CALCULATING THE UPOSATHA MOONDAYS

v0.4 · 1st September 2015 · link

TL,DR

Too Long, Didn't Read

- This is composed as a manual on how to calculate the Full- and New Moon day *uposathas*, and indicating the astronomical cycles that underlie the method.
- The method is based on a set of formulas called *suriyayatra*, originating from India and including additional rules observed in Thailand.
- A minimal description: Alternate 30 and 29 day lunar months, 12 months make one year. Add an extra month 7 times in every 19 years, add an extra day 11 times in every 57 years.
- Conventions on how to practise this can differ by countries and groups, resulting in self-consistent but different calendars.
- The Royal Thai Calendar sometimes includes unforeseen adjustments. The different monastic groups simply adjust the major moondays in their calendars for concord.
- Prediction: Common years and adhikamāsa (extra month) years follow a regular sequence which is generally realiable to predict. Adhikavāra (extra day) years occur more rarely and are not realiable to predict, because of the flexibility in choosing the year which the extra day will be assigned to.

Much appreciation for the answers from the Venerable Ajahns who endured my questions. Comprehension and consistency was only possible with their experience and understanding.

Download this PDF or a ZIP archive with references.

Comments, corrections and further information would be greatly appreciated:

Gambhiro Bhikkhu <gambhiro.bhikkhu.85@gmail.com>

Changelog:

2015-09-01, v0.4

- tutorial ready for review
- year diagram, year planners
- past years in .csv in references/calendar-data-mahanikaya folder
- more tl,dr
- general review

2015-08-04, v0.3

- Uposatha Calendar Tutorial

2014-10-09, v0.2

- Ven. Hāsapañño:
  - adhikavāra clarified
  - first and last day of a lunar month
  - occurrence of major moondays with the Pāli method

2014-10-07, v0.1

- ready for feedback

1 MAHĀNIKĀYA UPOSATHA CALENDAR TUTORIAL

This section is a step-by-step guide on how to calculate the uposathas for a given year.

I recommend printing the following pages to be able to reference them as you follow along:

- The diagram on p.14 shows the uposathas in a common-, adhikamāsa- and adhikavāra year.
- There are A4 format year planners included for 2014 (p.15), 2015 (p.16) and 2016 (p.17). This is a sequence of a common, adhikamāsa and adhikavāra year.

1.1 Collecting information about the year

We need to know the following:

- the last uposatha of the previous lunar year
- whether there is an extra lunar month (adhikamāsa),
- or an extra day (adhikavāra),
- or neither, and so it is a common year.

Find the Full Moon in last year November, this is the last uposatha of the previous lunar year.

In Thai practice a lunar year can't have both an adhikamāsa and an adhikavāra.

Table 2.1 shows a few adhikamāsa years. See if the given year will have an adhikamāsa.

Table 2.2 shows a few adhikavāra years. Keep in mind that this is provisional. Even when a year qualifies for an adhikavāra, the calendar authorities may choose to add it in a different year.

Now we know that the year is either:

- a common year,
- an adhikamāsa year, or
- an adhikavāra year.

Gregorian leap years don't affect the lunar calendar, but it may be useful to check when planning ahead. Table 5.1 shows a few leap years.

1.2 Common year

1.2.1 Alternate 30 and 29 day months

Counting from the last Full Moon of the previous lunar year (which will be in November), the first month is 30 days, the second is 29 days:

15 days	● New Moon	First uposatha of the Cold Season
15 days	○ Full Moon	End of first month, 30 days
14 days	● New Moon	
15 days	○ Full Moon	End of second month, 29 days

A Full Moon is always on the 15th day. Every second New Moon is on the 14th day.

The ◐ Waxing- and ◑ Waning Moons are on the 8th day.

Keep alternating 30 and 29 day months. One season is four months, one year is three seasons: Cold-, Hot- and Rainy Season. See Table 3.3 for the Pāli names of months and seasons.

1.2.2 Marking the Vassa and Major Moondays

Mark the months and seasons according to Table 3.3.

The key annual events are on the Full Moon of the given lunar months:

	Lunar Month
Māgha Pūjā	3rd
Visākha Pūjā	6th
Āsāḷha Pūjā	8th
Pavāraṇā Day	11th

Mark the Vassa (Rainy Season Retreat):

- The first day of the Vassa is the day after Āsāḷha Pūjā
- The last day of the Vassa is Pavāraṇā Day

In a common year, the calendar is finished.

