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# Iwahashi Zenbei's Sunspot Drawings in 1793 in Japan

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**Abstract** Three Japanese sunspot drawings associated with Iwahashi Zenbei (1756 – 1811) are shown here from contemporary manuscripts and woodprint documents with the relevant texts. We reveal the observational date of one of the drawings to be 26 August 1793, and the overall observations lasted for over a year. Moreover, we identify the observational site for the dated drawing as Fushimi in Japan. We then compare Zenbei's observations with the group sunspot number and the raw group count from the Sunspot Index and Long-term Solar Observations (SILSO) to reveal the context of the data, and we conclude that these drawings fill gaps in our understanding that are due to the fragmental sunspot observations around 1793. These drawings are important as a clue to evaluate astronomical knowledge of contemporary Japan in the late eighteenth century and are valuable as a non-European observation, considering that most sunspot observations up to the middle of the nineteenth century are from Europe.

## 1. Introduction

One of the longest ongoing scientific research projects that has generated large datasets for the review of solar activity is sunspot counting (Owens, 2013). While telescopic observations have been carried out for over 150 years to observe solar flares since the Carrington event in 1859 (Carrington, 1859; Kimball, 1960; Tsurutani *et al.*, 2003;

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Cliver and Svalgaard, 2004; Cliver and Dietrich, 2013; Hayakawa *et al.*, 2016), telescopic observations for sunspots exist for over 400 years since the early 17th century; they form one of the most important indices for solar physics (Owens, 2013). These datasets contributed to the reconstruction of the Wolf number (Zürich number) by R. Wolf (*e.g.* Waldmeier, 1961), and the group sunspot number by Hoyt and Schatten (1998). Recently, several authors revisited the sunspot number ($S_N$) in general to make crucial contributions (Clette *et al.*, 2014, 2015; Clette and Lefèvre, 2014; Svalgaard and Schatten, 2016; Vaquero *et al.*, 2016) based on the latest discussions on raw sunspot data within early modern scientific documents, which consist of sunspot counting and sunspot drawings (*e.g.* Vaquero, 2007a, 2007b; Vaquero, Gallego, and Trigo, 2007; Vaquero and Vázquez, 2009; Arlt, 2008, 2011; Diercke, Arlt, and Denker, 2014; Usoskin *et al.*, 2015; Arlt *et al.*, 2016; Aparicio *et al.*, 2014; Carrasco, Alvarez, and Vaquero, 2015a, 2015b; Willis *et al.*, 2013a, 2013b, 2016; Lefèvre *et al.*, 2016; Lockwood *et al.*, 2016b, 2016c, 2017; Carrasco and Vaquero, 2016; Cliver, 2017; Svalgaard, 2017). Within these datasets, sunspot drawings are of greater value as they provide information not only on the $S_N$, but also on the sunspot area, distribution, locations, and so forth (Vaquero, 2007a; Vaquero and Vázquez, 2009).

While most of these sunspot observations have been reported by European astronomers (Vaquero, 2007a), recent studies rediscovered sunspot drawings of other areas from non-European astronomers. They are of great importance to recover solar observations before the middle of the nineteenth century (Domínguez-Castro, Gallego, and Vaquero, 2017; Denig and McVaugh, 2017). In this context, it must be noted that considerably longer traditions of sunspot observations are present not only in Europe (*e.g.* Stephenson and Willis, 1999; Willis and Stephenson, 2001; Vaquero, 2007b), but also in East Asia or West Asia, even in pre-telescopic ages (Keimatsu, 1970; Clark and Stephenson, 1978; Willis, Easterbrook, and Stephenson, 1980; Willis, Davda, and Stephenson, 1996; Yau and Stephenson, 1988; Xu, Pankenier, and Jiang, 2000; Willis and Stephenson, 2001; Lee *et al.*, 2004; Hayakawa *et al.*, 2015, 2017a, 2017, 2017; Tamazawa *et al.*, 2017a; Goldstein, 1969; Vaquero and Gallego, 2002). After the seventeenth century, these non-European astronomers began to make contact with European astronomy, and some started to adopt European technology. In particular, contemporary Japanese astronomers imported European astronomy and the associated technologies through trade with Dutch merchants, in order to make some sunspot observations (Watanabe, 1987). More significantly, Kunitomo Ikkansai (国友一貫斎) improved European telescopes and carried out continuous sunspot observation in 1835 – 1836 (Kanda, 1932; Yamamoto, 1937; Kubota and Suzuki, 2003) and have been already known in the archives of sunspot number indices (*e.g.* Hoyt and Schatten, 1998; Vaquero *et al.*, 2016). However, Tamazawa, Hayakawa, and Iwahashi (2017) reported that one of the earliest sky-watching events with telescopes occurred in 1793. Iwahashi Zenbei (岩橋善兵衛, 1756 – 1811) operated a telescope that he constructed for sunspot observation in the sky-watching event. As participants left three accounts with sunspot drawings, we show these drawings and relevant records to determine the dates of the observation and to analyze their descriptions.

