

A Geomedical Approach to Chinese Medicine: The Origin of the Yin-Yang Symbol

Stefan Jaeger
*National Library of Medicine**
United States

1. Introduction

This chapter shows how to compute Yin and Yang for different latitudes so traditional Chinese herbalists can quantify the efficacy of herbal drugs. Based on daylight hours, the chapter provides a simple formula that allows computation of Yin and Yang for each day of the year. Moreover, using daily Yin and Yang values, the chapter shows how to render the Yin-Yang symbol properly in accordance with its original meaning. Considering the importance of Yin and Yang in traditional Chinese medicine (TCM), the rendering method presented in this chapter provides evidence that TCM, in its origin, is a geommedical science.

Herbal medicines collected from different geographic locations can significantly differ in their therapeutic efficacy. The concentration of bioactive substances varies depending on many local factors, such as sunshine hours or chemical and physical properties of the soil. To guarantee the optimal composition of herbal drugs, Chinese herbalists use “geo-authentic” herbs from recognized locations. However, it is often difficult to confirm geographical authenticity. The lack of formal models for Yin and Yang, and herbal efficacy in general, complicates objective comparisons and evaluations. Herbalists and practitioners of TCM need a better formal understanding of the Yin-Yang composition of each herb. This chapter contributes to the solution to this problem by providing a formal description of Yin and Yang. It shows in a mathematical way how Yin and Yang vary depending on latitude. The latitude of a herb’s location determines the number of daylight hours and sunshine the herb is exposed to during the year. The number of daylight hours is one of the components affecting the concentration and composition of bioactive substances and therefore the efficacy of the herb. To standardize herbal preparation and administration, rigorous mathematical methods are essential to measure the Yin-Yang composition of herbs quantitatively. The work presented in this chapter is a first step toward such standardization.

The chapter structure is as follows: Section 2 discusses the main ideas of the philosophical Yin-Yang concept. Section 3 shows today’s most common Yin-Yang symbol and discusses its typical shape. Then, Section 4 presents the origin of the Yin-Yang symbol and introduces a daylight model that allows computation of Yin and Yang depending on the daylight hours for each geographic latitude. Using the computed values for Yin and Yang, the section will show how to render the Yin-Yang symbol properly, and in accordance with its original meaning. The chapter concludes with a discussion of the consequences of the results for researchers in TCM and herbal medicine. Finally, the appendix contains examples of Yin-Yang symbols computed for different latitudes in the northern and southern hemispheres.

*Work on this study began while the author was affiliated with the Chinese Academy of Sciences.

2. Yin and Yang

Yin-Yang has become a universal philosophical concept that many people readily embrace to their advantage. The concept of Yin and Yang is deeply rooted in Chinese philosophy (Miller, 2003; Watts, 1999). Its origin dates back at least 2500 years, probably much earlier, playing a crucial role in the formation of the Chinese ancient civilization. Chinese thinkers have attached great importance to Yin and Yang ever since. In Asia's search for a universal formula describing balance and harmony, Yin-Yang today appeals to fields as different as medicine, arts, religion, sports, or politics.

According to the Chinese philosophical concept, there are two opposing forces in the world, namely Yin and Yang, which are constantly trying to gain the upper hand over each other. However, neither one will ever succeed in doing so, though one force may temporarily dominate the other one. Both forces cannot exist without each other; it is rather the constant struggle between both forces that defines our world and produces the rhythm of life. Yin and Yang are not only believed to be the foundation of our universe, but also to flow through and affect every being. For example, typical Yin-Yang opposites are night/day, cold/hot, rest/activity.

Chinese philosophy does not confine itself to a mere description of Yin and Yang; it also provides guidelines on how to live in accordance with Yin and Yang. The central statement is that Yin and Yang need to be in harmony. Any imbalance of an economical, biological, physical, or chemical system can be directly attributed to a distorted equilibrium between Yin and Yang. For example, an illness accompanied by fever is the result of Yang being too strong and dominating Yin. On the other hand, for example, dominance of Yin could result in a body shivering with cold. The optimal state every being, or system, should strive for is therefore the state of equilibrium between Yin and Yang. It is this state of equilibrium between Yin and Yang that Chinese philosophy considers the most powerful and stable state a system can assume.

Yin and Yang already carry the seed of their opposites: A dominating Yin becomes susceptible to Yang and will eventually turn into its opposite. On the other hand, a dominating Yang gives rise to Yin and will turn into Yin over time. This defines the perennial alternating cycle of Yin or Yang dominance. Only the equilibrium between Yin and Yang is able to overcome this cycle.

3. Yin-Yang symbol

Figure 1 shows the well-known black-and-white symbol of Yin and Yang. This Yin-Yang



Fig. 1. A common Yin-Yang symbol.

symbol, also known under the name Tai Chi symbol, is arguably one of the most flamboyant symbols today. It stands on the same level as the Christian cross and other mainstream

religious symbols. We can see the intertwining spiral-like curves in Figure 1, which are actually semicircles, separating the Yin and Yang area. The small spots of different color in each area indicate the above mentioned conception that both Yin and Yang carry the seed of their opposites; Yin cannot exist without Yang, and Yang cannot exist without Yin. These spots will play no role in this chapter. Neither will the assignment of black and white to Yin and Yang have any significance here, though Yin is typically associated with black and Yang with white.

Spiral-like curves are a common occurrence in nature. They appear in various forms in a wide range of living beings and processes; e.g., mollusk shells, hurricanes, or galaxies (Cook, 1979; Séquin, 1999). Depending on the form of these curves, the Yin-Yang symbol can take on different shapes. It is therefore necessary to define a standard rendering method before plotting the Yin-Yang symbol. For example, Figure 2 shows two versions of the South Korean Flag.