1.3 Adhikamāsa year

1.3.1 Marking the Vassa and Major Moondays

Adding the extra month has three consequences:

- the Major Moondays shift to the next Full Moon
- Gimhāna (Hot Season) has 10 uposathas instead of 8
- the Vassa starts 30 days later

The extra month is a 30 day month. In Thai practice, it is appended to the end of the Hot Season, after the 8th month (Āsāḷha). The convention is to call this the 'second 8th' or 'second Āsāḷha', marked as 8/8.

Āsāḷha Pūjā will be held in the 8/8 2nd Āsāḷha month, after which will be the first day of the Vassa. The Vassa remains the same length, 8 uposathas.

Āsāḷha Pūjā and Pavāraṇā Day therefore shifted because we added an extra month to the end of the Hot Season.

From a practical perspective, Māgha Pūjā and Visākha Pūjā are simply moved to the next month, and are marked in the 4th and 7th month instead of the 3rd and 6th. This is as though it happened in a parallel, separate system, and it doesn't influence the actual numbering or length of the months.

This has the advantage that there will not be a large gap between Visākha and Āsāḷha Pūjā (now in the 2nd Āsāḷha). See sec.2.1.1 for a further discussion of the logic.

See the diagram on page 14 to compare how the sequence of the uposathas and the major moondays fall in an adhikamāsa year compared to a common year.

1.3.2 Thai and monastic lunar months

In addition, there is a monastic and a Thai way of reckoning the beginning and the end of the lunar months. When looking up information, one needs to find out which system is being used.

In the monastic lunar months, the Full Moon is on the last day of the month.

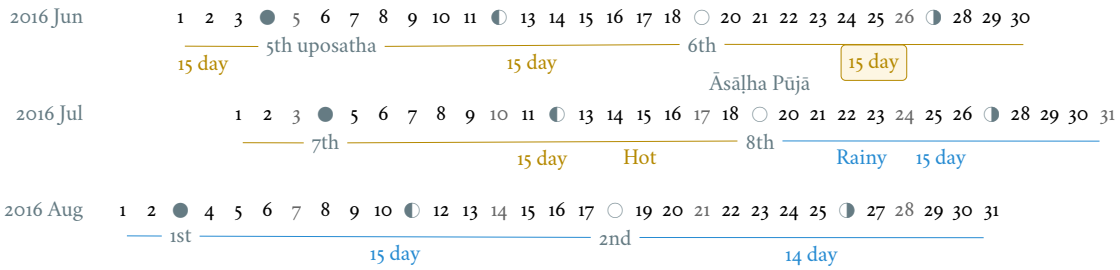
In the Thai lunar months, the Full Moon is in the middle of the month, and the New Moon is on the last day.

1.4 Adhikavāra year

The extra day is inserted in the 8th month (Āsāḷha), making the 7th uposatha of the Hot Season a 15-day uposatha instead of the expected 14-day, and making Āsāḷha a 30-day month that year.[1]

In adhikavāra years the Vassa starts one day later.

order	name	days
6	Visākha	29
7	Jeṭṭha	30
8	Āsāḷha	**30**
9	Savaṇa	30
10	Bhaddapāda	29



2 THE MAHĀNIKĀYA UPOSATHA CALENDAR METHOD

2.1 Adding the extra month

The extra month (adhikamāsa) is added 7 times in every 19 year, in a repeating pattern of 3-3-2 - 3-3-3-2 years. This is a shorthand for the formulas at 3.1 which generate this pattern. Table 2.1 shows adhikamāsa years for 1985-2039.

In Thai practice, the extra month is a 30 day month inserted after the 8th month (*Āsāḷha*), at the end of the Hot Season. The convention is to call this the 'second 8th' or 'second *Āsāḷha*', marked as 8/8.

In adhikamāsa years the Vassa starts 30 days later, after the 2nd Āsāḷha, on the day after the Full Moon uposatha of 8/8.

order	name	days
8	Āsāḷha	29
8/8	2nd Āsāḷha	30
9	Savaṇa	30

Table 2.1: Adhikamāsa years

Δm: years since the last adhikamāsa. Nth: place in the 19-year cycle.

		Δ m	Nth
1985	2528	3	3
1988	2531	3	6
1990	2533	2	8
1993	2536	3	11
1996	2539	3	14
1999	2542	3	17
2001	2544	2	19
2004	2547	3	3
2007	2550	3	6
2009	2552	2	8
2012	2555	3	11
2015	2558	3	14
2018	2561	3	17
2020	2563	2	19
2023	2566	3	3
2026	2569	3	6
2028	2571	2	8
2031	2574	3	11
2034	2577	3	14
2037	2580	3	17
2039	2582	2	19

2.1.1 *Marking the Major Moondays*

TODO

2.2 Adding the extra day

The extra day (adhikavāra) is added 11 times in every 57 year.

Whether a year should have an extra day can be determined with the conditions at sec.3.4.