## 2. Method

### 2.1. Analyses

In order to examine Iwahashi Zenbei's sunspot observations from 1793, we examined three documents from a contemporary source as explained below and compared their descriptions. We then analyzed the sunspot records to count the number of sunspots that were observed. Furthermore, we compared the data context in terms of group sunspot number and raw sunspot group counts to those by contemporary European sunspot observations. We have translated *kokuten* (黒點), which is a technical term for sunspot, as its literal meaning, "black spot," for historical significance as in other Japanese historical documents (*e.g.* Hayakawa *et al.*, 2017), and as "sunspot" in the context of scientific discussions as used in modern scientific works (*e.g.*, Koyama, 1985; Svalgaard and Schatten, 2016; Knipp, Liu, and Hayakawa, 2017).

## 2.2. Source Documents

In order to fulfill this purpose, we examined three historical documents written by participants of the sky-watching event in 1793. Listed below are the references to these documents in the archive that stores the documents, using their abbreviations, authors, and shelf marks as follows:

BK-J: Tachibana Nankei (橘南谿), *Bouenkyo Kanshoyoki* (望遠鏡觀諸曜記), MS MB-51-Ta in the Library of the National Astronomical Observatory of Japan [a manuscript in Japanese];

BK-N: Tachibana Nankei (橘南谿), *Bouenkyo Kanshoyoki* (望遠鏡觀諸曜記), MS 463 in the Library of the International Research Center for Japanese Studies [a manuscript in Japanese];

BK-T: Tachibana Nankei (橘南谿), *Bouenkyo Kanshoyoki* (望遠鏡觀諸曜記), MS Inada 44-210 in the Tsu City Library [a manuscript in Japanese];

KJ: Ban Koukei (伴蒿蹊), *Kanden Jihitsu* (閑田次筆), MS MY1491-2 in the National Institute for Japanese Literature [a woodprint in Japanese];

HZ: Iwahashi Zenbei (岩橋善兵衛), *Heitengi Zukai* (平天儀圖解), MS MY-1440-2 in the National Institute for Japanese Literature [a woodprint in Japanese].

*Bouenkyo Kanshoyoki* (BK) is a record of one of the earliest sky watchings with telescopes in Japan held on 26 August 1793 at Fushimi, written in classic Sino-Japanese by Tachibana Nankei (1753–1805), the host of the sky watching. On that day, Tachibana Nankei and Iwahashi Zenbei held a sky watching with 12 participants from various academic backgrounds. The participants observed not only the Sun, but also the Moon, Jupiter, Saturn, and Venus using Iwahashi Zenbei's telescope (Tamazawa, Hayakawa, and Iwahashi, 2017). At the time of writing, three variants of BK are known with an exact location: BK-J, BK-N, and BK-T, according to the Union Catalogue of Early Japanese Books.[1] Unfortunately, none of them has an explicit dating other in their colophons. All the variants commonly have observational records in 1793 (BK-N: f.2b; BK-T: f.2b; BK-J: f.4a). BK-T and BK-J have an additional description of another observation in 1795 (BK-T: f.4b; BK-J: f.4a). BK-J has an additional statement on contemporary European astronomy with the name of Agawa Biren (阿川美廉) that does not appear in other variants. Therefore, chronologically we regard BK-N as a first edition or its copy, BK-T as a second edition or its copy, and BK-J as a copy by Agawa Biren. Nevertheless, we have to admit that we cannot determine whether BK-J or BK-T is the autograph manuscript by Tachibana Nankei himself at the current stage. Therefore, we show the sunspot drawing in each variant.