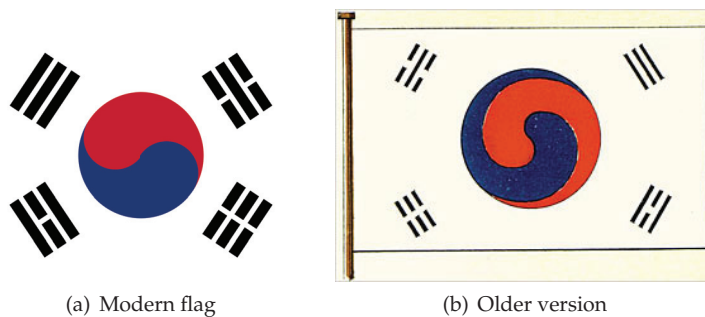


Fig. 2. Flag of South Korea (Wikipedia).

The South Korean flag's modern version is on the left-hand side of Figure 2. On the right-hand side is an older version of the flag. Both versions feature the Yin-Yang symbol prominently in their center, which is again testimony of the importance of the Yin-Yang concept for Asian countries. However, the shapes of the Yin-Yang spirals are clearly different for both flags. To agree on a common flag, it is necessary to define a standard construction scheme for rendering the Yin-Yang symbol. Figure 3 shows the standard construction sheet for the modern South Korean flag. However, the next section shows that the rendering method in Figure 3 does not reflect the original meaning of the Yin-Yang symbol.

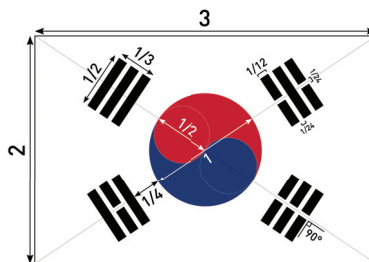


Fig. 3. Construction sheet for the South Korean flag (Wikipedia).

Contemporary literature has been mostly neglecting the plotting of the Yin-Yang symbol, paying more attention to philosophical questions. However, a mathematical formalization

of the Yin-Yang symbol is desirable to open hitherto mathematically inaccessible fields, such as Chinese traditional medicine, for rigorous scientific research.

4. The origin of the Yin-Yang symbol

Despite its presence in everyday life, it is fair to say that only a few people know about the origin of the Yin-Yang symbol. Very often, even the most devoted practitioners have to pass on the question about its origin. Contrary to what one would expect, literature dealing with the origin of the Yin-Yang symbol is rare. Contemporary books and articles typically deal in detail with the philosophical facets of Yin and Yang, but do not address the origin of the Yin-Yang symbol. It turns out that the original Yin-Yang symbol is more complex than its modern representation as two semicircles suggests (Browne, 2007; Graf, 1994).

The Yin-Yang symbol has its origin in the I-Ching; one of the oldest and most fundamental books in Chinese philosophy. The I-Ching, which is typically translated as “The Book of Changes”, deals with natural phenomena and their seasonal cycles. From the constant changes and transformations in nature, the I-Ching tries to derive the unchanging rules governing our cosmos and our very existence. The observation of celestial phenomena is therefore of central importance to the I-Ching (Hardaker, 2001). It is here, where one finds the roots of the Yin-Yang symbol (Tian & Tian, 2004).

For example, by observing the shadow of the sun and recording the positions of the Big Dipper at night throughout the year, the ancient Chinese determined the four points of the compass: The sun rises in the east and sets in the west. The direction of the shortest shadow measured on a given day reveals south (www.chinesefortunecalendar.com/yinyang.htm). At night, the Pole Star indicates North.

4.1 Shadow model

The Yin-Yang symbol is tightly connected with the annual cycle of the earth around the sun, and the four seasons resulting from it. To investigate this cycle, the ancient Chinese used a pole that they put up orthogonally to the ground, as shown in Figure 4. With this setup, the

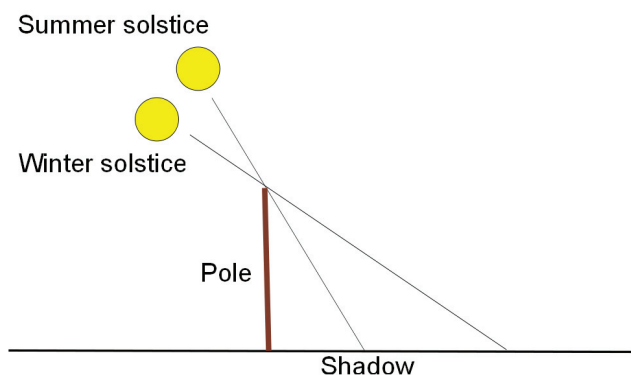


Fig. 4. Shadow model.

ancient Chinese were able to record precisely the positions of the sun's shadow and divide the year into different sections. They found the length of a year to be about 365.25 days.

Furthermore, they divided the circle of the year into segments, including the vernal equinox, autumnal equinox, summer solstice, and winter solstice. In addition, they used concentric circles around the pole, helping them to record the length of the sun's shadow every day. As a result, they measured the shortest shadow during the summer solstice, and measured the longest shadow during the winter solstice. After connecting the measured points and dimming the part that reaches from summer solstice to winter solstice (Yin), they arrived at a chart like the one in Figure 5. The resemblance between this chart and the modern Yin-Yang

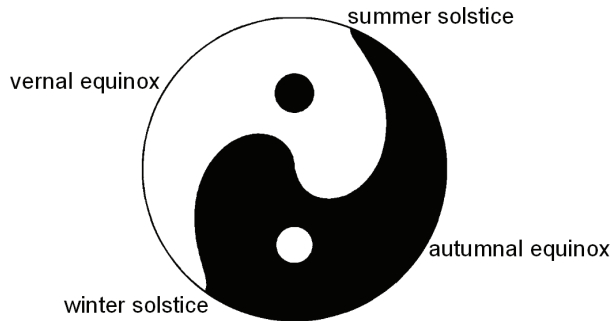


Fig. 5. Yin-Yang symbol for Latitude $L = 68^\circ$ (near polar circle) with equinoxes and solstices.

symbol in Figure 1 is striking. Figure 5 provides visual evidence that the original Yin-Yang symbol describes the change of a pole's shadow length during a year. In fact, by rotating the chart and positioning the winter solstice at the bottom, the Yin-Yang chart of the ancient Chinese becomes very similar to the modern Yin-Yang symbol depicted in Figure 1.

