Southeast Asian Traditional Astronomy at the Crossroads:

Local Original Astronomy and the influence of China, India, the Islamic World and the West

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Abstract

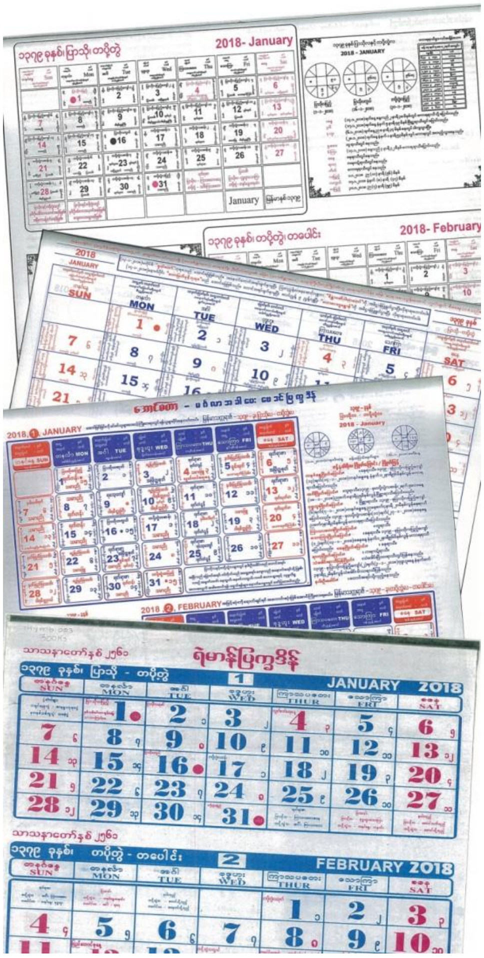
Southeast Asia has their tradition of astronomy which was formed from their original local astronomical knowledge with Chinese, Indian, Islamic, Western influences etc. In this paper, I would like to make an overview of astronomical tradition in Mainland Southeast Asia and Insular Southeast Asia, and their foreign elements. Vietnamese astronomy was largely influenced by Chinese astronomy. Other area of Mainland Southeast Asia was influenced by Chinese astronomy and Indian astronomy, and the influence of Indian astronomy is large. Insular Southeast Asia was mainly influenced by Indian astronomy and Islamic astronomy. As Southeast astronomy has its special feature, it is necessary to compare with the foreign astronomy carefully. We shall see some examples of multiplex astronomy in Southeast Asia. This paper is a revised version of my papers presented at the Ao Nang meeting (2015) and Mandalay meeting (2017).

I. Introduction

There are several traditional calendars in Asia. In some regions, traditional calendar is used for traditional festivals etc. till now.

For example, there are several Thai traditional calendars which are popular till now (Fig.1). And also, I could get some Burmese calendars at a bookshop in Mandalay at the time of the Mandalay meeting, where Burmese traditional dates are also mentioned (Fig.2).

[Fig.1, Modern Thai traditional calendars (author's collection).]



[Fig.2, Modern Burmese calendars (author's collection).]

There are several traditional festivals in Thailand and Myanmar, such as “Songkrān” in Thailand which corresponds to “Thingyan” in Myanmar; “Lōy Krathong” in Thailand which corresponds to “Tazaungdaing” festival in Myanmar, etc. (For Thai festivals, see Gerson (1996), Kajiwara (2013) etc.)

The “Songkrān” is originally a Sanskrit word “saṅkrānti” which means the Sun’s entrance to a sign of the zodiac. The famous Thai festival “Songkrān” is the Sun’s entrance to the sign Aries, that is the vernal equinox. However, the “Songkrān” is celebrated during 13 – 15 April in present Thailand, because Indian sidereal year is used in traditional Thai calendar.

According to Ma Thanegi (2014, p.51), Burmese New Year falls on the 17 April, and “Thingyan” is celebrated for five days prior to that date.

The “Lōy Krathong” is the full-moon day of the 12th month of traditional Thai luni-solar calendar.

We shall come back to the relationship between Indian sidereal year and lunar months in the traditional Thai calendar in the section of “some examples of multiplex astronomy” of this paper later.

Asian traditional astronomy at several places have multiplex structure consists of local original astronomical knowledge and the influences of China, India, the Islamic World, the West etc. For example, Tibetan traditional astronomy and related Mongolian astronomy are a kind of multiplex astronomy consists of local knowledge, Indian Classical astronomy, certain information of Islamic calendar and Chinese traditional astronomy. (For Tibetan astronomy, see Ôhashi (2000).) And also, Iran was a kind of crossroads of traditional astronomy, and there are some recent studies (Isahaya (2009), (2013), etc.).

In this paper, we shall see several kinds of multiplex astronomy in Southeast Asia. This paper is a revised version of my papers presented at the meeting “Researching the History of Astronomy in Southeast Asia” at Ao Nang, Krabi, Thailand in 2015 and its continuation meeting at Mandalay, Myanmar in 2017. After the Ao Nang meeting, I also presented an overview of Southeast Asian astronomy in Japanese in Tokyo, and it was published as Ôhashi (2016). And also, after the Mandalay meeting I presented a paper in Japanese at a seminar (Ôhashi (2018)).

II. Overview

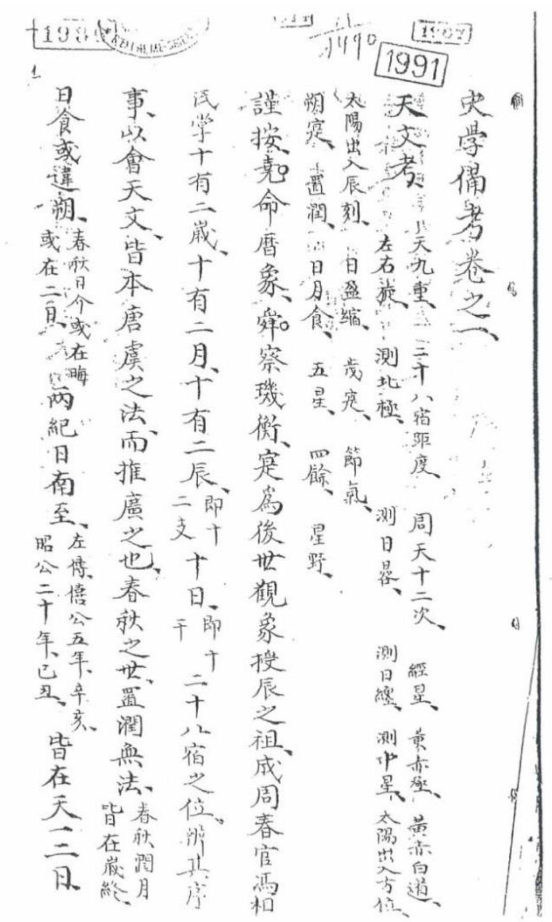
(II.1) Geographical Overview

(II.1.1) Mainland Southeast Asia

The Mainland Southeast Asia can be divided into Vietnam where Chinese influence is strong, and other area where Indian influence is strong. For the history of Mainland Southeast Asian astronomy in general, see Ôhashi (2008).

(II.1.1.1) Vietnam

Chinese classical calendars were introduced into Vietnam. Sometimes, Vietnam used old Chinese calendar even after the revision of calendar in China, and produced certain difference between Vietnam and China. Most of pre-modern Vietnamese works were written in Classical Chinese (Fig.3 is an example of a manuscript of a work on astronomy in Vietnam, in classical Chinese language, (*Thiên-văn khảo* (天文考, Study of astronomy), which is vol.1 of the *Sử-học bị-khảo* (史学備考) of Dặng Văn-phủ (鄧文甫), preserved in the Institute of Sino-Nom Studies, Hanoi).).



[Fig.3, A manuscript of a work on astronomy in Vietnam.]

From around AD 1300 to AD 1812, the Chinese theory of calendar *Shoushi-li* (授時暦) and its successor *Datong-li* (大統暦) were basically used in Vietnam, but it seems that the calculation was done in Vietnam. Even after the *Shixian-li* (時憲暦) was adopted in China, the *Datong-li* was continually used in Vietnam until AD 1812 (Ôhashi (2016a)).

From AD 1813, the *Shixian-li* was adopted in Vietnam. At the time of Emperor Minh-mạng (明命) (reign 1820 - 1840) of Nguyễn dynasty, calendar reformation was done, and it was declared in 1837 that the prime meridian for Vietnam passed through its capital Hue was used, and the longitudinal difference between Beijing and Hue was considered for the calculation of calendar since AD 1841. So, Vietnamese classical calendar differed from Chinese classical calendar since this time (Ôhashi (2004) and (2005)).

After the World War II, before the reunification of Vietnam, North Vietnam decided to use UTC+7 as standard time in 1968, while South Vietnam used UTC+8, which is the same as Chinese standard time. Since the reunification in 1975, UTC+7 has been used. So, Vietnamese traditional new year's day "Tết" sometimes differs from Chinese traditional new year's day. For example, Chinese traditional new year's day in 1985 was 20 Feb., but Vietnamese traditional new year's day was 21 Jan. (Takeuchi (1987)).

There are several works on traditional Vietnamese calendar and astronomy by Lê (2010), Lê and Nguyễn (2017), Okazaki (2017) etc. And also, I could learn many things from the presentation of Lê Thành Lân and Phạm Vũ Lộc at the Mandalay meeting.

Nguyen and Nguyen (2004) report the bamboo stick calendar of the Muong people in Vietnam.

And also, there was a kingdom Champa, which existed in present central and south Vietnam until the 17th century. It was much influenced by Indian culture, and dates in the inscriptions using Śaka Era were mentioned in Indian stile since the 6th century or so. (See Sugimoto (1953).) At present, Cham people (one of the Austronesian peoples), who are said to be the descendants of Champa kingdom, are living in Vietnam, and they have their own calendrical system. (See Nakamura (1999) and (2009), and Yoshimoto (2000), (2003) and (2011), and Sakaya (2016). Also see the section of "some examples of multiplex astronomy" of this paper below.)

(II.1.1.2) Thailand, Laos, Cambodia, Myanmar (Burma) etc.

(II.1.1.2.1) Introduction

Traditional astronomy in this area is a kind of combination of local indigenous astronomy, Chinese influence and Indian influence. For traditional calendars in this area, see Eade (1995). For Indian astronomy in Asian perspective, see Ôhashi (2009) and (2016b).

The Tai (傣, "Dai" in Chinese "pinyin" transliteration) people in Sipsong-panna (西双版纳, "Xishuang-banna" in "pinyin" transliteration) in Yunnan (云南) Province of China is closely related to Thai people, and has traditional astronomical texts. There are detailed studies of the astronomy of Dai people by Zhang and Chen (1981) and Zhang (2013, vol.3).

The traditional culture of Ahom people (one of the Tai peoples) in Assam, India, is also close to this area. For their astronomical knowledge, see Terwiel and Wichasin (1992).

And also, Champa (see above) is culturally close to this area.

(II.1.1.2.2) Thailand

In Thailand, Chinese influence and Indian influence can be seen in an early inscription.

In the inscription of King Ram Khamhaeng of the Sukhothai dynasty of Thailand (see Chamberlain (1991)), a year is mentioned as "In 1214 Śaka, year of the Dragon" (corresponding to AD 1292). Both Indian year (1214 Śaka) and Chinese year (year of the Dragon) are used.

And also, King Lithai of the Sukhothai dynasty wrote the *Trai-phūm (Three Worlds)* (14th century) which describes Buddhist cosmology in detail. (There is an English translation of this work by Reynolds and Reynolds (1982).)

There is a detailed record of culture etc., including traditional astronomy examined and explained by Cassini, of the Ayutthaya dynasty of Thailand made by Loubère (1693). This is the first information of Indianized calendar introduced to Europe.

For the traditional Thai calendar, see Suehiro (1987), Nonaka (1987), Komonjinda et al. (2017) etc. And also, I could discuss with Mr. Vorapon Maison (Thailand) about Thai calendar at the Ao Nang meeting.

Some different eras were used in Thailand. In the Sukhothai inscriptions, Śaka Era, which is called "Mahā-sakkarāt" in Thai, was used, of which the most well known one is that of King Ram Khamhaeng. Its 0th year begins from AD 78 (So, AD – 78/79 = Mahā-sakkarāt). Then, "Junla-sakkarāt", which is the same as Burmese Era, was used from sometime to March of AD 1889. Its 0th year begins from AD 638, (So, AD – 638/639 = Junla-sakkarāt). Until March of AD 1889, luni-solar calendar was used officially in Thailand. From AD 1889, Gregorian calendar has been used, but one year began from April (instead of January) until AD 1940. From April of AD 1889 to March of AD 1912, Rattanakosin Era, or "Rattanakōsin-sok" in Thai, was used. Its 1st year begins from AD 1782 (So, AD – 1781/1782 = Rattanakōsin-sok). From April AD 1912, Buddhist Era, which is called "Phuttha-sakkarāt" has been used. Its 0th year begins from 544 BC (So, AD + 542/543 = Phuttha-sakkarāt). From AD 1941, Thai year begins from January and Phuttha-sakkarāt is commonly used till now (Now, AD + 543 = Phuttha-sakkarāt).

Eade (1996) gives several examples of dated inscriptions and chronicles using Mahā-sakkarāt, Junla-sakkarāt and Phuttha-sakkarāt.

For Thai folk-astronomy, see Phengkaew (2009), Saibejra (2012) and Maison (2013). (I am grateful to Mr. Pisit Nityanant (Thailand) who provided me with Phengkaew (2009) at the time of Ao Nang meeting.) There are some Thai original constellations (See the section of cultural overview below.). Recently, NARIT (National Astronomical Research Institute of Thailand) published a series of books on Thai traditional astronomy in Thai language, namely, Phumphongphaet (2013) for Thai archaeo-astronomy, Maison (2013) for Thai folk-astronomy, and Sawasdee and Maison (2013) for Thai calendrical astronomy.

There was an independent kingdom Lanna in North Thailand from the end of the 13th century to the beginning of the 20th century. The people of Lanna had their own astronomy based on Indian astronomy (Soonthornthum (1998) and (2006)). For the northern Thai calendar, see Davis (1976).

According to Iijima (1971, p.81 and 109), who studied Karen people in north Thailand in 1963~64 and 1964~65, Kalen calendar begins from month Tale (from mid Dec. to mid Jan of Gregorian calendar), and months Teku, Tepe, Lasa, Denya, Lanwe, Laxo, Laku, Chimú, Chicha, Lano and Laplu follow.

And also, Mon people have their own literature including astronomical texts. The Mon language is one of the Austroasiatic languages. When King Mongkut (Rama IV) (reign 1851 – 68) predicted the total solar eclipse in 1968, he used astronomical texts of Siamese, Mon and English. According to Thongchai (1994), King Mongkut used a Mon text *Saram*, one of the two Mon treatises for planetary calculation known in Siam, the other text more conventionally used by astrologers at that time was *Suriyayat*. According to Komonjinda et al. (2017), King Mongkut created the *"Pkakanana"* system of luni-solar calendar following the *Saram*, which is complicated but more accurate than the usual Thai luni-solar calendar which follows the *Suriya-yatra*. According to Komonjinda et al., the *"Pkakanana"* system is now used only in *Dhammayuttika Nikaya*, which is an order of Theravada Buddhism in Thailand.

(II.1.1.2.3) Laos

Lao people are closely related to Thai people. For the traditional Lao luni-solar calendar, see Phetsarath (1940 and 1959) and Dupertuis (1981).

(II.1.1.2.4) Cambodia

There are dated inscriptions using Indian Śaka Era since 7th century AD in Cambodia

(Barth (1885)). There is a well known inscription dated Śaka 605 (=AD 683), which is one of the earliest inscriptions which have numerals with the symbol of "zero" (Cœdès (1931), Aczel (2015) and Hayashi (2018, p.31)).