In Thai practice a year with an extra month is not allowed to also have an extra day. If the year should have an extra day, but it already has an extra month, the extra day is assigned to one of the flanking years (next or previous, in the case of planning several years in advance).

In adhikavāra years the Vassa starts one day later.

If the year is going to have an extra day, it is inserted in the 8th month (Āsāḷha), making the 7th uposatha of the Hot Season a 15-day uposatha instead of the expected 14-day, and making Āsāḷha a 30-day month that year.[1]

order	name	days
6	Visākha	29
7	Jeṭṭha	30
8	Āsāḷha	**30**
9	Savaṇa	30
10	Bhaddapāda	29

However, this is the most unpredictable variable in the calendars published for a given year, and the various calendar authorities add the extra day in a flexible manner, in some of cases adding it in the years according to the formula but deviating from it in others.

Nonetheless they observe that:

- the count for 11 times in 57 years is maintained to keep the calendar at pace
- the extra day will not be in years that also have an extra month.

Table 2.2: Adhikavāra years

K, A, T for kammacubala, avoman and thaloengsok

Year	CS	K	A	T
1994	1356	535	54	6
2000	1362	93	627	11
2005	1367	658	656	7
2009	1371	630	119	22
2014	1376	395	137	17
2016	1378	781	566	9
2020	1382	753	29	24
2025	1387	518	47	19

2.3 Major Moondays

Buddhist communities observe the key annual events on and around the Full Moon days of the 3rd, 6th, 8th and 11th lunar months, see Table 2.3.

Table 2.3: Major Events in a Common Year

Event	Time
Māgha Pūjā	3rd Full Moon
Visākha Pūjā	6th Full Moon
Āsāḷha Pūjā	8th Full Moon
First Day of Vassa	the day after Āsāḷha
Pavāraṇā Day	11th Full Moon
Last Day of Vassa	Pavāraṇā Day

Also see sec.3.2 on *Thai* lunar months.

3 THE THAI LUNI-SOLAR CALENDAR

Luni-solar calendars are constructed so to count **years** according to the *solar* cycle, but to count **months** according to the *lunar* cycle.

tropical year[1] of the Earth	365.24219 days
synodic month[2] of the Moon	~29.53 days, can vary up to 7 hours

The epoch of the Thai calendar is 25 March 638 AD.

The Thai luni-solar calendar is *procedural*, it uses a few constant, key numbers derived from astronomical observations, and applies a series of mechanical calculations (i.e. the "rules") again and again to generate the dates of lunar phases and new years.

> This working is deliberately concise, since it thereby reflects how the calculation would have been made by a South East Asian calendrist. Each stage is subjected to an operation learnt by rote, and the underlying theory disappears from view. The rote operations, however, will provide a valid answer for any date in any year. It seemed greatly preferable to set out the procedure thus starkly, rather than to give a detailed exposition of what is involved.[4]

Southeast Asian astronomers refined a fraction to obtain the length of the year:

$$\frac{292207}{800} = 365.25875 \text{ days}[4] \tag{3.1}$$

This is 0.01656 days longer than the modern measurement (accumulating 1 day in ~60 years). Remarkably, the *suriyayatra* accounts for this and generates accurate results:

> For instance, a Pagan inscription of 14 April 1288 AD maintains that at midnight the Sun's position was 0 signs, 19 degrees and 59 minutes: the computer program returns 0 19 59.[3]

Nonetheless, the calendar dates published in Thailand (historical or recent) in a given year reflect not only these principles, but also adjustments and omissions which cannot be foreseen or retraced.

> The historical record however, frequently defies prediction, forcing the conclusion that the pressure upon the *horas* (astronomers / astrologers) was not to follow the "rules" but merely, within some more leisurely constraints, to ensure that the calendar did not get out of control.[3]

[1] tropical year: the time it takes the Earth to complete an orbit around the Sun
[2] synodic month: the time it takes the Moon to reach the same visual phase

3.1 Year Types

We are concerned with three types of calendar years:

Cal A Normal with 354 days

Cal B Adhikavāra with 355 days

Cal C Adhikamāsa with 384 days

Comparing these to normal and solar leap years:

	A	B	C
Lunar	354	355	384
Solar	365	365	365
difference	+11	+10	-19

	A	B	C
Lunar	354	355	384
Solar Leap	366	366	366
difference	+12	+11	-18

3.2 The first and last day of a lunar month

In monastic practice, the Full Moon day is on the last day of a given month. The next month starts on the following day (first day of the waning phase), thus the first uposatha will be on a New Moon.

In many Thai calendars, the New Moon day is the last day of the month, and the Full Moon day is in the middle. This only changes the numbering of the months, not the actual moondays. In these calendars the thresholds of months are shifted two weeks forward relative to the monastic calendar.

