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A study on Harada Shigeyoshi's *Jujireki Chukai*

Wen Zhang* and Ze-lin Xu†

Abstract

After being introduced to Japan, the important ancient Chinese calendar, the *Shoushi Calendar*, was reprinted and disseminated. The *Shoushili Yi* in *Yuan Shi-Li zhi* is an important document about the ancient Chinese calendar theory. No one studied it in the Ming and Qing dynasties, but Japanese scholars in the Edo period commented on it, such as Takebe Katahiro (1664 -1739), Nishimura Tōsato (1718-1787), and Harada Shigeyoshi (1740-1807), they annotated the *Shoushili Yi*. The article firstly verifies that the author of the *Jujireki Chukai* in the library affiliated to Tohoku University is Harada Shigeyoshi, not Takahashi Yoshitoki (1764-1804). Secondly, an investigation was carried out on Harada Shigeyoshi and his writings. The investigation found that there were three manuscripts of Harada Shigeyoshi's *Jujireki Chukai*, and the contents of the annotations and knowledge sources were verified and sorted out. It is believed that the *Jujireki Chukai* cited the contents of *Tianwen Tujie Fahui* (Nakane Genkei), *Lisuan Quanshu* (Mei Wending) and *Juji Kai* (Nishimura Tōsato) mostly. Finally, the article analyzes the annotations on "Yanqi (Collect or modify data for the solar terms)" and "Buyong Jinian Rifa (Abolition of the calendar epoch)" in Harada Shigeyoshi's *Jujireki Chukai*, and thinks that Harada's annotations in "Yanqi" through diagrams are commendable. The "Buyong Jinian Rifa" section is rich in annotations, which supplement the three possible situations that Li Qian and Qi Lvqian proposed to calculate Yanji Shangyuan. The two new situations which do not provide calculation procedures are similar to the methods of Li Qian and Qi Lvqian, and the other two situations are calculated by Seki Takakazu's Jianguan-Method. This method is essentially the same as that of Dayan-Zongshu-Method (Da-yan Rule)[大衍總數術].

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Key Words: *Jujireki Chukai*, Harada Shigeyoshi, Annotated books of *Shoushi Calendar*, Abolition of the calendar epoch, Collect or modify data for the solar terms, Jianguan-method
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Introduction

The *Shoushi Calendar* is not only the model of the calendar in the Edo period, but also the basis of mathematical science of the Edo period. There are many annotated documents about the *Shoushi Calendar* in the Edo Period, which are the historical witness of the influence of Chinese science and culture spread in Japan, and also important materials for understanding Chinese traditional science from overseas perspective. The quality of these annotated documents are uneven, and there are many copies of them, the Japanese academia has not conducted a systematic investigation, collation and in-depth interpretation of other annotated documents of the *Shoushi Calendar*, except for Seki Takakazu's [關孝和](1642?- 1708) annotations. With the electronic and informationization of ancient books and documents, it is possible to comprehensively investigate, collate and interpret these documents. We found that there are 86 kinds of annotated documents of the *Shoushi Calendar* in the Edo period [1]. However, the only complete annotations on the *Shoushi Calendar* (including *Shoushili Yi* [授時曆議] (Discussion on the *Shoushi Calendar*) and *Shoushili Jing* [授時歷經] (Text of the *Shoushi Calendar*)) are Takebe Katahiro's *Jujireki Kai Gi* [授時曆解議], Nishimura Tōsato's *Juji Kai* [授時解] and the unsigned *Jujireki Chukai* [授時曆注解]. Xu Zelin has conducted a survey, collation, translation (to be published), and preliminary research on the Takebe Katahiro's *Jujireki Kai Gi*, and obtained some research results [2][3]. However, as for the *Jujireki Chukai* and the *Juji Kai* [授時解], there is no relevant research literature, especially the *Jujireki Chukai* [授時曆注解], which has not attracted academic attention. Moreover, it has been mistakenly believed to be the writings of Takahashi Yoshitoki, so I would like to discuss it.

§ 1. Identify the author of *Jujireki Chukai*

§ 1.1 Different versions of *Jujireki Chukai*

The first transcript is now stored in the Kano Collection [狩野文庫] of the Tohoku University Library (see Figure 1), and there are three volumes of the *Jujirekigi Chukai* (*Annotations of Shoushili Yi* [授時曆議注解]) and one volume of the *Supplementary section of the Jujireki Kyou Gi Chukai* (*Supplement of Annotations of Shoushili Jing Yi* [授時歷經議注解別卷]), totaling four volumes. Three volumes of the *Jujirekigi Chukai* is lack of "Dingshuo (Fixed syzygy [定朔])" and "Buyong Jinian Rifa (Abolition of the calendar epoch [不用積年日法])" section. It is bound together with the *Supplementary section of the Jujireki Kyou Gi Chukai* [授時歷經議注解別卷] and *Shanbu Shoushili Jiaoshifa* [刪補授時曆交食法]¹. The font copied is exactly the same, and should be copied by the same person. The codex does not contain the *Jujirekikyo Chukai* [授時歷經注解]. The second copy is stored at the Yokohama Municipal University Library. According to the book registry, there are four volumes of the *Jujirekigi*

¹ This book is written by Takahashi Yoshitoki.