There is a Chinese record of the Angkor period of Cambodia entitled *Zhenla-fengtuji* (真臘風土記) written by Zhou Daguan (周達觀), who visited Cambodia, which was called "Zhenla" in Chinese at that time, from AD 1296 to 1297. (There are some publications. I have used Zhou (2000).) It has a section of calendar. According to this record, the first month of Cambodian calendar corresponded to the 10th month of Chinese calendar, and called "jiade" (佳徳). This name "jiade" is originated from Sanskrit name "Kārttika". So, we can see that certain Indian calendar had been used in Cambodia.

According to a record of Maspero in the early 20th century (Porée and Maspero (1938)), there were 4 astrologers called "hora" in the Cambodian court, and they made calendar and predicted auspicious time etc.

For the Cambodian astronomy, see Faraut (1910), which is a detailed monograph.

(II.1.1.2.5) Myanmar (Burma)

The Kingdom of Pagan, the earliest kingdom of Burmans, existed in present Myanmar from the mid-11th century to the 13th century. Luce (1969-1970) tells that Pagán became the Buddhist capital of a united Burma, including Mons and Burmans, from about 1060 AD. Luce (1970, Vol.II, pp.327-337) discusses the Old Burma Calendar used in Old Mon and Old Burmese inscriptions dated in Buddhist Era, Śaka Era or Burmese Era.

There are early records of Burmese culture, including cosmology etc., by Sangermano (1833/1893) and Shway Yoe (1882/1910). And also, Leider (2005/06) discusses the function of court astrologers etc. in the Konbaung dynasty (1752 – 1885).

Burma has its own constellations, and their early description is given in Buchanan (1799, pp.195-202), and partially in Khin Zaw (1937). There are some star maps in Burma, among which the most interesting maps are the three star maps drawn on the ceilings of corridors of the Kyauktawgyi Pagoda (built in 1847) at Amarapura (near Mandalay) (See the section of cultural overview below. Also see Nishiyama (1997).)

For the traditional Burmese calendar and astronomy, see Clancey (1906), Irwin (1909), de Silva (1914), Htoon-Chan (1918). (Also see Kiryū (1987).) And also, for the Indian Jovian 12-year cycle in Burmese inscriptions, see Furnivall (1922). In the traditional Burmese calendar, Burmese Era, of which the 0th year begins from AD 638, is used. This Burmese Era corresponds to the "Junla-sakkarāt" of Thai calendar.

Irwin (1909) reports the difference between the Burmese calendar and the Arakanese (Rakhine) calendar in the early 20th century. The Burmese calendar used the

Makaranta, which probably follows the "original *Sūrya-siddhānta*", until the 19th century or so. The *Thandeikta*, which chiefly follows the "present *Sūrya-siddhānta*" and is said to have been composed in about AD 1738 or AD 1838, was used in the Burmese calendar since then. On the contrary, the *Makaranta* was still used by Arakanese.

There are recent studies of Burmese astronomy by Gislèn and Eade (Gislèn and Eade (2014) and Gislèn (2015) and (2018)).

(II.1.2) Insular Southeast Asia

(II.1.2.1) Introduction

The traditional astronomy in Insular Southeast Asia is based on local original astronomical knowledge and Indian and Islamic influences etc.

For Indianized calendar in this area, see Damais (1967), Casparis (1978) and Eade and Gislén (2000). In Java, there are inscriptions dated by Indian Śaka Era from the 8th century (Nakada (1982)). And also, there is an inscription dated Śaka 605 (= AD 683) in Sumatra, which is one of the earliest inscriptions which have numerals with the symbol of "zero" (Cœdès (1931) and Hayashi (2018, p.31)). For Islamic calendar in this area, see Proudfoot (2006). For the astronomy in this area in general, see Maass (1924-1926), Hidayat (2000) and Ammarell (2008).

Apart from later immigrants, indigenous people in this area are sometimes roughly grouped in to the following groups, although they are highly tentative: (1) Australoid (Negrito etc.) (They are said to have been living there from very old time.), (2) Proto-Malay (They are said to have retain traditional culture.), and (3) Malay peoples.

Andaman and Nicobar Islands are belonging to India, but their traditional culture is close to the Insular Southeast Asia. For the astronomical knowledge in Andaman Islands, see Radcliffe-Brown (1933, p.141 – 150). For the astronomical knowledge in Nicobar Islands, see Man (1897).

And also, Austronesian people in Taiwan are culturally close to the Insular Southeast Asia, and there are several records made by Japanese ethnologists in the early 20th century (See Ôhashi (2017).).

We should also consider the cultural relationship between Insular Southeast Asia and other Pacific islands (See Lewis (1994).).

I should also note that I could learn many things about several kinds of local astronomy in Insular Southeast Asia from the delegates from Malaysia, Indonesia and the Philippines at the Ao Nang meeting and Mandalay meeting.

(II.1.2.2) Malay Peninsula

Early records of astronomical knowledge in Malay Peninsula are collected in Skeat (1900, pp.532 – 566). According to this work, the Malay people in the Malay Peninsula use 5-day cycle and 7-day week. The signs of zodiac have Arabic name. One lunar month is divided into days which seem to have originally corresponded to Indian lunar mansions, but their number is usually raised to 30 so as to fit a lunar month. Both the solar year (=tropical year) (365 days) and the lunar year (=12 synodic months) (354 days) are used. For the calculation of Islamic lunar year, 120-year cycle (=1440 synodic months = 42524 days) and 8-year cycle (=96 synodic months = 2835 days) are used. They are usual simplified methods to calculate Islamic lunar years.

In modern Malaysia, there is a controversy regarding Islamic calendar. According to Horii (1987) who studied in Malaysia, some people prefer the actual observation of the crescent moon (*rukyah*) while other people prefer calculation (*kiraan falak*) for the determination of the first day of an Islamic month. For example, Horii reports that in August 1981, Sultans of Perak State and Johor State decided the day of the festival Hari Raya Aidilfitri (the first day of the month Syawal after the end of the month Ramadan) by the actual observation of the crescent moon, and it was one day earlier than the other states of Malaysia.

The indigenous minorities in Malay Peninsula are called "Orang Asli". They consist of "Semang" (Negrito), "Senoi" (speaking Austroasiatic languages), and Proto-Malay peoples. Their culture is described in Skeat and Blagden (1906). According to this work, a Proto-Malay people denote seasons by north and south monsoons, and also harvest of rice and ripeness of fruits. They know time by the inclination of a stick directed to the sun. (Skeat and Blagden (1906), vol.I, p.393.) Semang peoples think that the sun and the moon are female, and each has a husband. The stars are the moon's children. The eclipses are attempts of a gigantic serpent or dragon to enfold or swallow the luminary, and there is a great fear. (Skeat and Blagden (1906), vol.II, pp.202-203.)

(II.1.2.3) Indonesian islands

(II.1.2.3.1) Sumatra

Marsden (1811, pp.193 – 194) records that the Malays use Islamic calendar (one year is 354 days), but original Sumatrans estimate their annual periods from the revolution of the seasons. To denote the time of day, they pointed with their finger to the height of the sun. They noticed the planet Venus, but did not imagine that the morning Venus and the evening Venus are the same. During an eclipse, they made a loud noise with sounding instruments.

In Sumatra, there are Batak people, Nias people, etc. (Proto-Malay peoples), and also, Acehnese people, Minangkabau people, Lampung people, etc. (Malay peoples), etc.

There is a detailed work on Acehnese culture by Hurgronje (1906), and Acehnese calendar is also described there (p.194 ff.). According to this work, Islamic lunar year is used by Acehnese people (in north Sumatra). Although the commencement of each month should basically be determined by observation, in many districts the calculation is adhered to, and 8-year cycle and 120-year cycle are used. There are 3 intercalary years (355 days) in 8 years. In this method, 1 day is excess in 120 years, but Hurgronje have not been able to discover whether Acehnese people would correct this at the end of every 120 years by skipping a day. Acehnese people are agricultural people, and a seasonal calendar is needed. For this purpose, stars are used. Acehnese people knew three stars of Orion, Venus (The morning star and the evening star are considered to be two distinct stars.), Southern Cross, Scorpion, Pleiades etc. The line joining three stars of Orion was considered to indicate Qibla. This idea also prevails in Java. The conjunction of Scorpion and moon was considered to regulate seasons. There are 13 (sometimes 14) conjunctions in a solar year. Sometimes conjunctions of Pleiades and moon were also used. The navigation of Acehnese people is based on N.E. and S.W. monsoons. (There is also a paper in Japanese of Kurata (1982) mainly based on Hurgronje's research.)

Kiyono (1943, pp.492 – 497), referring to the works of a German ethnologist A. Maass, mentions some astronomical knowledge of Minangkabau people (in central Sumatra). The time was known from the altitude of the sun. At one o'clock p.m. a vertical rod was erected, and the prayer "Asr" had to be done before the length of the shadow exceeds the height of the rod. One month is from a new moon to the next new moon as the usual Islamic calendar. The seasons were known from the south, east, west, north monsoons. And also, there are rainy season and dry season. Minangkabau people knew the morning star, evening star, the three stars of Orion, and Scorpion. Some specialists also knew the pole star, comets, planets, Great Bear, Virgo, Magellanic Clouds etc.

Lampung people (in south Sunatra) used the usual Islamic calendar. And also, they used 30-day month (Ginzel (1906, p.426ff.)).

According to Loeb (1935, pp.139-140), the Nias people (in the island of Nias) begun a year with the rising of Pleiades, and planting was started one month after the rise of Pleiades. A year was divided into 12 numbered lunar months, and a month was divided into the waxing and the waning of the moon. There was a story that 7 children (Pleiades) went to the sky, and the parents and a slave (Orion) followed. There was also a story that there were once two suns and no moon, and also the stars are the children of the sun and moon. According to Loeb (1935, pp.172-173), people in the Mentawai Islands also ascertained the beginning of a year from the position of Pleiades and begun in June.

There is an interesting traditional calendar of Batak people (in around Lake Toba) (Winkler (1913/ 1989-1993), Kimball (1989-1993) and Shinotsuka (1987)). The Batak calendar is called “porhalaan”, and engraved on a bamboo cylinder. It has 12 or 13 columns (for months) by 30 row rectangular grids (for days). A year begins when Orion disappears in the western sky, while Scorpio rises in the eastern sky. When the rising crescent moon passes by Orion immediately after sunset, the Batak year begins. Although modern Batak people use Indonesian day-names of the week of Arabic origin, the traditional Batak calendar uses day-names of the week of Sanskrit origin.

(II.1.2.3.2) Java

In Java, there are Javanese people in central and east Java, Sundanese people in west Java, Madurese people in east Java and Madura Island, etc. They are Malay peoples.

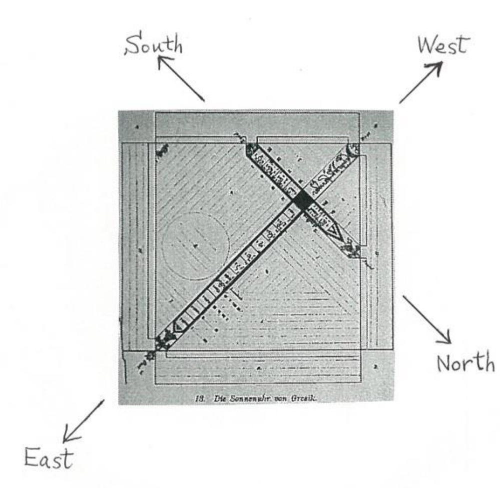
There are several dated inscriptions, using Indian Śaka Era, in Java (Damais (1967), Nakada (1982) and Eade and Gislén (2000)).

Raffles (1817, pp.473 – 479) gives an early description of astronomy in Java. Some early information is collected in Ginzel (1906, pp.414ff.). Geerts (1960, pp.77–81) discusses the religious aspect of the calendrical cycle in Java. Igarashi (1987) gives a detailed description of the Javanese calendar. (Also see Takahashi (1987).)

The Javanese lunar calendar was established by Sultan Agung (the third king of Mataram Sultanate) (reign 1613-1645). It is a combination of the traditional Javanese calendar and the Islamic calendar. One day begins at sunset. Besides the 7-day week, the 5-day cycle “pasaran” is used. One year of the Javanese calendar is a lunar year, and 8-year cycle and 120-year cycle are used for the calculation. One usual year is 354 days, but there are three 355-day year in 8 years. And also, one day is omitted in every 120-year cycle. For counting years, the Indian Śaka year is used instead of Islamic Hijri year, and AD 1633 was 1555 Javanese year. As one lunar year is shorter than one solar year, the Javanese year is different from the Śaka year of solar calendar by now.

The traditional Javanese solar calendar was reformed by Pakubuwono VII (a ruler of Surakarta) (reign 1830-1858) in AD 1855. It begins from summer solstice, and the length of a month varies from 20’s to 40’s. This system of calendar is called “Pranoto-mongso” (= Pranata-mangsa). Java people also recognized some constellations (Daldjoeni and Hidayat (1987)).

There is a detailed discussion about “Pranoto-mongso” in van den Bosch (1980). One year consists of 12 months from the summer solstice, which consist of 41 days, 23 days, 24 days, 25 days, 27 days, 43 days, 43 days, 26~27 days, 25 days, 24 days, 23 days and 41 days. This calendar is based on the observation by a gnomon like Fig.4 (Maass (1924, Fig.13); see also Ammarell (2008) p.326) (Also see Fig.25 of this paper below.). The noon shadow is observed by its North-South scale. A rectangular gnomon is erected at the square of the intersection of the North-South scale and the East-West rod. The North-South scale is divided into 6 equal segments (two in the North, and four in the South), and one segment corresponds to a month. As the change of solar declination is not uniform, and the equal segments of the flat scale do not correspond to equal angles, the length of a month is not uniform.



[Fig.4, Gnomon from Gresik Regency in Java (Maass (1924, Fig.13) with my additional notes).]

Recently, Ali Sastramidjaja (1935-2009) reconstructed “Sunda Calendar” (also called “Kala Sunda”) (Sastramidjaja (1991/1998)). There are Sunda solar calendar system and Sunda lunar calendar system. In the Sunda solar calendar system, one year ends with the summer solstice, and one month consists of 30 or 31 days. A common year consists of 365 days, and a leap year consists of 366 days. A leap year occurs once in 4 years, but it becomes common year once in 128 years. In the Sunda lunar calendar system, a half month begins from half bright moon and called “sukla paksa”, and another half month begins from half dark moon and called “kresna paksa”. So, one month consists of 29 or 30 days. There is no intercalary month. The 8-year cycle and the 120-year cycle are used to regulate short year (354 days) and long year (355 days). The 5-day cycle, 7-day week etc. are also used. Sastramidjaja says that the rules were unknown until he refound by his research from 1983 until 1991.

(II.1.2.3.3) Bali

Bali has an interesting tradition of calendar, which is relatively well known. There is a detailed study in 1930's by Covarrubias (1937), and also Eiseman (1990, Volume I) has a detailed description. Eiseman (1990, Volume II) describes star lore in Bali. There are also studies by Japanese: Nagata (1985) and Igarashi (2008). Igarashi (2008) is a very detailed study. And also see Ginzel (1906, pp.424-426).

There are two traditional Bali calendars. One is the "Saka calendar" which is originated in Indian calendar, and the other is the "Pawukon calendar" which is a unique calendar introduced from Java.

According to Covarrubias (1937, chap.9), the "Saka calendar" had been used by the mountainer Bali Agas (original Bali people). There are some differences of the calendar according to the calendar makers (Igarashi (2008)). In the "Saka calendar", one day begins from sunrise, and one month begins from the next day of the new moon. One month is divided into two halves: from the next day of the new moon to the day of the full moon is the white half month (*sukla paksa*), and from the next day of the full moon to the day of the new moon is the black half month (*kresna paksa*). This method is similar to the Hindu calendar. The 0th year of the Saka era is AD 78, and the 1st day of the 10th month (Kadasa) (according to Igarashi (2008)), or the 1st day of the 9th month (according to Covarrubias (1937)), is the beginning of a year called "nyepí" around the vernal equinox. One month consists of 30 lunar days (*titi*), and one day is jumped over every 63 days. One lunar day is 1/30 of a lunar month, and 64 lunar days = 63 civil days in this method. The *titi* corresponds to the *tithi* in Hindu calendar. For intercalation, there are two methods. One method is to add an intercalary month every 30 months, and the other method is to add 7 intercalary months every 19 years. Now the method of 7 intercalary months in 19 years is used (Igarashi (2008)).

