

Night Time System in *Nuju-tongui* during Early *Joseon* Dynasty

Lee, Yong Bok^{1,2}

¹Seoul National University of Education, Seoul 137-742, Korea

²SohNam Institute for History of Astronomy, Seoul 151-050, Korea

yblee@snue.ac.kr

Abstract

Dual time keeping system was used in *Joseon* Dynasty. One is the twelve *Jin* (辰) system which is divided into 12 hours in a day. The other is the unequal time system named *Gyeongjeom* which is separate into five intervals during the night time. The night time is defined as duration between 2.5 *Gak* (刻) after sunset and 2.5 *Gak* before sunrise. Of cause the interval of one day is used as 100 *Gak* in early *Joseon* Dynasty till the year in 1653 (*Hyojong* 4th year) reformed calendar system.

We study on the *Gyeongjeom* system (更點法) that is appeared in the *Nuju-tongui*. The book was used as comparing the 12 *Jin* system with *Gyeongjeom* for managing the clepsydra in night time. We analyze the time keeping system of night time in *Nuju-tongui* and meridian transit time of constellations named 28-*Su* at the morning and evening twilight time in each 24 seasons.

1. Introduction

It is very important to keep time and calendar during *Joseon* Dynasty. For the purpose, they studied on the motion and position of the stars as well as the Sun and the Moon. When the *Joseon* Dynasty founded in 1392, they made the world geographic map and constellation map which shows the justness in Confucianism ideology for the new kingdom. They developed various astronomical instruments for observations of astronomical phenomena. It is important to determine the time in a day and the

calendar system in a year.

Subsequently, they research the time keeping system in day and night time by many astronomers. It had important role for stabilizing the public society from disorder or rebellion. One of them was the understanding of astronomical phenomena as a scientific view, which are the duration of night time, the time of sunrise and sunset, and the date of new moon and 24 seasons. For those reason, they published the *Nuju-tongui* that contains eleven kinds of float rods and its use for clepsydra in each 24 seasons.

The book was introduced and explained simply by Yoo *et al.*(1973) and Nam(1995). We study on the book's contents and application methods on the clepsydra. Especially we calculate the astronomical phenomena by modern spherical astronomy which are appeared the book, and compared with them.

2. Analysis of the *Nuju-tongui*

Contents of *Nuju-tongui* (漏籌通義) are consisted of four part, which are introduction, list of eleven float rods for each 24 seasons, night time intervals during five *Gyeong* (更) and five *Jeom* (點), the directions of sunrise and sunset in each season, meridian transit times of 28-*Su* constellations on the evening and morning twilight time in each seasons, and the 28 constellations at the evening and morning twilight time in each 24 seasons.

十一箭日錄	第一箭	自冬至初日至大寒後二日	第二箭	自小雪前四日至冬至前一日	第三箭	自大寒後三日至立春後二日	第四箭	自立冬前四日至小雪前五日	第五箭	自立春後三日至雨水前一日	第六箭	自霜降前一日至立冬前五日
-------	-----	-------------	-----	--------------	-----	--------------	-----	--------------	-----	--------------	-----	--------------

Fig. 1. List of eleven float rods and available durations for each rods.

Fig. 1 shows the list of eleven float roads which duration are available for use. We transform the table in the *Nuju-tongui* into new form as Table 1 to analyze the content. We calculate day and night time in each days in the year of 2012 as a example. The Sun's data are referred in U.S. Naval Observatory (1998) and Korea Astronomy & Space Science Institute (2011). The results would be similar values that are compared with 15 century. Because the Sun's declination of each days in the year has no big differences in any year.

Duration 1 in Table 1 shows the number of date elapsed from winter solstice and duration 2 elapsed from Summer solstice. The night times in Table 1 are calculated simply by the present Sun's declination. We find that the suitable duration for each roads are between 0.38 and 0.52 hours and mean 0.44 hours (26.4 minutes).

Table 1. Eleven float rods and using duration in a year.