*Kanden Jihitsu* (KJ) is an essay with four volumes by Ban Koukei (1733 – 1806) published as a woodprint edition in 1806. This essay consists of miscellaneous topics, including

[1] http://base1.nijl.ac.jp/infolib/meta_pub/G0001401KTG (last accessed on 10 Oct. 2017).

the description of the sky watching in 1793 in classic Japanese. At the time of writing, we have at least 43 copies with exact locations in various archives in Japan and the United States, according to the Union Catalogue of Early Japanese Books. We used a copy stored in the National Institute for Japanese Literature (NIJL) in our article.

*Heitengi Zukai* (HZ) is an introductory account of astronomy by Iwahashi Zenbei published as a woodprint edition in 1802. Iwahashi had studied Confucianism under Minagawa Kien at Kyoto, and hence the latter offered the introduction to the former's account. This account consists of explanations of various topics in astronomy and meteorology, with figures of observations of astronomical bodies and phenomena. In particular, this account aims at explaining how to use the *heitengi* (平天儀), a kind of star chart connecting disks of the Earth, the Moon, the Sun, and constellations of 28 lunar mansions, with basic knowledge of astronomy and observational records of the Sun, the Moon, or planets with the telescopes he invented. At the time of writing, we have at least 38 known copies with an exact location in various archives in Japan and Germany, according to the Union Catalogue of Early Japanese Books. We used a woodprint copy stored in the NIJL in our article.

## 3. Results and Discussions

### 3.1. Sunspot Observations

As documented in the previous section, we examined three contemporary sunspot records in BK, KJ, and HZ. BK and KJ have sunspot drawings (BK-N, f.3b; BK-T, f.3b; BK-J, f.4b; KJ, v.1 f.4a) named *nisshinsho* (日眞象), as shown in Figures 1 and 2. HZ has a sunspot drawing (f.35a) named *taiyouzu* (太陽圖), as shown in Figure 3. Here, we show their abbreviations, references, transcriptions, and translations below.

A: BK-N, f.1a, BK-T, f.1a, BK-J, f.1b
Transcription:[2]
觀曰，四邊有気如毛，気皆左旋，日面有黒點五，大小不一，善兵衛言，黒点歴十餘日，
徑日面，若冬春之際，則黒點最多，又或見梵字形者，其色亦[2]眞黒，不能辮其何物
Translation:
Observations state that there are vapors similar to hair around the disk. All vapors rotate leftward. On the surface of the Sun, there are five black spots. Their sizes are different from one another. Zenbei states that these black spots go around across the solar disk, spending more than ten days. The black spots move across the solar surface. In winter and until spring, the number of black spots is largest. We observe a sunspot whose shape resembled that of a Sanskrit character. The color of it is also deep black, and we are not able to know what it is.

B: KJ, v.1, f.1b
Transcription:
日面黒點五つ有り．大小一ならず．善兵衛言う．黒點十餘日を歴ると．日面に亘る．冬・春の間ハ，則ち黒點最多しと．又或ハ蚯蚓のごとく梵字のごとく形もつものあり．其色純黒ふて，それ何ものといふこと無し．

[2]BK-J (f.1b) reads “赤 (red)” instead of “亦 (also)”, although it seems a miscopying considering the context. The copyist of BK-J frequently miscopies this character in other places as well (*e.g.* BK-J, f.2a).

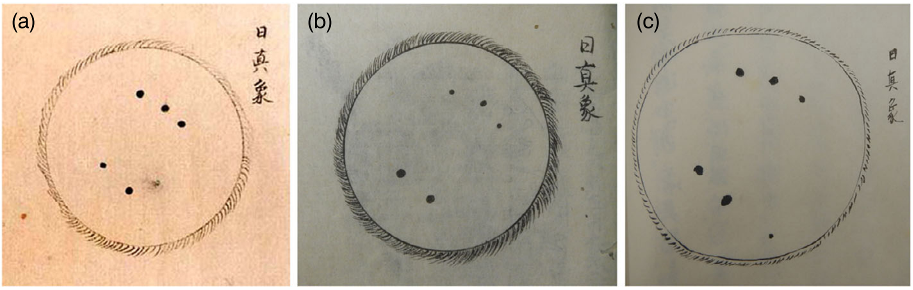


**Figure 1** Sunspot drawing in variants of BK; (**a**) a variant in BK-N (courtesy: the National Astronomical Observatory of Japan); (**b**) a variant in BK-T (courtesy: Tsu City Library); and (**c**) a variant in BK-J (courtesy: the International Research Center for Japanese Studies).

