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The Effect of Annual Apparent Motion of the Sun on the Early Oscillation of Shubuh Prayer Time, Case Study of Pontianak City

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ABSTRACT– This study aims to determine the effect of the Sun's annual apparent motion on the oscillations of the Subuh prayer time, especially in the city of Pontianak. The research method used is the literature review or reference method. In the literature review, the things that were done included: looking for the schedule of the dawn prayer in the city of Pontianak over one year, knowing the geographical position of the city of Pontianak, the apparent annual motion of the Sun, and the effect of the annual apparent motion of the Sun on the initial oscillation of the Subuh prayer time. Apart from that, another thing done in the literature review was to look for the influence of the earth-sun distance on the oscillations of the dawn prayer time. The results showed that there were similarities between the oscillations of the annual apparent motion of the Sun and the oscillations of the dawn prayer time in the city of Pontianak. However, there is a time difference with an average of 41 days between the oscillation of the Sun's annual apparent motion and the oscillation of the time of the Subuh prayer. The results of the Study also show that the distance from the Earth to the Sun (aphelion and perihelion) affects the initial oscillation of the dawn prayer time. When the Earth is at the aphelion point, the time for the Subuh prayer falls later than usual. Meanwhile, when the Earth is at perihelion, the time for the dawn prayer falls faster than usual.

KEYWORDS : apparent motion of the sun; subuh, aphelion; perihelion.

INTRODUCTION

Prayer is the second pillar of Islam (Hasanah 2018). The command to pray came down directly from Allah SWT to the Prophet Muhammad SAW during the Isra Mi'raj event (Haris and others 2015). There are five Fardhu prayers in Islam: Zuhur, Asr, Maghrib, Isha, and Shubuh (Widi *et al.* 2017). As written in QS Al Isra verse 78, "Establish prayer from the decline of the sun until the darkness of the night and (also perform the prayer) Shubuh! Verily, the Shubuh prayer is witnessed (by angels)" (Agung 2023).

Prayer is worship which is limited by time. As stated in QS An-Nisa verse 103, "Verily, prayer is a fardhu whose time is determined for those who believe" (Setiawan and Rakhmadi 2019). One of the conditions for the validity of prayer is that it is time for prayer (Raisal *et al.* 2022). It is not valid if the dhuhr prayer is held outside the dhuhr prayer time.

The time for the Zuhur prayer begins when the Sun is released from its culmination, or we know it as the Sun, is slipping (Farah 2020). Asr prayer time begins when the shadow of an object is longer than the object's length until the Sun sets (Zar'ah 2022). Maghrib prayer begins at sunset. The time for the Isya prayer starts with the waning of the red megaphone or the disappearance of the red megaphone (Farah 2020). The time for the Shubuh prayer begins with the appearance or rising of the sadiq dawn and ends at sunrise (Muhajir 2020).

Prayer times are affected by the apparent daily motion of the Sun, or more precisely, the

motion of the Earth rotating on its axis (rotation) while revolving around the Sun (revolution) (Rahmatiah 2017). Earth rotates from west to east for 23 hours 56 minutes 4.091 seconds, or rounded up to 24 hours, or one day (Maftuh and Widiyatmoko 2012). As a result of the Earth's rotation, the Sun appears to be moving, rising from the east and setting in the west, or what we know as the apparent daily motion of the Sun (Zar'ah 2022).

In astronomy, the determination of the start of the prayer time is determined by calculating the height (position) of the Sun (Furziah 2019). In Indonesia, many astronomers determine the criteria for the start of the Shubuh prayer when the Sun's altitude is between -18^o to -20^o (Raisal *et al.* 2019). In fiqh, the time for the morning prayer starts at the dawn of the sadiq and lasts until the Sun rises. Sadiq dawn can be understood as the dawn of astronomical twilight, which is when the sky is no longer dark and the Earth's atmosphere is able to refract the Sun's light from below the horizon (Utari and Wahab 2018). Meanwhile, the deadline for Fajr is the Syuruq (rising) time, which is the Sun's altitude of -1° (Azhari 2013).