It is said that the "Pawukon calendar" probably came into use at the time of Majapahit's domination of South Bali (the 14th century AD). It is made by the cycles of 1 day, 2 days, 3 days, 4 days, 5 days, 6 days, 7 days, 8 days, 9 days and 10 days. One "wuku" year in this calendar consists of thirty 7-day weeks, that is 210 days.

(II.1.2.3.4) Lesser Sunda Islands

Bali island (see above) in an island belonging to Lesser Sunda Islands. There are some information about other islands.

For the calendar of Savu Islands, see Cuisinier (1956).

Uno (1941, p.120), referring to Dutch literature, tells that in Ende area of Flores island, when a star called "red pig" (probably Antares) is seen around altitude 30 degrees from the western horizon arounf 7 PM, the season of the cultivation begins.

The star “red pig” belongs to a constellation which is considered to be a balance. In this season, the stars which are probably Pleiades are seen in the East sky.

Maass (1924, pp.347 – 357) gives an information about astronomy around Timor island. Some information about calendar of Timor and Letti (now Leti, included in Moluccas) is mentioned in Ginzel (1906, pp.430 – 431).

(II.1.2.3.5) Borneo

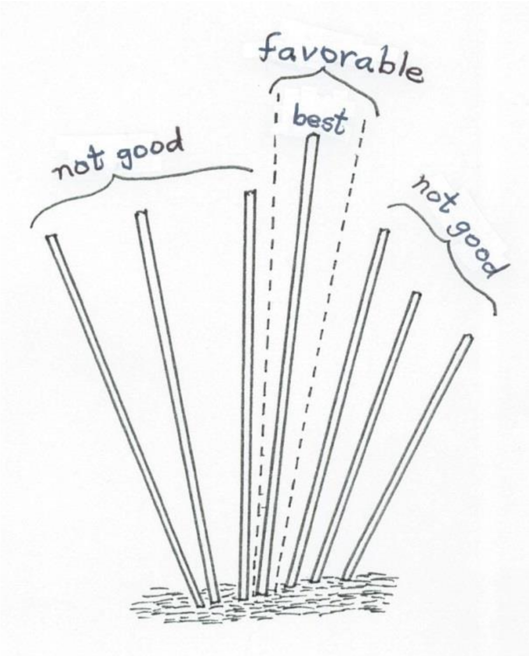
The Borneo Island consists of Kalimantan (of Indonesia), Sabah and Sarawak (of Malaysia), and Brunei. In the seaside area, there are Malay people etc., and in the inland area, there are Proto-Malay people called “Dayak people” etc.

Transilvano, who was a member of Magellan’s voyage (1519 – 22) records that when they visited the Borneo island in 1521, the local people was thinking that the sun and moon are the major gods, the sun is male and the god of daytime, the moon is female and the god of nighttime, and stars are small gods who are relative of the sun and moon, and belonging to the sun and moon (Chōnan (2011), p.313). This may be one of the earliest records of the astronomical folklore in the Insular Southeast Asia.

Hose and McDougall (1912) described some astronomical knowledge in Borneo. They divide the Dayak people (Proto-Malay people in Borneo) into 6 main groups (Sea Dayaks (=Ibans), Kayans, Kenyahs, Klemantans, Maryts and Punans). Hose and McDougall (1912, vol.1, pp.105 – 111) tells that Kenyah people erect a vertical wooden gnomon in the ground, whose verticality is ascertained by a plumb, and the length of the midday shadow is measured by a sticks with marks in order to know season for agriculture. Some Kayan people observed the position of midday sunlight through a hole of the roof of a chamber. The Klemantan people directed a bamboo cylinder filled with water towards a certain star, and knew the season of planting by the remaining water. The Sea Dayak people knew season by the direction of Pleiades. And also, Hose and McDougall (1912, vol.2, pp.139) tells that the Klemantan people considered that the great square of Pegasus is the storehouse, the Pleiades is a well, the constellation including Aldebaran is a pig’s jaw, and the Orion is the figure of a man.

Ammarell and Tsin (2015) report some skylore in South Kalimantan. The South Kalimantan people use the three stars Orion to know the direction of Qibla.

According to Lumholtz (1921, Vol.2, pp.441~444), who studied the central Borneo from 1913 to 1917, reports that Katingan people (one of the Dayak people in south-west Borneo) used seven inclined gnomons, and when the sun is above the central gnomon at noon (when the sun is around the zenith), they considered that it is the best season for the sowing (Fig.5).



[Fig.5, Seven gnomons of Katingan people in Borneo (after Lumholtz (1921)).]

King (1985, p.156) records that Maloh people (belonging to the Klemantan group of Proto-Malays) used stars to determine the times for commencing the agricultural cycle and sowing. The most important constellation was “bintang tuju” (Pleiades). The constellation “bintang talu” (Orion) was also recognized.

For the traditional astronomy of the people in north Borneo, see Evans (1922), (1923) and (1953).

Freeman (1970, pp.171 – 172)) reports that Iban (Sea Dayaks) in Sarawak used “bintang banyak” (Pleiades), “bintang tiga” (Orion) and “bintang tangkong peredah” (Sirius) to know seasons. Iban agricultural year was signalized by the dawn rising of the Pleiades.

(II.1.2.3.6) Sulawesi

In the Sulawesi Island, there are Makassar people, Bugis people, both of which are Malays, in the south-west area, and Toraja people (Proto-Malay) in central area.

Wallace (1869), a noted British naturalist, recorded an interesting navigation of a local vessel of Makassar. They used a floating bowl type of water clock. (See Fig.33 below.)

Yamashita (1988, p.81) records that the Toraja people use stars to know seasons, and that a year is divided into 3 seasons. The observation of stars to know season is called “pentiro taunan”. Stars used are “Lemba” (Ursa Major), “Bunga’” (Pleiades), “Manuk” (Crux) etc. Three seasons are the season when they are visible in dawn (the end of Nov.

to the end of Mar.), the season when they are visible in the evening (the end of Mar to the end of Sept.), and the season when they are invisible (the end of Sept. to the end of Nov.).

For Bugis navigation, see Ammarell (1999) and Wakita (2010). Ammarel (1999, p.127) gives a table of asterisms with identification. Wakita, referring to a work of Abu Hamid published in 1992, mentions some constellations of Bugis people without identification: "Bintang Sulo Bawi", "Bintang Wara Wara", "Bintang Tanra" (consists of 3 stars), "Bintang Manu" (consists of 6 stars), "Bintang Woromporong" (consists of 7 stars), "Bintang Lambaru" (consists of 6 stars) and "Bintang Tellu Tellu" (consists of 3 stars). And also, Pelras (1987, pp.27-32) and (1996, p.231and 264) mention the constellations of Bugis people for agriculture and navigation. (See the section of cultural overview below.)

(II.1.2.3.7) Moluccas (Maluku Islands)

In the records of Magellan's fleet's voyage (1519 – 1522), which was continued after Magellan's death, there are some records of Moluccas. Pigafetta writes that the king of Tidore Island was a Muslim and astrologer. (Chōnan (2011), p.166.) Transilvano writes that the king said that he knew that the fleet is coming by the observation of stars. (Chōnan (2011), p.324.) This is not astronomical, but they might have been interested in stars.

For the astronomical knowledge in Moluccas, also see Maass (1924, pp.364 – 375).

(II.1.2.4) Philippine islands

In the modern Philippines, Gregorian calendar is officially used. Until 1884, Gregorian day in the Philippines was one day before the present method of Gregorian calendar, because Spanish rulers considered that Philippine time is 16 hours later than Spain time. So, 31 December 1884 does not exist in the Philippines, and the next day of 30 December 1884 is 1 January 1885 (Umehara (1987)).

There are some information about traditional calendars in the Philippine islands in Zaide (1961, p.38), Umehara (1987) etc. The ancient calendar of the Bisayans (in the islands between Luzon Island and Mindanao Island) had, according to a record in the early Spanish period in AD 1582, 12 months in a year, among which 8 month had name, and the beginning of a year was the time of appearance of Pleiades. Zaide tells that one month had 30 days each except for the last 26-day month, so one year had 356 days. The calendar of the Ifugaos (in the north area of Luzon Island) contains 13 months (28 days each), so one year contains 364days, but one day is added to the 13th month.

Gōda (1989) studied the Bontok people in the north hill area of Luzon Island from the 1970's to 1980's, and reports their calendar (Gōda (1989), pp.56 – 71). There, one year begins, after the harvest of rice, when they are going to start a new cultivation around Oct. ~ Nov., one year is divided into 4 seasons, and the calendar itself is not related to lunar phase, although the lunar phase is recognized by them.

For the astronomical knowledge in Davao district of the Mindanao Island, see Cole (1913).

Schlegel (1987-1988) reports the celestial calendar of the Tiruray, a Philippine hill people in the Mindanao Island.

For the folk astronomy of the Philippines, Ambrosio (2010) is a monumental work. And also we could learn many things about folk astronomy in the Philippines from Prof. Jesus Torres and his colleagues at the Mandalay meeting.

(II.2) Cultural Overview

(II.2.1) Indigenous astronomy

(A) Local names and folklore of the stars and constellations

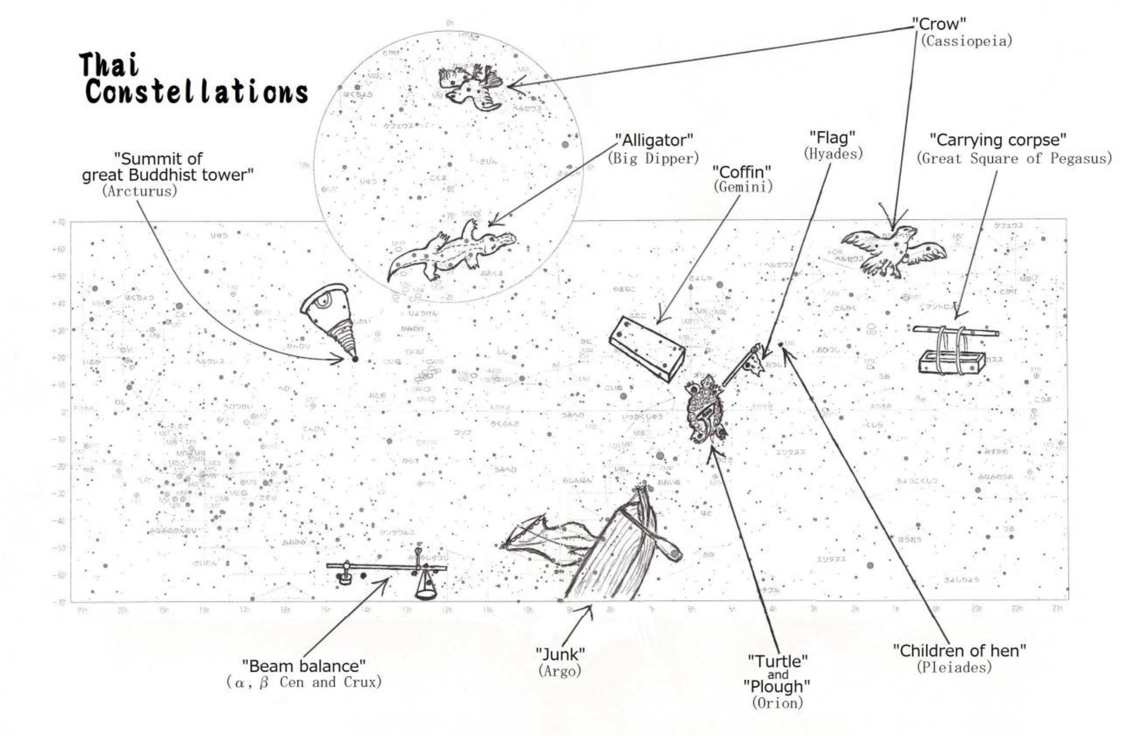
(A.1) Thai constellations

There are some Southeast Asian constellations which are not found in other area.

Saibejra (2012), quoting from the epic *Phra Aphay Manī* written by Sunthorn Phū (1786 – 1855), mentions the following Thai constellations.

Orion: Star "turtle" and Star "plough" (Dāw-tau, Dāw-thai).
Hyades: Star "flag" (Dāw-thong).
Pleiades: Star "children of hen" (Dāw-lūkkai).
Gemini: Star "coffin" (Dāw-lōng).
Cassiopeia: Star "crow" (Dāw-kā).
Argo: Star "junk" (Dāw-duang-lam-samphau).
Big Dipper: Star "alligator" (Dāw-cōrakhē).
Arcturus: Star "summit of great Buddhist tower" (Dāw-yōt-mahā-culāmanī).
Crux and α and β Centauri: Star "beam balance" (Dāw-khanchang).
Great Square of Pegasus: Star "carrying corpse" (Dāw-hām-phī).

And also, Phengkaew (2009) and Maison (2013) describe several other Thai astronomical folklores etc. Fig.6 is an overview of Thai constellations drawn by the author basing on Saibejra (2012).



[Fig.6, Thai constellations, drawn by the author basing on Saibejra (2012).]

(A.2) Burmese constellations

Burma has its own constellations. The earliest description of Burmese constellations in Western language is probably Buchanan (1799, particularly pp.195-205). He says that during his stay in Amarapura, he saw several treatises on astronomy, besides the almanacs, including a plan of "twenty-seven signs" and a plan of "nine signs" (See Fig.7), and also a "delineation of the sixty-eight *Burma* constellations" (See Fig.8) with a short explanation in the *Burma* language.

The small plan in Fig.7 represents Burmese 9 northern constellations, and the large plan in Fig.7 represents the Burmese northern constellations (outer circle) and Indian 27 lunar mansions (inner circle).

Fig.8 gives figures of 68 heavenly bodies (Burmese 9 northern constellations, Indian 27 lunar mansions, other Burmese constellations, the sun, Venus and Jupiter). In Fig.8, I added blue frame for Burmese 9 northern constellations, red frame for Indian 27 lunar mansions, and yellow background for the sun, Venus and Jupiter. Buchanan gives verbal English translation, following the arrangement of the words in the original, of their Burmese explanation with his notes. Some constellations are related to certain cities or countries. The following is a list of the Buchannan's translation of the heavenly bodies (I excluded Buchanan's notes.). The first numerals are corresponding to the numbers in Fig.8. In Buchanan's translation, a "circle" means a star. As it is a "verbal translation", the word order is different from usual English word order. I rearranged, and divided them into four groups. The Burmese 9 northern constellations could be identified by their names and their figures by comparison with Fig.7. It seems that the Indian 27 lunar mansions could not be fully identified with the heavenly bodies in the list by Buchanan, but I could identify by their names and their figures by comparison with a figure of Burmese lunar mansions quoted in Nishiyama (1997). Most of the constellations have not been identified with modern Western constellations by Buchanan..