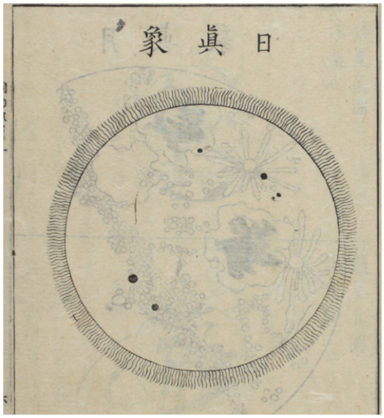


**Figure 2** Sunspot drawing in KJ (courtesy: NIJL).

Translation:
There are five black spots on the surface of the Sun. Their sizes are different from one another. Zenbei states that these black spots go around for more than ten days across the solar surface. In winter and until spring, the number of sunspots is largest. We have black spots whose shape is similar to that of an earthworm or a Sanskrit character. The color of it is deep black, and we cannot say what it is.

C: HZ, f.35a
Transcription:
又図の如く日輪の中に黒きもの出る事あり形龍のごとく或ハ虫の如く大小数定りなし出る時は東の方より方より出て凡そ日数十四・五日計り有之西の方ニ終る
Translation:
In addition, as shown in the figure, sometimes there appear black objects on the solar disk. They resemble a dragon or a worm in terms of their shape. They are different in size. When they appear, they appear from the east side and end to the west side over ∼14 – 15 days.

## 3.2. Their Observational Dates and Sunspot Number

In Figures 1–3, we can easily distinguish the figure in HZ from those in BK and KJ. BK clearly dates its observation on Kansei as fifth year, seventh month, and twentieth day. Ac-

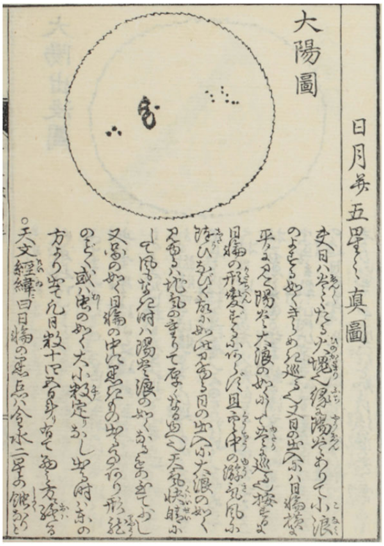


**Figure 3** Sunspot drawing in HZ (courtesy: NIJL).

cording to the conversion table by Uchida (1992), we convert this date in the Japanese lunisolar calendar into 26 August 1793 in the Gregorian calendar. In this observation, BK reports "five black spots" on "the solar surface" (BK-J: f.1a; BK-T: f.1a; BK-N: f.1b). We find the relevant text in KJ mostly a Japanese translation of BK with some minor changes. The sunspot locations are generally identical in the sunspot drawings of KJ and variants of BK, except for BK-N (a copy by Agawa Biren): three dots in the upper right of the disk, and two dots in its lower left. The sizes of sunspots found here are different from one another, as documented in the relevant text. Note that nevertheless, the sizes are differently depicted even within the variants of BK. Thus, we consider that these dots for a sunspot only represent the sunspot locations.

We can therefore locate these sunspot drawings in BK and KJ on 26 August 1793 fairly well in the sky watching at Tachibana Nankei's personal residence (Kobayashi, 2009). Takayama Hikokurou (高山彦九郎, 1747 – 1793) visited his residence near "the mansion of the lord of Satsuma (薩摩屋敷: N34°56′17″, E135°45′30″)", going southward from "Kujoumura Takeda (久条村竹田)" on 19 May 1791 (THN, v.4, p. 99). We also found his address as "Bungo Toyohashi-suji Tachiuri-cho (豊後豊橋筋立売町: N34°55′53″, E135°46′07″)" in the register of Iwahashi Zenbei in February 1798 (SNH, f.26a). While we cannot identify his residence in 1793, we can locate his residence and hence the observational site in the middle of Fushimi fairly well.