In addition to rotating on its axis, the Earth also makes a revolution, which rotates around the Sun. As a result of the Earth's revolution, the Sun makes an annual apparent motion of the Sun (Rohman 2016). Where the Sun seems to oscillate, sometimes to the North, or sometimes around the Equator, or to the south. As a result of the Sun's annual apparent motion, there is a difference in the length of day and night in various regions (Rostikawati and others 2022). This has also resulted in changes to the start of prayer times in various areas, including Pontianak.

The Earth revolves around the Sun in an elliptical path, this results in a difference in the distance between the Earth and the Sun in a certain period (Vallo *et al.* 2022). Sometimes, the Earth-sun distance is at the closest point, which is known as the perihelion. Sometimes the Earth-sun distance is at its furthest point, called the aphelion (Wahyu *et al.* 2022). The average distance between the Earth and the Sun is 150 million km or 149.597.870 km to be more precise (Da Silva *et al.* 2019).

Pontianak City itself is located in West Kalimantan Province. An imaginary line of the Equator crosses the city. Geographically, Pontianak City is located at 0^o 02′ 24″ North Latitude (NL) to 0^o 05′ 37″ South Latitude (SL) and 109^o 16′ 25″ to 109^o 23′ 01″ East Longitude (EL) (Raja *et al.* 2015). Because of its geographical location, the city of Pontianak will be illuminated by the Sun throughout the year.

Based on the description above, it is necessary to conduct further research regarding the effect of the annual apparent motion of the Sun on the time of Shubuh prayer. Further research is also needed regarding the effect of the earth-sun distance on changes in the time of the dawn prayer. Meanwhile, Pontianak was chosen because of its location, which is passed by the Equator.

METHODOLOGY

The research method used is to review the literature or references (Adlini *et al.* 2022). A literature review was conducted to answer several research questions: 1). Study why there is a change in the time of dawn prayer throughout the year. 2). Study the effect of the Sun's annual apparent motion on the oscillations of the Subh prayer time. 3) Study the influence of the earth-sun distance on the oscillations of the Subh prayer time.

The data was obtained from various websites, scientific articles, and other sources. The data obtained will be processed and analyzed descriptively to answer several research questions.

RESULTS AND DISCUSSION

Shubuh Preyer Time

Astronomically, the Shubuh prayer starts when the Sun is at an altitude of -18^o to -20^o . The time for the Shubuh prayer ends when the Sun reaches -1^o (Ardi 2020). The determination of prayer time schedules in Indonesia is under the Ministry of Religion's (Kemenag) authority.

Institutions that are used to determine prayer schedules are called Falkiyah institutions. Several religious organizations, such as Nahdlatul Ulama (NU) (Hafiz and Tanjung 2022) and Muhammadiyah, have their falakiyah institutions (Fitra and Silvana 2021).

Table 1 shows the early Shubuh prayer times for Pontianak in a period of 1 year, from May 27, 2022, to May 26, 2023. This prayer time data in Pontianak City is obtained from the page https://www.jadwalsholat.org. The prayer time schedule on the website is the same as that on the Nahdlatul Ulama's Hijriyah calendar (Hafiz and Tanjung 2022). In addition to data on the time for the Shubuh prayer, the page also provides other prayer times, such as Dhuhr, Asr, Maghrib, Isha, Imsak, and Syuruq (Amri 2015). There is also an option to find out the prayer schedule in various other cities in Indonesia

