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## Research

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## Evolutionary biology

## Violence in the prehistoric period of Japan: the spatio-temporal pattern of skeletal evidence for violence in the Jomon period

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Whether man is predisposed to lethal violence, ranging from homicide to warfare, and how that may have impacted human evolution, are among the most controversial topics of debate on human evolution. Although recent studies on the evolution of warfare have been based on various archaeological and ethnographic data, they have reported mixed results: it is unclear whether or not warfare among prehistoric hunter-gatherers was common enough to be a component of human nature and a selective pressure for the evolution of human behaviour. This paper reports the mortality attributable to violence, and the spatio-temporal pattern of violence thus shown among ancient hunter-gatherers using skeletal evidence in prehistoric Japan (the Jomon period: 13 000 cal BC–800 cal BC). Our results suggest that the mortality due to violence was low and spatio-temporally highly restricted in the Jomon period, which implies that violence including warfare in prehistoric Japan was not common.

## 1. Introduction

The origin of lethal violence, particularly warfare (i.e. 'coalitionary aggression against other groups' [1]), has been a subject of intense discussion in biological and social sciences, as well as the humanities. Since Hobbes [2] in 1651, it has been argued that warfare is inherent in human nature [3–6]. Furthermore, recent theoretical and empirical studies have suggested that warfare was an important selective pressure for the evolution of human social behaviours [7,8].

These ideas are based on ethnographic and archaeological evidence, suggesting that warfare is common among hunter-gatherer societies [5–7]. For example, by estimating the mortality due to war from the fraction of injured individuals in various archaeological sites and ethnographic records, Pinker [5] argued that war was common in prehistory but the emergence of states has significantly reduced violence. Most recently, some skeletal findings at Lake Turkana in Kenya [9] and Schöneck-Kilianstädten in Germany [10] show a relatively high mortality due to violence, which might further support the above claim. Likewise, Bowles [7] used similar datasets, suggesting that the level of intergroup aggression was sufficiently high as a selective pressure for intragroup cooperation (altruism).

However, these arguments have been challenged. It has been suggested that war is not prevalent in hunter-gatherer societies, based on data from the standard cross-cultural sample [1]. Similarly, Ferguson [11,12] pointed out that archaeological evidence presented by Pinker [5] is biased, and also argued

**Table 1.** Estimates of the rate of mortality attributable to violence over the Jomon period as the percentage of injured individuals (ID) among (i) the total population, (ii) adults only and (iii) adults only for sites with skeletal remains of 10 or more individuals.

phase	total	adults	ID	adults <sup>a</sup>	ID <sup>a</sup>	rate of mortality attributable to violence		
						ID/total (%)	ID/adults (%)	ID <sup>a</sup> /adults <sup>a</sup> (%)
Initial	91	31	0	17	0	0	0	0
Early	244	129	1	110	1	0.41	0.78	0.91
Middle	371	172	5	87	3	1.35	2.9	3.45
Late	944	472	7	400	6	0.74	1.48	1.5
Final	932	471	10	430	9	1.07	2.12	2.09
total	2582	1275	23	1044	19	0.89	1.8	1.82

<sup>a</sup>Excluding data for sites with skeletal remains of fewer than 10 individuals.

that the actual prehistoric evidence does not support the idea that warfare was common in prehistoric populations.

The aim of this paper is to examine whether or not warfare was common among hunter–gatherers in prehistory based on archaeological data on violence in Japan [5,7,13]. In the following, we use the term ‘violence’ rather than ‘warfare’ because we cannot readily distinguish injuries as due to warfare versus homicide for skeletal remains owing to the nature of archaeological data. But if evidence for the overall level of violence is low, this would indirectly show that warfare could not have been prevalent in the case of Japan. We could thus conclude that warfare was not universally common among ancestral hunter–gatherers, and the above ideas that warfare is part of human nature and was an important selective pressure are also challenged. To this end, we focus on the Jomon period, a Japanese prehistoric period of hunter–gatherers. The Japanese data are suitable to test the above hypothesis because (i) the Jomon subsistence strategy was basically hunting-and-gathering and (ii) administrative excavations have accumulated rich data across the Japanese archipelago extending over a long period of time. Japanese archaeologists have traditionally argued that warfare was rare in the Jomon period [14–17], although a systematic analysis throughout the period has not been conducted so far.