No. of rods	Duration 1 of Date	Night Time 1 (Hour unit)	Diff. (Hour)	Duration 2 of date	Night Time 2 (Hour unit)	Diff. (Hour)
1	0 - 31	14.59 - 14.12	0.48	150 - 182	14.07 - 14.59	0.52
2	32 - 45	14.09 - 13.68	0.41	135 - 149	13.60 - 14.05	0.45
3	46 - 57	13.64 - 13.24	0.40	123 - 134	13.16 - 13.56	0.40
4	58 - 69	13.20 - 12.78	0.42	111 - 122	12.69 - 13.12	0.43
5	70 - 81	12.73 - 12.29	0.44	98 - 110	12.17 - 12.65	0.48
6	82 - 93	12.25 - 11.81	0.44	87 - 97	11.73 - 12.13	0.40
7	94 - 105	11.77 - 11.33	0.44	75 - 86	11.27 - 11.70	0.43
8	106 - 119	11.30 - 10.79	0.51	62 - 74	10.78 - 11.23	0.51
9	120 - 131	10.76 - 10.37	0.39	50 - 61	10.36 - 10.74	0.38
10	132 - 147	10.34 - 09.89	0.45	32 - 49	09.83 - 10.33	0.50
11	148 - 180	09.86 - 09.41	0.45	0 - 31	09.41 - 09.81	0.40

However, there are no large discrepancies among durations for the rods between Winter solstice to Summer solstice and Summer to Winter. We obtain the result that the float rods were decided and applied on the difference of night time, not on the date of 24 seasons.

One *Gyeong* is the one of fifth of night time, and one *Jeom* the fifth if one *Jeong*.

The total duration of night time is consisted of 5 *Gyeong* and 25 *Jeom*. The one *Jin* (辰) is the same of 2 hours in present time, and 10,000 *Bun* in *Joseon* period. The duration of one day is 100 *Gak* (刻), 12 *Jin* (辰) and 120,000 *Bun*. Therefore one *Gak*(刻) was used as 1,200 *Bun*. The time system of 12 *Jin* divided into equi-distance time of the day, and *Gyeong-Jeom* system depends on the variation of night time in each seasons.

The most important part of *Nuju-tongui* is the time of *Gyeong* and *Jeom* by 12 *Jin* (辰) system. The table of *Gyeong-Jeom* system in *Nuju-tongui* shows the available date and duration of day and night time in each eleven float rods.

Fig. 2. The time of *Gyeong* and *Jeom* by 12 *Jin* time system in *Nuju-tongui*.

We make a table from the original data that contains day and night time, and time interval of *Gyeong* and *Jeom* in each rod. Table 2 shows the variation of day and night time in each season. The column of half-day time means half duration of day time, and the column of night time is duration of whole time of night. We derived the same intervals among each rods which are all 2,400 *Bun*. The number of rods were decided by time interval of 2,400 *Bun* which is the one of fifth of a day and 28.8 minutes in present. Almost the value agree with former calculation by present method.

We find difference of night time between Winter and Summer solstice in *Nuju-tongui* that is 24,000 *Bun* or 5.0 hours. Present value is 5.18 hours at latitude of Seoul that is almost same with value of *Nuju-tongui*.

Table 2. Table for duration of day and night time.

Rod No.	Half-day time (<i>Bun</i> unit)	Night Time (<i>Bun</i> unit)	Dif. of <i>Gyeong</i>	Dif. of <i>Jeom</i>
1	27000	66000	13200	2640
2	28200	63600	12720	2544
3	29400	61200	12240	2448
4	30600	58800	11760	2352
5	31800	56400	11280	2256
6	33000	54000	10800	2160
7	34200	51600	10320	2064
8	35400	49200	9840	1968
9	36600	46800	9362	1870
10	37800	44400	8880	1776
11	39000	42000	8400	1680

3. Results

We find the method how to calculate and edit the *Nuju-tongui* by Joseon astronomers. First, they have to decide the number of the float rods. If they take eleven kinds of rods, the number of intervals in each rods can be ten. They chose the ten intervals of the time so that is easy to calculation.

Second, they have to find the time difference at latitude of Seoul between Winter and Summer solstice, as well as the night time in each days of the year. They found that difference is 24,000 *Bun* or 15 hours in present.

Third, they have to find the interval of one *Gyeong* and *Jeom*. It is relatively easy to calculate.

Fourth, the time of *Gyeong* and *Jeom* determine from time of noon, and add the half day time. It would be the sunset time and add time differences of *Gyeong* and *Jeom*. After that, we change the *Bun* into 12 *Jin* unit.

References

- Korea Astronomy & Space Science Institute, 2011. Korean Astronomical Almanac 2012.
- Meeus, J., 1991. Astronomical Algorithms, Willmann-Bell, Inc.
- Nam, M. H., 1995, Korean Water Clocks, Kon-Kuk University Press.
- Nuju-tongui, 15 century, by Unknown Author.
- U.S. Naval Observatory, 1998. Multiyear Interactive Computer Almanac 1800-2050, Willmann-Bell, Inc.
- Yoo, K. R., Lee, E.S., Hyun, J.J. 1973. King Sejong's Chronicles 26, Chiljeongsan-naepyeon, The Great King Sejong's Memorial Association.