wood and string" that the Europeans made fun of can make a formidable navigational instrument that can be used to determine latitude and longitude, especially when combined with an advanced knowledge of trigonometry (calculus), and the ability to carry out mental calculations. What the British actually achieved by teaching navigation in the Lakshadweep islands was to destroy the indigenous knowledge, without replacing it with something particularly better. On the contrary, whether deliberately or otherwise, what the British really succeeded in doing was to destroy the self-sufficiency of the islanders, and to make their way of life dependent on imported instruments and books manufactured in far away lands.

III
LONGITUDE DETERMINATION

While the *kamāl* is a very accurate instrument for measuring north–south distances, it does not enable the measurement of east–west distance. The Lakshadweep islands (barring Minicoy) are very small coral islands, and accurately navigating to small islands is a difficult matter, which requires the sort of precision that was not easily available to late 19th c. European navigators, as already noted.

Traditional Indian Methods of Longitude Determination

Therefore, it is worth recollecting the several traditional methods which enabled precise angle measurements, coupled with precise trigonometric values, to be used also in connection with the measurement of longitude at sea.

First, we recall that the principle of time varying with longitude was well known to Āryabhaṭa (*Gola* 13):

> When it is sunrise at Lanka, it is sunset at Siddhapura, midday at Yavakoti, and midnight at Romaka.

The four names refer to four equidistant imaginary cardinal points on the equator, with Lanka being the point at which the Indian prime meridian (Meridian of Ujjayinī) met the equator.

Secondly, the stock technique for determining longitude on land was to use the time difference between the local time of an eclipse and its calculated time on the prime meridian (*LaghuBhāskarīya*, I.29)

> The difference between the computed and observed times of an eclipse is the longitude in terms of time.

Thirdly, we recollect Bhāskara I's method of determining longitude by the method of ephemeris, using a water clock (*Mahā Bhāskarīya*, II.8):

> On any day calculate the longitude of the Sun and the Moon for sunrise or sunset without applying the longitude correction, and therefrom find the time (since sunrise or sunset), in *ghatīs*, of rising or setting of the Moon; and having done this, note the corresponding time in *ghatīs* from the water clock. From the difference, knowledgeable astronomers can calculate the local longitude in time.

Fourthly, we recall Bhāskara I's method of solving a plane "longitude" triangle (*Mahā Bhāskarīya* II.3–4):

> Subtract the degrees of the latitude of . . . [a known point on the prime meridian] from the degrees of the [local] latitude, then multiply [the resulting difference of latitude] by 3299 minus 8/25 [the radius of the earth], and divide [the result] by the number of degrees in a circle [i.e., 360]. The resulting *yojana*-s constitute the *koṭī* [upright of the right-angled "longitude" triangle]. The oblique distance from the local place [to the point on the prime meridian chosen above], which is known. . . is the *karṇa* [hypotenuse]. The square root of the difference between the square of the *karṇa* [hypotenuse] and the *koṭī* [upright] is defined by some astronomers to be the distance [in *yojana*-s of the local place to the prime meridian].

We also recollect from Chapter 4 that the above Indian method uses the radius of the earth, or equivalently a knowledge of the distance per degree latitude, a, so that it is perfectly possible to solve the longitude triangle from a knowledge of the difference of latitude l and the course angle C, to obtain the departure p:

$$p = a \times l \times \tan C. \tag{5.16}$$

Furthermore, we recall that this Indian technique, available from before the 5th c., was *not* available to European navigators in the 16th and 17th c. CE, for the reason that Europeans lacked a precise knowledge of the size of the earth until the end of the 17th c. CE.

Finally, we recall that, knowing the size of the earth, it was an easy matter to convert distance from the prime meridian to longitude, and it was only necessary to invert a rule explicitly stated by Bhāskara I (*Laghu Bhāskarīya*, I.32), relating this distance to longitude:

> The *yojanas* (of the distance of the prime meridian) from the local place are obtained on multiplying the longitude in *ghatīs* by the local circumference of the Earth and dividing (the product) by 60.

Some Clarifications

The method of determining longitude/departures by solving a plane triangle was known to Arab navigators as a *tirfa* calculation. However, the examples of actual *tirfa* calculations given by Tibbets are rather crude, suggesting that Arab navigators were unaware of elementary plane geometry in the 16th century CE, and did not even know that two sides of a triangle are greater than the third.