Chukai and one volume of the *Supplementary section of the Jujireki Kyou Gi Chukai*, but we can't see the original book because it's not available for download. The third kind of transcripts are stored at The Japan Academy (see Figure 1), including the *Jujirekigi Chukai* (4 volumes), the *Jujirekikyo Chukai* (7 volumes), and the *Supplementary section of the Jujireki Kyou Gi Chukai* (1 volume), fourteen volumes remain. A comparison of the Japan Academy's transcripts and Tohoku University Library's transcripts show that the contents of the two copies are completely consistent. Most of the contents have not been modified by the copyists, but there are some corrections in this copy caused by transcription errors. In addition, in some individual places, the contents of the Japan Academy's transcripts are rich in annotations, while the Tohoku University Library's transcripts is slightly deleted (omitted)². In addition, there is a note at the top of the page in the notes on the *Jujirekigi Chukai* of the Tohoku University Library, which is not in the notes of The Japan Academy's transcript. The Yokohama Municipal University Library's transcript doesn't know the details because it hasn't seen the original.

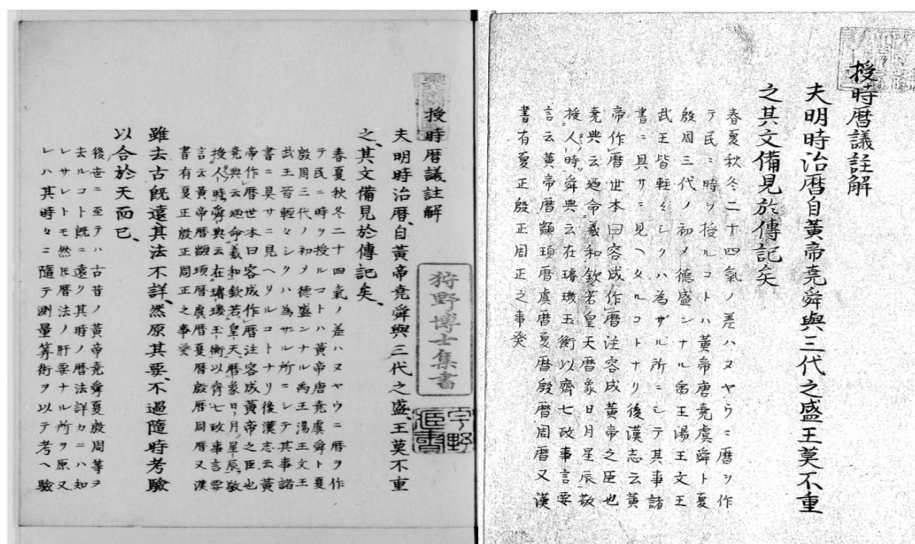


Fig-1 The first page of different transcripts

§ 1.2 Confirm the author of the *Jujireki Chukai*

The transcript of the The Japan academy, Yokohama Municipal Library and Tohoku University Kano collection have not been given the author's name or date of publication. However, the book registration of Tohoku University library shows that the book was written by Takahashi Yoshitoki (1764-1804). Through careful study of the content of the *Jujireki Chukai*, we have doubts about the Tohoku University Library's information on the *Jujireki Chukai* as the work of Takahashi Yoshitoki.

First of all, Takahashi Yoshitoki was an astronomer who was deeply influenced by the almanac theories of the *Lixiang Kaocheng*[曆象考成] and the *Lixiang Kaocheng Houbian*[曆象

² As the content of the cut is not much, it is suspected that it was omitted.

考成後編], and traces of astronomy and algebra of the *Lixiang Kaocheng* can hardly be seen in the *Jujireki Chukai*. Second, the *Jujireki Chukai* cited a large number of the writings of Shibukawa Shunkai (1639-1715), Nakane Genkei(1662-1733) and Nishimura Tōsato(1718-1787), but it was not found that the contents of the writings of Takahashi's teacher, Asada Goryu[麻田剛立]³(1734-1799) were quoted. In addition, looking at the works of Takahashi Yoshitoki, there are three kinds of works related to the *Jujireki Chukai*, namely, *Zengxiu Xiaozhangfa* (*modification the Tropical year*[增修消長法]), *Shoushili Rishifa Lunjie* (*Explain the methods of solar eclipse of Shoushi Calendar*[授時曆日食法論解]), *Shanbu Shoushili Jiaoshifa*⁴(*Delete and supplement the method of eclipses of Shoushi calendar*[刪補授時曆交食法]), but the content of these works is not found in the *Jujireki Chukai*. Therefore, the author of the *Jujireki Chukai* is obviously not Takahashi Yoshitoki.

As mentioned above, there are a lot of references to the annotations of Shibukawa Shunkai, Nakane Genkei, and Nishimura Tōsato in the *Jujireki Chukai*, moreover, when citing the writings of these people, the author only calls Nishimura Tōsato "Mr. Nishimura", while citing others, he calls him by his first name. This shows that the relationship between the author and Nishimura Tōsato is unusual, and it is very likely that it is a master-apprentice relationship. Following this clue to investigate the students of Nishimura Tōsato, it was found that there was indeed a disciple named Shigeyoshi Harada (1740-1807). According to records, Shigeyoshi Harada went to Kyoto during the Baoli[寶曆] period (1751-1764) and followed Nishimura Tōsato to learn the astronomy and calculating calendar, and Nishimura Tōsato also is annotating the *Shoushi Calendar* during the Baoli[寶曆] period (1751-1764). Therefore, on the basis of his teacher's annotations of the *Shoushi Calendar*, Shigeyoshi Harada also made annotations to the *Shoushi Calendar* with ease. The *Jujireki Chukai* refers to a large number of contents of the *Juji Kai*[授時解] by Nishimura Tōsato, which is the circumstantial evidence that the *Jujireki Chukai* was written by Shigeyoshi Harada (see Figure 2).