In what follows, following previous studies [5,7,13], we calculate mortality due to injury caused by violence as indirect evidence of warfare in the Jomon period. Further, based on the spatio-temporal pattern of mortality at sites where injured individuals were discovered, we argue that warfare was probably not common among hunter–gatherers of the Jomon period.

## 2. Material and methods

We collected data on mortality due to violence from published exhaustive lists of skeletal remains of the Jomon period [18,19]. The Jomon period is defined as the time when the Japanese archipelago was inhabited by hunter–gatherers who used pottery and is subdivided into six phases: Incipient (13 000–10 000 cal BC), Initial (10 000–5000 cal BC), Early (5000–3500 cal BC), Middle (3500–2400 cal BC), Late (2400–1250 cal BC) and Final (1250–800 cal BC). The Incipient phase was omitted from our analysis owing to lack of skeletal remains. Our dataset contains the presence or absence of injury, sex, age (adult/child), site and period for each individual. See the electronic supplementary material for more details and the definition of injured individuals in the data.

As a measure of mortality attributable to violence, we calculated for each phase the percentage of injured individuals (i) among the total population including children and individuals whose sexes and ages are unknown, (ii) among adults and (iii) among adults after excluding sites where the number of individuals is less than 10, following Bowles [7]. The average mortality values calculated for each phase and across the entire Jomon period are shown in table 1.

In addition, we plotted the spatio-temporal pattern of sites with injured individuals discovered on a map of Japan and attempted to identify ‘hot spots’ of violence: if there was a large-scale violence in which multiple groups were involved, then a region should be observed where sites with injured individuals are spatially and temporally clustered.