Such historical depictions tend to raise a doubt. As we shall see later on, the real question is whether the slightest credibility is to be attached to Western accounts of history. For the time being, however, let us address this doubt. Could the techniques in the *Laghu Bhaskariya* have diffused to the islanders over a period of several centuries? Could the islanders have known about Mādhava's more precise sine tables? Clearly it would be inappropriate to assume that the average navigator was as knowledgeable as Bhāskara or al Bīrūnī. It would be equally inappropriate to assume that the average navigator on the Indian ocean or Arabian sea was as unskilled in astronomy and mathematics as Columbus or Vasco da Gama. There are two reasons for this.

First, navigational techniques here placed far greater reliance on celestial navigation. Unlike Columbus, therefore, Indian, Arabic, or Chinese navigators had to have *some* knowledge of astronomy. A modern-day analogy may help to explain the cultural difference: a semi-literate carpenter in India today is likely to be better at mental computations than a cash-register operator at a US supermarket, who has never done arithmetic without the aid of machine or paper. However, colonial historians found it galling to admit that the average navigator by the stars knew more than their own star navigators. How much knowledge of astronomy a navigator might have had, naturally depended on his competence, but given that his own life and the lives of many others depended on his knowledge, it would be a rare navigator who did not seek to expand his knowledge by acquiring at least the knowledge incorporated in the most popular texts in astronomy. Such a navigator is unlikely to have been much sought after.

Secondly, because of the monsoons, a navigator here could earn a living from navigation for at most some six months in a year. What did he do the rest of the time? Clearly, some, at least, of the navigators would have done exactly what Kepler did: use their knowledge of astronomy to make a living through astrology; others may have turned their attention to tasks such as calendar-making, etc. For this purpose too they would have had to consult the basic texts in astronomy. So it would hardly be too much to attribute to the average navigator the knowledge available in concise practical manuals of astronomy, such as the *Laghu Bhaskarīya* or the *KaranaPaddhati*, for the reason that

> both the *Maha-Bhāskarīya* and the *Laghu-Bhāskarīya* were popular works, having been studied in south India up to the end of the fifteenth century..., the latter being an excellent text-book for beginners in astronomy.[12]

To summarize, there is a difference between the knowledge required to derive and correct the rules, and the knowledge required simply to use these rules. One must attribute to the pre-colonial navigators at least the latter type of knowledge of astronomy.

On the Lakshadweep islands, Kunhi Kunhi Malmi, of Kavaratti for instance, made a living partly through astrology. His preoccupations are reflected in the fact that more than 50% of his *Rahmani* (released at the 10th Indo Portuguese Conference on History, INSA, New Delhi, 1998) is concerned with astrology. (Indeed Kunhi Kunhi made a good living and had two wives—as astonishing a thing in a matriarchal society as a woman with two husbands would be in a patriarchal society, and a definite indication of prosperity.) For the relatively simple needs of the Lakshadweep islanders, of course, spherical trigonometry was not required, and the solution in plane triangles, as in Fig. 5.3, was adequate.

Since some of the concerned texts, incorporating the requisite precise trigonometric values, are in Malayalam, in Kerala itself they enjoyed considerable circulation, as evidenced, for example, from the large number of copies of Jyeṣṭadeva's *Yuktibhāsā* which are still in existence, and the *KaraṇaPaddhati*, whose encapsulated rules continue to be very popular. (The relevant verses are also in the *KaraṇaPaddhati*.[13]) So why should the relevant sine values not have been known at least to some knowledgeable navigators on the island who knew something of the astronomical tradition in Kerala?

It is true that the islanders, like the Māpilā-s, spoke Arabic-Malayalam, and it is possible that they were hence regarded as illiterate by both Arabs and Malayalis! None of the *malmī*-s I spoke to was much educated in the Western tradition, but that did not prevent any of them from knowing about Norie's tables. Why, then, should the earlier *malmī*-s not have known about Mādhava's tables? The *tirfa* calculation done using these tables would indeed have made the *kamāl* a complete instrument which could be used to decide both latitude and transverse position at sea.

Thus, the name *kamāl* (= complete) was justified, since the instrument could be used across a wide range, was very accurate for navigation to small islands, and it was possible also to determine longitude at sea from a knowledge of the difference of latitudes.

Currently-Used Techniques of Longitude Determination

As opposed to this situation prevalent with traditional knowledge, currently the islanders use two techniques for longitude determination.

A watch (chronometer) is one technique used today by the islanders to decide longitude (though the figure commonly stated was 5 minutes per degree of longitude).