In addition, there are dozens of "Jia an (notes which made by Jia[嘉按])" in the *Jujireki Chukai*. "Jia" is the name of the person, that is, the author, which shows that the author is the confirmation of Shigeyoshi Harada. In addition, Shigeyoshi Harada (1740-1807) was a calendar calculator in the middle of the Edo period. There are dozens of his works, among which the existing editions mainly include the *Suankelu*[算類錄], the *Tianxue Koushou Mulu*[天學口授目錄](*Catalog of Dictation of Astronomy*) and the *Tianxue Koushou Mulu Jijie*[天學口授目錄

³ He is the almanac of scholars who was born in the 18th year of Xiangbao[享保] (1734). He studied astronomy and calendar. Later, he took Takahashi Yoshitoki as his apprentice and died in the 11th year of Kuanzheng[寬政] (1799).

⁴ The three works were all written by Takahashi Yoshitoki and they are manuscripts. Among them, the *Shanbu Shoushili Jiaoshifa*[刪補授時曆交食法] is collected by the Library of Tohoku University, the Japan Academy, and the Tokyo National Observatory. It was written in the first year of the Kuanzheng[寬政](1789). *Shoushili Rishifa Lunjie*[授時曆日食法論解] was stored in the College of Bachelor. The *Zengxiu Xiaozhangfa*[增修消長法] is stored in the Tokyo National Observatory, it was made by Takahashi Yoshitoki in the tenth year of Kuanzheng[寬政](1798).

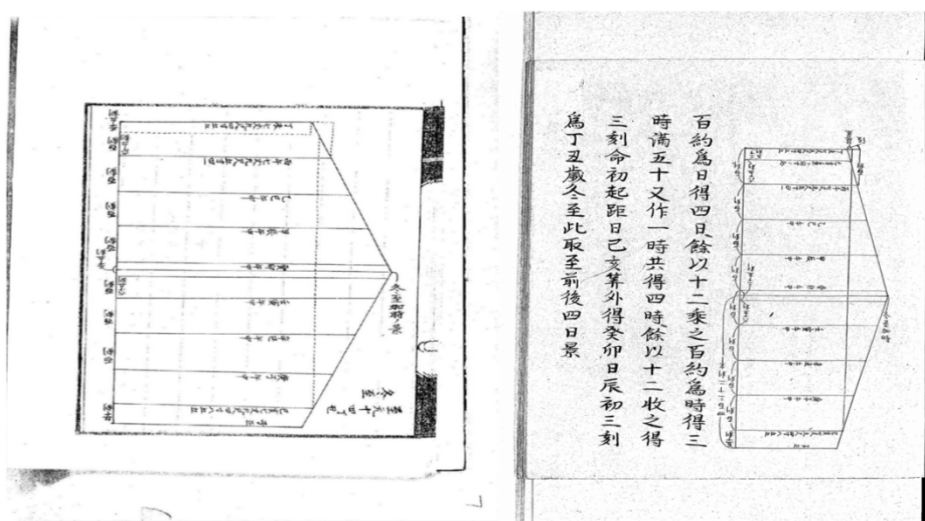


Fig-2 The similarities between the *Jujireki Chukai* and the *Juji Kai*

集解][Collect and Interpret Catalog of Dictation of Astronomy)⁵, etc., there are quite a few contents in the *Jujireki Chukai* that are similar to the contents of the above three works. The *Tianxue Koushou Mulu* and the *Tianxue Koushou Mulu Jijie* also quoted the writings of Shibukawa Shunkai, Nakane Genkei, and the contents of *Tianjing Huowen*[天經或問]. There are also several "Jia an" in the *Tianxue Koushou Mulu Jijie* [4], which can further confirm that the author of the *Jujireki Chukai* is Harada Shigeyoshi.

§ 2. Harada Shigeyoshi and his writings

Harada Shigeyoshi (1740-1807), named Yuangoro[元五郎], was a mathematician and astronomer in the middle of the Edo period. He showed interest in mathematics at an early age, and then received a systematic sum-calculation education. During the Baoli[寶曆] period(1751-1764), he went to Edo to study Japanese arithmetic, and then worked in Kyoto. During his stay in Kyoto, he studied astronomical arithmetic from Nishimura Tōsato (1718-1787) [5].

The experience of Harada Shigeyoshi in the Okayama in his early years is unclear due to the lack of sufficient historical data. During his stay in Kyoto and Edo, he came into contact with a large number of books on Japanese calculus and astronomy, and his mathematical ability and academic level improved rapidly. When Harada Shigeyoshi followed Nishimura Tōsato to learn the astronomy and calculating calendar, it was during the Baoli[寶曆] period that the calendar was changed. Nishimura Tōsato won the trust of the Tokimon[土禦門] family of the Yin-Yang dormitory (astronomical organization[陰陽寮]) in the Baoli period, and participated

⁵ *Tianxue Koushou Mulu*[天學口授目錄], collected in Kyushu University. The author of *Tianxue Koushou Mulu*[天學口授目錄](*Catalog of Dictation of Astronomy*) and *Tianxue Koushou Mulu Jijie*[天學口授目錄集解](*Collect and Interpret Catalog of Dictation of Astronomy*)" is noted as Harada Shigeyoshi.

in the campaign of reforming calendar which host by Yasukuni Dogemon in the second year of Baoli(1752)[6]. Therefore, Nishimura Tōsato spent a lot of time and energy in compiling the *Juji Kai*[授時解], and his annotation work influenced Harada's research on the *Shoushi Calendar*.

Before he studied under the tutelage of Nishimura Tōsato, Harada was mainly engaged in the study of sum and arithmetic, and then his research work turned to astronomy and algebra. According to the available sources, he has about 29 works. His works can be divided into two categories, one for mathematics and the other for astronomy. Because Harada lived in a transitional period from the traditional Chinese astronomy centered on the *Shoushi Calendar* to Western astronomy centered on the *Chongzhen Lishu*[崇禎曆書], both ancient Chinese calendar knowledge and Western astronomical knowledge are involved in Harada's works.