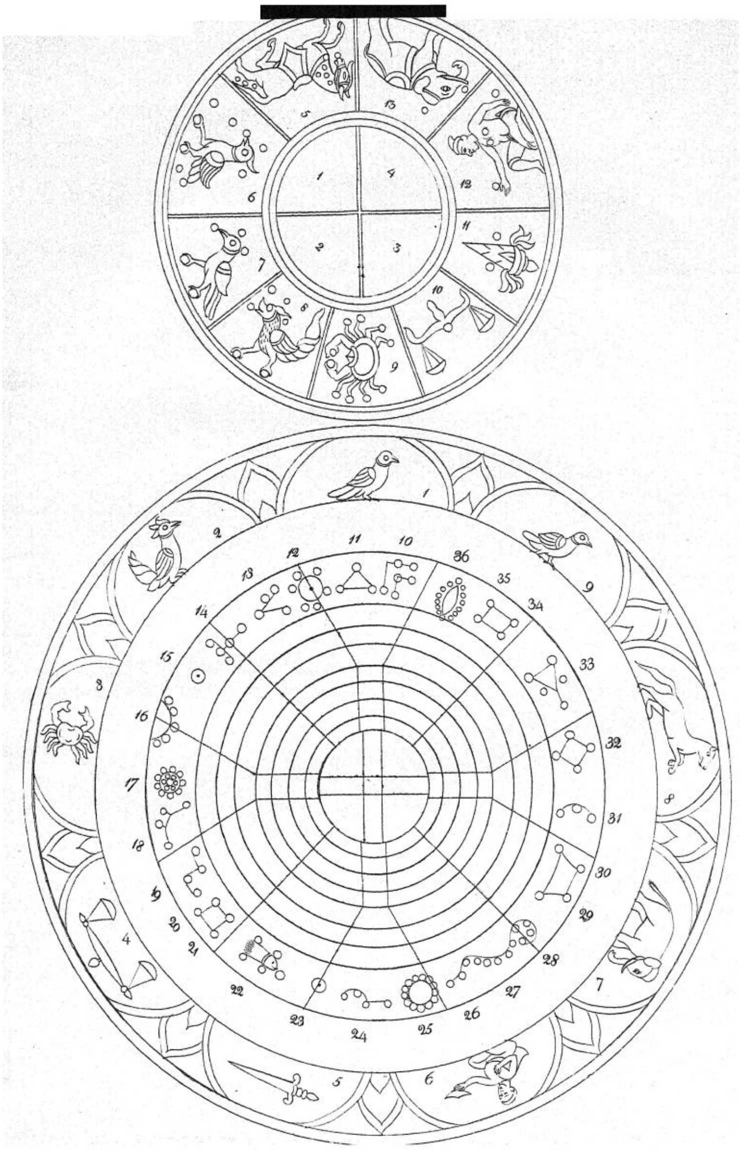


Fig.7, Plans of Burmese 27 lunar mansions and 9 northern constellations (Buchanan (1799)).

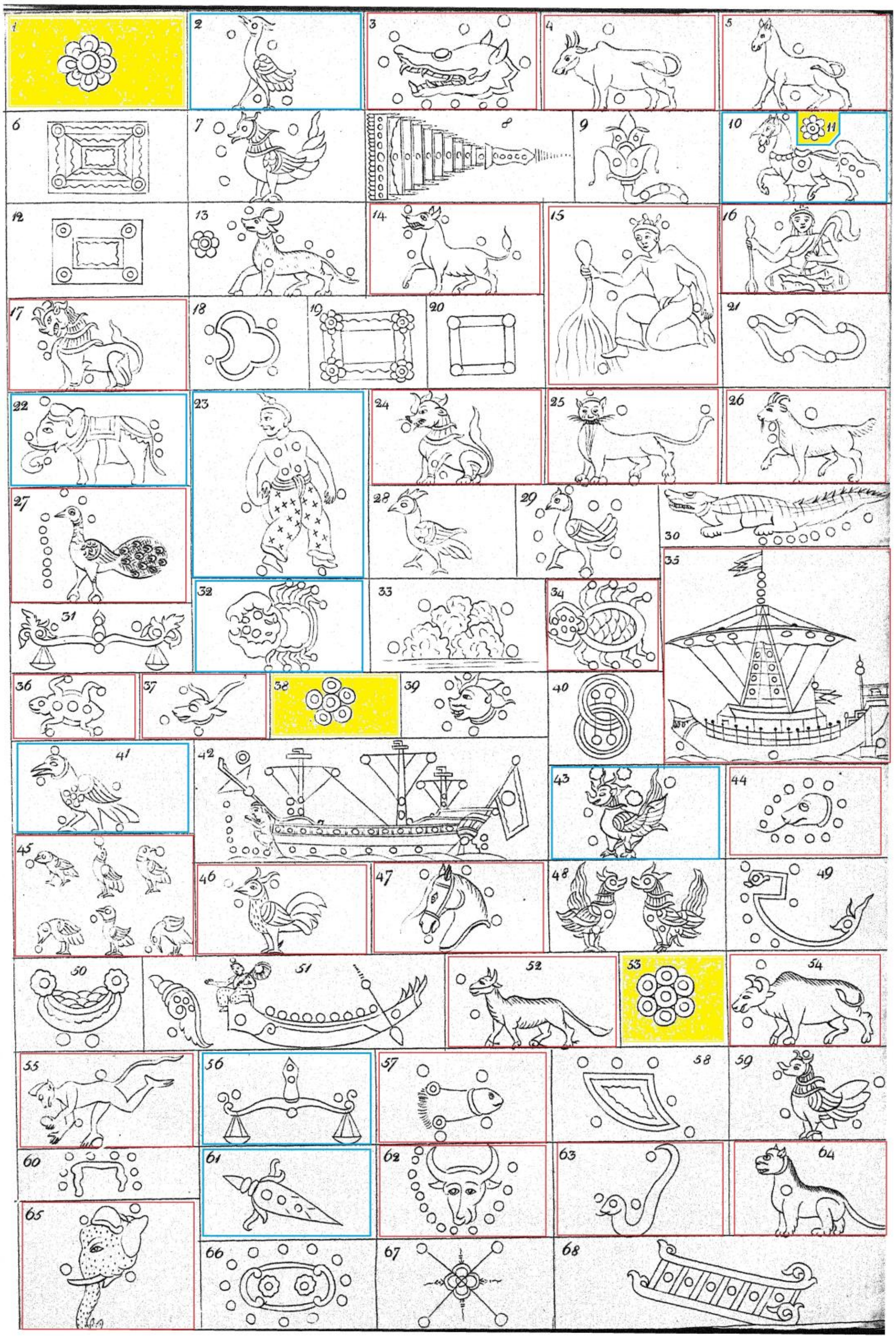


Fig.8, Figures of Burmese 68 heavenly bodies (Buchanan (1799) with my addition of blue frames for 9 northern constellations, red frames for 27 lunar mansions, and yellow backgrounds for the sun Venus and Jupiter).

Sixty eight heavenly bodies in the Buchanan's paper (1799) (rearranged by me):

(a) Burmese 9 northern constellations (I rearranged the order in accordance with Fig.7 (prograde direction), and added some notes within bracket. And also, I added corresponding Roman numerals in my identification.):

41. "The crow constellation eleven circles has, and the *Thayndua* country" (II).

43. "*Hayntha*, a constellation of seven circles, belong to *Radanapura*". (III)

32. "The crab constellation of ten circles has, *Rasagyol* country". (Buchanan says that no.34 is the Burmese constellation, but no.34 is actually an Indian lunar mansion, and no.32 should be the Burmese constellation.) (IV)

56. "The balance constellation, four circles has". (V)

61. Of *Thanliœk*, a constellation of three circles, *Kothambe* is the country". (VI)

23. "The *Brahmen* constellation of eight circles, *Kaleingareet* country governs". (Buchanan says that no.15 is the Burmese constellation, but no.15 is actually an Indian lunar mansion, and no.23 should be the Burmese constellation.) (VII)

22. "The *Shan* country the elephant constellation with six circles has". (VIII)

10. "The horse constellation has eleven circles, *Europe* is its country". (IX)

2. "The *Pyain* constellation five circles has, of *Thoukkada* country the constellation". (I)

(b) Indian 27 lunar mansions (I rearranged the order in accordance with the usual order of Indian lunar mansions, and added Sanskrit name within brackets.):

47. "Of *Athawane* the horse's head picture has six circles, and the *Rakain* country". (Aśvinī)

46. "*Pagan* country is governed by the old cock's figure". (Bharaṇī)

45. "*Kiatteka* has a fowl's picture, and six circles". (Kṛttikā)

44. "Of *Rohane* the snake's-head figure has ten circles". (Rohiṇī)

37. "*Mecathe* has of an antelope's head the picture, three circles, and *Haynthawade* country". (Mṛgaśiras)

36. "Of *Adara Daway* is the country". (Ārdrā)

35. "The *Brahmen's Buchia* has a boat's picture, and the *Dagoun* country". (Punarvasu)

34. "*Buchia* the crab constellation ten circles has". (Puṣya)

57. "Of *Athaletha* the horse's-yard picture, four circles has, and the *Thattoun* country". (Āśleṣā)

55. "*Matha* has of a monkey the figure, four circles, and the *Baranathe* country". (Maghā)

54. "Of *Pyouppabaragounne* the cow's picture three circles has". (Pūrva-Phālgunī)

52. "Of *Uttarabaragounne* the bullock's picture two circles has". (Uttara-Phālgunī)

65. "*Hathadda* of an elephant's head the picture has, *Dhagnawade* is its country". (Hasta)

64. "Of *Zeittara* the tiger's picture, has one circle, and the *Wethale* country". (Citrā)

63. "Of *Thuade* a great snake's-head picture, has three circles, and the *Thayndua* country". (Svātī)

62. "*Wethaga* has of a buffaloe's head the picture, and fourteen circles". (Viśākhā)

27. "Of *Anurada* the peacock's picture has fifteen circles, and the *Zedouttara* country". (Anurādhā)

26. "Of *Seitta* the goat's picture five circles has, *Zedouttara* is its country". (Jyeṣṭhā)

25. "Of *Mula* the cat's picture five circles has, *Peenzalareet* is its country". (Mūla)

24. "Of *Pyouppathan* the lion's picture two circles has, *Mouttama* country it governs". (Pūrva-Āṣāḍhā)

17. "Of *Uttara* the lion's picture two circles has, *Moranun* country govering". (Uttara-Āṣāḍhā)

16. "*Tharawun* constellation a hermit's picture three circles has". (Śravaṇa)

15. "Of *Danatheidha* the fisherman's picture four circles has". (Dhaniṣṭhā)

14. "*Thattapescia* with a leopard's picture six circles has". (Śatabhiṣaj)

5. "*Pyouppa parabaik* of a cow the picture has, and two circles, *Patanago* country it governs". (Pūrva-Bhādrapadā)

4. "*Uttara-parabaik* a cow's figure has, and two circles, and the *Kappelawut* country". (Uttara-Bhādrapadā)

3. "*Rewade* an alligator's figure has, *Kutheinnaroun* country, and nine circles it has". (Revatī)

(c) Other Burmese constellations:

6. "A couch is *Sataga* constellation, four circles it has, and the *Kathee* country".

7. "The *Pyathat* of twenty-four circles, is of *Kieen* country the constellation".

8. "The duck constellation, five crcles has, *Shan* is its country".

9. "The *Kyabuayn aroo* leaf is the *Talain* country constellation, it ha seven circles".

12. "The table constellation four circles has, of the *Kiayn* country the constellations".

13. "*Zain* constellation eleven circles has".

18. "The *Pangiayn* mountain constellation four circles has, of *Rakain* country the constellation".

19. "*Tareindane* constellation four circles has, of *Yoodaya* country the constellation".

20. “A couch is *Pagan* constellation with four circles, of *Shethœk* country

21. “The cloud constellation has five circles, of *Thulabe* the constellation”.

28. “The fowl male of *Peenza* constellation circles fifty has, of *Sawa* country the constellation”.

29. “The fowl female of *Utta* constellation eight circles has, of *Uzaung* country the constellation”.

30. “Of an alligator the *a-me-kah-han* is the picture of *Uttara* constellation with eight circles, and the *Lahu* country”.

31. “The balance constellation”.

33. “The mountain constellation four circles has”.

39. “*Buchia* constellation has eight circles, and *Yun* country”.

40. “*Zaduka* constellation four circles has, in a pair of fetters, of *Giun* country the constellation”.

42. “The *Kyay* ship of twenty-eight circles”.

48. “*Pozoke* a constellation of eight circles belongs to the *Talain* country, like the *Hayntha* male and femaile”.

49. “*Putthata* constellation seven circles has, of the *Raneezee* tree the fruit”.

50. “*Aykatheitta* a constellation of four circles of *Kale* country the constellation, is like a bason”.

51. “*Tarouttara* constellation two circles has, and the *Taroup* country”.

58. “The flag is *Pathatta* constellation, six circles it has”.

59. “*Eessa* constellation six circles has, of *Momain* country the constellation”.

60. “Of *Akap*, a constellation of eight circles, *Daway* is the country”.

66. “*Kobiape* constellation with eleven circles has, the *Myamma* country”.

67. “A fowl’s foot is *Thareiddha*, a constellation of four circles, of *Laynzayn* country the constellation”.

68. “A boat’s ladder is *Tareiddha*, a constellation of six circles, of *Kula* country the constellation”.

(d) The sun, Venus and Jupiter:

1. “Of *Sunday* the star”.

11. “The morning constellation one circle has, of *Dunwun* plant the fruit”.

38. “Of *Friday* the Star”.

53. “Of Wednesday the Star”.

There is also a paper by Khin Zaw (1937). Khin Zaw used a star map in the form of parallelogram in the "Bernard Free Library", and identified 27 Indian lunar mansions and 8 (out of 9) Burmese inner (northern) constellations with modern Western constellations. There were already studies of Indian lunar mansions in Indian Sanskrit texts, but there are some differences between India and Burma as Khin Zaw pointed out, and this paper is an early important contribution.

In Myanmar, there are some star maps, among which the most famous interesting maps are the three star maps (two circular star maps and one rectangular star map) drawn on the ceilings of corridors of the Kyauktawgyi Pagoda (built in 1847 by King Pagan of the Konbaung Dynasty) at Amarapura (near Mandalay, Myanmar) (See Fig.9.). There described several Burmese original constellations which cannot be found in other areas. The existence of the star maps in the Kyauktawgyi Pagoda in Amarapura was known to researchers of Burmese Buddhism, and a picture of one star map was published in Ōno and Inoue (1978) etc.

Fig.9, The entrance (southern side) of Kyauktawgyi Pagoda, Amarapura (taken by the author in 2017).

I visited there in 1984. When I visited the pagoda, the taxi driver who accompanied with me was a nice man, whose hobby was photography, and his camera happened to be the same as mine. I sometimes borrowed his wide-angle lens, and could successfully take their photographs.

Later, I was informed that Mr. Nishiyama is interested in the Burmese constellations, and I presented my photographs to him, and he stared to study the Burmese constellations with the help of some specialists of Burmese language. He published Nishiyama (1997) in English, and some other papers in Japanese. In Nishiyama (1997), he presented a list of 161 heavenly bodies in the star map in southern corridor. He tried to identify Burmese constellations with modern Western constellations, but many of the constellations not included in the 27 Indian lunar mansions and 9 Burmese northern constellations could not be identified. (Later, Mr. Nishiyama visited the pagoda in 1996, and took his own pictures.)

Now, after the end of the Mandalay meeting of SEAAN H&H, in 29 Nov. 2017, I could visit the Kyauktawgyi Pagoda with Mr. Visanu Euarchukiati (Thailand) after 33 years. The star maps were well preserved, and were almost the same as 33 years ago, but there were some small damages.

The Fig.10, 12, 14 and 16 are my photographs taken in 2017, and Fig.11, 13, 15 and 17 are my tentative (partial) identification of constellations (Indian 27 lunar mansions (in red numerals) and Burmese 9 northern constellations (in blue Roman numerals)). In the case of the star map "B" (in its northern corridor), they are all constellations with Burmese captions. In the case of the star maps "A" (in its southern corridor) and "C" (in its western corridor), there are other constellations with Burmese captions, and further research is needed. Some constellations without caption are identified by their figure and position. The identification of Indian 27 lunar mansions is not necessarily the same as usual Indian identification, but is my tentative identification based on the Burmese star maps. I referred to the identifications in Khin Zaw (1937) and Nishiyama (1997), but my identification is not necessarily the same as their identifications. Regarding the Roman numerals of the Burmese 9 northern constellations, I tentatively followed Mr. Nishiyama's list in Japanese which was previously circulated through internet. (I first presented my identification in Ôhashi (2018).) The list of my identification with modern Western constellations is as follows.

