International Journal of Paleopathology 38 (2022) 107–114

Contents lists available at ScienceDirect

International Journal of Paleopathology

journal homepage: www.elsevier.com/locate/ijpp

Case study

A sting in the tail: An embedded stingray spine in a mid-1st millennium AD adult male skeleton from Rebun Island, Hokkaido, Japan

Rick J. Schulting[a,*,1], Daisuke Kubo[b,2], Kiyonori Nishida[c], Izumi Braddick[a,3], Minoru Yoneda[d,4], Hirofumi Kato[e], Hajime Ishida[f,5]

[a] School of Archaeology, University of Oxford, 1 South Parks Rd, Oxford 0X1 3TG, United Kingdom
[b] Faculty of Medicine, Hokkaido University, Kita 15, Nishi 7, Kita-ku, Sapporo 060-8638, Japan
[c] Osaka Aquarium Kaiyukan, 1-1-10 Kaigandori, Minato-ku, Osaka 552-0022, Japan
[d] The University Museum, The University of Tokyo, Hongo 7-3-1, Bunkyo, Tokyo 113-0033, Japan
[e] Centre for Ainu & Indigenous Studies, Hokkaido University, Kita 8, Nishi 6, Kita-ku, Sapporo 060-0808, Japan
[f] Department of Human Biology and Anatomy, Graduate School of Medicine, University of the Ryukyus, Uehara 207, Nishihara, Okinawa 903-0215 Japan

ARTICLE INFO

Keywords:
Violence
Conflict
Okhotsk
Japanese prehistory

ABSTRACT

Objectives: We report here a stingray spine (Dasyatidae) found embedded in the femur of a male skeleton from the archaeological site of Uedomari-5, Rebun Island, Hokkaido, Japan.
Materials: A single well-preserved but incomplete human skeleton.
Methods: Macroscopic observation and low power magnification, CT imaging, radiocarbon dating and stable isotope (carbon, nitrogen) analysis.
Results: The stingray spine is tentatively identified as *Bathytoshia brevicaudata*. CT imaging shows no healing, indicating that death occurred shortly afterwards. The skeleton has been directly radiocarbon dated to the Okhotsk period (cal AD 429–827), with δ^{13}C (−13.7‰) and δ^{15}N (19.3‰) values indicating a diet focused on marine foods.
Conclusions: The absence of healing in what would have been a non-lethal injury strongly suggests that the spine tipped an arrowhead, rather than being the result of an accidental encounter with a living stingray. It is possible that the injury reflects a period of increased conflict coinciding with, or following on from, the expansion of the Okhotsk culture from Sakhalin into northern Hokkaido.
Significance: Uedomari-5 provides the first example, to our knowledge, of a stingray spine directly embedded in human bone at an archaeological site. More widely, the finding contributes to our knowledge of conflict in northern hunter-gatherer communities.
Limitations: Given the early excavation date (1949–50), there is little contextual information available for the burials.
Suggestions for further research: ZooMS (Zooarchaeology by Mass Spectrometry) may be able to identify the stingray species. Archival research may provide more information concerning the excavations at Uedomari-5.

1. Introduction

The use of stingray spines as spear and projectile armatures is widespread in the ethnographic and ethnohistorical literature, including accounts from Japan (Ishikawa, 1962; Ohnuki-Tierney, 1976), Southeast Asia (Gimlette, 1915), Australia (Roth, 1909), Melanesia (Haddon, 1890), the South Pacific (Bascom, 1965; Martin, 1991), and the Americas (Keegan and Carlson, 2008; Lothrop, 1937; Wilbert, 1972; Purdy, 1977). Uses include terrestrial hunting and fishing, as well as warfare, while in Mesoamerica stingray spines were used for ritual