§ 3. Contents and References of the *Jujireki Chukai*

§ 3.1 The main content of the *Jujireki Chukai*

The *Jujireki Chukai* is mainly composed of three parts, namely *Jujirekigi Chukai* (*Annotations of Shoushili Yi*[授時曆議注解]), *Jujirekikyo Chukai*(*Annotations of Shoushili Jing*[授時歷經注解]) and the *Supplementary section of Jujireki Kyo Gi Chukai* (*Supplement of Annotations of Shoushili Jing Yi*[授時歷經議注解別卷]). *Shoushili Yi* is a calendrical theory are discussed and presented in the work, such as how to determine, collect or modify data for the solar terms (Yanqi[驗氣]), the decimal part of the tropical year's length (Suiyu[歲餘]) and precession (Suicha[歲差]), the time of the winter solstice (Dongzhi ke[冬至刻]), the Sun's uniform motion (Richan[日躔]), the non-uniform motions of the Sun and the Moon (Yuxing chiji[月行迟疾]), the nodes of the Moon's path to the ecliptic and the equator (Baidao jaozhou[白道交周]), length of day and night (Zhouyeke[晝夜刻]), eclipse (Jiaoshi[交食]), fixed syzygy (Dingshuo[定朔]), and abolition of the calendar epoch (Buyong Jinian Rifa[不用積年日法]). The *Jujirekigi Chukai* is Harada Shigeyoshi's Japanese annotation to the *Shoushili Yi* which is compiled in the *YuanShi·Lizhi*[元史·曆志]. The commentary is very detailed and comprehensive, explaining the original texts sentence by sentence. The *Jujirekigi Chukai* is divided into four volumes: The first volume is annotated collecting or modifying data for the solar terms, Harada Shigeyoshi gives a complete overview of the development of ancient Chinese calculate the shadow length (Ceying[測影]) methods, especially the historical context of the development of calculate the shadow length instruments and measurement methods, and draws a large number of diagrams and pictures to illustrate the working principle of the imaging equipment.⁶ The second volume is annotated from the decimal part of the tropical year's length to the length of day and night, this part mainly expounds the theory of solar motion. The third

⁶ Annotating the *Shoushi Calendar* by drawing diagrams and pictures was very popular in the Edo period. In the Edo period, there were many works that illustrated the *Shoushi Calendar*, such as *Shoushili Tujie*[授時曆圖解], *Shoushili Tujie Fahui*[授時曆圖解發揮], *Shoushili Jing Tujie*[授時歷經圖解], etc. Harada Shigeyoshi was obviously influenced by these works.

volume, annotated eclipse, examines certain solar and lunar eclipses in history by reviewing a large number of ancient Chinese historical books and materials. The fourth volume annotates the fixed syzyg and the bolition of the calendar epoch, focusing on the latter.

The *Jujirekikyo Chukai* is a commentary on the method of calculation steps of the *Shoushi Calendar* and it is divided into four parts. Respectively calculate solar terms and new moon (Bu qishuo[步氣朔]), (Bu falian[步發斂]), (bu richan[步日躔]), (Bu yueli[步月離]), (Bu zhongxing[步中星]), (Bu jiaohui[步交會] and (Bu wuxing[步五星]), (bu licheng[步立成]) which is depleted in the *Shoushi Calendar* is added in the last section, a total of seven volumes. The first volume contains (Bu qishuo[步氣朔]) and (Bu falian[步發斂]). Harada Shigeyoshi mainly annotates the steps of Ding Shuo[定朔] in detail, and then demonstrates the specific steps of fixing the new moon. In the part of Bu falian[步發斂], he mainly translates the original text and annotates the professional terms. The second and third volumes are the contents of Bu richan[步日躔] and Bu yueli[步月離] respectively. In these two parts, Harada Shigeyoshi's annotations are extremely detailed, and the content of the annotations is several times that of the original text. The core content of this part is the motion of the sun and the movement of the moon, he mainly interprets the calculation of irregular movements of the sun and moon, the purpose of which is to solve the correction of the sun and the moon. Therefore, in this part, Harada focuses on explaining the calculation process and structural principle of the Zhaocha-method[招差法].

The fourth volume is Bu zhongxing. In this part, Harada Shigeyoshi mainly discusses the Hushi-Geyua-method[弧矢割圓術], expounds the Hushi-Geyuan-methods from many aspects, and combs the construction process of Hushi-Geyuan-method in detail. The fifth volume is a commentary on the Bu Jiaohui(Caculate Eclipse of Sun and Moon), which can be divided into two aspects: First, Harada Shigeyoshi's commentary on the basic method and the number which is used to caculate eclipse, including the explanation of terms, the relationship of different number, and the measurement method of relevant data. Second, he annotated the method of calculating the eclipses of the sun and the moon, and discussed the principle of constructing the algorithm of calculating eclipses. The sixth volume is a commentary on the Bu Wuxing. Harada Shigeyoshi's commentary focuses on the calculation of the uneven motion of five planets (Venus, Jupiter, Mercury, Mars, Saturn), the determination of certain specific positions of the planet, and the angular distance between the planet and the perihelion of the orbit at these positions. The content of the seventh volume is the annotation of Bu Licheng (Caculating the Table of the *Shoushi Calendar*). The main content is to annotate all kinds of tables, to annotate all kinds of calendar terms, and to check and modify data in different tables.

The *Supplementary Section of Jujireki Kyo Gi Chukai* is a supplement to the parts that have not been discussed or omitted in the *Jujirekigi Chukai* and the *Jujirekikyo Chukai*.