The principle behind using a watch to determine longitude is straightforward, and well known to all international travellers. Because of the diurnal rotation of the earth, as one travels east, one gains time—the sun seems to rise earlier. Consider an accurate watch set to local Bombay time, i.e., its hands read 12 o'clock when it is noon (the time of the shortest shadow) at Bombay. If this watch is carried to Calcutta, noon at Calcutta will seem a little early. In a complete circuit of 360° round the earth, the watch will appear to gain or lose 24 hours = 24×60 minutes, so that the watch will gain or lose 4 minutes per degree longitude.

The other technique the islanders currently use is a sand clock (*tappu kuppī*, lit. sand bottle) of 7 or 14 s and a log line (with the rope knotted at equal distances) to measure the speed of the boat. The speed of the boat can be used to calculate the distance travelled in a known period of time: this technique is known to be notoriously inaccurate. From a knowledge of the speed, and the duration for which the speed was maintained, one calculates the distance travelled. The course angle is known through a magnetic or stellar compass. Hence, the departure can be computed by resolving the problem into the solution of a plane triangle, as in Fig. 5.3 reproduced from Chapter 4. The solution itself was obtained using traverse tables from British sailing manuals.

IV
THE VALUE OF BRITISH EDUCATION

The islanders have evidently learnt this technique from the British efforts to "educate" them, as described earlier. This enables us to assess the value of British education in a microcosm. This is useful because, compared to mathematics education, which we will consider later on, the issues involved here are relatively simple.

First, the process of navigational education itself was initiated based on certain historical premises. It is worthwhile examining these historical premises: while distorted historical depictions of navigation history like that of Tibbets are amusing for the trained historian, the dissemination of false historical narratives at the popular level has had significantly mischievous political consequences.

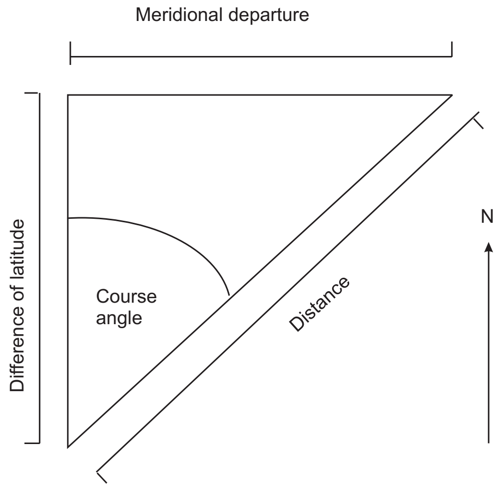

Figure 5.3: **Solving the nautical triangle.** The right-angled triangle shown above, also called the plane sailing triangle, can be solved from a knowledge of either (1) course angle and distance travelled, or (2) course angle and the difference of latitude. The first method was used by Europeans in dead-reckoning navigation. The second method requires an accurate estimate of the size of the earth: such an estimate was available to Indians from at least the 5th c. and Arabs from at least the 9th c. CE, but not to Europeans until the late 17th c. CE. Hence, European navigators could not use the second method. This is what led to the famous problem of determining longitude at sea—a problem specific to European techniques of navigation.

According to the grand historical narrative, the British were a great superpower, on account of their knowledge of navigation, while the islanders were "primitive" people, who lacked a knowledge of navigation. This sort of account of the "natives" is found most clearly in novels like *Coral Island* by R. M. Ballantyne.

Swept away by such fake historical narratives within which they situated themselves, the British seem not to have stopped to think how the islanders had survived if they did not have reliable techniques of navigation. This survival had a history going back to at least pre-Islamic times, considering that there are statues of the Buddha on the islands, which were subsequently defaced. Though these statues have not been dated to my knowledge, they could quite possibly go back a long time in the past. In fact, navigation no doubt existed also in the era when Ashoka's daughter, Sanghamitra, travelled to the island of Sri Lanka. At any rate the Lakshadweep islands were inhabited for over a thousand years before the British came to them. During all this period, how did the islanders solve the problem of navigating to small islands? (Recall that this was recognized as a difficult navigational problem by 19th c. CE British sailing manuals.)

Apparently, swept away by the military power of the British, the islanders too did not stop to think about it either, and the youth seem to have assumed that the navigation techniques taught to them by the British were intrinsically superior, just as youth today thoughtless tend to accept that Western ways are intrinsically superior. The point is that the islanders seem to have adopted the British techniques of navigation in a somewhat thoughtless way, and without having made a relative assessment of the two systems, just as youth today might adopt Western music in preference to Indian classical music without a clear understanding of the two systems. Although a technique of navigation is more directly relevant to survival than music, that the islanders' choice was not informed by any such relative assessment is confirmed by the fact that none of the islanders was able to tell me about the functioning of the *kamāl*.