Table 1. Shubuh prayer time in Pontianak

No	Date	Time	No	Date	Time	No	Date	Time
1	27-31 May 2022	4.16	33	13-15 Octo 2022	4.10	65	16-17 Janu 2023	4.29
2	1-7 June 2022	4.16	34	16-19 Octo 2022	4.09	66	18-19 Janu 2023	4.30
3	8-13 June 2022	4.17	35	20-23 Octo 2022	4.08	67	20-22 Janu 2023	4.31
4	14-19 June 2022	4.18	36	24-27 Octo 2022	4.07	68	23-25 Janu 2023	4.32
5	20-23 June 2022	4.19	37	28-31 Octo 2022	4.06	69	26-28 Janu 2023	4.33
6	24-17 June 2022	4.20	38	01 Nov 2022	4.06	70	29-31 Janu 2023	4.34
7	28-30 June 2022	4.21	39	2-22 Nov 2022	4.05	71	1-4 Feb 2023	4.35
8	1-2 July 2022	4.21	40	23-27 Nov 2022	4.06	72	5-11 Feb 2023	4.36
9	3-6 July 2022	4.22	41	28-30 Nov 2022	4.07	73	12-28 Feb 2023	4.37
10	7-10 July 2022	4.23	42	1 Decem 2022	4.07	74	March 01 2023	4.37
11	11-15 July 2022	4.24	43	2-4 Decem 2022	4.08	75	2-8 March 2023	4.36
12	16-20 July 2022	4.25	44	5-7 Decem 2022	4.09	76	9-12 March 2023	4.35
13	21-28 July 2022	4.26	45	8-9 Decem 2022	4.10	77	13-16 March 2023	4.34
14	29-31 July 2022	4.27	46	10-12 Decem 2022	4.11	78	17-20 March 2023	4.33
15	1-17 August 2022	4.27	47	13-14 Decem 2022	4.12	79	21-23 March 2023	4.32
16	18-24 August2022	4.26	48	15-16 Decem 2022	4.13	80	24-27 March 2023	4.31
17	25-29 August 2022	4.25	49	17-18 Decem 2022	4.14	81	28-30 March 2023	4.30
18	30 August, 2022	4.24	50	19-20 Decem 2022	4.15	82	March 31, 2023	4.29
19	1-3 Sept 2022	4.24	51	21-22 Decem 2022	4.16	83	1-2 April 2023	4.28
20	4-6 Sept 2022	4.23	52	23-24 Decem 2022	4.17	84	3-4 April 2023	4.27
21	7-10 Sept 2022	4.22	53	25-26 Decem 2022	4.18	85	5-7 April 2023	4.26
22	11-13 Sept 2022	4.21	54	27-28 Decem 2022	4.19	86	8-10 April 2023	4.25
23	14-16 Sept 2022	4.20	55	39-30 Decem 2022	4.20	87	11-13 April 2023	4.24
24	17-19 Sept 2022	4.19	56	31 Decem 2022	4.21	88	14-16 April 2023	4.23
25	20-22 Sept 2022	4.18	57	1 Janu2023	4.21	89	17-19 April 2023	4.22
26	23-25 Sept 2022	4.17	58	2-3 Janu 2023	4.22	90	20-22 April 2023	4.21
27	26-28 Sept 2022	4.16	59	4-5 Janu 2023	4.23	91	23-26 April 2023	4.20
28	29-30 Sept 2022	4.15	60	6-7 Janu 2023	4.24	92	27-29 April 2023	4.19
29	1 -3 Octo 2022	4.14	61	8-9 Janu 2023	4.25	93	Apr 30 -May 03, 2023	4.19
30	4-6 Octo 2022	4.13	62	10-11 Janu 2023	4.26	94	4-8 May 2023	4.18
31	7-9 Octo 2022	4.12	63	12-13 Janu 2023	4.27	95	9-15 May 2023	4.17
32	10-12 Octo 2022	4.11	64	14-15 Janu 2023	4.28	96	16-26 May 2023	4.16

Based on Table 1, prayer times in the city of Pontianak change throughout the year, sometimes falling faster or slower. The fastest Shubuh prayer time in Pontianak is November 2nd – 22nd, 2022, at 4.05 WIB (West Indonesian Time). Meanwhile, the late Subh prayer occurs from February 12 to March 01, 2023, at 4.37 WIB. The average time for Shubuh prayers in Pontianak city occurs at 4.21 WIB.

The data in table 1 were processed using the Microsoft Excel application to produce a Subuh prayer time oscillations graph. Figure 1 shows a graph of the results of table 1 data processing. Figure 1 shows the oscillation of Shubuh prayer times for one year in Pontianak, from May 27, 2022, to May 26, 2023.