While the two sunspot drawings in BK and KJ are nearly identical with one another and their own descriptions, the sunspot drawing in HZ is different in its sunspot distribution. HZ does not clarify the observational date. We find nine small sunspots on the right side of the solar disk, three medium sunspots on the left side of the solar disk, and a large and complex sunspot close to the disk center. The largest spot might be identical with a sunspot like "a dragon or a worm." The number of sunspot groups is also different from five, that was reported in the former two accounts, and hence the observational drawing is considered to have been made on a different day. BK and KJ cited Iwahashi Zenbei's explanation that they have seen a sunspot that resembles "a Sanskrit character" (both in BK and KJ), or "an earthworm" (only in KJ), and hence these sunspots with strange structure are considered to have been observed before the sky watching. Especially the latter seems to correspond to another report with a similar expression to compare sunspot with "a dragon or worm" found in HZ, while we need to expect exaggeration to some extent for its size and shape. Therefore, we can regard the sunspot drawing in HZ as a drawing made before the observation on 26 August 1793. Iwahashi Zenbei lived at Kaidzuka in Izumi (BK-J: f.1a; BK-T: f.1a; BK-N: f.1a; Kobayashi, 2009), and hence we can identify his daily observational site as around his residence (N34°27′, E135°21′), except for the location for the sky-watching event on 26 August 1793.

We therefore regard the descriptions in BK and KJ as identical with their sunspot drawings in these documents, but we cannot date the sunspot drawing in HZ because we lack explicit dating. This fact attests that Iwahashi Zenbei had observed the solar surface for a considerable period. At least, he correctly understood that it takes 14 – 15 days for sunspots (black spots) to move from east to west on the solar disk. In the observational period, no source documents mention explicitly the number of years that he made the observations. Therefore, it is difficult to determine whether Iwahashi Zenbei mentioned this trend as a general law of sunspot activity that he deduced from his observational experience for multiple years or simply as a fact that he saw more sunspots in the previous winter and spring. Grammatically, it is likely that Iwahashi Zenbei regarded this as a general law, as KJ in classic Japanese uses present tense to describe the sunspot rotation period and the more frequent appearance of sunspots in winter and spring. When it was in the context of an explanation of his observational report, it is expected to see past tense here. Note that the observation took place in a declining phase of solar activity, as noted later, and it might also be possible to expect Iwahashi Zenbei to have witnessed many more sunspots in the preceding spring and winter than in 26 August 1793. At least, Japanese astronomers of later generations seemed to interpret this as "a general law." For example, Kunitomo Ikkansai, who observed sunspots in 1835 – 1836, owned a copy of KJ and is considered to have examined this "general law" by himself (Nakamura, 2003). A similar apparent tendency is found on Plate XXXI for the distribution of a "solar spotted area" during 1832 – 1868 that was compiled by De la Rue, Stewart, and Loewy (1870) as well. However, this tendency does not originate in the Sun, but it is possible to relate it to better atmospheric conditions for sunspot observations in winter, as discussed in Willis, Easterbrook, and Stephenson (1980), for example.

### 3.3. The Telescope in Use

In HZ, the telescope used by Iwahashi Zenbei can be seen. It was an octagonal reflecting telescope called *kitenkyo* (窺天鏡, Figure 4) by Iwahashi Zenbei (HZ: f.34b). It was recorded that its perimeter was 25 cm and its length was 2.5 m (BK: f.1a; Kobayashi, 2009), and hence its diameter was considered to be approximately 8 cm. Iwahashi Zenbei was originally a craftsman who specialized in glasses, but he applied his knowledge and technique on the imitation of telescopes that were newly brought in from the Netherlands. He used an objective lens, erecting lens, and eyepiece lens in his telescope, and supported them with frames made of wood or paper, and fixed them using brass fittings (Date, 1933; Arisaka, 1952; Kobayashi, 2009). His telescopes became standard in contemporary Japan, and hence were used by feudal lords such as those in Kii, Hikone, and Akashi, and scholars in urban areas such as Edo, Osaka, or Kyoto. In addition, Inou Tadataka (伊能忠敬) used his telescope to make the earliest measured map of Japan (Watanabe, 1987). While Iwahashi Zenbei himself did not clarify how he filtered the sunlight during solar observations, we might estimate the usage of *zongurasu*; a kind of filtering glass originally known as *zonglas* that was imported from the Netherlands in the middle of the eighteenth century (*Tokugawa Jikki*, v.9, p. 294; Vos, 2014; Zuidelvaart, 2007).