The white area of the Yin-Yang symbol is typically called Yang. It begins at the winter solstice and indicates a beginning dominance of daylight over darkness, which is the reason why the ancient Chinese associated it with the sun (or male). Accordingly, the dark area of the Yin-Yang symbol represents Yin, which begins with the summer solstice. Yin indicates a beginning dominance of darkness over daylight. The ancient Chinese therefore associated it with the moon (or female).

Note that the shape of the Yin-Yang symbol also depends on the ecliptic angle of the earth. The ecliptic affects the angle between the white Yang area, or black Yin area, and the outer circle of the Yin-Yang symbol. The ecliptic is the sun's apparent path around the earth. It is tilted relative to the earth's equator. As a result, one can observe four different seasons throughout the year. In the year 2000, the obliquity of the ecliptic was about $23^\circ 26' 19''$. The ecliptic's obliquity is not stable and can change during the millennia. This is due to the different forces exerted by the bodies in the solar system on the earth. The obliquity varies between about $21^\circ 55'$ and $24^\circ 18'$ within a period of 40,000 years (Wikipedia, March 2008). For example, in the year 3,000 BC, the ecliptic was about $24^\circ 1.6'$. Therefore, the ancient Yin-Yang symbol looks slightly different than the modern Yin-Yang symbol when rendered based on the shadow model.

4.2 Daylight model

This section presents a rendering method for the Yin-Yang symbol based on daylight hours, which are connected with shadow lengths. A long day has the sun standing high on the

horizon at noon, casting a short shadow. On the other hand, a short day is the result of the sun standing low on the horizon at noon, which in turn produces a long shadow. For computing the daylight time for a given day in the year, this section uses the formula given in (Forsythe et al., 1995). The formula takes many different factors into account, most notably the refraction of the earth's atmosphere. The daylight model presented here is therefore an accurate description of the actual daylight measurement of an observer on the ground. A detailed investigation of the formula is beyond the scope of this paper, though. The formula requires two input parameters, namely the day of the year J and the latitude L of the observer's location. It consists of two parts. The first part computes an intermediate result P , which is the input to the second part. The equation for the first part is as follows:

$$P = \arcsin[0.39795 * \cos(0.2163108 + 2 * \arctan\{0.9671396 * \tan[0.00860(J - 186)]\})] \quad (1)$$

Given P , the second part then computes the actual day length D in terms of sunshine hours:

$$D = 24 - \left(\frac{24}{\pi}\right) * \arccos\left\{\frac{\sin\left(\frac{0.8333 * \pi}{180}\right) + \sin\left(\frac{L * \pi}{180}\right) * \sin(P)}{\cos\left(\frac{L * \pi}{180}\right) * \cos(P)}\right\} \quad (2)$$

Using Equation 2, Figure 6 shows the daylight time for each day of the year and a latitude of 68° . This latitude is close to the polar circle, or Arctic Circle, in the northern hemisphere. The

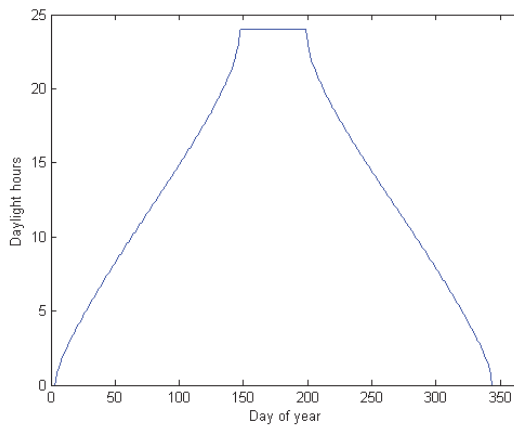


Fig. 6. Daylight hours for Latitude $L = 68^\circ$ (near polar circle).

equivalent latitude in the southern hemisphere is the Antarctic Circle. The Arctic Circle marks the southernmost latitude in the northern hemisphere where the sun shines for 24 hours at least once per year (midnight sun) and does not shine at all at least once per year. Theoretically, the Arctic Circle marks the area where these events occur exactly once per year, namely during the summer and winter solstices. However, due to atmospheric refractions and because the sun is a disk rather than a point, the actual observation at the Arctic Circle is different. For example, the midnight sun can be seen south of the Arctic Circle during the summer solstice. According to Figure 6, the midnight sun shines for about 50 days at latitudes around 68° . Figure 7 shows the daylight hours in Figure 6 as a polar plot. In this polar plot, the distance to the origin stands for the daily sunshine hours. One full turn of 360° corresponds to one year. There is another important difference to Figure 6, though. For the second half of the

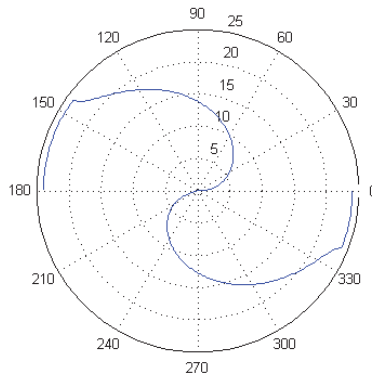


Fig. 7. Polar daylight plot for Latitude $L = 68^\circ$ (near polar circle).