My identification of 27 lunar mansions and 9 northern constellations in the Burmese star maps:

Indian 27 lunar mansions:

1. Aśvinī (α, β, γ Ari)
2. Bharaṇī (35, 39, 41 Ari)
3. Kṛttikā (Pleiades)
4. Rohiṇī (Hyades)

5. Mṛgaśiras (λ, φ^1, φ^2 Ori)

6. Ārdrā (Orion)

7. Punarvasu (Gemini)

8. Puṣya (Cancer)

9. Āśleṣā (Western part (κ, λ, ε, μ) of Leo ?)

10. Maghā (α, η, γ, ζ Leo)

11. Pūrva-Phālgunī (δ, θ Leo)

12. Uttara-Phālgunī (β, 93 Leo)

13. Hasta (Northwestern part of Virgo ?)

14. Citrā (Spica)

15. Svātī (Arcturus)

16. Viśākhā (Corona Borealis)

17. Anurādhā (Northwestern part (β, δ, π) of Scorpius)

18. Jyeṣṭhā (α, σ, τ Sco)

19. Mūla (Southeastern part of Scorpius)

20. Pūrva-Āṣāḍhā (δ, ε (and γ, η ?) Sgr)

21. Uttara- Āṣāḍhā (ς, σ (and τ, φ ?) Sgr)

(* Abhijit (Disused in Burma))

22. Śravaṇa (α, β, γ Aql)

23. Dhaniṣṭhā (α, β, γ, δ Del)

24. Śatabhiṣaj (Western part of Aquarius)

25. Pūrva-Bhādrapadā (α, β Peg)

26. Uttara-Bhādrapadā (γ Peg, α And)

27. Revatī (Northeastern part of Pisces)

Burmese 9 northern constellations:

I. Byain “Heron”, (Cassiopeia).

II. Kyi “Crow”, (Perseus).

III. Hindha “Ruddy Sheldrake (duck)”, (Auriga).

IV. Puzun “Crab”, (Head and forelimbs of Ursa Major).

V. Khyein “Balance (scales)”, (Hindlimbs of Ursa Major).

VI. Hsankyin “Hairpin”, (Coma Berenices).

VII. Tanga “Fisherman”, (Hercules).

VIII. Hsin “Elephant”, (Cygnus).

IX. Myin “Horse”, (Cepheus).

Fig.10, The star map “A” in the southern corridor of Kyauktawgyi Pagoda, Amarapura (taken by the author in 2017).

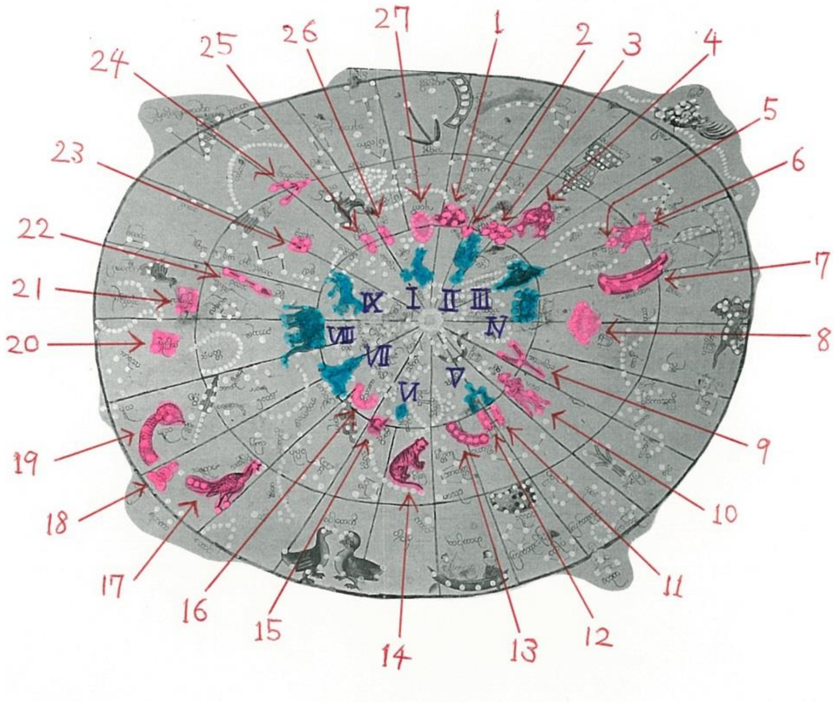


Fig.11, My identification of 27 lunar mansions and 9 constellations in the star map “A”.

Fig.12, The star map “B” in the northern corridor of Kyauktawgyi Pagoda, Amarapura (taken by the author in 2017).

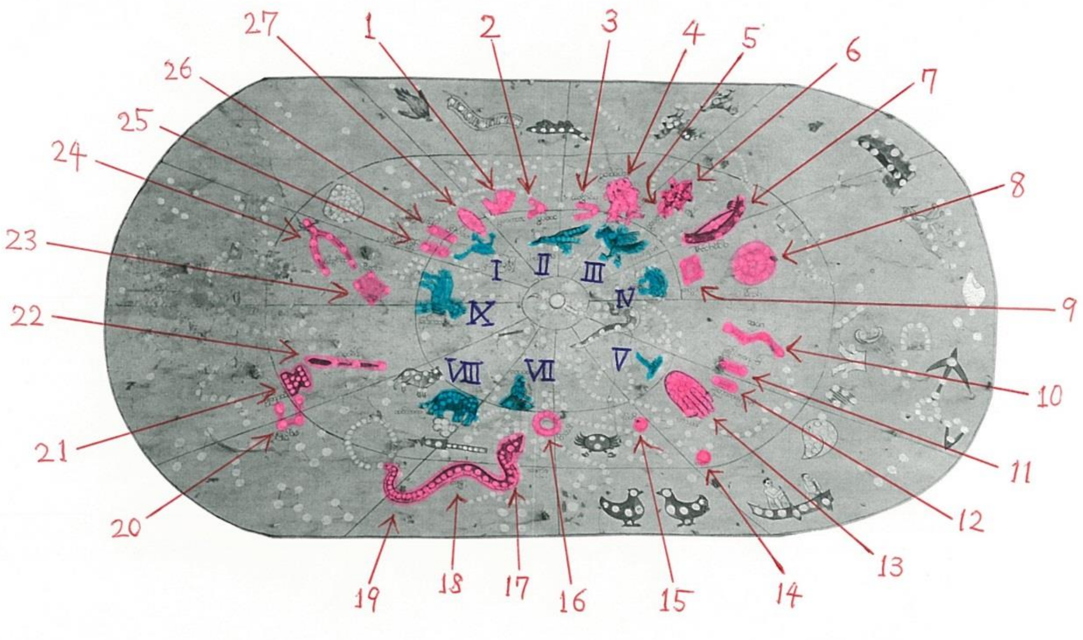


Fig.13, My identification of 27 lunar mansions and 9 constellations in the star map “B”.

Fig.14, The star map “C” in the western corridor of Kyauktawgyi Pagoda, Amarapura (looking from its inner side) (taken by the author in 2017).

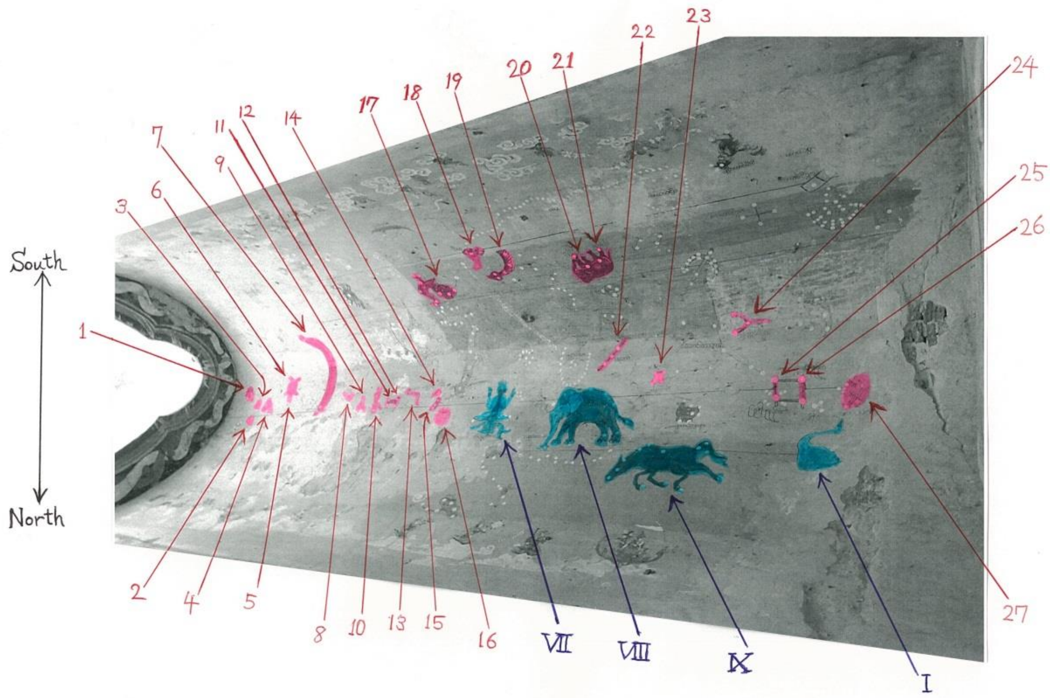


Fig.15, My identification of 27 lunar mansions and some constellations in the star map “C” (looking from its inner side).

Fig.16, The star map "C" in the western corridor of Kyauktawgyi Pagoda, Amarapura (looking from its outer side) (taken by the author in 2017).

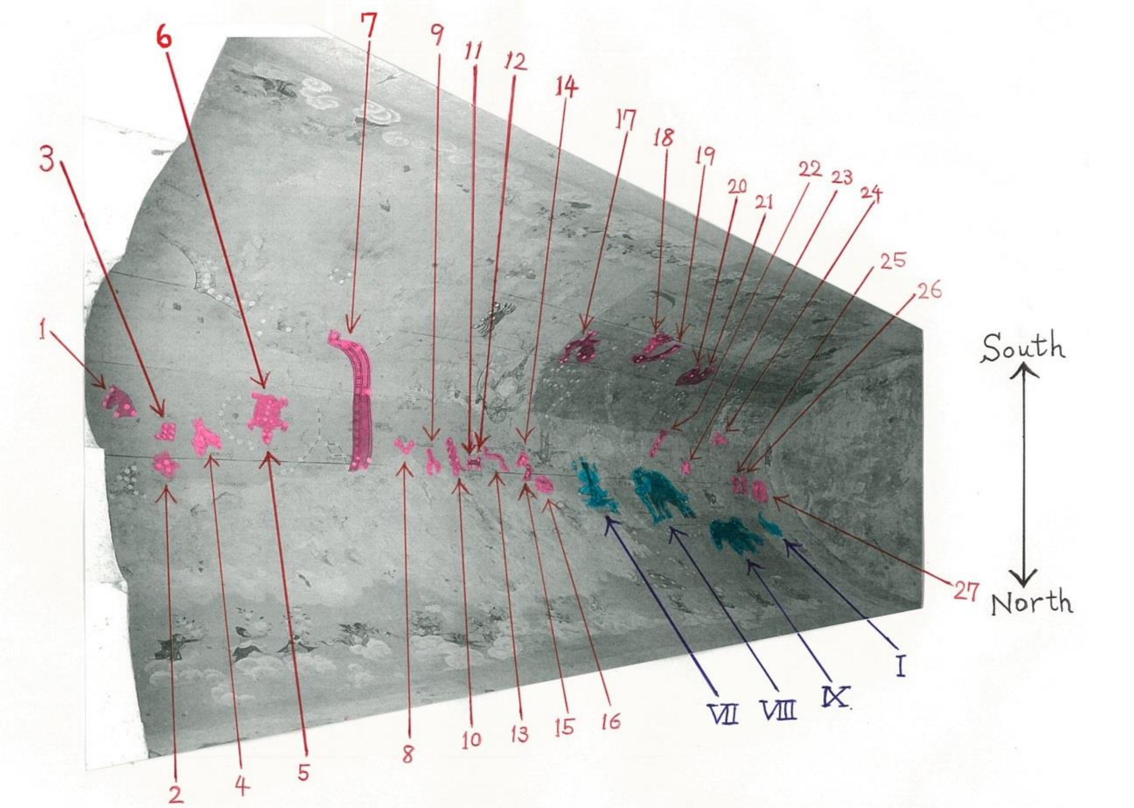


Fig.17, My identification of 27 lunar mansions and some constellations in the star map "C" (looking from its outer side).

As there are some small damages at the innermost part of the star map "C" at present, I present my pictures taken in 1984 and 2017 as Fig.18 and 20 (taken in 1984) and Fig.19 and 21 (taken in 2017) to make a comparison.

Fig.18, Outer part of the star map "C" (taken by the author in 1984).

Fig.19, Outer part of the star map "C" (taken by the author in 2017).

Fig.20, Inner part of the star map “C” (taken by the author in 1984).

Fig.21, Inner part of the star map “C” (taken by the author in 2017).

(A.3) Bugis constellations

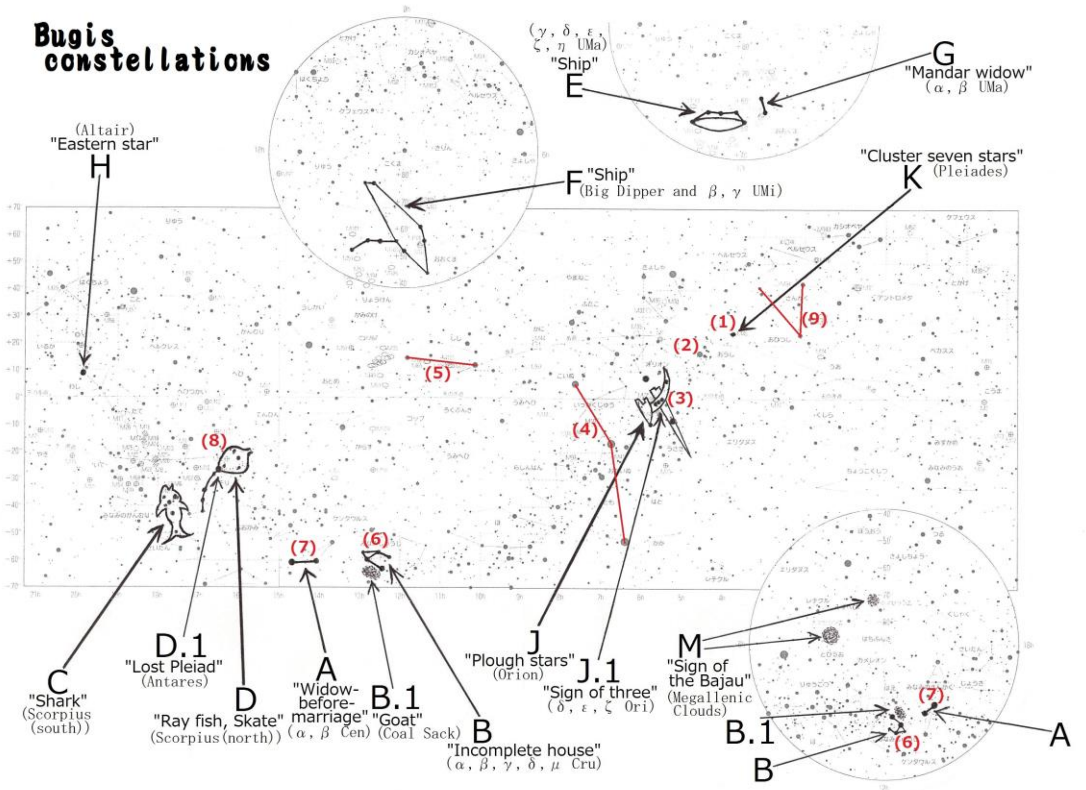
There are several original constellations in Indonesia. Ammarell (1999, pp.122-142) gives the following Bugis constellations in Sulawesi.