* Corresponding author.
E-mail address: rick.schulting@arch.ox.ac.uk (R.J. Schulting).
[1] ORCID: 0000-0002-4444-766X.
[2] ORCID: 0000-0002-6100-8669.
[3] ORCID: 0000-0002-3234-4647.
[4] ORCID: 0000-0003-0129-8921.
[5] ORCID: 0000-0003-0129-8921

https://doi.org/10.1016/j.ijpp.2022.06.006
Received 18 December 2021; Received in revised form 18 June 2022; Accepted 24 June 2022

bloodletting (de Borhegyi, 1961). Archaeologically, the evidence is rather more ambiguous, since stingrays were also taken for food, and so their spines could become incorporated into midden deposits without necessarily having been utilised as implements. Nevertheless, on occasion both context and working of the spines provide clear evidence of their use, specifically as armatures in the latter case. The oldest known examples come from Niah Cave, Borneo, where stingray spines worked at their proximal ends, and with evidence for hafting, were recovered from levels radiocarbon dated to 8982–8645 cal BP (Barton et al., 2009). Importantly, in the context of this paper, examples of worked stingray spines are also known from prehistoric and early historic Hokkaido, northern Japan, including the sites of Hamanaka and Kafukai on Rebun Island (Kodama and Oba, 1952; Oba and Ohyi, 1976, 1981).

Even when archaeological examples of stingray spines can be accepted as having been used as armatures, this does not inform on how they were used; specifically, whether they were they used in hunting or in warfare. At the site of Na Galera (100 BC/AD 100) on Mallorca, Spain, for example, the skeleton of a young adult male was found with a complete stingray spine in the abdominal area (Argüello Menéndez, 2020: 145–147). As it was not embedded in bone, it is unknown whether this was the cause of death. A similar example comes from the pre-Columbian (ca. AD 1000) site of Maisabel, Puerto Rico, where a stingray spine was found lying parallel to the ribs in the mid-chest area of an adult male skeleton and interpreted as an armature causing the death of the individual (Budinoff, 1991: Fig. 1), though again the fact that the spine was not actually embedded in bone makes this tenuous. In this paper, we present a case of a stingray spine tip embedded in a human femur from the site of Uedomari-5, Rebun Island, Hokkaido, northern Japan (Fig. 1). The skeleton has been directly radiocarbon dated to the Okhotsk culture of the mid- to late first millennium AD.

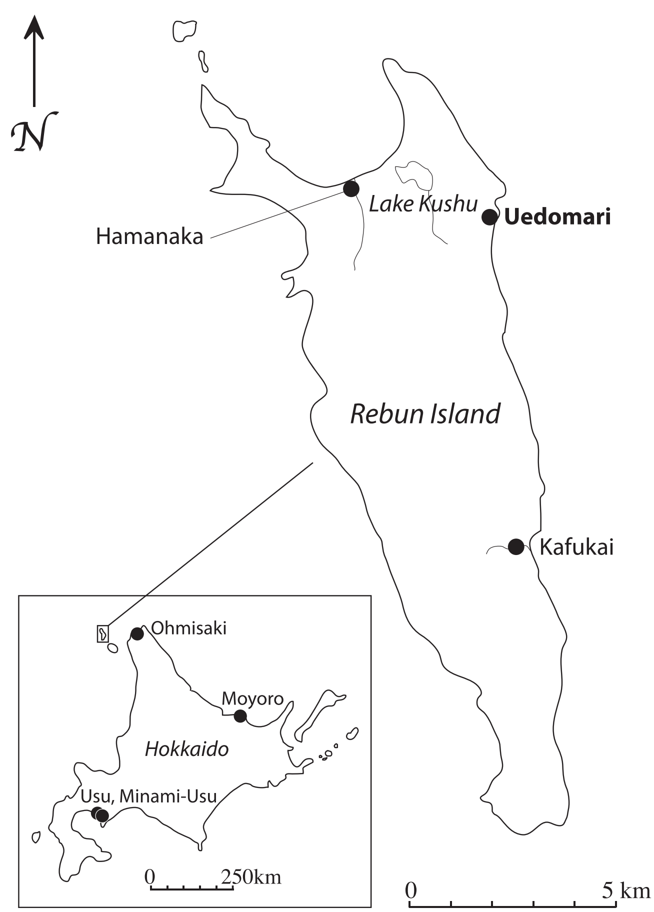

Fig. 1. Location of the Uedomari site, Rebun Island, and other sites mentioned in the text.

After considering other alternatives, we argue that it provides the earliest known direct evidence for the use of a stingray spine in interpersonal conflict. The wider sociocultural context is then considered.