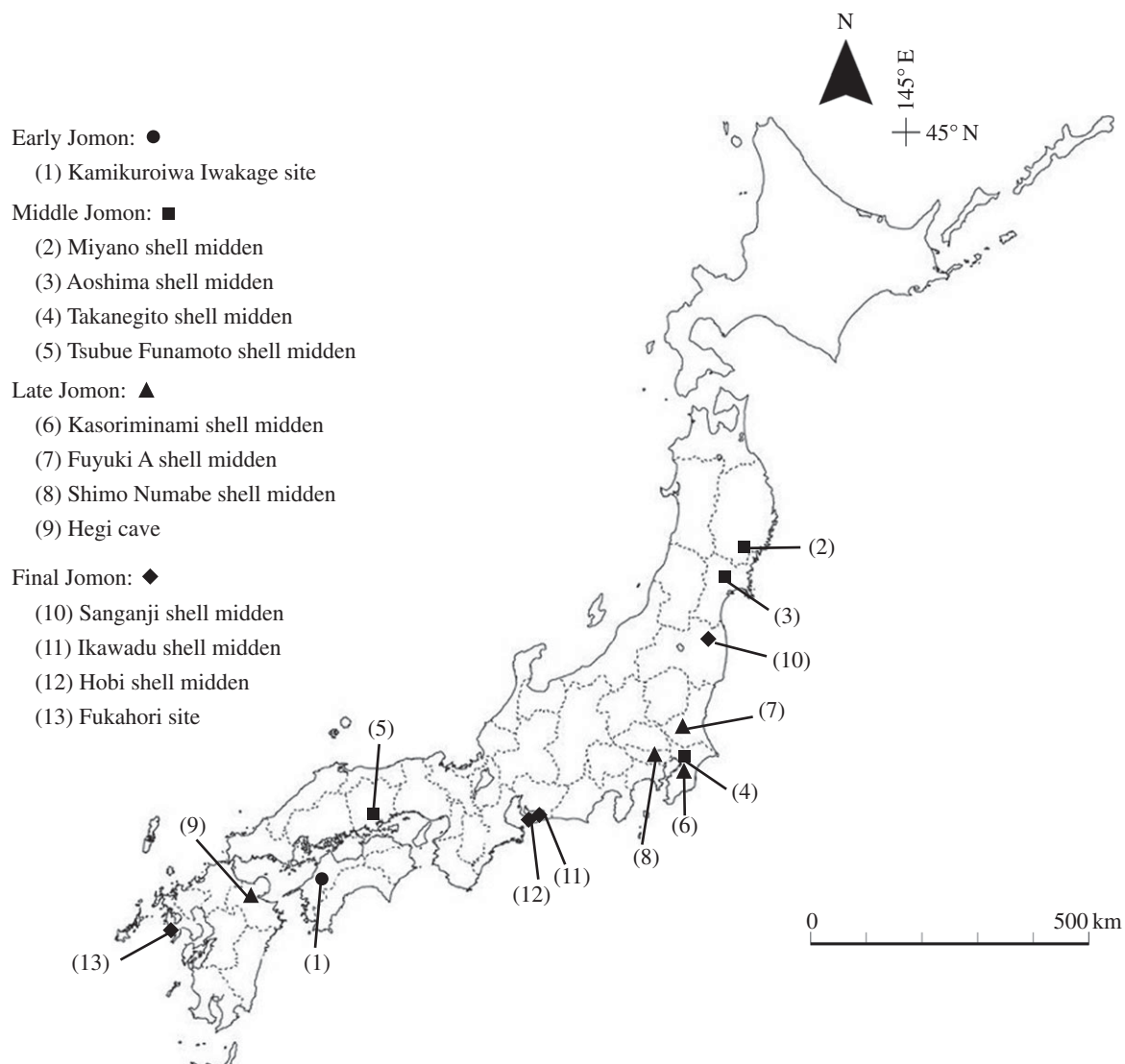
## 3. Results

Table 1 shows the rates of mortality attributable to violence in the Jomon period (a mainly hunter–gatherer era) calculated as a percentage of injured individuals among (i) the total population, (ii) adults only, and (iii) adults only at sites with skeletal evidence for 10 or more individuals. Because we found no qualitative difference between the results of these methods of assessing mortality from violence, we hereafter use the values obtained by the third way, which tended to yield the most liberal estimates of the level of violence mortality. Nevertheless, the average violence mortality value across the entire Jomon period was found to be just 1.82%, much lower than those from previous studies (12–14%) [5,7,13]. Moreover, the mortality from violence for each phase of the Jomon period was less than 4% in our study.

Next, figure 1 shows the spatio-temporal pattern of the sites where injured individuals were discovered. As the sites are both widely and sparsely distributed, we found no ‘hot spots’ of violence. Actually, the spatio-temporal pattern of the sites is very sparse throughout the entire period: only a few sites with injured individuals (i.e. Miyano and Aoshima shell middens in the Middle, Kasori Minami, Shimo Numabe and Fuyuki A shell middens in the Late, and Ikawazu and Hobi shell middens in the Final phase) are spatio-temporally close.

## 4. Discussion and conclusion

In this study, we analysed archaeological data from Japan to examine whether or not warfare was common among ancestral hunter–gatherers. Our results suggest that violence and thus



**Figure 1.** Spatio-temporal pattern of the sites where injured bones from the Jomon period were discovered.

warfare were not common in prehistoric Japan: the values of mortality attributable to violence both over the entire Jomon period (1.82%) and in each phase (0–3.45%) are much lower than the ones in previous studies (12–14%) [5,7,13]. Mortality attributable to warfare could not have exceeded these rates, and indeed should be lower because some injuries were likely due to homicide or accident rather than warfare. In addition, we have found no injured individuals in the Initial Jomon period (and perhaps also in the Early phase, see the electronic supplementary material), lasting for 5000 years or more, though non-injured individuals were discovered for the period. Some scholars have claimed that warfare ‘is found throughout prehistory’ ([6], p. 191) and that warfare was sufficiently common among hunter–gatherer populations to have affected social evolution by promoting intragroup altruism [7]. Despite the uncertainties about whether measures of mortality taken from archaeological data are representative [7], it is likely that our results pose a counterexample to these claims and are further inconsistent with arguments that warfare is inherent in human nature and was an important selective pressure [2–8].

The spatio-temporal pattern of sites with injured individuals indicates that the scale of violence in the Jomon period was not large. We observed no ‘hotspots’ of violence. This result is rather consistent with the traditional archaeological

view that warfare was not common and not conducted on a large scale in the Jomon period [14–17].