This can be particularly important to watch at the end of the lunar year:

The New Moon of the 12th *Thai* lunar month is the New Moon (1st uposatha) of the 1st *monastic* lunar month.

Table 3.1: Monastic and Thai lunar months in a year

Nth	phase	month	Monastic	Thai
1	New		1	12
2	Full	Magasira	1	1
3	New		2	1
4	Full	Phussa	2	2
5	New		3	2
6	Full	Māgha	3	3
7	New		4	3
8	Full	Phagguṇa	4	4

3.3 Adhikamāsa years

The *suriyayatra* principle to determine adhikamāsa (Thai: adhikamat) years is:

> If the day of *thaloengsok* (astronomical New Year) lies either within 25 to 29 (in Citta-māsa) or 1 to 5 (in Visākha-māsa), then the year is adhikamāsa.[5]

The *thaloengsok* is the value of T in Figure 3.1.

Figure 3.1: Finding astronomical values with the *suriyayatra* calculation[4]

Start with Y, the given Common Era year. Significant values are assigned names. K for *kammacubala*, A for *avoman*, T for *thaloengsok* (the New Year). 638 AD is the Thai calendar epoch (CS years).

$$
\begin{aligned}
a &= ((Y - 638) * 292207) + 373 && (3.2)\\
h &= \lfloor a/800 + 1 \rfloor && (3.3)\\
K &= 800 - (a \bmod 800) && (3.4)\\
A &= ((h * 11) + 650) \bmod 692 && (3.5)\\
b &= \lfloor ((h * 11) + 650)/692 \rfloor && (3.6)\\
T &= (b + h) \bmod 30 && (3.7)
\end{aligned}
$$

3.4 Adhikavāra years

(Thai: adhikawan อธิกวาร)

> Two components of the *suriyayatra* are known as the *kammacubala* and the *avoman*, and it is the values of these two elements at the start of the year that determine the matter:
>
> - if the kammacubala value is 207 or less, then the year is leap year
> - in a leap year, if the avoman is 126 or less, the year will have an extra day
> - in a normal year, if the avoman is 137 or less, the year will have and extra day[4]

The *kammacubala* and *avoman* are the value of K and A in Figure 3.1.

In Thailand, years with an extra month are not allowed to also have an extra day, and the adhikavāra will be assigned to the previous or next year.

3.5 Suriyayatra formulas

See Figure 3.1.

3.6 Names of the months

The name of a given month is determined by the astrological sign which the Full Moon enters at midnight. See Table 3.3.

Table 3.2: Adhikamāsa and adhikavāra in the period 1958 to 1978 (CS 1320-1340).[4]

m for adhikamāsa, d for adhikavāra years, Δm and Δd for years since last adhikamāsa and adhikavāra.

Δ d			Δ m	year	type	Asalha	2nd Asalha
		0		1320	m	19:42	22:24
0		1		1321	d	21:05	
1		2		1322		20:40	
2		3	3	1323	m	19:12	22:00
3		4		1324		20:38	
4	4	5		1325	d	19:34	
5		6	3	1326	m	19:38	22:05
6		7		1327		21:15	
7		8	2	1328	m	19:20	22:55
8		9		1329		21:48	
9	5	10		1330	d	20:26	
10		11	3	1331	m	19:59	22:50
11		12		1332		21:20	
12		13		1333		20:02	
13		14	3	1334	m	19:03	21:33
14	5	15		1335	d	20:40	
15		16		1336		20:44	
16		17	3	1337	m	19:44	22:19
17		18		1338		21:11	
18		19	2	1339	m	19:45	22:35
19	5			1340	d	21:05	

Table 3.3: Lunar and Solar Months and Zodiacs[1]

Season		days	Lunar Month	Solar Month	Solar Zodiac (Western / Sanskrit)
Hemanta-utu	1	30	Magasira-māsa	December	Sagittarius / Dhanus
Cold Season	2	29	Phussa-māsa	January	Capricorn / Makara
	3	30	Māgha-māsa	February	Aquarius / Kumbha
	4	29	Phagguṇa-māsa	March	Pisces / Mīna
Gimha-utu	5	30	Citta-māsa	April	Aries / Meṣa
Hot Season	6	29	Visākha-māsa	May	Taurus / Vṛṣabha
	7	30	Jeṭṭha-māsa	June	Gemini / Mithuna
	8	29	Āsāḷha-māsa	July	Cancer / Karkaṭa
Vassāna-utu	9	30	Savaṇa-māsa	August	Leo / Siṃha
Rainy Season	10	29	Bhaddapāda-māsa	September	Virgo / Kanyā
	11	30	Assayuja-māsa	October	Libra / Tulā
	12	29	Kattika-māsa	November	Scorpio / Vṛścika

4 ADDING THE EXTRA MONTH, PALI METHOD

The following is adapted from Ajahn Khemanando for recent years.[2]

Table 4.1 shows adding the adhikamāsa in the 19-year cycle between 2001-2020.