§ 3.2 Quoted content of the *Jujireki Chukai*

The *Jujireki Chukai* is mainly the translation and annotation of *Shoushi Calendar*, including

the analysis of some algorithm construction principles. Harada Shigeyoshi asked for extensive quotations, and the cited materials are rich, and a considerable part of them are direct quotations, and in the annotations they directly use "Meizi said", "Mr.Nishimura said", "Nakane Genkei said", and so on.⁷ In addition, there are citations without clear source, such as "Mr. said"⁸. After comparison, textual research and retrieval, it can be determined that the works cited are mainly from the works of Mei Wending, Shibukawa Shunkai, Nakane Genkei and Nishimura Tōsato. In addition, it also cited astronomical works such as *Zhoubi Suanjing*[周髀算經], *Tianjing Huowen*[天經或問], *Tianwen Tujie Fahui*[天文圖解發揮], *Shoushili Tujie Fahui*[授時曆圖解發揮], *Lisuan Quanshu*[曆算全書] and *Guankui Jiyao*[管窺輯要], especially citing Nakane Genkei's *Tianwen Tujie Fahui*, Mei Wending's *Lisuan Quanshu* and Nishimura Tōsato's *Juji Kai* are the most cited, and the citation statistics are shown in Table 1 below.

Tab-1 Collate quotations of each volume of the *Jujireki Chukai*

	所在冊 Part Of book	Nakane Genkei 中根元圭	Mei Wending 梅文鼎	Nishimura Tōsato 西村遠裏
<i>Jujirekigi Chukai</i> 授時曆議 注解	The first volume (Yanqi) 第一冊 (驗氣)	1	0	1
	The second volume (Suiyu suicha-Zhouyeke) 第二冊 (歲餘歲差-晝夜 刻)	5	1	0
	The third volume (Eclipse) 第三冊 (交食)	0	0	3
	The fourth volume (Dingshuo- Buyong Jinian) 第四冊 (定朔-不用積年日 法)	5	0	3
<i>Jujirekikyo Chukai</i> 授時歷經 注解	The first volume (Qishuo- Falian) 第一冊 (氣朔、發斂)	6	2	1
	The second volume (Richan) 第二冊 (日躔)	10	4	4
	The third volume (Yueli)	4	5	5

⁷ Compared with *Tianwen Tujie Fahui*[天文圖解發揮](Nakane Genkei), *Lisuan Quanshu*[曆算全書](Mei Wending) and *Juji Kai*[授時解](Nishimura Tōsato). This kind of direct quotation is taken from these writings.

⁸ Most of these citations are in Chinese, and after comparing and searching, it is found that most of them are the contents of Mei Wending's *Lisuan Quanshu*[曆算全書].

	第三冊（月離）			
	The fourth volume (Zhongxing) 第四冊（中星）	4	8	1
	The fifth volume (Eclipse) 第五冊（交會）	20	23	18
	The sixth volume (Wuxing) 第六冊（五星）	2	5	2
	The seventh volume (Licheng) 第七冊（立成）	1	0	0
<i>Supplementary section of Jujireki Kyo Gi Chukai</i> 授時歷經 議注解別 卷		6	0	3

The table above shows the statistics of the citations of Harada's annotations. Among them, the annotations cited by Nakane Genkei are the most, followed by Nishimura Tōsato and Mei Wending respectively. Most of the comments by others are quoted in the parts on the motion of the sun, the movement of the moon, the movement of the five planets and the eclipse of the moon and the sun. The *Jujireki Chukai* cites a large number of other scholars' writings, which not only reflects the fruitful research results of the *Shoushi Calendar* in East Asia in the 17th and 18th centuries, especially the wide dissemination of the engraved version of the annotated literature. For example, Nakane Genkei's *Tianwen Tujie Fahui* was published in the tenth year of Genroku (1697) [7], Mei Wending's *Lisuan Quanshu* was introduced to Japan in the eleventh year of Xiangbao (1726) [8], and Nishimura Tōsato's *Juji Kai* was published in the eleventh year of Baoli (1761) [9]. The publications of these works provide a good reference for Harada's annotation work. On the other hand, the calendar reform movement during the Baoli period aroused the interest of the mathematicians at that time in the issue of Chinese and Western astronomy and almanac.

Compared with Takebe Katahiro's *Jujireki Kai Gi*, the *Jujireki Chukai* has the following outstanding characteristics: First, the *Jujireki Chukai* is in the form of citing others' annotations, and then express their own views in the form of "note" to evaluate the contents of the *Shoushi Calendar* or the annotations of others. From this, it can be seen that Harada Shigeyoshi traces and corrects the relevant astronomical and almanac issues, and also conducts basic analysis on the measurement methods and calculation methods of calendrical data. Second, the astronomical

knowledge involved in the annotations of Takebe Katahiro's *Jujireki Kai Gi* is almost entirely traditional East Asian astronomical knowledge, while the annotation content of Harada Shigeyoshi's *Jujireki Chukai* contains some Western astronomical content.⁹ In addition, Takebe Katahiro checked and annotated almost all the table data in the *Jujireki Kai Gi* one by one, while Harada Shigeyoshi was not so meticulous. Finally, in the *Jujireki Chukai*, the structure of several measuring instruments is explained and its measurement principle is explained by drawing pictures, which reflects the characteristics of popular diagrams in the Japanese astronomical and mathematical literature in the 18th century. Nishimura Tōsato specifically opened a chapter called "The Measuring Instrument Pictures of the *Juji Kai*" in the *Juji Kai*, and Harada Shigeyoshi may have been influenced by his teacher.