Previous studies have reported considerable variation in mortality due to warfare across archaeological sites and hunter–gatherer populations [5,7]. Our dataset, however, shows that the mortality values in most sites are equal, or nearly equal to zero (see electronic supplementary material, table S1). This result is consistent with Fry & Söderberg’s [1] results that nearly half of the societies they investigated had no lethal interaction among multiple individuals.

Anthropologists have claimed that sedentism could increase warfare [20]. It has been reported that sedentary settlements increased in the Early and Middle phases of the Jomon period [21]. We found an increase in the violence mortality in those phases; hence our results are consistent with the hypothesis. However, sedentary settlements in the Jomon period have been found unstable [22]. Considering this uncertainty regarding the Jomon settlement system and the sparseness of archaeological data, further investigations are required.

Several mathematical models have been proposed to investigate the effects of intergroup violence on the evolution of human social behaviours (e.g. [8]). Our dataset suggests that skeletal evidence for warfare is spatially and temporally restricted. A possible direction of further theoretical investigation is to examine whether levels of intergroup violence sufficient

to affect social evolution would produce patterns similar to or different from those we observed under various assumptions about bone preservation. Investigating the relative importance of additional factors, including demography or environmental fluctuation, may be another direction of research.

Note that we are not asserting warfare was uncommon among hunter–gatherers in *all* areas and times. Indeed, several archaeological sites and ethnographic records show high mortality due to violence [9,10]. However, as Ferguson [12] points out, it is possibly misleading to treat a few cases of massacre as representative of our hunter–gatherer past without an exhaustive survey. We think warfare depends on specific conditions, and the Japanese data indicate that we should examine these more closely [10]. In fact, a limitation of the present study is that we have not considered factors that might promote warfare, owing to data availability.

More close statistical investigations on warfare and its possible determinants warrant further research.

**Data accessibility.** The data are available in the electronic supplementary material and at Dryad doi:10.5061/dryad.60d18.

**Authors' contributions.** H.N. designed the study, and H.N. and T.N. collected the data. All authors interpreted the data and wrote the paper. All authors approved the final version for publication and accept accountability for all aspects of the work.

**Competing interests.** We have no competing interests.

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## Correction

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<http://dx.doi.org/10.1098/rsbl.2016.0847>

# Correction to: 'Violence in the prehistoric period of Japan: the spatio-temporal pattern of skeletal evidence for violence in the Jomon period'

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After publication of our article, we found that Kamikuroiwa Iwakage site was wrongly categorized to the Early Jomon phase and counted doubly in the electronic supplementary material; however, the site should belong to the Initial phase. Also, the number of individuals at some sites were slightly wrong. We have therefore modified figure 1, table 1 and the electronic supplementary material (see also Dryad: <http://dx.doi.org/10.5061/dryad.60d18>). Following these modifications, some parts of the main text in §3. Results and §4. Discussion and conclusion have also been corrected as follows (corrected expressions are emphasized in bold). Note that these corrections do not affect our main conclusion at all.