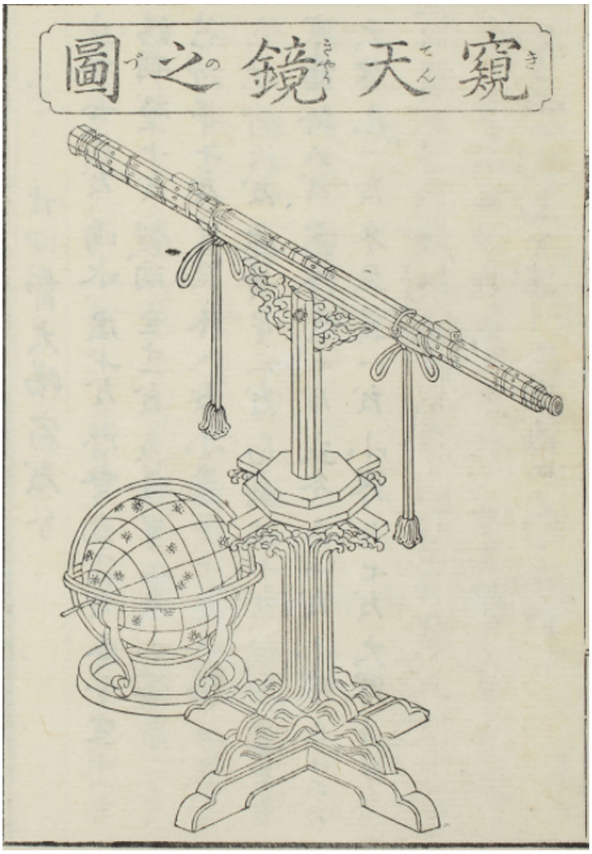


**Figure 4** *Kitenkyo* (窺天鏡) used by Iwahashi Zenbei (HZ: f.34b; courtesy: NIJL).

### 3.4. Data Context

Figures 1 and 2 show the sunspot drawings dated 26 August 1793. Figures 5a, 5b, and 5c show the annual sunspot number, the monthly sunspot number spanning from 1790 to 1799, as reported by Clette *et al.* (2014), and the raw group count reported in Vaquero *et al.* (2016) in comparison with this study. Table 1 shows the data context of Iwahashi Zenbei's sunspot drawing in comparison with the daily raw group count shown in Vaquero *et al.* (2016). As shown in Figures 5a and 5b, this observation is situated in the declining phase of solar activity from the nearest maximum in 1787 to the Dalton Minimum (Usoskin, 2013; Clette *et al.*, 2014).

Nevertheless, as shown in Table 1 and Figure 5c, there are only 18 previously known sunspot observations in 1793. We have observations by Bode at Berlin, Schröter at Lilienthal, Huber at Basel, Staudach at Nuremberg, and Hahn at Basel in this period (*e.g.* Arlt, 2008; Vaquero *et al.*, 2016; Svalgaard, 2017). This scarcity of raw observational data calls for the discussions on the "lost cycle" just before the Dalton Minimum (*e.g.*, Usoskin *et al.*, 2009; Zolotova and Ponyavin, 2011). On the one hand, Usoskin *et al.* (2009) reconstructed a butterfly diagram in the 1790s to claim that the occurrence of a high solar latitude in 1793 – 1796 shows the start of "the lost cycle" in 1793. On the other hand, Zolotova and Ponyavin (2011) analyzed a latitude-time diagram in 1784 – 1798 to claim that the local minimum in 1793 and "the lost cycle" were only a gap between impulses of so-