2. Stingrays and stingray spines

Stingrays (order Myliobatiformes) are widely distributed worldwide, both in oceans and in large rivers. Various species of the Dasyatidae family of whiptailed stingrays frequent the waters of the Northwest Pacific Ocean, including those around Hokkaido (Schwartz, 2007). They generally inhabit near-shore waters, with adult wingspan ranging ca. 0.35–0.5 m. The caudal spine of the lower third of the tail is modified into from one to four barbed spines composed of vasodentine, each encased in an integumentary sheath covering two ventrolateral grooves that contain venom glands producing proteinaceous toxins, including phosphodiesterase, 5'-nucleotidase and serotonin (Cook et al., 2006; Haddad et al., 2016; Forrester, 2005). The spines are used for defence, the stingray arcing its body forward to deliver a powerful whip-like strike with its tail when threatened. Most injuries to humans today occur when the fish are inadvertently trodden upon in shallow waters, and so mainly affect the foot and lower leg (Clark et al., 2007; Haddad et al., 2013; Myatt et al., 2018; Russell, 1953; Russell et al., 1958; Smarrito et al., 2004; Srinivasan et al., 2013). The next most frequent injuries occur when fishermen remove stingrays from their nets, and are mainly to the hand and forearm, but may impact other parts of the body (Russell, 1953; Russell et al., 1958). Stingray injuries cause immediate and intense pain if the venom-containing integumentary sheath is intact, although this is sometimes lost in larger stingrays, and is easily damaged, e.g., when caught in nets (Russell et al., 1958). Deaths are very infrequent, and usually involve penetration of the heart or of the abdomen, or, when medical attention is not received, result from subsequent infection (Cook et al., 2006; Diaz, 2008; Fenner et al., 1989; Lippmann et al., 2011; O'Malley et al., 2015; Rathjen and Halstead, 1969; Russell, 1953; Russell et al., 1958).

3. The Uedomari site

Uedomari is located on the northeast coast of Rebun Island, Hokkaido, northern Japan. Professor Sakuzaemon Kodama of Hokkaido University excavated the site in 1949 and 1950. The published account focusses mainly on the pottery, with no mention of human remains (Oba, 1968). Nevertheless, the available records only refer to these excavations, hence Uedomari-5 and the other skeletal remains attributed to Uedomari in Hokkaido University's Faculty of Medicine were most likely recovered at this time.

3.1. *The Uedomari-5 skeleton*

While much of the postcranial skeleton of Uedomari-5 is present, the skull is represented by only a few small fragments (Fig. 2). The surviving right pubic bone together with the size and robusticity of the longbones strongly suggest that the individual is male (Buikstra and Ubelaker, 1994). A relatively precise age-at-death of 18–20 years can be determined by longbone fusion. The mean maximum length of the two femora is 43.8 cm, and that of the tibiae (including the medial malleolus) is 35.5 cm. Using the regression formulae for native northern North Americans (Auerbach and Ruff, 2010), the stature of Uedomari-5 is estimated as 160.5 $\pm$ 2.7 cm, within one standard deviation of mean stature for Okhotsk males (Kudaka et al., 2013).

3.2. *Radiocarbon dating and the cultural affiliation of Uedomari-5*

Radiocarbon dating and stable carbon (δ^{13}C) and nitrogen (δ^{15}N) isotope measurements, using AMS and EA-IRMS, respectively, were undertaken at The University Museum, University of Tokyo. The extracted gelatin meets the quality control criteria for well-preserved