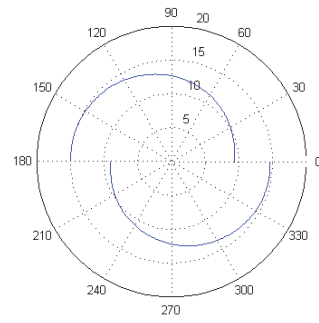
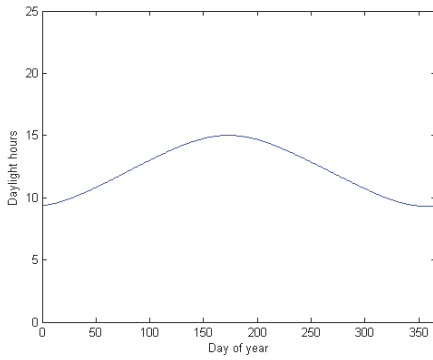
year, Figure 7 shows the hours of darkness instead of the daylight hours. The number of hours with darkness is simply the number of daylight hours subtracted from 24. Drawing the daylight hours in such a way produces the two spirals depicted in Figure 7. Coloring the areas delimited by both spirals and the outer circle in black and white then produces a rotated version of the Yin-Yang symbol in Figure 5. Note that this symbol is not quite symmetrical. This is correct because spring and fall are not completely symmetrical in terms of the solar cycle; a fact not discussed further in this chapter. For latitudes around the polar circle, the spirals in Figure 7 originate either directly in the origin of the polar plot or in a point close to it. This is because there will be at least one day with no sunshine.

Figure 8 shows the daylight hours and polar plots generated in the same way for different latitudes L , according to Equations 1 and 2. In particular, Figure 8 shows plots for $L = 40^\circ$ (near Beijing), $L = 0^\circ$ (Equator), and $L = 88^\circ$ (near North Pole). For Latitude $L = 40^\circ$, which is about the latitude of Beijing, the daylight curve is flatter compared to the daylight curve for $L = 68^\circ$ in Figure 6. The reason for the flatter shape is that each day of the year has sunshine as well as darkness at $L = 40^\circ$. For this latitude, the shapes of the spirals in the polar plot are approaching semicircles. Their starting points are relatively far from the center of the polar plot. This degeneration into semicircles continues with decreasing latitude. It reaches its extreme at the equator, with $L = 0^\circ$. Here, each day has the same number of sunshine hours, namely exactly 12 hours. Consequently, the Yin and Yang spirals complement each other to form a perfect cycle for observers on the equator.

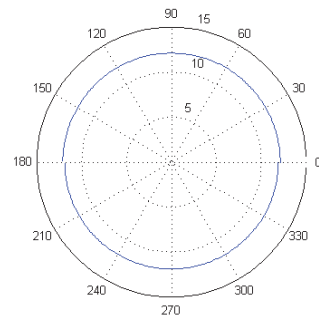
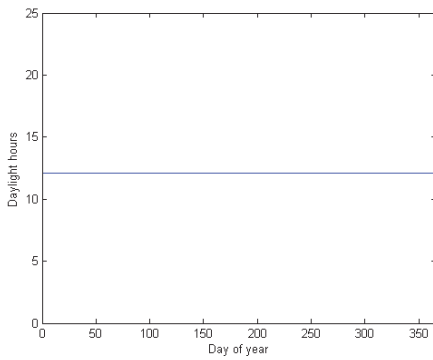
The last example in Figure 8 shows the daylight hours and polar plot when the observer's location is close to one of the earth's poles. For $L = 88^\circ$, which is close to the North Pole, the year is split into two halves. For one half, the sun shines continuously for 24 hours on each day. For days in the other half, the sun does not shine at all. The transition from one half to the other happens very quickly. Due to this rapid transition between day and night, each of the Yin and Yang spirals in Figure 8 covers a sector in the polar plot. Both spirals together describe an almost vertical axis.

5. Conclusion

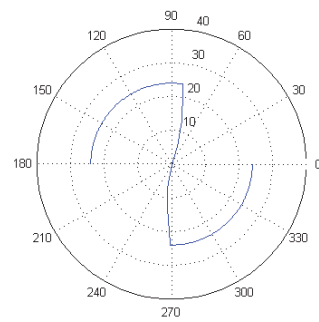
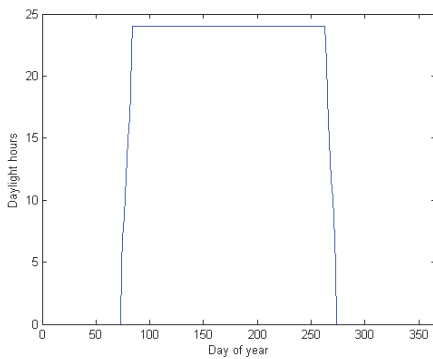
The chapter shows that the origin of the Yin-Yang symbol lies in the graphical representation of the daily change of a pole's shadow length. This length varies for each day, when measured



(a) Daylight hours and polar plot for Latitude $L = 40^\circ$ (near Beijing).



(b) Daylight hours and polar plot for Latitude $L = 0^\circ$ (Equator).



(c) Daylight hours and polar plot for Latitude $L = 88^\circ$ (near North Pole).

Fig. 8. Daylight hours and polar plots for different latitudes.

at the same time, and depends on the geographic latitude of the observer. Given the significant role the Yin-Yang symbol plays in TCM, ancient herbalists and practitioners of TCM must have attached great importance to geographic location from the outset. It is reasonable to assume that they considered geographical aspects for both drug preparation as well as administration. To ensure an authentic TCM treatment, modern practitioners of TCM need to take geographic location into account not only when preparing drugs but also during the treatment of their patients. They must be aware of the geomaterial origin of TCM. Latitude is one important factor in finding geo-authentic herbs. A mathematical formalization of this factor is a first step toward a well-defined and standardized TCM; a TCM that has the same scientific foundation as western medicine. This chapter equips herbalists with a means to compute Yin and Yang for different locations. They can now begin formalizing their daily work routine, such as herb evaluation, with the results presented here. The mathematical formalization of other factors determining the geo-authenticity of herbs, such as the physical and chemical soil properties, is a goal of future research. With a formalization of all these factors, herbalists can compute the overall Yin-Yang composition of herbs and herb combinations.