§ 4 Harada Shigeyoshi 's annotation on "Collect or modify data for the solar terms" and "Abolition of the calendar epoch"

Although the *Jujireki Chukai* quotes a lot of previous annotations, it also has its own opinions. Comments on "Collect or modify data for the solar terms" and "Abolition of the calendar epoch" of *Shoushili Yi*, "Uniform motion of the Sun", "the movement of the moon", "eclipse of the sun and the moon", "Hushi Geyuan-method"(弧矢割圓術) of *Shoushili Jing* are the most detailed, from his annotations on "Collect or modify data for the solar terms" and "Abolition of the calendar epoch", we can see his understanding of the ancient Chinese calendar theory.

§ 4.1 Harada Shigeyoshi 's annotation on "Collect or modify data for the solar terms"

There are 24 solar terms in a year, reflecting the different positions of the sun on the ecliptic, which can be determined by means of standing watch and shadow measurement. The ancients called it "Yan Qi". The essence of "Yan Qi" is to measure the twenty-four solar terms, the most important of which is the determination of the winter solstice and the summer solstice. Therefore, "the determination of the time of the winter solstice is one of the important subjects of the ancient Chinese calendar"[10]. Chinese astronomical and calendrical scholars have done a lot of work in measuring the winter solstice, and have gradually advanced on the basis of their predecessors, leaving a batch of measurement results. With the progress of standard measurement technology and the improvement of the calculation method of the winter solstice time, these achievements have become more and more precise, and reached their peak in the *Shoushi Calendar*.

⁹ It is not clear when the two annotated books were compiled, but according to their contents, it is speculated that the *Jujireki Kai Gi* compiled during Takebe Katahiro visit to Edo as a calendar advisor, and the *Jujireki Chukai* should have been compiled when Nishimura Tōsato compiled the *Juji Kai* (around 1760). At the time of the compilation of the *Jujireki Kai Gi*, the Chinese-translated Western astronomical works had not been fully spread in Edo Japan, but by the time of the compilation of the *Jujireki Chukai*, the Chinese-translated Western astronomical works had gained a certain level of dissemination.

Guo Shoujing made two improvements to the measurement of determining the winter solstice. Improvements were made by a scene symbol, solving the problem of virtual shadows on the surface, and improving the observation accuracy. Harada Shigeyoshi recognized Guo Shoujing's contribution, and gave a high evaluation of Guo Shoujing's improvement in the *Jujireki Chukai*. Harada Shigeyoshi said "the length of the shadow which is measured by Jing Fu[景符], the accuracy can be said to be not bad"[11]. After that, Harada gave a complete description of the development of photometry in ancient China, and the development context from instruments to calculation methods was clearly explained, especially in the annotations to explain the working principle of photometry instruments (see Figure 3).

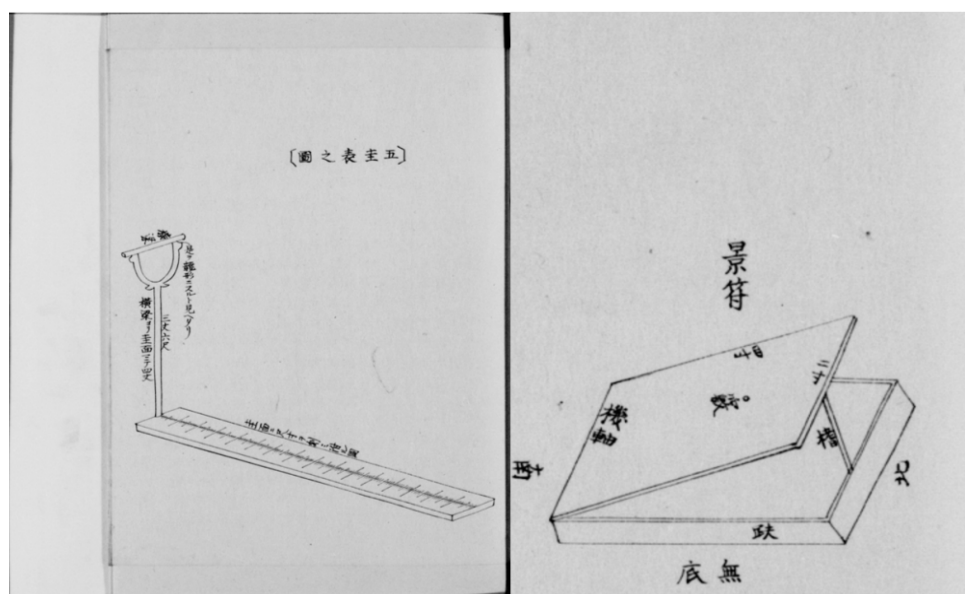


Fig-3 The picture of Gui Biao[圭表] and Jing Fu[景符] in the *Jujirekigi Chukai*

§ 4.2 Harada Shigeyoshi 's annotation on "Abolition of the calendar epoch"

Harada has the longest annotation on "Abolition of the calendar epoch". Regarding the Shangyuan Jinian[上元積年], in order to compile the calendar, ancient Chinese astronomers and calendarists will set a moment when the celestial phenomenon of "the sun, the moon and other five planets are united in one line". In order to conveniently calculate the twenty-four solar terms, the new moon and full moon, and eclipses, it is often necessary to set an overall starting point for the entire calendar, and this moment is called Shangyuan[上元]. The number of years from Shangyuan to the calendar year is called the accumulated years, commonly known as Shangyuan Jinian. Qu Anjing believes, "The traditional Chinese calendar is based on the choice of the upper element, forming an astronomical constant system. Usually, the upper element is determined according to the two basic constants of the synodic month and the tropical year, and then other calendar constants are called from this, such as the sidereal year, the perigee month, the nodal month and the five-star conjunction cycle are the calendar values"[12]. Before the *Shoushi Calendar*, the ancient Chinese calendars generally used the Shangyuan Jinian, except the *Futian*