Table 4.1: Adding the adhikamāsa for 2001-2020 according to the Pali method.

Δm for years since last adhikamāsa. Months and moon are in Thai lunar months.

		Nth	Δ m	Season	Month	New	Full
2001	2544	19	2	Cold	2	● 12	○ 5
2002	2545	1					
2003	2546	2					
2004	2547	3	3	Rainy	10	● 8	○ 12
2005	2548	4					
2006	2549	5					
2007	2550	6	3	Hot	7	● 4	○ 8/8
2008	2551	7					
2009	2552	8	2	Cold	3	● 12	○ 5
2010	2553	9					
2011	2554	10					
2012	2555	11	3	Cold	12	● 12	○ 5
2013	2556	12					
2014	2557	13					
2015	2558	14	3	Rainy	8	● 8	○ 12
2016	2559	15					
2017	2560	16					
2018	2561	17	3	Hot	5	● 4	○ 8/8
2019	2562	18					
2020	2563	19	2	Cold	2	● 12	○ 5

Δ m: years since the last adhikamāsa

Month: the Thai lunar month into which the adhikamāsa is inserted

Season: the season in which the adhikamāsa falls in that particular year

New and Full: the first and last uposatha of the 5-month season in which the adhikamāsa falls, numbered in Thai lunar months

If the adhikamāsa falls on the 2nd, 3rd, or 12th Thai lunar month, there will be *two* 8th months (8 and 8/8) the following year.

E.g. In 2001, the adhikamāsa comes as the 2nd lunar month in the Cold Season, so the following year, 2002, has two 8th months (8 and 8/8). There will thus be *ten* uposathas in the Cold Season. The first being the New Moon of the 12th Thai lunar month (of 2543, at the end of 2000), the last being the Full Moon of the 5th Thai lunar month in 2001.

5 GREGORIAN LEAP YEARS

Table 5.1: Gregorian leap years

2004	2016	2028	2040
2008	2020	2032	2044
2012	2024	2036	2048

if (*year* is not exactly divisible by 4) **then** (it is a common year)
else
if (*year* is not exactly divisible by 100) **then** (it is a leap year)
else
if (*year* is not exactly divisible by 400) **then** (it is a common year)
else (it is a leap year) [6]

BIBLIOGRAPHY

[1] Hāsapañño Bhikkhu. The lunar and solar zodiac, 2014.

[2] Khemanando Bhikkhu. The cycle of the adhikamāsa.

[3] J.C. Eade. The calendrical systems of mainland south-east asia (using the preview bits available on Google Books). 1995.

[4] J.C. Eade. Rules for interpolation in the thai calendar: *Suriyayatra* versus the *Sasana*. *Journal of the Siam Society*, 88(1 and 2), 2000. Accessed 2014-10-02.

[5] Prasert na Nagara. *Ngan charuk lae prawatisat*.

[6] Wikipedia. Leap Year.

COLOPHON

Org-mode and LaTeX. Sources at Github.

Comments, corrections and further information would be greatly appreciated.