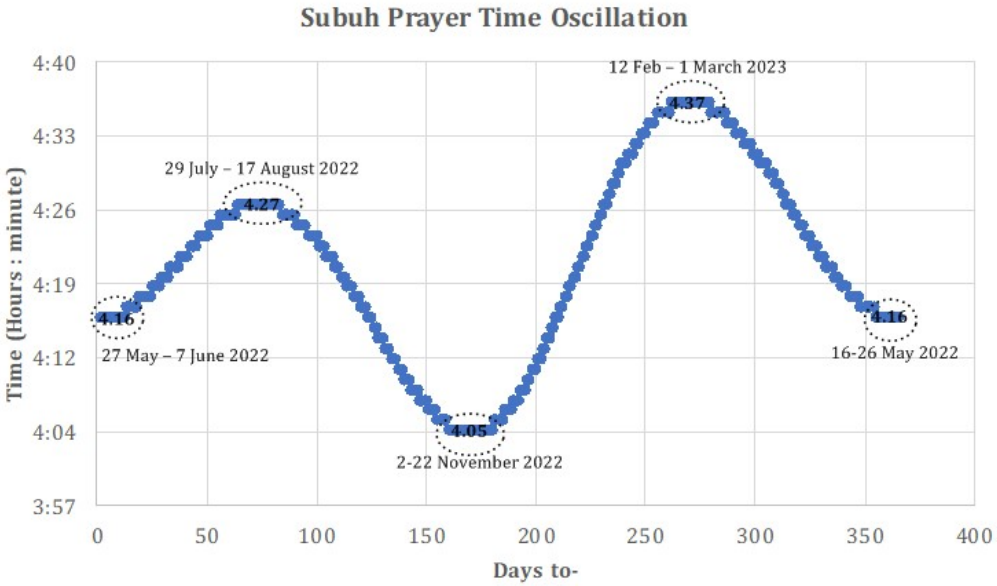

Figure 1. Oscillation of Shubuh prayer times in Pontianak City in 2022-2023

From figure 1, the time for the Subuh prayer seems to oscillate, starting from 4.16 WIB on May 16 to June 07, 2022. Day to day, the time for the Shubuh prayer is slower than before, and the peak falls at 4.27 WIB. This happened from July 29 to August 17, 2022. The time for the Shubuh prayer is gradually getting faster than before, and the peak will occur on November 2nd - 22nd 2022. At that time, the Shubuh prayer fell at 04.05 WIB.

From November 2022 to February 2023, there was a delay in the dawn prayer time in the city of Pontianak. The peak will occur from February 12 to March 01, 2023. At that time, the dawn prayer time fell at 4.37 WIB. The time for the dawn prayer returns to normal, namely at 04.16 on May 16th – 26th, 2023.

The graph of the oscillations of the dawn prayer time in Figure 1 has similarities to the oscillations of the apparent annual motion of the Sun in Figure 2. This indicates that there is an influence of the annual apparent motion of the Sun on the oscillations of Subuh prayer time (Siti Asma 2016). The apparent annual motion of the sun causes a change in the position of the rising sun in an area, thereby affecting the time of Shubuh prayer (AFIFUDIN 2013).

The apparent annual motion of the Sun

In addition to rotating on its axis, the Earth revolves around the Sun for one year: 365 days, 9 minutes, and 10 seconds (Duffett-Smith and Zwart 2017). Therefore, in one year, there are 365 to 366 days. In a leap year, there are 366 days in a year.

The position of the Earth when it evolves is not fixed but "swinging," moving up and down around the Equator (Afida *et al.* 2019). The position of the Earth's orbit is sometimes around the Equator. Sometimes it is also in orbit more northerly or southerly, maximum at position 23.5° (Hinnov 2018).

The orbit of the Earth as it evolves changes all the time (Afida *et al.* 2019). This causes it to appear as if within a certain period of time, the Sun rises further North or south. This event is known as the Sun's annual apparent motion (Raisal and Rakhmadi 2020).

The apparent annual motion of the Sun is its movement, which seems to move up north and down south around the Equator, even though it is the Earth that makes this up-and-down movement (Akhyar *et al.* 2021). Figure 2 shows the periodization of the Sun's annual apparent motion.

