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

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**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.



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 *Gyeon-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 (*Bun* unit) | Night Time (*Bun* unit) | Dif. of *Gyeong* | Diff. of *Jeom* |
|---|---|---|---|---|
| 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.

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