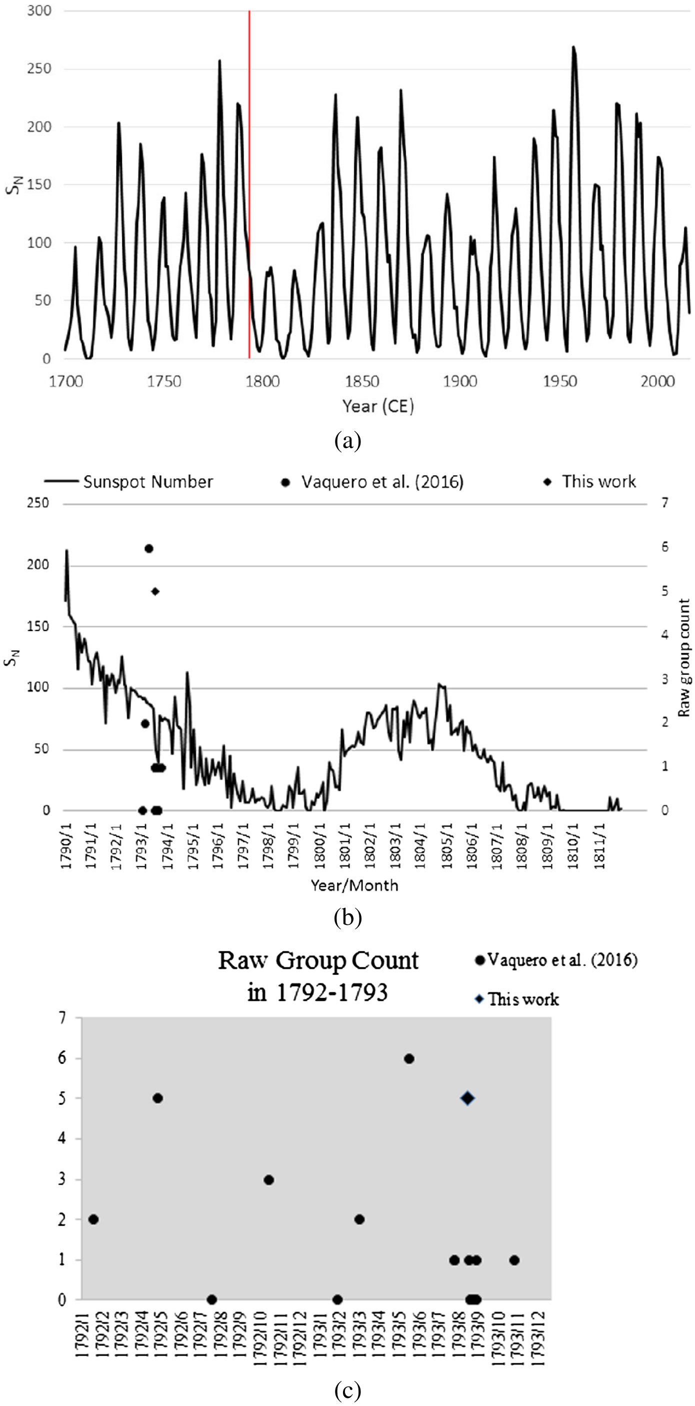


**Figure 5** (**a**) Data context of Iwahashi Zenbei's sunspot drawing in the yearly $S_N$ reported by Clette *et al.* (2014). (**b**) Data context of Iwahashi Zenbei's sunspot drawing in the monthly $S_N$ reported by Clette *et al.* (2014). (**c**) Raw group count during 1792 – 1793 with Iwahashi Zenbei's observation in comparison with those in Vaquero *et al.* (2016).

**Table 1** Data context of Iwahashi Zenbei's sunspot drawing in the raw group count reported by Vaquero *et al.* (2016).

| Year | Month | Date | raw group count | Observer | Observational Site | Reference |
|---|---|---|---|---|---|---|
| 1793 | 2 | 4 | 0 | Hahn | Berlin | Vaquero *et al.* (2016) |
| 1793 | 3 | 9 | 2 | Staudach | Nuremberg | Vaquero *et al.* (2016) |
| 1793 | 5 | 28 | 6 | Huber | Basel | Vaquero *et al.* (2016) |
| 1793 | 8 | 5 | 1 | Staudach | Nuremberg | Vaquero *et al.* (2016) |
| 1793 | 8 | 6 | 1 | Staudach | Nuremberg | Vaquero *et al.* (2016) |
| 1793 | 8 | 26 | 5 | Iwahashi Zenbei | Fushimi | This Work |
| 1793 | 8 | 29 | 1 | Schröter | Lilienthal | Vaquero *et al.* (2016) |
| 1793 | 8 | 30 | 0 | Schröter | Lilienthal | Vaquero *et al.* (2016) |
| 1793 | 8 | 31 | 0 | Schröter | Lilienthal | Vaquero *et al.* (2016) |
| 1793 | 9 | 1 | 0 | Schröter | Lilienthal | Vaquero *et al.* (2016) |
| 1793 | 9 | 2 | 0 | Schröter | Lilienthal | Vaquero *et al.* (2016) |
| 1793 | 9 | 3 | 0 | Schröter | Lilienthal | Vaquero *et al.* (2016) |
| 1793 | 9 | 4 | 0 | Bode | Berlin | Vaquero *et al.* (2016) |
| 1793 | 9 | 4 | 0 | Schröter | Lilienthal | Vaquero *et al.* (2016) |
| 1793 | 9 | 4 | 0 | Staudach | Nuremberg | Vaquero *et al.* (2016) |
| 1793 | 9 | 5 | 0 | Bode | Berlin | Vaquero *et al.* (2016) |
| 1793 | 9 | 5 | 1 | Schröter | Lilienthal | Vaquero *et al.* (2016) |
| 1793 | 9 | 5 | 0 | Staudach | Nuremberg | Vaquero *et al.* (2016) |
| 1793 | 11 | 3 | 1 | Staudach | Nuremberg | Vaquero *et al.* (2016) |