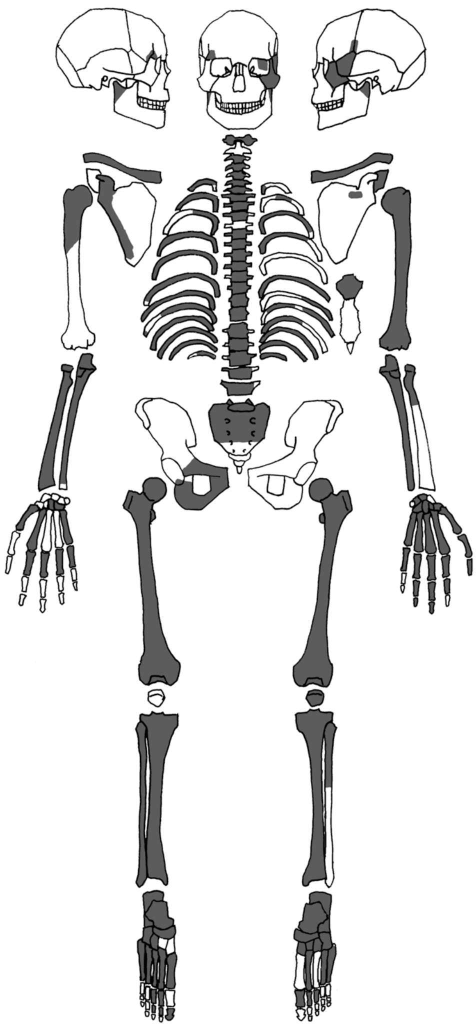

Fig. 2. Uedomari-5 showing skeletal elements present.

collagen, based on collagen yield, %C, %N and C/N ratio (Table 1) (DeNiro, 1985), with δ^{13}C and δ^{15}N values of – 13.7‰ and 19.3‰, respectively, suggesting a near-total (95 ± 5%) reliance on high-trophic-level marine protein.

This high consumption of marine resources complicates the calibration of the radiocarbon date of 2172 ± 28 BP (TKA-18612). Two different ΔR values are possible for this area (Table 1, Fig. 3). That of 30 ± 58 ^{14}C years is based on the difference between dates on marine shell (3518 ± 39 BP) and charcoal (3008 ± 25 BP) from Hamanaka II on Rebun Island (Miyata et al., 2016; re-calculated using *deltar* (Reimer and Reimer, 2017)). This gives Uedomari-5's age as cal AD 172–563 (95.4% confidence), encompassing the Epi-Jomon and spanning the Early Okhotsk period. Applying a larger ΔR offset of 304 ± 70 ^{14}C years, estimated from foodcrust on Jomon pottery from Hamanaka II (3794 ± 25 BP; Miyata et al., 2016), shifts the age to cal AD 429–827 (95.4%), spanning the Early to Late Okhotsk (Junno et al., 2020). This latter estimate is preferred, since the high δ^{13}C and δ^{15}N results from Uedomari-5 are more consistent with the Okhotsk period as seen elsewhere in northern Hokkaido, with diets more heavily based on marine mammals than were those of the preceding Jomon (Tsutaya et al., 2014).

4. A sting in the tail

The greater trochanter of the left femur of the Uedomari-5 skeleton retains the firmly embedded tip of a bilaterally serrated stingray spine (Figs. 4 and 5). It protrudes from the bone at a sharp downward angle of ca. 70° with a maximum of ca. 6 mm exposed, and a maximum width of ca. 4.5 mm. Five serrations are visible on one side, with a spacing of ca. 1 mm. CT imaging demonstrates the presence of six and eight serrations and an intact distal point of the spine, penetrating the bone to a depth of 13 mm (Fig. 6).

There are no clear indications of healing (Fig. 6). The affected area serves as the attachment site for the gluteus minumus muscle, surrounded by the gluteus medius and tensor fasciae latae muscles and iliac band. Penetration here would not involve the severing of any major arteries; therefore, the injury would not be immediately life-threatening. The fact that the point is still embedded suggests either that no attempt was made to pull out the barb, or that the tip of the point broke off during such an attempt, remaining lodged in the bone.

4.1. Species identification

The candidate species based on their likely presence in the waters surrounding Hokkaido are the red stringray (*Hemitrygon akajei*), the pitted stringay (*Bathytoshia brevicaudata*, previously *Dasyatis matsubarai* – Last et al., 2016), the Japanese eagle ray (*Myliobatis tobijei*) and the pelagic or blue stingray (*Pteroplatytrygon violacea*) (Table 2). The spine tip embedded in the Uedomari skeleton is too incomplete for species identification, but based on the size of the stingray spines from the Okhotsk site of Kafukai, Rebun (see below), and on modern species distributions, the most likely candidates are *H. akajei* and *B. brevicaudata*. *M. tobijei* can likely be excluded because of its small spines, while *P. violacea* is a pelagic species rarely caught inshore. While *H. akajei* is common in the waters surrounding southern Hokkaido, its modern range does not extend as far north as Rebun Island. *B. brevicaudata*, however, has been recorded off of northeast Hokkaido, and would likely also be present in the Okhotsk Sea (Nagao et al., 2011). This, together with the size of the spines, makes *B. brevicaudata* the most likely candidate for the large specimens recovered from Kafukai (Table 3) and for Uedomari.