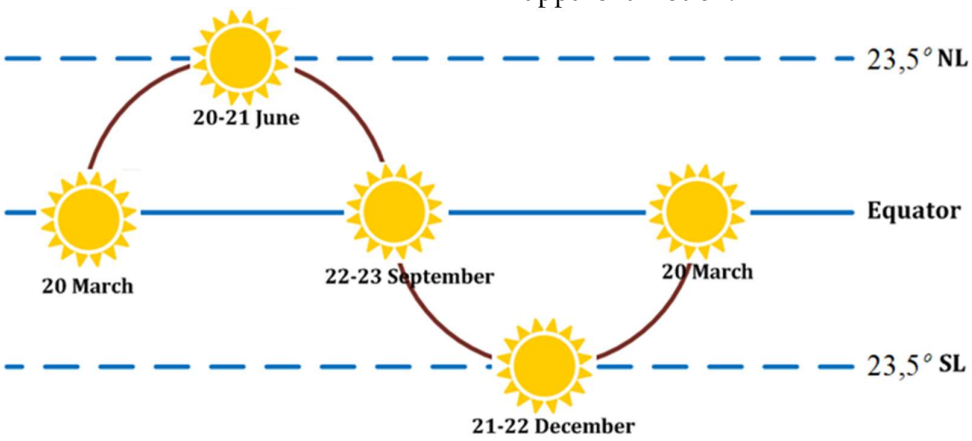

Figure 2. Periodization of the Sun's Annual Apparent Motion

The apparent annual motion of the Sun causes seasonal changes in the subtropics, for example, spring, autumn, summer, and rain (Larsen 2021). In addition, the Sun's annual apparent motion also causes changes in the length of day and night in various regions (Sari *et al.* 2015).

From Figure 2, it can be seen that around March 20, the Sun rises right around the Equator. The Sun then seems to move towards a more northerly direction until the maximum point is 23.5^{o}, around June 20-21st (Wilujeng *et al.* 2022). The Sun moves again around the Equator on September 22-23th. The Sun then moves as if it is more to the south, around December 21-22nd (PRADANA 2021). Moreover, the Sun returns to circulate on the Equator around March 20.

Correlation of the Sun's annual apparent motion to the oscillations of the Subuh prayer time

Based on Figures 1 and 2, you can see the same pattern between the Sun's annual apparent motion oscillations and the initial oscillations at dawn. This indicates an influence of the Sun's annual apparent motion on the oscillations of the Shubuh prayer time (Jamil 2020). The results of research conducted by Rahmatiah (2017) show an influence of the annual apparent motion of the Sun on the initial oscillations of the Subh prayer time. However, there is a time difference between the Sun's annual apparent motion patterns and the oscillations during the Shubuh prayer (Mubit 2017). The following is a further discussion of the effect of the Sun's annual apparent motion on the time of the Shubuh prayer.

Around March 20

Around March 20, the Sun shines more on the Equator, including in Pontianak. When the Sun revolves around the Equator, it is assumed that the Sun will rise earlier in the city of Pontianak than in previous months. This results in the start of the dawn prayer time, which will be faster than the previous times.

However, in reality, around March 20, 2022, the time for the dawn prayer is not the fastest. The faster dawn prayer time occurs from May 15 to June 07, 2022. The Shubuh prayer time starts at 4.16 WIB. There is a difference of approximately 46 days between the apparent position of the Sun at the Equator and the time of the Shubuh prayer.

Around June 20-21st

Around June 20-21, the Sun is at its northernmost point, 23.5° NL. The Sun shines more in the North, so the day in the North is longer than in the south.

When the position of the Sun is more north, the Sun should rise later so that the time for the Shubuh prayer will be later than before. However, the time for the Shubuh prayer around June 20 is not the slowest. The time for the Shubuh prayer is from July 29 to August 17. The time for the Shubuh prayer at that time occurred at 04.27 WIB. There is a difference of 39 days in the apparent annual position of the Sun at 23.5° NL with the time of the Shubuh prayer.

Around September 23rd

Around September 23rd, the Sun again circulates the Equator. As is the case around March 21, the Sun will rise earlier, affecting the time for the dawn prayer which falls earlier. However, the time for the Shubuh prayer is faster in the range of November 2-22nd, which is at 4.05 WIB. There is a difference of 39 days between the position of the Sun in its annual apparent motion and the time of the dawn prayer.