A. *bintoéng balué* "widow-before-marriage", (α, β Cen).
B. *bintoéng bola képang* "incomplete house", (α~δ, μ Cru).
B.1. *bembé'é* "goat", (Coal Sack nebula in Crux).
C. *bintoéng bale mangngiweng* "shark", (Scorpius (south)).
D. *bintoéng lambarué* "ray fish, skate", (Scorpius (north)).
D.1. (identified without name) "lost Pleiad", (Antares).
E. *bintoéng kappala'é* "ship", (α~η UMa).
F. *bintoéng kappala'é* "ship", (α~η UMa; β, γ UMi).
G. *bintoéng balu Mandara'* "Mandar widow", (α, β UMa).
H. *bintoég timoro'* "eastern star", (Altair).
J. *pajjékoé* (Makasar term) or *bintoéng rakkalaé* "plough stars", (α~η Ori).
J.1. *tanra tellué* "sign of three", (δ, ε, ζ Ori).
K. *worong-porongngé* or *bintoéng pitu* "cluster or seven stars", (Pleiades).
M. *tanra Bajoé* "sign of the Bajau", (Magellanic Clouds).

Pelras (1987, pp.27-32) gives the following Bugis constellations for agriculture. The Roman capital letters indicate their corresponding constellations in Ammarell's list, and their corresponding Makassar names are shown in square brackets. (Bugis language and Makassar language are in close relationship.)

1. (=K) *worong-mpolong* "Tuft", [*borong-borong*], (Pleiades).
2. *wara-wara* "Burning Coal", [*bara-bara*], (Aldebaran).
3. (=J.1) *tanra tellu* "Triple Beacon", [*tanra tallu*], (δ, ε, ζ Ori).
4. *manu'* "Chicken", [*jangang*], (Canopus, Sirius and Procyon).
5. *watang-mpata* "Job's Tears Stalk", [*batang-bata*], (α, β Leo)
6. (=B) *éppang* "Lame", [*balla'képpang* "the Crooked House"], (Crux).
7. (=A) *walu* "Widow", [*balu*], (α, β Cen).
8. (=D) *lambaru* "Rayfish", [*lambaru*], (Scorpius (north)).
9. *tékkoroso* "Pushed Plough", (Triangulum?).

Fig.22 is an overview of Bugis contellations drawn by the author basing on Ammarell (1999) (indicated by Roman letters) and Pelras (1987) (indicated by numerals).



[Fig.22, Bugis constellations, drawn by the author basing on Ammarell (1999) and Pelras (1987).]

(A.4) Philippine constellations

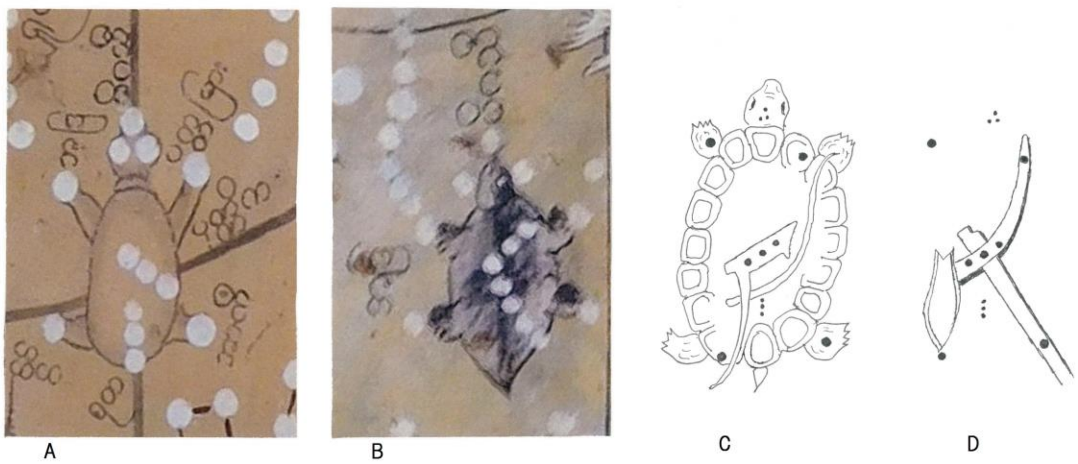
Ambrosio (01/26/2008) lists the following Philippine constellations.

Batik (Orion's belt),
Mupu (Pleiades),
Bubu (Big Dipper),
Paliyama (parts of Aquila),
Mamahi Uttara (North Star),
Saloka (Scorpius),
Anakdatu and Sahapang (Alpha and Beta Centauri),
Bunta (Southern Cross),
Lakag or Maga (morning star),
Mamahi Kagang,
Mamahi Pagi,

And also, Ambrosio (02/02/2008) tells that “Balátik” (Orion) and “Moropóro” (Pleiades) are very important in the Philippines. As there are different names of constellations in different languages in the Philippines, these names are different from the above list. (Also see Ambrosio (2010).)

(A.5) Additional remarks

There are some similar constellations in Southeast Asia. Fig.23 shows Southeast Asian constellations corresponding Orion. In Fig.23, A and B are from the Burmese star maps of Kyauktawgyi Pagoda (Fig.10 and 12) which are pictures of “turtle”, C is the Thai constellation based on Saibejra (2012) which is a combination of “turtle” and “plough”, and D is the Javanese constellation based on Ammarell (1996) which is a “plough”. By the way, in the Philippines, Orion is a “trap” for hunting as is shown in the front cover of Ambrosio (2010) (See Fig.24.).



A B C D

[Fig.23, Similarity of Southeast Asian constellations.]

There are some recent works on the folk-astronomy in Asia.

Fig.24 shows the front covers of Phengkaew (2009), Saibejra (2012) and Maison (2013) in Thai, Ambrosio (2010) in Filipino, and Kaifu (2014) in Japanese. It will be fruitful to discuss them in international seminars in the future.

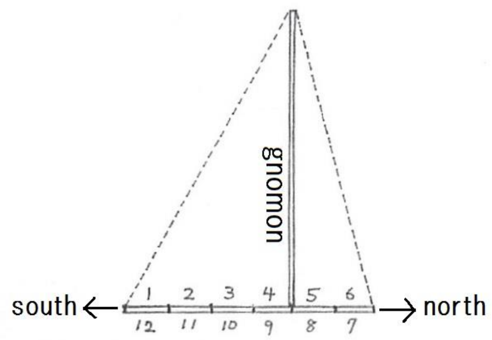
[Fig.24, Front covers of some recent books on the folk-astronomy in Asia.]

(B) Timekeeping and season determination

Some kinds of sun dial were used at several places. As they depend on local latitude, they are indigenous. We have seen some examples in the section of geographical overview.

There are several different indigenous calendars particularly in Insular Southeast Asia as was have seen in the section of geographical overview.

One interesting example is a gnomon for the determination of months of the calendar "Pranoto-mongso" used in Java (Fig.4 and Fig.25). It was used to determine the months by the observation of noon shadow. The latitude of Java is around 7° S or so. So, the solar midday zenith distance varies from 30.5° N to 16.5° S. So, if we assume that the length of the vertical gnomon is 1, the length of the shadow (tangent of the zenith distance of the sun) varies from 0.589 south to 0.296 north. If the scale is divided into 6 equal segments, the length will be 0.589, 0.442, 0.294, 0.147 north, 0 (the root of the gnomon), and 0.148, 0.296 south. Then, considering the zenith to be 7°S, the sun's zenith distance in each division will roughly be 23.5°, 16.9°, 9.4°, 1.4°, -7.0°, -15.4°, and -23.5°. Then, considering the spherical astronomical equation $\sin\lambda = \sin\delta/\sin\varepsilon$ (λ is solar longitude, δ is solar declination, and ε is the obliquity of the ecliptic.), the longitudinal differences of each segment are approximately: 43°, 23°, 21°, 21°, 24°, 48°. In the actual observation, the equation of the centre should also be considered. Disregarding the equation of the centre, they approximately correspond to 44, 23, 21, 21, 24, 49 days. By the above rough calculation, we can understand the unequal lengths of the months in "pranoto mongso" in Java (See the section of "Java" above.). In the "Pranoto-monso", one year consists of 12 months from the summer solstice, which consist of 41 days, 23 days, 24 days, 25 days, 27 days, 43 days, 43 days, 26~27 days, 25 days, 24 days, 23 days and 41 days. This calendar must be based on their original astronomical knowledge which could only be created at particular terrestrial latitude.



[Fig.25, Gnomon used for "Pranoto-monso" in Java.]

(C) Determination of directions and navigation

Astronomical knowledge is used for the determination of directions and local navigation etc. (For Bugis navigation (in Sulawesi), see Ammarell (1999).) It will be necessary to compare Southeast Asian traditional navigation with traditional navigation in other islands in the Pacific Ocean. Lewis (1994) gives a good survey of the traditional navigation in the Pacific Ocean.

(II.2.2) Chinese influence

(A) 12 animal names of the years

The Chinese 12-year cycle of animals (rat, ox, tiger, rabbit, dragon, snake, horse, goat, monkey, cock, dog and pig) is very popular in several parts of Asia with some variations in some areas. In Vietnam, usually ox is replaced by buffalo, and rabbit is replaced by cat (See Fig.26).

As there are Indian Jovian 12-year cycle and 60-year cycle, which are independent of the Chinese cycle, we should distinguish them carefully. For the Indian 12-year cycle in Burmese inscriptions, see Furnivall (1922).

The Chinese 12-year animal cycle is widely used in Thailand. We have seen that it was used in the inscription of Ram Khamhaeng besides Indian Śaka Era. And also, Chinese 60-year cycle (combination of 10-year cycle and 12-year cycle) was used in Vietnamese traditional calendar, and also by Thai people outside the Central region (For the case of Thai calendar, see Eade (1995), pp.24 – 25.).

Fig.26 is an example of the figures of 12-year animal cycle in modern Vietnamese postage stamps to celebrate traditional New Lunar Year's Day "Tết", and Fig.27 is an example of the figures of 12-year animal cycle in modern Thai postage stamps.

[Fig.26, Figures of 12-year animal cycle in modern Vietnamese postage stamps.]

[Fig.27, Figures of 12-year animal cycle in modern Thai postage stamps.]

(B) Chinese luni-solar calendar

Serial numbers are used to denote lunar months in Thailand. Loubère (1693, pp.168 – 169) recorded that this method was used in the Ayutthaya dynasty of Thailand. Eade (1995, pp.28 – 29) mentions some variations of this method in Thailand.

This method is not found in India, where name of lunar mansions is usually used to denote lunar-months. I suspect that the method to use serial number might be Chinese origin.

In ancient China, 19-year cycle was used for intercalation. This 19-year cycle was not popular in ancient India, but was cery popular in ancient China. I suspect that there is a possibility that the 19-year cycle in Southeast Asia is Chinese influence. See the section of "some examples of multiplex astronomy" below.

(II.2.3) Indian influence

(A) Zodiac

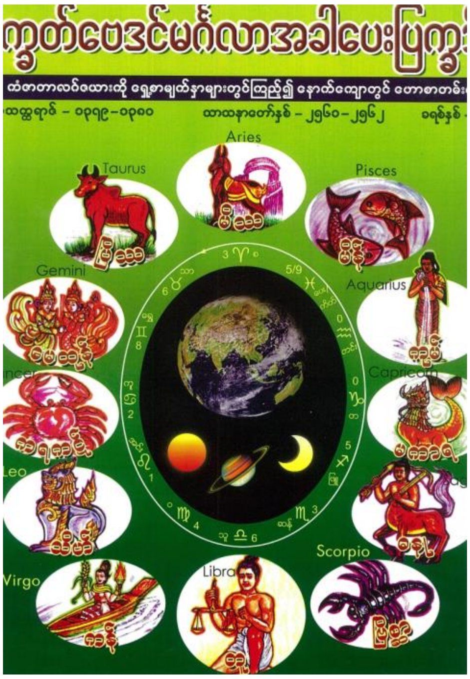
The 12-sign zodiac originate in Mesopotamia, and widely used in the Hellenistic World. Then, it was introduced to India, the Islamic World, the West etc.

The 12 zodiacal signs were introduced into India in around 3^{rd} century AD from the Hellenistic World, and then introduced into Southeast Asia as well as East Asia from India. As the zodiac is used in Islamic World also, the name of the signs of zodiac originates with Arabic in some areas, while the name originates with Sanskrit in other areas of Southeast Asia.

In India, the zodiacal signs are usually fixed to their sidereal position around the second half of the 6^{th} century AD or so. This Indianized zodiacal signs are used to regulate some Southeast Asian calendars. For example, the Thai festival "Songkrān" is the Sun's entrance to the sign Aries. As the signs are fixed to their sidereal position, the Sun's entrance to the sign Aries, which corresponds to the vernal equinox, is now different from the usual (Western tropical) vernal equinox due to the effect of precession. So, the Thai "Songkrān" is celebrated in 13-15 April now.

In present Thailand, name of the 12 months of Gregorian calendar are named by Sanskrit name of zodiacal signs.

Fig.28 is an example of the figures of zodiacal signs from the front page of a modern Burmese calendar which I purchased at a book shop in Mandalay at the time of the meeting.



[Fig.28, Figures of zodiacal signs from the front page of a modern Burmese calendar.]

(B) Lunar mansions

India has 27 or 28 lunar mansions, and China has 28 lunar mansions. They are probably originally independent. Eade (1995, pp.31 – 37) tells that 27 lunar mansions are used in Thai and Burmese traditional calendars. In Thai traditional calendars, (see Fig.32 below), the position of the moon is indicated by Indian 27 lunar mansions besides 12 zodiacal signs. And also, the Indian 27 lunar mansions are shown in the star maps of the Kyauktawgyi Pagoda in Amarapura (near Mandalay, Myanmar) (Fig.10, 12, 14 and 16).

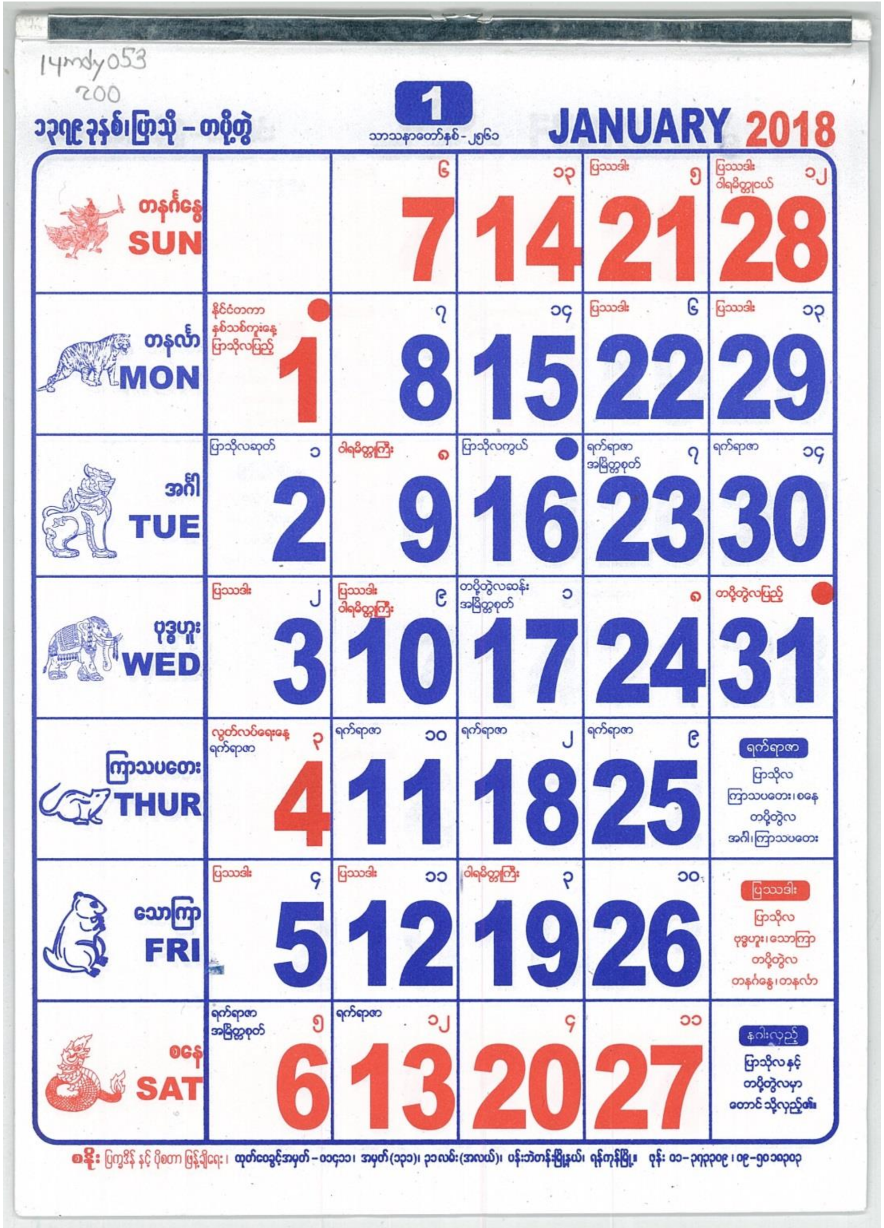
(C) Seven-day Week

The 7-day week originates in Hellenistic world, and introduced to India, the Islamic World, the West etc.