lar activity, possibly caused by the lack of data. Note that this "lost cycle" has been discussed for contemporary cosmogenic radioisotope data as well (*e.g.* Karoff *et al.*, 2015; Owens *et al.*, 2015).

The sunspot drawing on 26 August 1793 is also valuable because it was recorded near the minimum candidate year 1793. From the point of view of the $S_N$, this drawing supports the view of Vaquero *et al.* (2016), who confirmed a relatively high number of sunspot groups. Nevertheless, this sunspot drawing is unfortunately too isolated, as is shown in Table 1, and hence we cannot estimate the heliographic latitudes of the sunspots that are shown in this drawing. As far as we know, Iwahashi Zenbei left only one more drawing without an explicit date (Figure 3). Other sunspot observations are not close enough to help estimating the sunspot latitudes except for those by Schröter from 29 August 1793 (*e.g.* Vaquero *et al.*, 2016). However, Schröter (S1794, p. 265) himself provided only a short description of these sunspot observations as follows: "Not having for several days before, and likewise on the very day of the eclipse, noticed any spots on the disk of the sun, three small ones only excepted, which were perceived on 29 August". Considering that we do not have further descriptions or drawings, we cannot analyze the latitude of the sunspots in this drawing on 26 August 1793 at the present stage. However, as attested by this sunspot drawing itself, we may have further unexamined sunspot drawings in the context of reconstructing the $S_N$. Therefore, further surveys on sunspot records and drawings around this date in comparison with contemporary data of cosmogenic radioisotopes (*e.g.* Karoff *et al.*, 2015; Owens *et al.*, 2015) may let us examine the distribution of sunspot latitudes to contribute to our understanding in the discussion about "the lost cycle" around 1793. In this way, this drawing can contribute to the reconstruction of sunspot activity immediately before one of the grand minima.

## 4. Conclusion

In this article, we have shown two sunspot drawings by Iwahashi Zenbei and his companions. We have established the date of one of them to be 26 August 1793, but we were unable to find an explicit date for the other. Although we do not have any further sunspot drawings by Iwahashi Zenbei, his sunspot observation can contribute to fill the poorly documented sunspot records in 1793; this is also located near the Dalton Minimum. This article also demonstrates a further possibility of finding unexamined sunspot drawings in non-European countries before the middle of the nineteenth century.

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**Disclosure of Potential Conflicts of Interest** The authors declare that they have no conflicts of interest.

## Appendix 1: References to Historical Documents

BK-J: Tachibana Nankei (橘南谿), *Bouenkyo Kanshoyoki* (望遠鏡観諸曜記), MS 463 in the Library of the International Research Center for Japanese Studies [a manuscript in Japanese].

BK-N: Tachibana Nankei (橘南谿), *Bouenkyo Kanshoyoki* (望遠鏡観諸曜記), MS MB-51-Ta in the Library of the National Astronomical Observatory of Japan [a manuscript in Japanese].

BK-T: Tachibana Nankei (橘南谿), *Bouenkyo Kanshoyoki* (望遠鏡観諸曜記), MS Inada 44-210 in the Tsu City Library [a manuscript in Japanese].

KJ: Ban Koukei (伴蒿蹊), *Kanden Jihitsu* (閑田次筆), MS MY1491-2 in the National Institute for Japanese Literature [a woodprint in Japanese].

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