To render the Yin-Yang symbol, the chapter presents a daylight model to compute daylight hours for each day and latitude. However, the rendered Yin-Yang symbols differ from the common Yin-Yang symbol shown in Figure 1. The common symbol is an oversimplification. It represents Yin and Yang as two semicircles, which is a rough approximation at best. Therefore, the most popular Yin-Yang symbol is not in accordance with the original meaning of the Yin-Yang symbol. In fact, none of the symmetrical symbols existing today can coincide with any of the asymmetric symbols generated by the rendering method presented in Section 4. In particular, all symbols presented in the appendix of this chapter are asymmetric. This raises the question whether the common Yin-Yang symbol should be replaced by a symbol closer to the original meaning. In principle, any of the Yin-Yang symbols presented here could replace the common symbol and serve as a new standard. A particular good candidate would be the Yin-Yang symbol of the Arctic Circle, shown in Figure 5, because it looks very similar to the common symbol. Whatever the choice, there is yet another problem. Due to the cyclic change of the earth's ecliptic, any chosen Yin-Yang symbol is only a snapshot in time. It will eventually become less accurate. To avoid this problem, one could simply continue using the old Yin-Yang symbol or design a new symbol that does not feature these defects. Anyway, the choice of the standard Yin-Yang symbol depends on many factors, including personal taste. The ultimate answer to this question is therefore beyond the scope of this chapter.

6. Appendix

On the following six pages, the appendix shows examples of Yin-Yang symbols computed for different latitudes in the northern and southern hemispheres. All examples are polar plots of the output of Equations 1 and 2 for different input latitudes. All polar plots are rotated counter-clockwise by 45° so the x-axis is vertical. A closer inspection shows that none of the symbols is symmetrical. The symbols of the southern hemisphere are mirrored versions of the corresponding symbols in the northern hemisphere, apart from some numerical inaccuracies close to the polar circles and poles. Several popular variants of the Yin-Yang symbol are visible north of the Arctic Circle and south of the Antarctic Circle. Both spots in each Yin-Yang symbol lie on the vertical axis, plotted halfway between the polar plot's origin and the outer circle. Note that for latitudes L with $|L| \leq 68^\circ$, the Yin-Yang symbol will look similar to the symbols observed at the polar circles when plotted as a polar plot in the following way: Instead of the daylight hours, the polar plot shows the daylight hours minus the minimum day length. Furthermore, instead of the number of hours with darkness, the polar plot shows the difference between the maximum day length and the number of daylight hours.

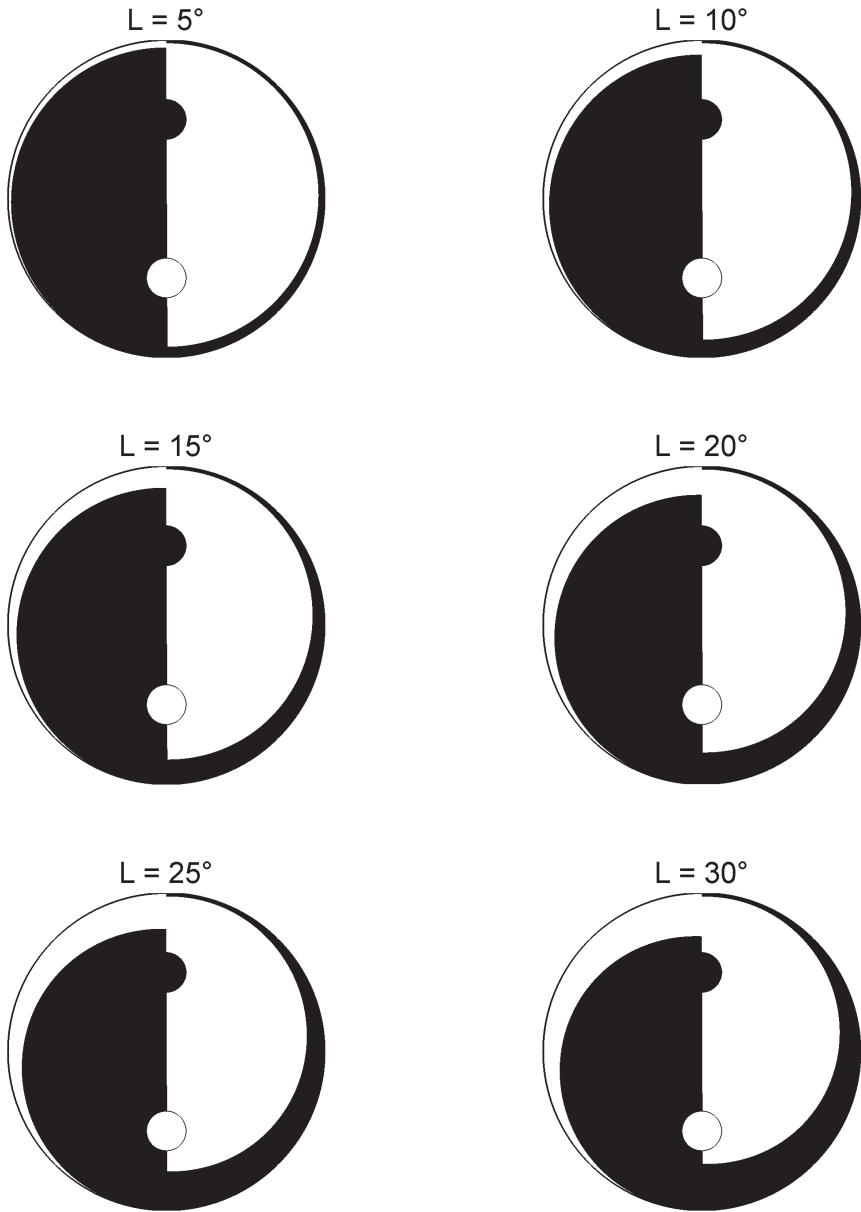
6.1 Yin-Yang symbols for the northern hemisphere

Fig. 9. Yin-Yang symbols for $L = 5^\circ, 10^\circ, 15^\circ, 20^\circ, 25^\circ, 30^\circ$.