The 7-day week was introduced into India in around 3rd century AD from the Hellenistic World, and then introduced into Southeast Asia and East Asia from India. In Thailand and Myanmar, the day of the week of one's birth is considered to be very important. As the 7-day week is used in Islamic calendar also, the name of the days of the week originates with Arabic in some areas, while the name originates with Sanskrit in other areas.

In Thailand, there are symbolic colours of the days of the week. Sunday is red, Monday is yellow, Tuesday is pink, Wednesday is green, Thursday is orange, Friday is blue, and Saturday is purple (Saibejra (2012, p.10), Segaller (2005, p.195 etc.)). In Thai astrology, Wednesday is divided into daytime and nighttime (after 6PM), and nighttime corresponds to Rāhu. Sometimes, the symbolic colour of the night of Wednesday is considered to be black.

In Myanmar, Sunday is symbolized by Garuda, Monday by Tiger, Tuesday by Lion, Wednesday (forenoon) by Elephant with tasks, Wednesday (afternoon) by Elephant without task, Thursday by Rat, Friday by Guinea-pig, and Saturday by Dragon. Sunday, Monday, Tuesday etc. are corresponding to the Sun, Moon, Mars etc. as usual. Wednesday (forenoon) corresponds to Mercury as usual, and Wednesday (afternoon) corresponds to Rāhu in Myanmar. Usually, the first letter of one's name is related to the day of the week of one's birth. (Shway Yoe (1910, pp.4-6) and Meiji Soe (2012, pp.57-69) give detailed descriptions.) Fig.29 is an example of the figures of days of the week in a modern Burmese calendar which I purchased at a bookshop in Mandalay at the time of the meeting.



[Fig.29, Figures of days of a week in a modern Burmese calendar.]

(D) Indian eras

There are several eras in India. We have seen that Indian Śaka Era was used in the inscriptions in Champa, Thailand (particularly that of King Ram Khamhaeng), Cambodia, Burma, Indonesia, etc. And also, Buddhist Era is used in some regions of Mainland Southeast Asia. In Thailand, Buddhist Era ("Phuttha-sakkarāt" in Thai) is usually used (Buddhist Era = AD + 543). It should be noted that the 0th year of Buddhist Era begins from 544 BC in Thailand, Laos and Cambodia, while the 1st year of Buddhist Era begins from 544 BC in Burma and Sri Lanka.

(E) Sidereal year

Traditional calendars of Mainland Southeast Asia (expect for Vietnam) use sidereal year. It is Indian origin. This is the result that the zodiacal signs are fixed to their sidereal position around the second half of the 6th century AD or so as we have seen in the section of "zodiac". Therefore, one calendrical year is the sun's revolution around the fixed stars, that is a sidereal year.

(F) Indian luni-solar calendar

Hindu traditional calendars are mostly luni-solar calendar, and it was introduced into Southeast Asia. As Chinese traditional calendar is also a luni-solar calendar, it is sometimes difficult to distinguish Indian influence and Chinese influence in this respect.

One Indian specialty is that Hindu method divide one synodic month into a white half month (from new moon to full moon) and a black half month (from full moon to new moon). This method is used in some Southeast Asian calendars. This division is absent in Chinese luni-solar calendar. Another Indian specialty is to use Sanskrit names of lunar mansions to name lunar months.

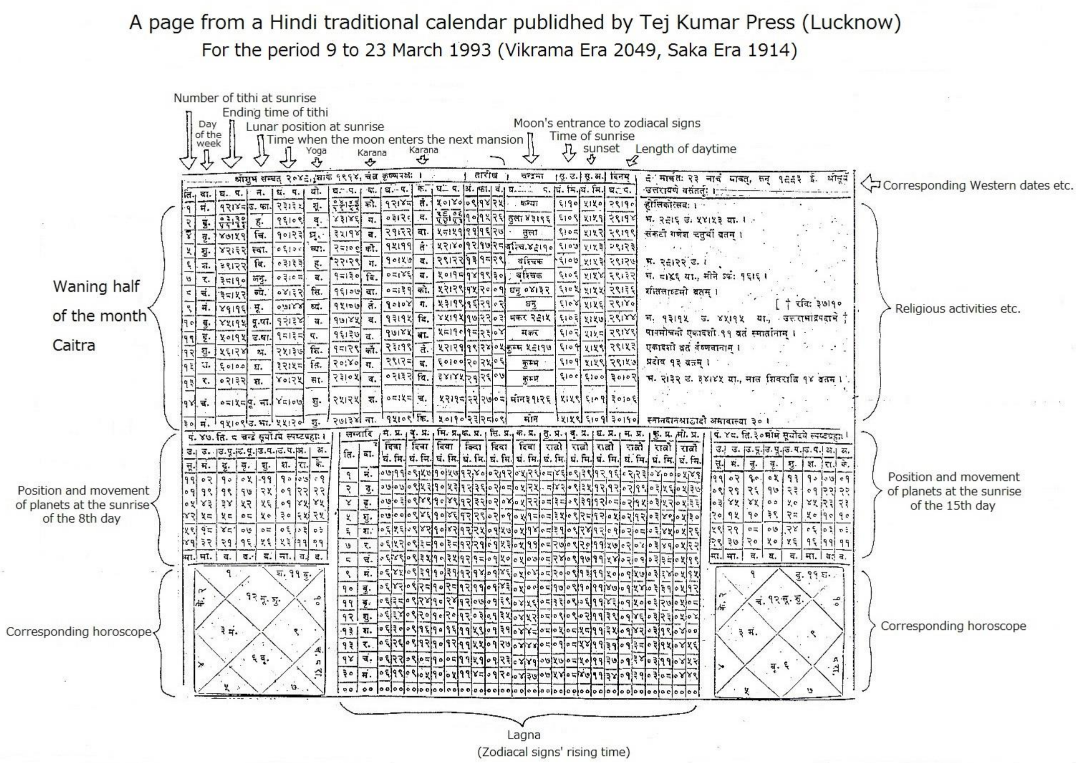
And also, one synodic month is divided into 30 *tithi*s in Hindu calendar. (In usual Hindu calendar, one *tithi* (lunar day) is a period during which longitudinal difference between the sun and moon changes by 12°.) This kind of lunar days are used in some Southeast Asian calendars.

The Indian Jovian 12-year cycle, which is independent of the Chinese 12-year cycle of animals, was used in Burmese inscriptions (Furnivall (1922)).

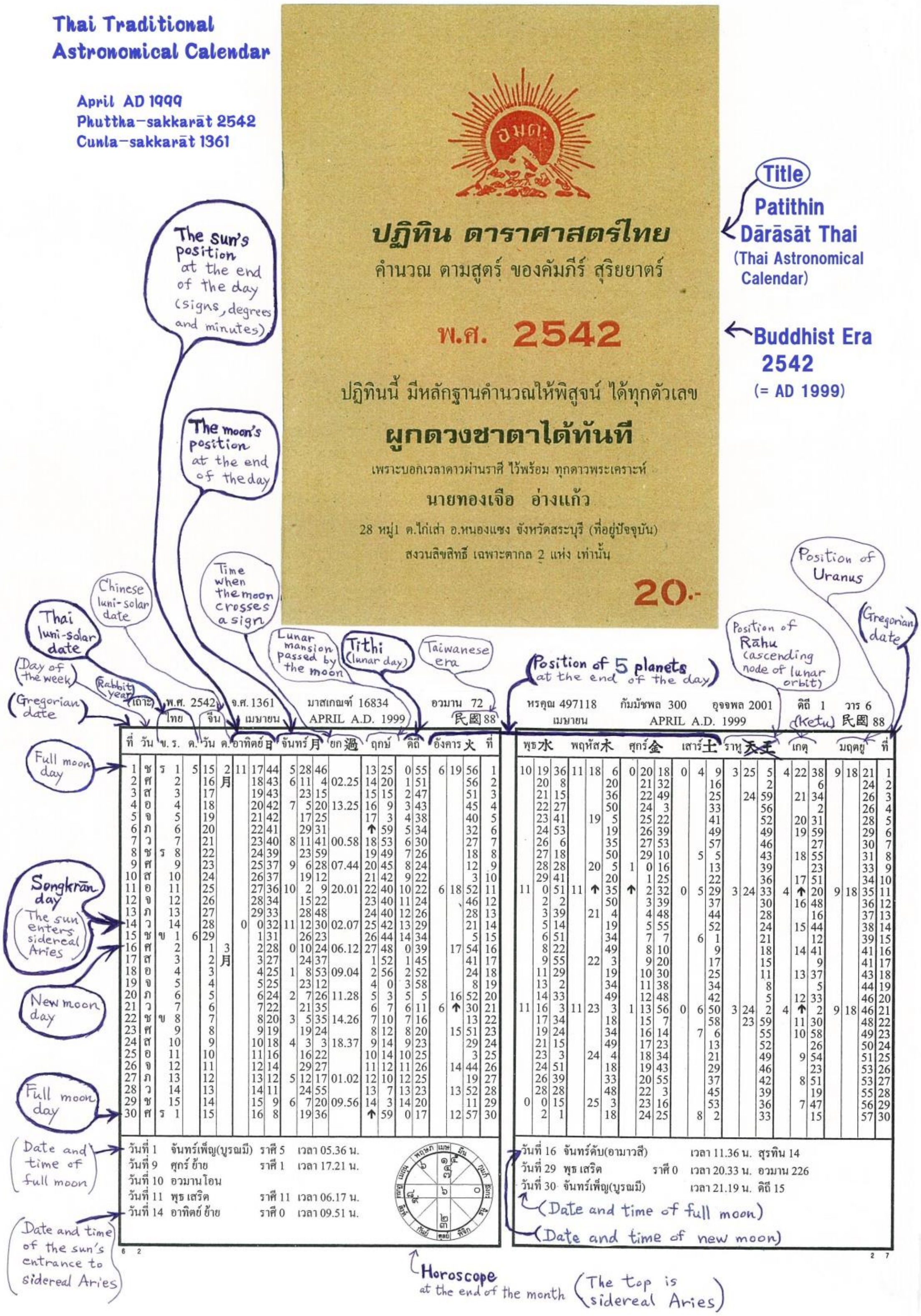
In India, there are several traditional astronomical calendars in several area in several languages. Fig.30 shows some examples of Indian traditional astronomical calendar in Hindi language, and Fig.31 shows an example of a page in Hindi traditional astronomical calendar.

Fig.32 is an example of a Thai traditional astronomical calendar. Here, we can see that the positions of the sun, moon, planets and the ascending node of the lunar orbit at the end of the day (24:00) are given in sidereal signs, degrees and minutes. We can see that the sun enters sidereal Aries in 14, April, 1999, which is the day of Songkrān. The "Ketu" usually means the descending node of the lunar orbit or, sometimes, comets or meteors in Hindu astronomy, and usually means Neptune in Thai astrology, but the position of the "Ketu" in Fig.32 is different from them, and its meaning is not clear to me at present. (For Thai astrology, I consulted Suriyā'ārak (1983).) We can see that Thai traditional luni-solar date is maximum 15th, because one sidereal month is divided into two half months. This is Indian stile.

[Fig.30, Some Indian traditional astronomical calendars in Hindi language (author's collection).]



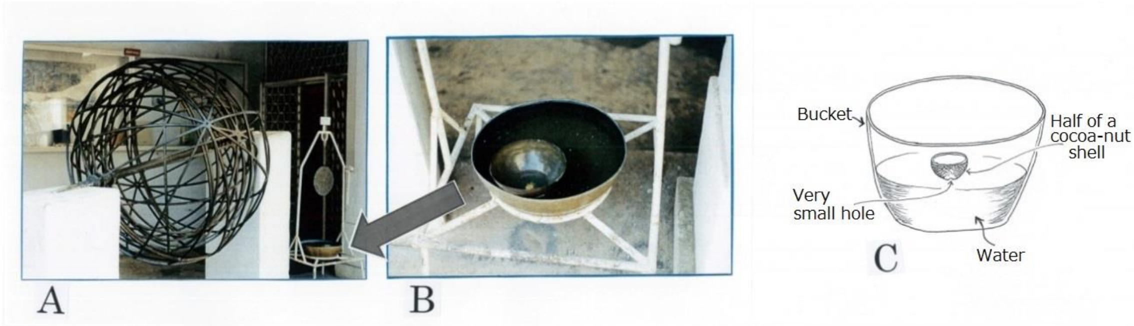
[Fig.31, A page from a Hindi traditional astronomical calendar.]



[Fig.32, An example of Thai traditional astronomical calendar.]

(G) Time keeping

Wallace (1869, Chapter 28) recorded a water clock used in a local vessel of Makassar (Fig.33, C is my drawing based on Wallace's description.). This floating type of water clock was used in India since the end of the 5th century or so, and was very popular (Fig.33, A and B are the photographs of the water clock in Rao Madho Singh Museum, Kota, Rajasthan, India, taken by the author.). (For Indian water clock, see Ôhashi (1994).)



[Fig.33, Indian water clock (A and B) and my drawing of water clock of Makassar (C).]

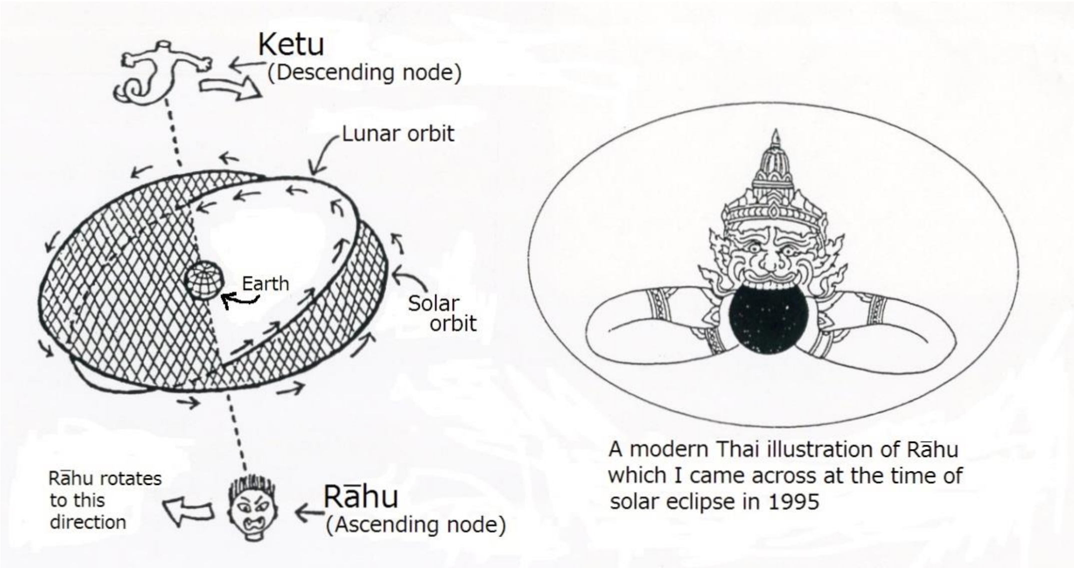
(H) Horoscope

Horoscopes are found in inscriptions of Southeast Asia (In the case of Thailand, see Eade (1996).). And also, there are several other examples which are popular till now (See Fig.1, Fig.2 and Fig.32 in Thai and Burmese calendars.). And also, a horoscope is shown in Burmese traditional birth certificate called "zata" as in the Fig.34 (For the Burmese birth certificate, see Shway Yoe (1910), pp.7-13, and Meiji Soe (2012), p.69.).