Another possibility is that stingray spines were traded up from southern Hokkaido (e.g., for *H. akajei* spines) or further afield. There is ample evidence for long-distance contacts and exchange in both the Jomon and Okhotsk periods on Rebun Island, with shells deriving from the waters of southern Japan (Yamaura, 1998), and walrus tusks from the north worked into figures, and well as jade from Niigata in central Honshu (Matsumoto, 2011).

5. Discussion

5.1. Accident or intent?

A crucial point to consider is whether the injury was the result of an encounter with a living stingray or whether the spine tipped an arrow or light spear: in other words, accident or intent? As noted above, most injuries involving encounters with live stingrays in the water are to the feet and lower limbs rather than the upper thigh. But if the stingray had been brought into a boat – the second most common situation resulting in modern injuries – then it may have struck essentially anywhere. In the alternative case of its use as an armature, the downward angle of the

Table 1
Bone chemistry and dating results for Uedomari-5. Calibrated in OxCal 4.4 using mixed atmospheric (IntCal20) and marine (Marine20) calibration curves (Heaton et al., 2020; Reimer et al., 2020).

Lab code	^{14}C yr	ΔR	cal AD	δ^{13}C	δ^{15}N	% col	%C	%N	C:N
TKA-18612	2172 ± 28	30 ± 58	172–563	-13.7‰	19.3‰	2.5	46.7	16.2	3.4
”	”	304 ± 70	429–827	”	”	”	”	”	”