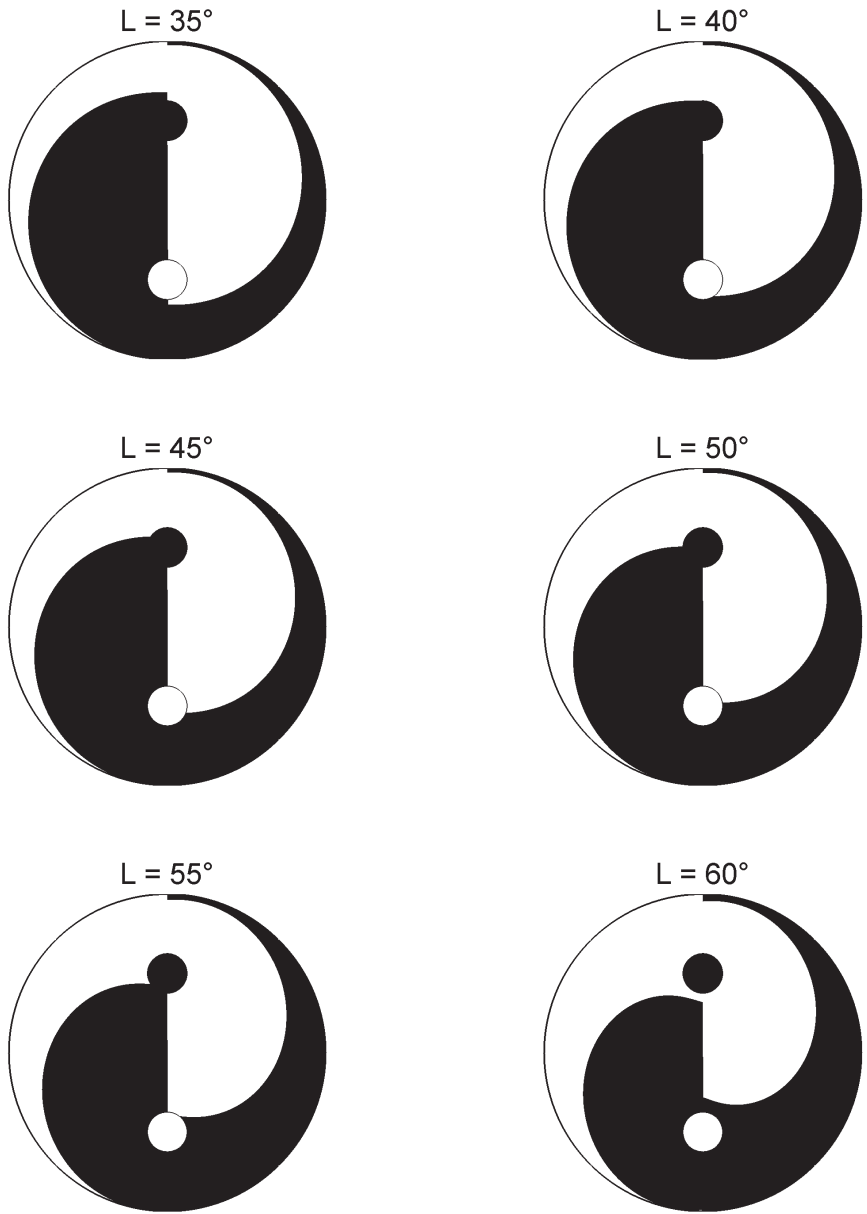


Fig. 10. Yin-Yang symbols for $L = 35^\circ, 40^\circ, 45^\circ, 50^\circ, 55^\circ, 60^\circ$.