Calendar of the Tang Dynasty, the *Tiaoyuan Calendar* of the Five Dynasties and Ten Kingdoms period, and the *Tongtian Calendar* of the Song Dynasty, and were completely abolished by the *Shoushi Calendar*. Li Qian (1234~1312) and Qi Lvqian (?~1329) made a relevant discussion on the complete abandonment of the Shangyuan Jinian in the *Shouhsili Yi*, and systematically investigated the Shangyuan Jinian of various calendars of the previous dynasties, and deduced the three possible situations that may occur in the Shangyuan period according to the Tangsong-Yanji-method (a method of calculating accumulated years in the Tang and Song Dynasties), and listed their accumulated years and days, as well as the actual measurement of Qiying[氣應], Runying[閏應], and Jingshuo[經朔] in the eighteenth year of Zhiyuan (1281).

In the annotation of "Abolition of the calendar epoch", Harada Shigeyoshi first commented that abolition of the calendar epoch of the *Shoushi Calendar*, he pointed out that

The task of calculating the Shangyaun Jinian is difficult and easy to cause errors. However, other calendars are still used, so these calendars can't be used for a long time. So compiling the calendar should be formulated in accordance with the law of celestial motion, the celestial bodies have their own rules, not people can decide, if artificial attachment, the calendar can never be in harmony with the law of celestial motion. The sun, the moon and the five stars move in the sky, and their advance and retreat have their own rules. To calculate the accumulated years by their cycles is to seek the far away from the near. The *Shoushi Calendar* has stopped deducing the Shangyuan Jinian, and the data used are obtained from actual measurement, not from man. Compared to other calendars, the *Shoushi Calendar* is in accordance with the law of celestial motion and the sky. [13]

Harada Shigeyoshi made such a comment, indicating that Harada has realized the positive significance of abolishing the calendar epoch, which instead of using the method of accumulating years and days, used the method of close epoch. Although this method has great advantages in calculating the period, addition and subtraction of different dates, time difference, etc., as the calculation of the planetary, solar, and lunar cycles continue to be refined, the accumulation of years and days method becomes larger and larger. It becomes more and more cumbersome, which is not conducive to the calculation of the calendar.

After that, Harada conducted research on the accumulated years and used years of 43 calendars since the Han Dynasty, and amended accumulated years and Ri Fa of some calendars. After comparing with the original text of *Shoushili Yi*, there are three places where the data has been modified, which are

Daxiang Calendar: which was made by Ma Xian in the first year of Daxiang, used for five years, until Jiachen[甲辰] of Kaihuang. Accumulated years: 42257¹⁰. Ri Fa: 12992.

Jiyuan Calendar: which was made by Yao Shunfu in the fifth year of Chongning, used for 21 years, until Dingwei[丁未] of Jingtian. Accumulated years: 28613641. Ri

¹⁰ The *Yuanshi-Lizhi* is recorded as forty-two thousand two hundred and fifty-five.

Fa: 7290. (It should be 28613641 not 28613467)

Chengtian Calendar: which was made by Chen Ding in the seventh year of Xianchun, used for 4 years, until Xinshi[辛巳] of Zhiyuan. Accumulated years: 71758152. Ri Fa: 7420. (It should be 71758152 not 71758157)¹¹[14]

The data corruption in the *Daxiang Calendar* was caused by the negligence of the copyists. Harada made modification on the accumulated years data of *Jiyuan Calendar*[紀元曆] and *Chengtian Calendar*[成天曆]. It is unclear whether Harada Shigeyoshi performed actual calculations during the annotation process.

In addition to commenting on the accumulated years and daily methods of the forty-three calendars since the Han Dynasty, Harada Shigeyoshi supplemented the three possible situations that Li Qian and Qi Lvqian could have inferred from the Yanji-method[演紀法] in accordance with the performance rules. Then Harada gives the other four cases, which are listed in the Table-2.

Tab-2 The data of the Shangyuan Jinian and Ri Fa in the *Jujirekigi Chukai*

	Rifa[日法]	Qiyong[氣應]	Runying[閏應]	Jingshuo[經朔]	Shangyuan Jinian [上元積年]
	實測	55. 0600	20. 1850	34. 8750	
The three old cases 舊法三條	2190	55. 0602 (+2)	20. 1853 (+3)	34. 8748 (-2)	己亥 98251422
	8270	55. 0534 (-66)	20. 1808 (-42)	34. 8720 (-30)	甲子 5670557
	6570	55. 0631 (+31)	20. 1919 (+69)	34. 8712 (-38)	甲子 39752537
The two new cases 新制二條	7420	55. 0539 (-61)	20. 1851 (+1)		戊辰 263956813
	5720	55. 0627 (+27)	20. 1851 (+1)		甲子 393221957
The two other cases 另制兩條	10000	55. 0575 (-25)	20. 1850 (0)		壬寅 1121426395 9
	10000	55. 0725 (+125)	20. 1850 (0)		甲子 6231521455 7

¹¹ Harada Shigeyoshi made supplementary content in parentheses.

The three old cases listed in the table above are the data of Qiying, Runying and Jingshuo based on the Yanji-method (no specific accumulation method is included) obtained by Li Qian and Qi Lvqian by selecting three groups of different Rifa and accumulated years in the *Shoushili Yi*. Mr. Harada questioned the three sets of data selected by Liqian and Qi Lvqian¹² and represented two similar sets of data. These five groups of data are based on Qiying, Runying and Rifa to calculate the Shangyuan Jinian. Harada did not specify the process of calculating the Shangyuan Jinian for the "two new cases", but if the selection of Rifa to calculate the Shangyuan Jinian, it is easy to lead to the release of Sushi inconsistent with the data of the *Shoushili Jing*. Therefore, Harada believed that "the three old cases and the two new cases are calculated by the Rifa, so their Suishi are not closely related to the *Shoushili Jing*"[15], so he gave another method of deduction (namely, two different cases). In these five cases, Harada did not give the new Rifa, and Rifa was the same as the *Shoushi Calendar*.