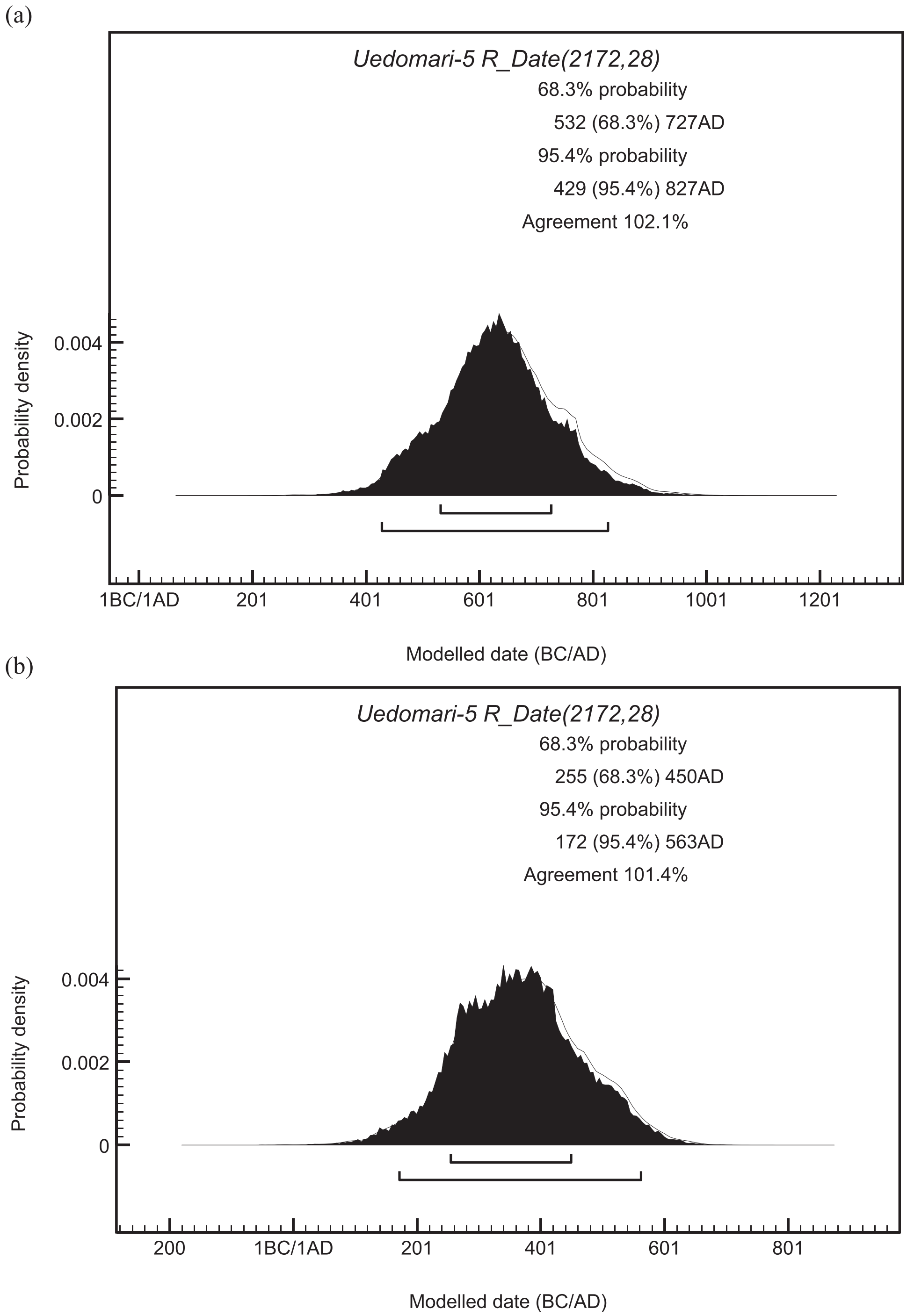

Fig. 3. Plots of the calibrated date for Uedomari-5, using alternative ΔR values of: a) 304 ± 70 yr; and b) 30 ± 58 yr.

embedded barb indicates that the spine was driven down from above, which could indicate either that the arrow was at the very end of a long arcing trajectory, or that was shot down from a height (e.g., from an individual positioned on a hillside).

While both scenarios – accident or intent – are plausible, and therefore difficult to choose between, the absence of any bony reaction around the barbed spine indicating the onset of healing suggests that the individual died soon after. Yet the location of the injury would not have been life threatening, nor are the toxins in stingray barbs lethal to humans, especially not to a young adult male. In 1392 cases of stingray injuries reported in the literature for US waters, there were only two fatalities (0.14%), both involving young boys struck in the abdomen (Clark et al., 2007; Forrester, 2005; Russell, 1953; Russell et al., 1958). While a stingray may be able to drive its spine into bone, such cases are rare; indeed it is rare for the spine to be retained in the wound at all, recorded in only 13 of 713 (1.8%) of reported cases, none of which are noted specifically as involving bone (Clark et al., 2007; Myatt et al., 2018; Russell et al., 1958, Table 1). This strongly implies that another injury or injuries received around the same time resulted in the death of the Uedomari-5 individual. The missing cranium is particularly unfortunate in this regard, as any lethal blow would likely have been delivered to the head (cf. Hudson et al., 2020).

Examples of stingray spines known from Okhotsk contexts at Hamanaka and Kafukai on Rebun Island itself (Fig. 7) (Kodama and Oba, 1952; Oba and Ohyi, 1976, 1981), and at Moyoro on mainland Hokkaido (Oba, 1955) as well as many Jomon sites in the Japanese Archipelago (Kaneko

Fig. 4. Anterior (left) lateral (right) views of proximal left femur of Uedomari-5, with the location of the barbed spine circled.