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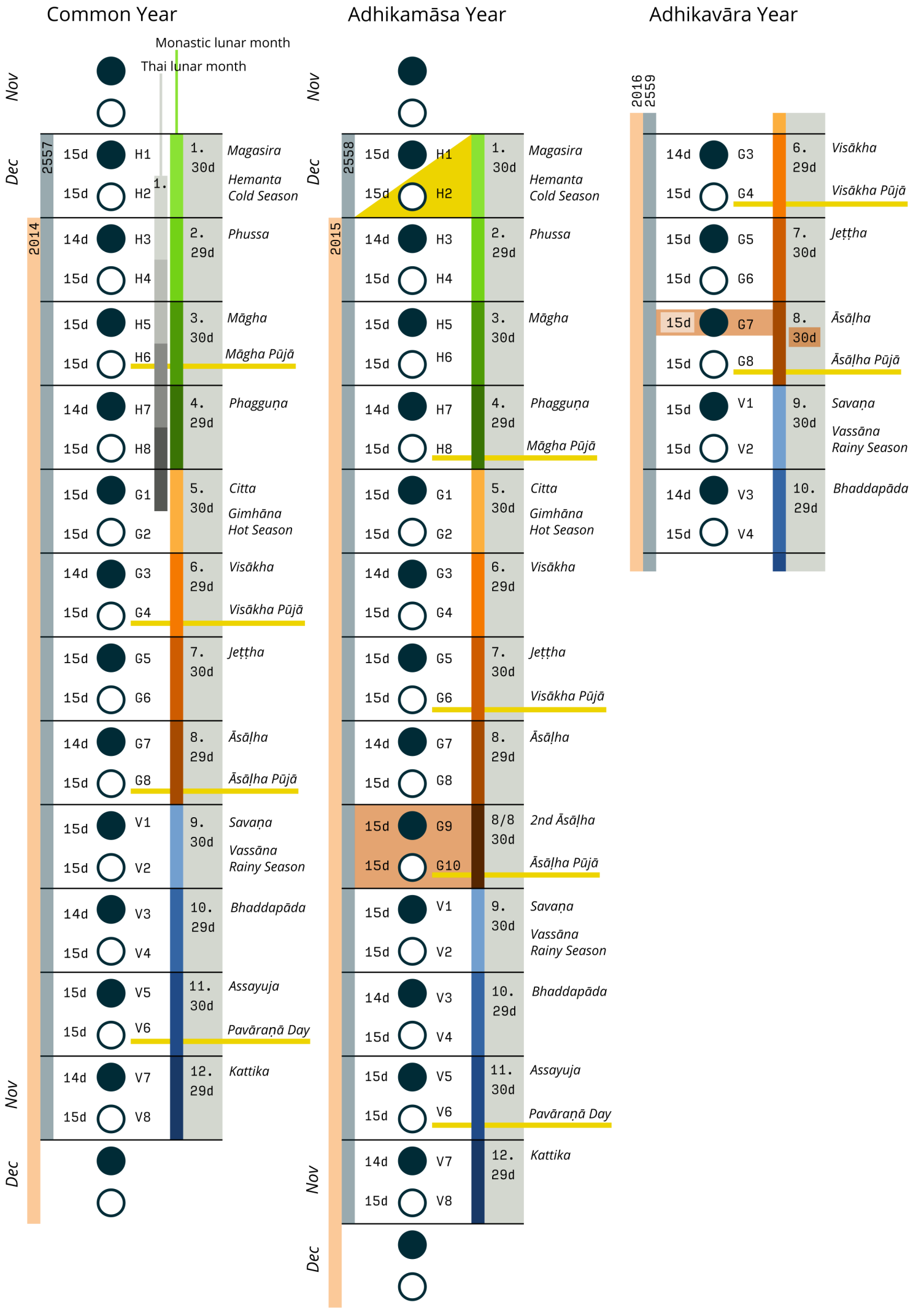
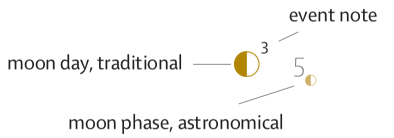

Common Year
Adhikamāsa Year
Adhikavāra Year
Monastic lunar month
Thai lunar month
Nov
Dec
2557
2014
2558
2015
2016
2559
15d H1
15d H2
14d H3
15d H4
15d H5
15d H6
14d H7
15d H8
15d G1
15d G2
14d G3
15d G4
15d G5
15d G6
14d G7
15d G8
15d V1
15d V2
14d V3
15d V4
15d V5
15d V6
14d V7
15d V8
15d G9
15d G10
1. 30d Magasira
Hemanta
Cold Season
2. 29d Phussa
3. 30d Māgha
Māgha Pūjā
4. 29d Phagguṇa
5. 30d Citta
Gimhāna
Hot Season
6. 29d Visākha
Visākha Pūjā
7. 30d Jeṭṭha
8. 29d Āsāḷha
Āsāḷha Pūjā
9. 30d Savaṇa
Vassāna
Rainy Season
10. 29d Bhaddapāda
11. 30d Assayuja
Pavāraṇā Day
12. 29d Kattika
8/8 30d 2nd Āsāḷha
Āsāḷha Pūjā