Around December 21-22nd

Around December 21-22nd, the Sun is in the southernmost position of its apparent path, at 23.5o SL. For the Pontianak city area around the Equator, the dawn prayer time will fall later than usual. However, the dawn prayer is later than usual on February 12-28, at 04.37 WIB. There is a difference of about 41 days between the Sun's position in its annual apparent motion and the time of the dawn prayer.

Based on the previous description, there is a similarity between the graph of the annual apparent motion of the Sun and the graph of the oscillation of the Subuh prayer time. This can indicate the Sun's apparent motion's influence on the Subuh prayer time oscillations (Raisal & Rakhmadi, 2020). However, there is a difference in the periodization time between the Sun's annual apparent motion and the initial oscillation of the dawn prayer time. The average difference is around 41 days.

One other thing that affects the oscillation of the time of the dawn prayer is the distance between the Earth and the Sun (Jannah 2020). The distance between the Earth and the Sun varies . This is because the trajectory of the Earth's motion around the Sun is elliptical.

Aphelium dan Perihelium

The distance between the Earth and the Sun when the Earth makes a revolution is not fixed, but changes (Utama 2012). This is caused by the elliptical orbit of the Earth's revolution (Buis 2020). The average distance between the Earth and the Sun is 149,597,870 km (Sopwan 2018). Earth's closest distance to the Sun is the perihelion, 147,093,163 km (Widodo 2013). At the same time, the farthest distance from the Earth to the Sun is called the aphelion, which is 152,100,527 km (Da Silva *et al.* 2019). The aphelion point occurs on July 2-6th. At the same time, the perihelium point occurs around January 1-5th (Raisal *et al.* 2020).

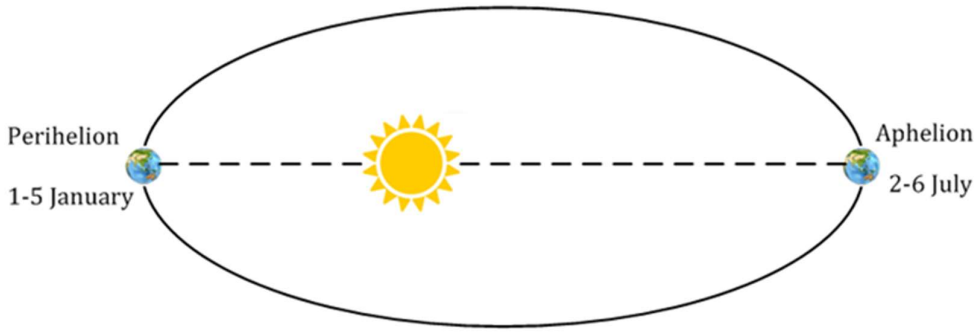

Figure 3. The movement of the Earth's revolution around the Sun

When the Earth is at the aphelion point, the point farthest from the Sun. The assumption is that sunlight will rise more slowly to Earth . Based on the data contained in Figure 1, on July 2-6, the time for the Shubuh prayer is also slower than usual. This can

indicate the influence of the earth-sun distance on the start of the Shubuh prayer time. The peak time for the Shubuh prayer is later than usual, on July 29 to August 17. This means there is a difference of 23 days between the farthest distance from the Earth to the Sun and the start of the Shubuh prayer.

When the Earth-sun distance is at its closest point (perihelion), the Sun's rays will reach the Earth more quickly, making it seem like it will rise faster. Based on the data in table 1, around January 1-5th, the start of the Shubuh praye r is faster than the times after. This indicates the influence of the earth-sun distance on the time of the Shubuh prayer. The peak time for the dawn prayer is earlier than usual on November 2-22nd. This means that there is a difference of 39 days between the closest distance from the Earth to the Sun and the time of the Shubuh prayer.

CONCLUSION

There is a similar pattern between the graph of the annual apparent motion of the Sun and the graph of the oscillation of the Shubuh prayer time. This shows the influence of the annual apparent motion of the Sun on the oscillations of the Shubuh prayer time. There is an average difference of 41 days between the apparent annual motion of the Sun and the oscillations at dawn prayer. The Study's results also show an effect of the Earth-sun distance on the early Subuh prayer time. When the earth-sun is at its closest distance, the time for the dawn prayer will fall more quickly. When the earth-sun is at its farthest distance, the time for the dawn prayer will fall more slowly.

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