Harada Shigeyoshi quoted Nakane Genkei's method of calculating the Shangyuan Jinian in his *Tianwen Tujie Fahui*, and gave a complete calculation process for calculating the Shangyuan Jinian in the "two different cases". The calculation steps are as follows:

The first step is to obtain the data of Suishi[歲實], the data of Xunzhou[旬周] and the data of Shuoshi[朔實] through Zhuyue-method[逐約術];

The second step to calculate Qiying Yingfa[氣應因法] and Runying Yingfa[閏應因法];

The third step is to get the Qushu by the Suishi[歲實] and Shuoshi[朔實];

The fourth step is to determine the minutes and seconds of Qiying[氣應] and Runying[閏應];

The fifth step, through the Qiying[氣應], Runying[閏應], Qiying Yingfa[氣應因法] and Runying Yingfa[閏應因法] to calculate the Shangyuan Jinian[上元積年].

Harada Shigeyoshi's method for calculating Suishi[歲實] and Shuoshi[朔實], also known as the Zhuyue-method of Seki Takakazu, is to give some integers and then determine one of their divisors so that these divisors are pairwise prime and their sum is equal to the least common multiple of these integers. The second step is to the Shengyi method of Seki Takakazu. Finally, the Shangyuan Jinian can be deduced by Jianguan-Method, and Jianguan-Method is the method of solving congruence system, that is, to solve $b_1x \equiv a_1 \pmod{m_1}$, $b_2x \equiv a_2 \pmod{m_2}$, $b_nx \equiv a_n \pmod{m_n}$ which is also the same as Seki Takakazu's Jianguan method. Seki Takakazu's *Kuoyao Suanfa*[括要算法] contains this algorithm of Zhuyue-method, Shengyi-method and Jianguan-method, its calculation program is the same as the algorithm of Qin Jiushao's *Shushu Jiuzhang*, Seki Takakazu may have been influenced by the *Shushu Jiuzhang* or its spreading books[16]. Shen Kangshen also believed that "the Zhuyue-method in the second volume of *Kuoyao Suanfa* are equivalent to the operation of Qin Jiushao's Dayan-Zongshu-Method, Shengyi-Method[剩一術] and Jianguan-method are the same as Qin Jiushao's method"[17], which shows that the

¹² Most scholars believe that the *Shoushili Yi* was compiled by Li Qian on the basis of Guo Shoujing's *The Draft of Shoushili Yi*. I believe that Qi Lvqian also participated in the compilation of the *Shoushili Yi*. It is recorded in the *Yuanshi-Biography of Qi Lvqian*.

two algorithms are essentially the same.

Harada's method of using the Jianguan-method to calculate Shangyuan Jinian is different from that of Li Qian and Qi Lvqian, and there are differences in the specific calculation between the two. Li Qian and Qi Lvqian deduced the Yanji Shangyuan[演紀上元] according to the Yanji method, while Qu Anjing confirmed it through theoretical analysis and examples of the Yanji method. It is pointed out that "during the Tang and Song Dynasties, the items involved in the calculation of the Yanji Shangyuan did not exceed the four basic calendar cycles, such as Riming[日名], Suiming[岁名], tropical year and synodic month. In principle, it is required that the absolute adjustment error between Qiyong, Runyong and the measured data should be less than 0.01 days (1 minute), and the accumulated years required should be less than 100 million"[18]. Due to these limitations of the Yanji-method, Li Qian and Qi Luqian could only sacrifice the accuracy of the tropical year to ensure that the error value of Qiyong and Runyong was less than one moment. In order to get rid of this limitation, Harada chose to use Jianguan-method to calculate the Yanji Shangyuan. Therefore, he manually modified the value of Qiyong in the calculation, and artificially widened the error of the value of Qiyong in the last case to a range of two minutes. In addition, it is not feasible to calculate the accumulated years according to the Jianguan-method under the condition that the Qiyong data is unchanged. The Jianguan-method is the same as the Dayan-Zongshu-method, and it does not have the function of adjusting and selecting the remainder (Qiyong data). Harada can only calculate by manually modifying the Qiyong data.

§ 5. Conclusion

Through the textual research of this paper, it can be confirmed that in the numerous annotated documents of the *Shoushi Calendar* in the Edo Period of Japan, there are only three complete annotations to the *Shoushi Calendar*, namely Takebe Katahiro's *Jujireki Kai Gi*, Nishimura Tōsato's *Juji Kai* and the unsigned *Jujireki Chukai*. Although Harada's level of annotation is not as good as Takebe Katahiro's *Jujireki Kai Gi*, and he has quoted a lot of the annotations of his predecessors, there are also Harada's own opinions, which have a certain reference value for our study of the *Shoushi Calendar*. The book cites a large number of Chinese and Japanese astronomical calendrical works and Chinese translations of Western astronomical works. From the perspective of philology, it has a certain value for us to identify and verify some authors of astronomical almanac literature authors. In addition, the commentary reflects the influence of the traditional Chinese mathematical astronomy centered on the *Shoushi Calendar* in the Edo period to the Western classical mathematical astronomy centered on the *Chongzhen Calendar*. It is of great academic value to study the scientific and cultural exchanges between China and Japan and between the East and the West.

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