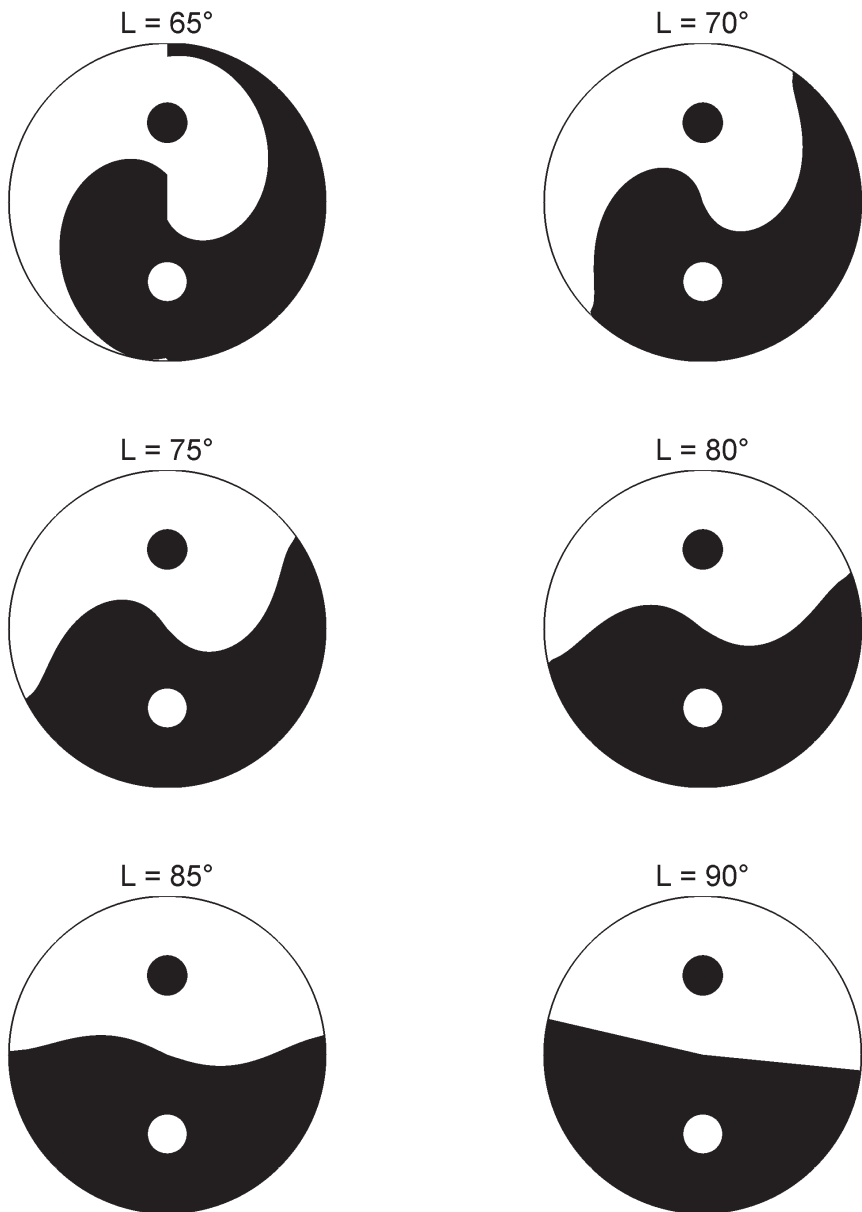


Fig. 11. Yin-Yang symbols for $L = 65^\circ, 70^\circ, 75^\circ, 80^\circ, 85^\circ, 90^\circ$.

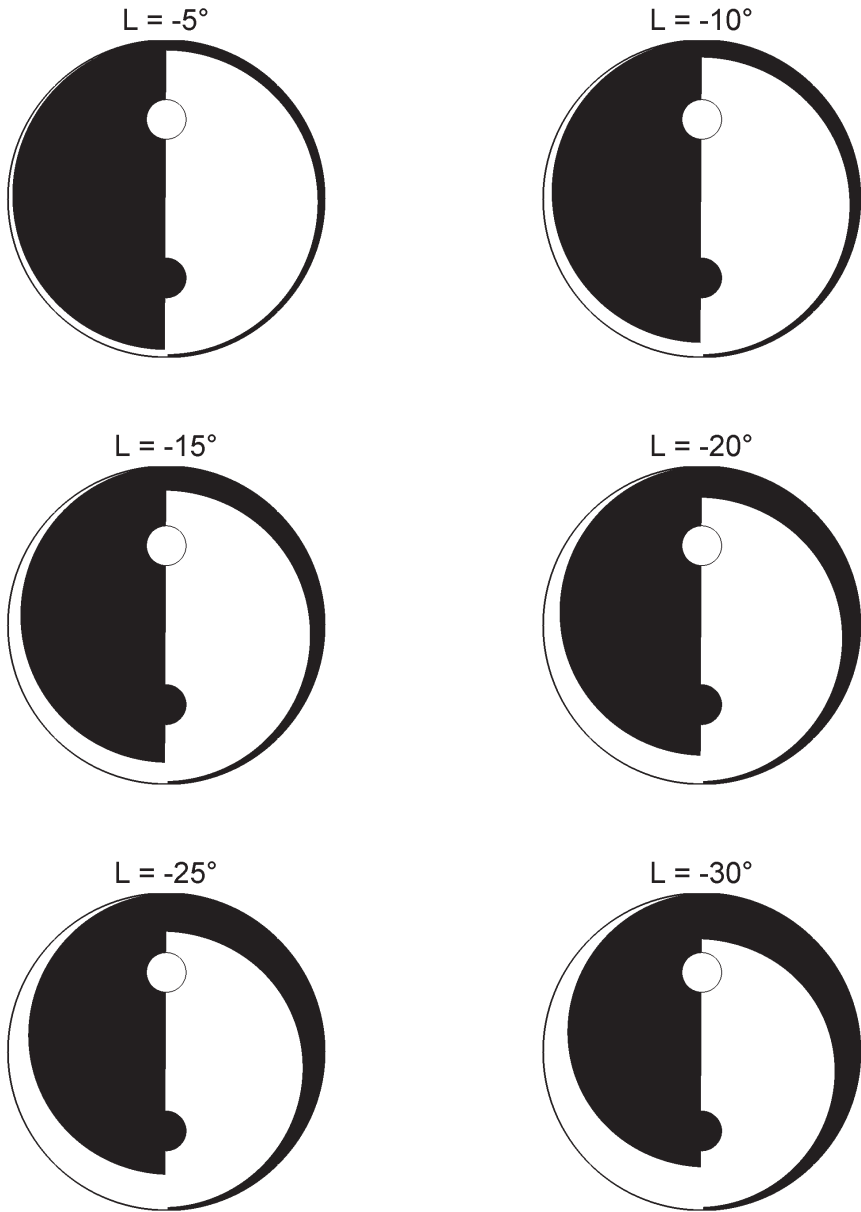
6.2 Yin-Yang symbols for the southern hemisphere

Fig. 12. Yin-Yang symbols for $L = -5^\circ, -10^\circ, -15^\circ, -20^\circ, -25^\circ, -30^\circ$.