The process of British education changed things in two significant ways. First, the islanders were taught about the sextant (*kamān*), but not about the *kamāl*, and as a direct consequence of this training they abandoned the *kamāl* in favour of the sextant. While stone sextants were used in Arab astronomical observatories from the 10th c. CE, the portable sextants used in navigation are made of steel. Since steel was not something they could make themselves, the islanders became dependent on far-off British engineering for their very survival. Merely to purchase appropriate instruments they would have needed to sail as far off as Bombay, and those who were most closely linked to the British were the one's best able to survive.

What advantages the sextant (*kamān*) had over the *kamāl* was obviously not discussed in the British text either, and the *kamāl* was never mentioned, just because the historical narrative in which the British situated themselves, assured them that the progress brought about by the march of science had made their knowledge superior to that of the "primitive" tribes of the world.

However, the sad fact is that the sextants actually used by the islanders typically had an accuracy of about 1°, and hence were a lot LESS accurate than the *kamāl*. Thus, the British, smug about their own superior techniques of navigation, ultimately ended up educating the islanders in inferior techniques of navigation! Noticeably, there was no colonial plot here, except an attempt to try and make the British empire more popular!

It is also a sad fact that the determination of longitude by using a sand clock and heaving the log also made the situation worse for the islanders: since the islanders did not rely on charts in the manner of the British, did not really use dead reckoning, and had no particular use for loxodromes, since they did not intend to sail to Europe by means of charts. The islanders would have done better by persisting with the traditional techniques of using ephemeris time or solving the longitude triangle in the manner of the *Laghu Bhāskarīya*, but they were taught instead the use of traverse tables as in British sailing manuals.

That the islanders became dependent also upon British sailing manuals is clear from the "Noorie" tables in the Rahmani of Kunhi Kunhi Koya. There was no way anyone on the island could have produced such tables. Thus, the islanders became consumers of knowledge that they could not themselves produce or even properly understand.

Thus British education systematically created a situation of dependency and inferiority as regards both knowledge and education. While the islanders could not earlier match

British violence and duplicity, this was not necessarily a matter of inferiority. From an ethical perspective this made them superior rather than inferior. However, after being educated by the British, the islanders actually became inferior, since their livelihood, which required navigational aids, became dependent upon the British, reducing them to a state of servility. Since the islanders never received enough education to make them producers of knowledge, they remained passive consumers of knowledge. Thus, education, instead of serving the purpose of liberation, became a means of bondage. Like a self-fulfilling prophecy, the fake historical narrative was thus turned into a distressing reality.

A Revised History of the European Longitude Problem

A brief examination of the actual sequence of historical events is also worthwhile, for our later purposes of understanding transmissions and diffusion from an epistemic perspective.

This dead-reckoning method was used extensively by early European navigators, who plotted the ship's course on charts to carry out the computation graphically. However, the method of estimating the ship's speed by "heaving the log" was well known to be extremely unreliable.

Early Portuguese navigators, however, had no alternative to dead reckoning, since they had not quite learnt the techniques of celestial navigation from the Arabs. In using the *kamāl*, the knots are counted by keeping the string between one's teeth; hence the name *kau* (=teeth) for the pole star. Vasco da Gama's men thought that the pilot (Malemo Cana) was telling the distance by his teeth!

Vasco da Gama carried back a copy of the instrument "to have it graduated in inches",[14] suggesting that he did not understand the difference between a linear scale and a harmonic scale. In fact, Europeans seem never to have quite understood the principle of harmonic interpolation used in the *kamāl*.

By the mid-16th century, the Portuguese had learnt some techniques of celestial navigation. What they learnt was, however, so inadequate compared to the tremendous economic importance of correct navigation, that in 1567 Philip II of Spain offered a big reward to anyone who could produce an accurate method of navigating at sea. One difficulty concerned latitude. From the time of Brahmagupta and the Sind-Hind tradition, it was known that latitude could be determined from solar altitude and declination (or the transits of circumpolar stars). The Europeans, however, had difficulties with this method, since they relied on an inaccurate ritual calendar that was partially corrected only in 1582. (Due to religious quarrels between Protestants and Catholics, even the corrected calendar was not uniformly adopted in all of Europe—Isaac Newton believed he was born on Christmas day, while many parts of Europe had already celebrated the New Year a few days before his birth.)