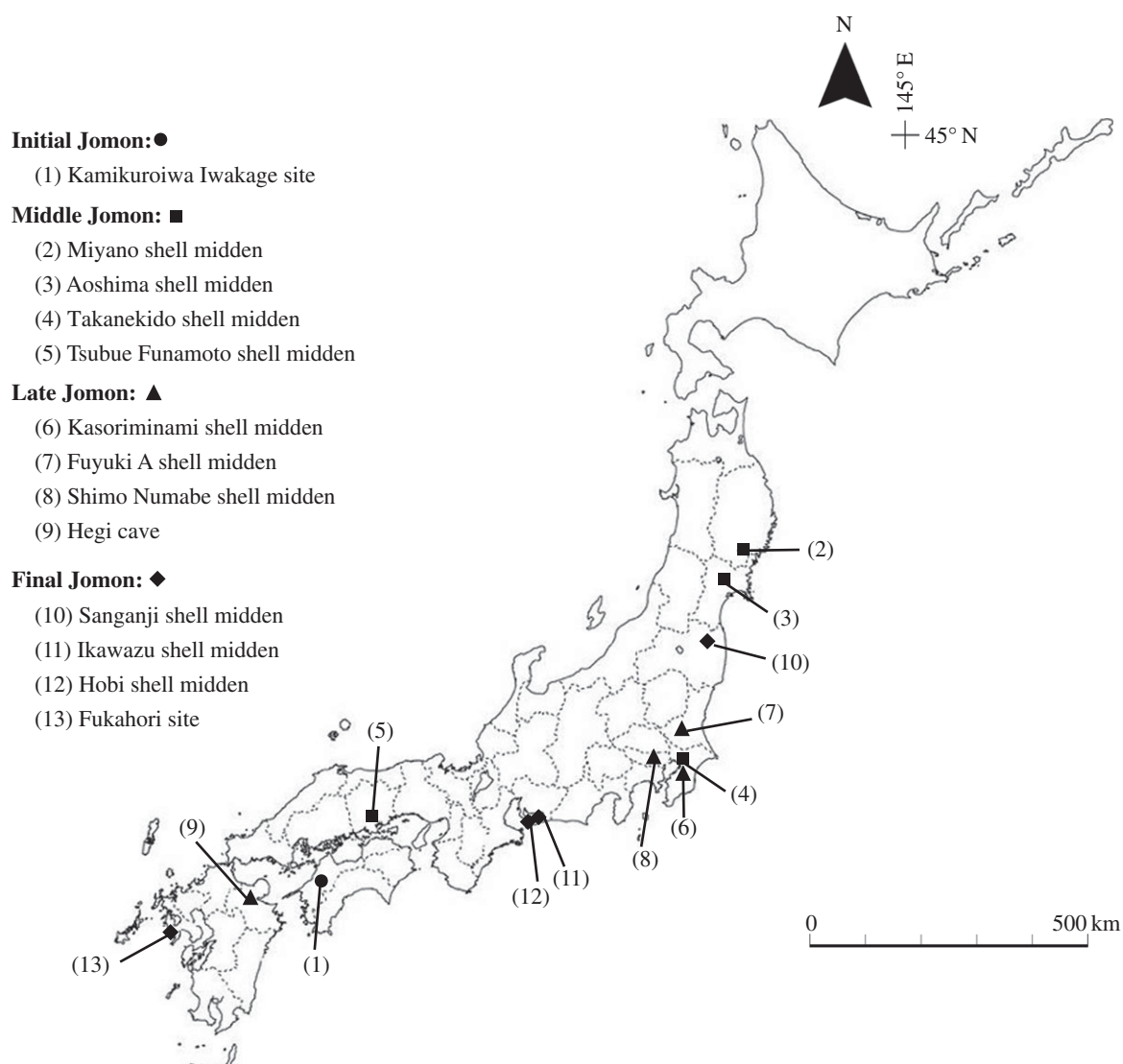
### 3. Results

... Nevertheless, the average violence mortality value across the entire Jomon period was found to be just **1.81%**, much lower than those from previous studies (12–14%) [5,7,13].

### 4. Discussion and conclusion

... the values of mortality attributable to violence both over the entire Jomon period (**1.81%**) and in each phase (0–**3.57%**) are much lower than the ones in previous studies (12–14%) [5,7,13]... In addition, we have found no injured individuals in the **Early** Jomon period (and perhaps also in the **Initial** phase, **lasting for 5000 years or more, see the electronic supplementary material**) though non-injured individuals were discovered for the period.

Electronic supplementary material is available online at <https://dx.doi.org/10.6084/m9.figshare.c.3579983>.



**Figure 1.** Spatio-temporal pattern of the sites where injured bones from the Jomon period were discovered.

**Table 1.** Estimates of the rate of mortality attributable to violence over the Jomon period as the percentage of injured individuals (ID) among (i) the total population, (ii) adults only and (iii) adults only for sites with skeletal remains of 10 or more individuals.

phase	total	adults	ID	adults <sup>a</sup>	ID <sup>a</sup>	rate of mortality attributable to warfare		
						ID/total (%)	ID/adults (%)	ID <sup>a</sup> /adults <sup>a</sup> (%)
initial	113	39	1	28	1	0.89	2.56	3.57
early	216	117	0	98	0	0.00	0.00	0.00
middle	371	172	5	97	3	1.35	2.91	3.09
late	944	470	7	398	6	0.74	1.49	1.51
final	932	471	10	430	9	1.07	2.12	2.09
total	2576	1269	23	1051	19	0.89	1.81	1.81

<sup>a</sup>Excluding data for sites with skeletal remains of fewer than 10 individuals.