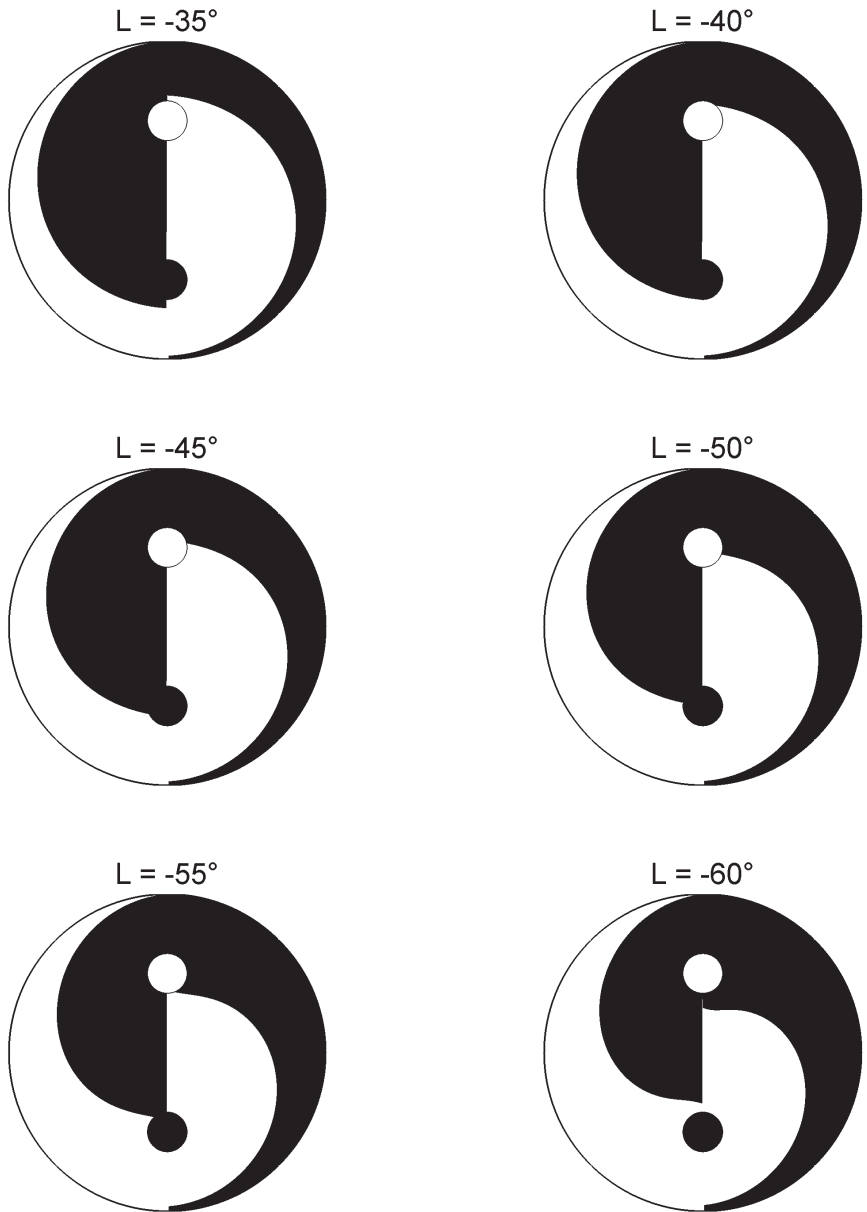


Fig. 13. Yin-Yang symbols for $L = -35^\circ, -40^\circ, -45^\circ, -50^\circ, -55^\circ, -60^\circ$.

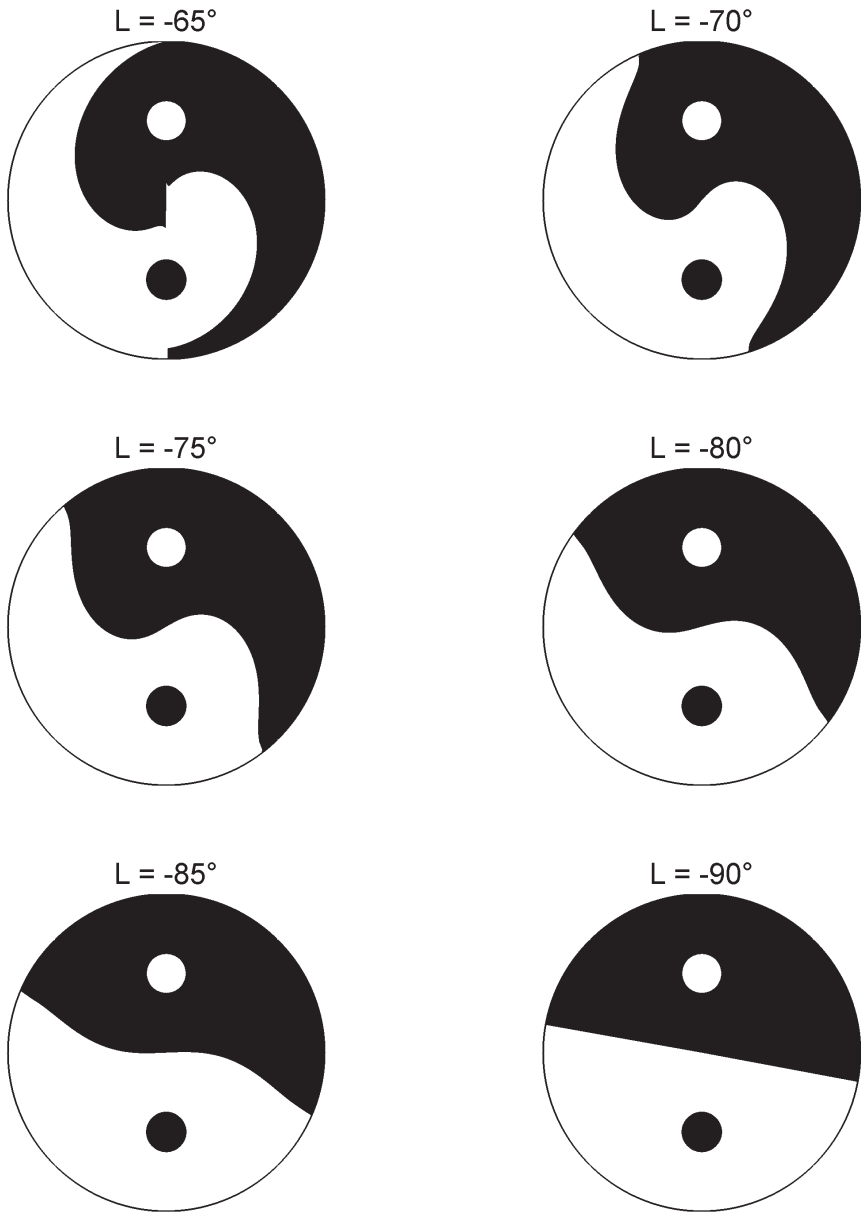


Fig. 14. Yin-Yang symbols for $L = -65^\circ, -70^\circ, -75^\circ, -80^\circ, -85^\circ, -90^\circ$.

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