Forest Sangha Calendar 2014 - 2557

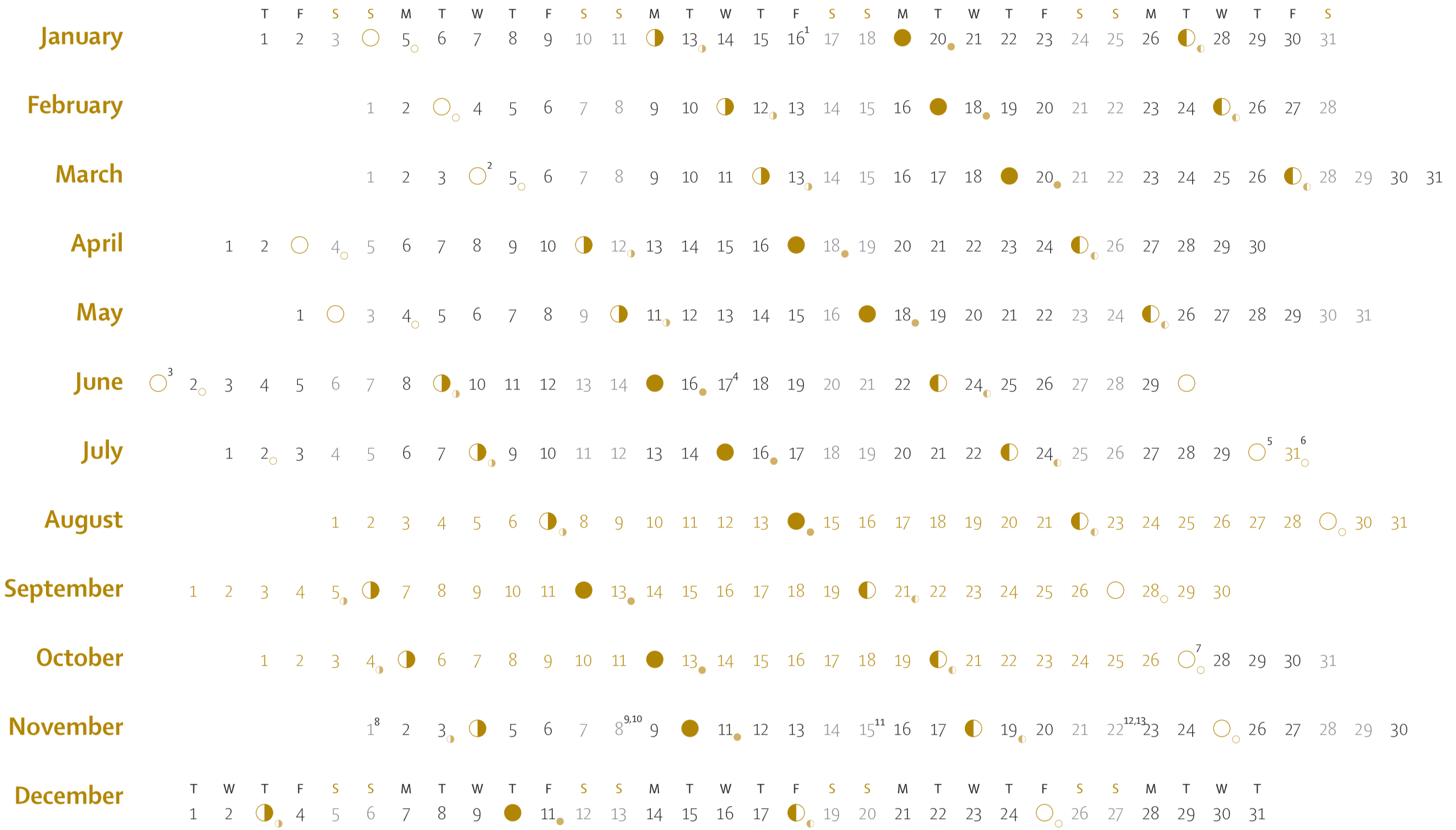
[1] Jan 16: *Ajahn Chah Memorial Day*
[2] Feb 14: *Māgha Pūjā*
[3] May 13: *Vesākha Pūjā*
[4] Jun 17: *Ajahn Chah's Birthday*
[5] July 11: *Āsāḷhā Pūjā*
[6] July 12: *Vassa begins*
[7] Oct 8: *Pavāraṇā*

Robe offering ceremonies:
[8] Oct 12: *Dhammapala*
[9] Oct 12: *Hartridge*
[10] Oct 12: *Santacittarama*
[11] Oct 19: *Aruna Ratanagiri*
[12] Oct 26: *Cittaviveka*
[13] Nov 2: *Amaravati*



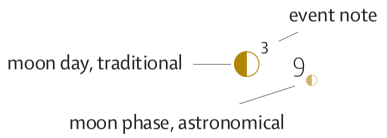
Download from www.forestsangha.org/calendar

Forest Sangha Calendar 2015 - 2558



[1] Jan 16: *Ajahn Chah Memorial Day*
[2] Mar 4: *Māgha Pūjā*
[3] Jun 1: *Vesākha Pūjā*
[4] Jun 17: *Ajahn Chah's Birthday*
[5] July 30: *Āsāḷhā Pūjā*
[6] July 31: *Vassa begins*
[7] Oct 27: *Pavāraṇā*