[Fig.34, Burmese birth certificate (author's collection).]

(I) Rāhu ----- a demon who produces eclipses

In Indian astronomy, the ascending node and descending node are called Rāhu and Ketu. The legend of Rāhu is widely found in Southeast Asia (Fig.35).



[Fig.35, Rāhu and Ketu.]

(J) Cosmology ----- Mount Meru etc.

The influence of Indian cosmology is found at several places in Southeast Asia (Quaritch Wales (1977) and Swearer (2010)). Bogle (2016) explains the Buddhist cosmology in Burma with several beautiful figures.

Buddhist cosmology (Mount Meru model) is mainly based on the *Abhidharma-koṣa* of Vasubandhu (ca. 4th – 5th century AD).

King Lithai of the Sukhothai dynasty of Thailand wrote the *Trai-phūm* (Three Worlds) in the mid-14th century (Reynolds and Reynolds (1982)). This is a celebrated text of traditional Thai cosmology, and some information about traditional astronomy is also found there.

There are several traditional pictures of Mount Meru in Thailand.

And also, it is said that the central tower of the Angkor Vat in Cambodia etc. symbolizes Mount Meru.

(K) Architecture

The Indian traditional science of architecture is called "Vāstu-śāstra" in Sanskrit. For the determination of directions, astronomical method was used. At the Mandalay meeting, I could realize that the influence of Indian architecture into Southeast Asian temple architecture etc. is also an interesting subject.

(II.2.4) Islamic influence

(A) Islamic lunar calendar

Basically, when new crescent moon is observed in the western sky in the evening, a new Islamic lunar-month begins from the sunset. So, the length of a month (29.530589 days) is exact. One year is 12 lunar months regardless seasons.

There are some simplified methods to predict lunar visibility. Proudfoot (2006) discussed the methods used in the early Insular Southeast Asia.

One method is trigesimal calendars using 30-year cycle (360 months), which has 11 leap years. It means that one lunar-month is "$(30 \times 6 \times (29 + 30) + 11) / (30 \times 12)$" = 29.530556 days.

A simpler method is octaval calendars using 8-year cycle (96 months), which has 3 leap years. It means that one lunar-month is "$(8 \times 6 \times (29 + 30) + 3) / (8 \times 12)$" = 29.53125 days. Proudfoot says that the octaval calendar was widely used in pre-nineteenth century Southeast Asia.

And also, we have seen in the section of geographical overview that there is also 120-year cycle (1440 months) with 44 leap years, which consists of 42524 days. This is actually just four times of the 30-year cycle.

At present, the visibility of the crescent moon is still very important (for the case of India, see Ôhashi (2006b)), and there are several reports about it. One report by Kawada (2008) is that there is a committee "Ruyat-e-Hilal Committee-Japan" to observe the crescent moon at the beginning and the end of the month Ramadhan (month of fasting) etc. in Japan also, and when it is not observed, they follow the result in Malaysia. However, there are some Muslims in Japan who follow the result in Turkey. So, there is a possibility that there may be one day's difference of Islamic calendar between different Muslims in the same area.

According to Horii (1987) who studied in Malaysia, some people prefer the actual observation while other people prefer calculation, and sometimes different states of Malaysia use different Islamic date (See the section of Malaysia above.).

(B) Time keeping and Qibla

There are five prayers called "ṣalāt" daily, and time keeping is very important for muslim. There is an interesting record of the prayer time in the East India (now Indonesia) in the early 20th century (Izutsu (1942), pp.29-30), as follows.

(1) ẓuhr (after the time when the sun is going to move from its highest point and before the shadow becomes the same length (or double length) as the height of itself): Starting from 12 noon in East India (while starting shortly after 12 AM in Mecca).

(2) ‘aṣr (in the afternoon after ẓuhr and before the sun is going to set): Done around half past 4 PM in East India (while done about 3 hours after ẓuhr in Mecca).
(3) maghrib (after complete sunset within evening twilight): Done around 6 PM in East India (while done right after sunset in Mecca).
(4) ishā (at night after evening twilight and before morning twilight (before sleeping)): Done around half past 8 PM in East India (while done about two hours after maghrib in Mecca).
(5) ṣubḥ (after ishā and before sunrise): Done between 4 AM and 5 AM in East India (while done about one and a half hour before sunrise in Mecca).

The method of determination of time in pre-modern Southeast Asian Islamic World will have to be studied further.

The direction of the Kaaba in Mecca is called “Qibla”. The prayers should be done towards this direction. According to Hurgronje (1906), Acehnese people and Javanese people considered that the rising three stars of Orion indicate Qibla. Ammarell and Tsin (2015) say that Banjar wet-rice farmers (in South Kalimantan) also called the three stars of Orion’s belt to be pointers to the Qibla.

The lunar visibility, prayer time and the direction of Qibla are very important in Islamic daily life, and there are several attempts to modernize them. One attempt was made by a Malaysian astronomer Mohammad Ilyas (Ilyas (1984), (1997) etc.).

(II.2.5) Western influence

From the mid-16th century, Jesuit missionaries visited Asia, and Western astronomy was introduced into Asia through them. For example, King Narai of the Ayutthaya Dynasty observed a lunar eclipse with Jesuits sent by French King in AD 1685. And also, King Mongkut (Rama IV) studied Western astronomy as well as traditional Siamese and Mon astronomy, and predicted the total solar eclipse of AD 1868. Cook (1993) is an interesting study of the astronomy of King Mongkut. It should also be noted that NARIT (National Astronomical Research Institute of Thailand) recently published a series of books on the history of modern astronomy in Siam/Thailand in Thai language, Phumathon (2012a) about the reign of King Narai of the Ayutthaya dynasty, Phumathon (2012b) about the reign of King Mongkut (Rama IV), Euarchukiati (2015) about the reigns from King Rama V to King Rama VIII, and Soonthornthum and Thajchayapong (2012) about the reign of King Bhumibol Adulyadej (Rama IX).

And also, we should consider the Western influence to the traditional astronomy in Asia. For example, the last Chinese traditional calendar *Shixian-li* (時憲暦) (used in China from 1645) is based on Western astronomy. The *Shixian-li* was adopted in

Vietnam in AD 1813. In Vietnam, the prime meridian was declared to pass through its capital Hue in AD 1837, and the longitudinal difference between Beijing and Hue was considered since AD 1841. At that time, longitude was measured from Paris. Here also, we can see the Western influence to the traditional astronomy of Vietnam.

At the Mandalay meeting, I was informed by Prof. Jesus Torres (the Philippines) that the influence of Christianity is also important in folk astronomy in the Philippines.

It may be added here that the history of modern astronomy in some areas of Southeast Asia after the introduction of Western astronomy can be known from relevant papers in Batten (2001), Hearnshaw and Martinez (2007) and Nakamura and Orchiston (2017).

III. Some examples of multiplex astronomy

(III.1) Cham Calendar

There was a kingdom "Champa" in central and south Vietnam from the late 2nd century to the 17th century.

They used Indianized calendar using Śaka Era, and there are inscriptions using Śaka Era since the 6th century. So, we know that the Indianized calendar has been used from quite early period in Southeast Asia. (See Sugimoto (1968).)

The Cham people in present Vietnam are said to be the descendants of the Champa kingdom. They have quite interesting calendrical system. (See Nakamura (1999, 2009), Yoshimoto (2000, 2003, 2011).)

The Cham calendar consists of the following two calendars.

(A) *"Ahier"* Calendar: This is an Indianized luni-solar calendar. The 12-year Chinese cycle with animal names is also used.

(B) *"Awal"* Calendar: This is an Islamic lunar calendar.

These two systems of calendar are used by Cham people in Vietnam. This is an interesting example of a multiplex astronomy.

At the Mandalay meeting, I was informed by Mr. Lộc Phạm Vũ (Vietnam) that there is a detailed research of the Cham calendar by Prof. Trương Văn Món ("Sakaya") in Vietnam (Sakaya (2016)). I am grateful to Mr. Phạm Vũ Lộc who provided me with this book.

(III.2) Thai Traditional Calendar

One year of Thai traditional calendar is a sidereal year, that is 365.25875 days. This is similar to a year of Indian Ārdharātrica school, and is evidently Indian origin.

The Chinese 12-year cycle of animals is also used in Thai traditional calendar. And also, the use of serial number to denote lunar months may be Chinese influence.

For intercalation, a kind of simplified method using 19-year and possibly 57-year ($57 = 19 \times 3$) cycle is used. For 19 years, 7 intercalary months are added. The 19-year cycle of intercalation is mentioned in the "Souriat" of the Ayutthaya dynasty (Loubère (1693) Tome II, p.190). The 19-year cycle was quite popular in ancient China, but was not popular in ancient India.

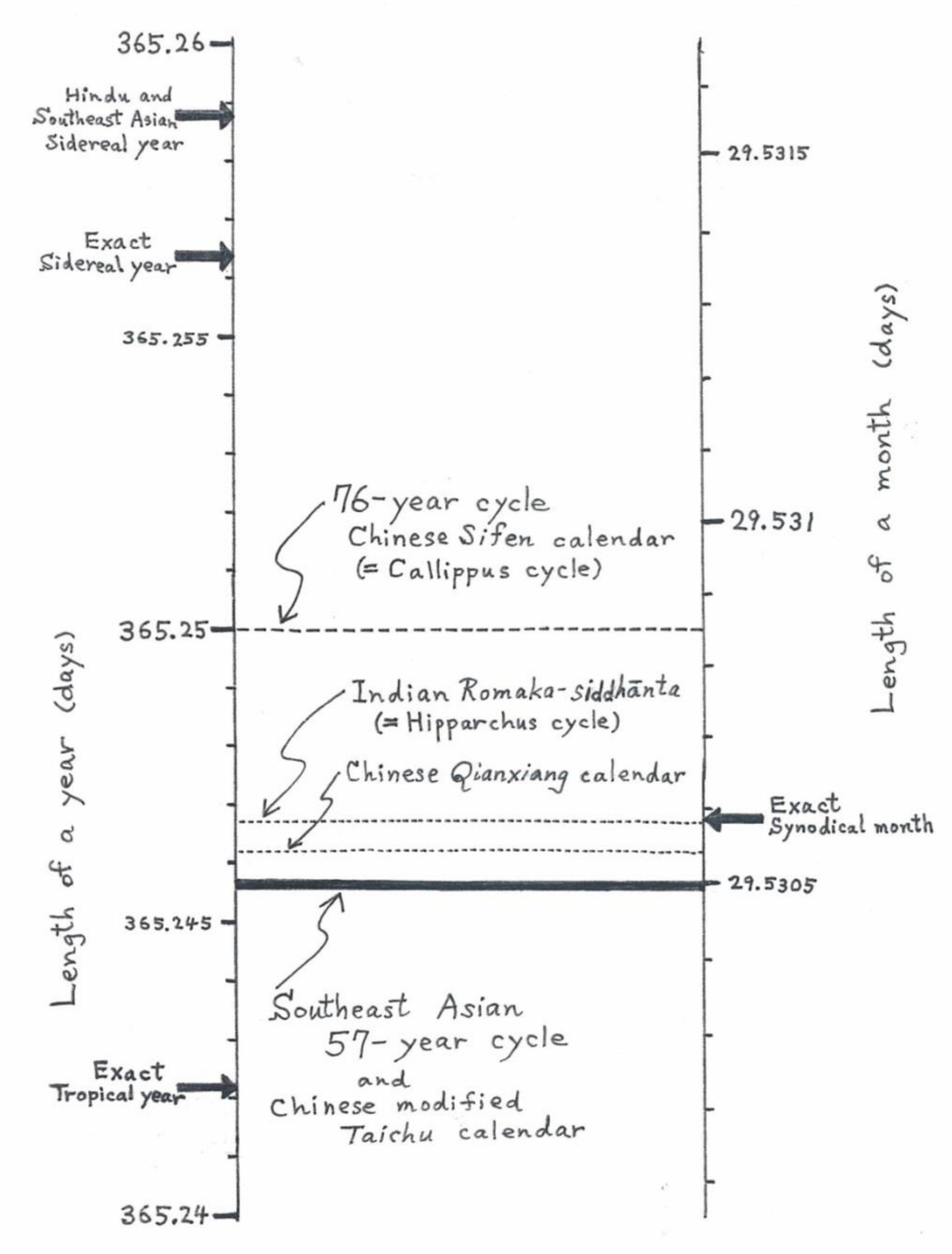
If 57-year cycle is strictly used, 57 years are 705 months ($705 = (19 \times 12 + 7) \times 3$) and are 20819 days ($20819 = 6 \times 57 \times (29 + 30) + 7 \times 3 \times 30 + 11$). Then, one year becomes 365.2456 days, and one lunar-month becomes 29.530496 days. Here, one year is close to a tropical year.

This 57-year cycle is not found in Indian calendars as well as Chinese official calendars. However, there was a modified *Taichu* (太初) calendar, which was not officially used, in the Eastern Han dynasty (AD 25 – 220) of China, and is the same as the Southeast Asian 57-year intercalation. So, I made a hypothesis that the Southeast Asian intercalation is originated from the Chinese modified *Taichu* calendar. (See Ôhashi (2002), (2006a) and (2011).) See Fig.36 for the relationship between the length of a year and the length of a month. The line is horizontal when 19-year cycle (or its multiple) of intercalation is used.

Eade (1995, p.56) mentions the 57-year cycle consists of 20819 days, but it seems that the actual use of this cycle in Southeast Asia is uncertain. The usually used cycle in Southeast Asia is 703-month cycle consists of 20760 days (instead of 705-month cycle consists of 20819 days). Zhang and Chen (1981, pp.250-251) suggested the actual use of the 57-year cycle in the "Xitan" system of calendar of Dai people in Yunnan Province, China. This matter will have to be examined further.

Similar calendar is used in Laos, Cambodia, Myanmar etc., but in the actual calendar, some modifications are made in different areas, including Thailand, in different way as Dr. Lars Gislén pointed out at the Mandalay meeting. I could discuss with Dr. Gislén at the meeting, and this point should be studied further, and I shall continue to study the records of the calculation of traditional calendar in different areas. Gislén (2018) explains the difference between Thai calendar and Burmese calendar, and suggests the possibility that the original Burmese calendar was influenced by the *Romaka-siddhānta* (one of the five astronomical systems described in a Sanskrit text *Pañca-siddhāntikā* of

Varāhamihira, the 6th century, India), and later imported the Hindu sidereal year. This suggestion will have to be considered.



[Fig.36, Length of a year and a lunar-month when 19-year cycle (or its multiple) is used.]

IV. Conclusion

Several different astronomical traditions are found in Southeast Asia, which have regional originality.

Foe example, the Thai traditional astronomy and some other Mainland Southeast Asian astronomy are created as a kind of combination of local astronomical knowledge, Chinese influence and Indian influence, and their astronomy have Southeast Asian specialty.

In the Ao Nang meeting (2015) and Mandalay meeting (2017), I could receive several valuable information from the participants, some of which were utilized in this paper. I hope we continue to study Southeast Asian astronomy, exchange information, and establish a foundation for further research.

And also, when I was reading Thai books, I received several suggestions from my Thai teacher Ms. Nataya Yamakanon, and I am grateful for her guidance for several years. Of course, any mistake in this paper is my responsibility.

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