Robe offering ceremonies:
[8] Nov 1: *Aruna Ratanagiri*
[9] Nov 8: *Santacittarama*
[10] Nov 8: *Hartridge*
[11] Nov 15: *Amaravati*
[12] Nov 22: *Cittaviveka*
[13] Nov 22: *Dhammapala*



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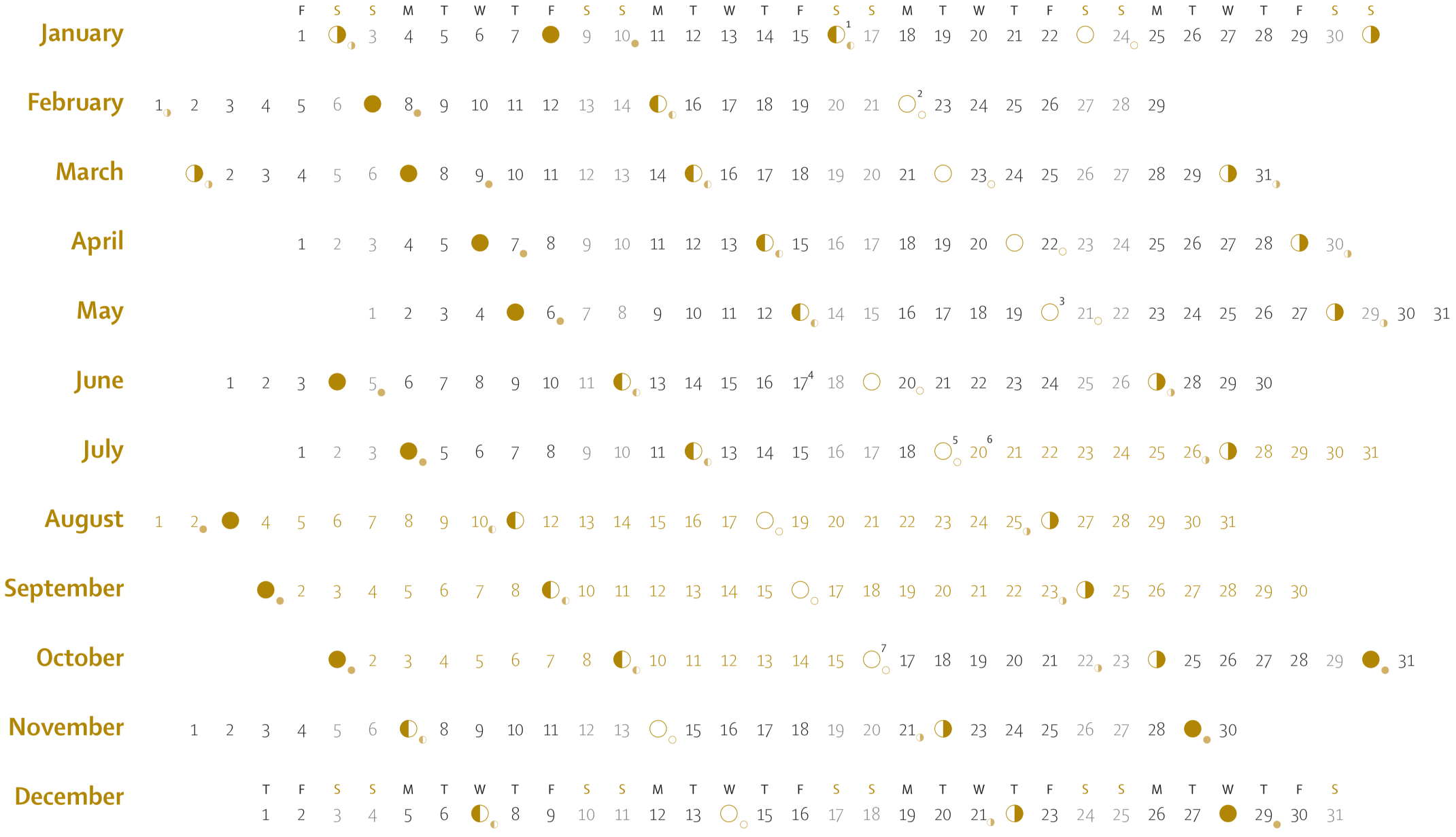
Forest Sangha Calendar 2016 - 2559



[1] Jan 16: *Ajahn Chah Memorial Day*
[2] Feb 22: *Māgha Pūjā*
[3] May 20: *Vesākha Pūjā*
[4] Jun 17: *Ajahn Chah's Birthday*
[5] July 19: *Āsāḷhā Pūjā*
[6] July 20: *Vassa begins*
[7] Oct 16: *Pavāraṇā*

event note
moon day, traditional — 3
5
moon phase, astronomical

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