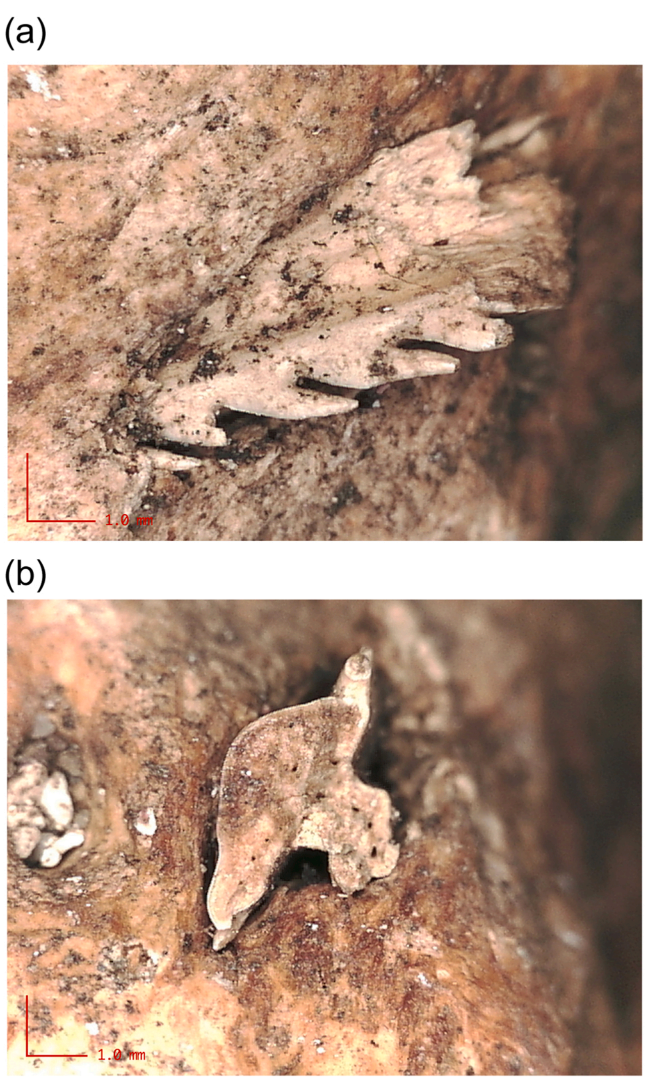

Fig. 5. Lateral (left) and end (right) views of the embedded spine. Scale is 1 mm.

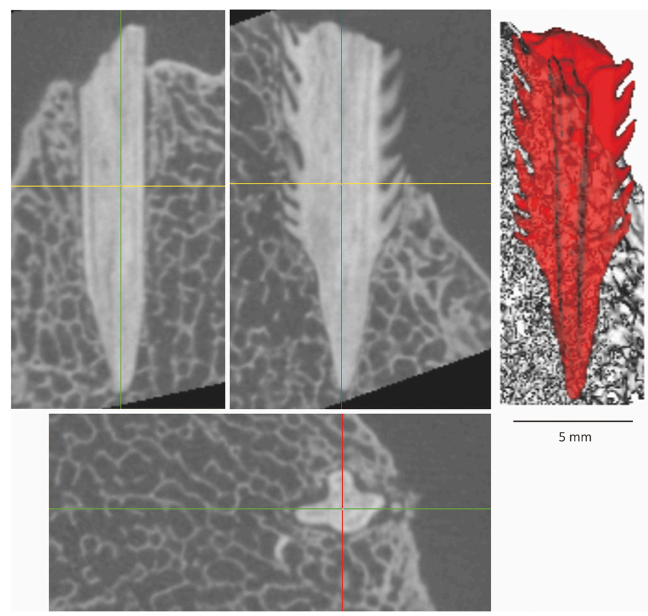

Fig. 6. Orthogonal views of cross-sectional CT images and the colour enhanced rendering image of the embedded spine.

and Oshizawa, 1986a, 1986b; Kawazoe, 2009), including Kitogane on southern Hokkaido and Satohama on northern Honshu, where a stingray spine was found embedded in the scapula of a sika deer (*Cervus nippon*) (Okamura, 1984). In a number of cases it is clear that the spines have been worked, usually modified at the base, but sometimes resharpened at the tip (Fig. 8) (Kaneko and Oshizawa, 1986a; Kawazoe, 2009).

Spears tipped with stingray spines were reportedly used by the Ainu for hunting bears (Ishikawa, 1962; Ohnuki-Tierney, 1976). They are also reported to have used *Aconitum* sp. (monkshood or wolf's bane) plant toxins mixed with ground stingray spines for hunting (Bisset, 1976; Ishikawa, 1962), though the efficacy of this is not clear: its addition to the undoubted powerful aconite toxins may have been more ritual than practical.

In any case, it is unlikely that the reason for the use of stingray spines as armatures was entirely a matter of their 'readymade' quality; rather, there may have been powerful magico-religious elements at play, particularly when employed in warfare. For the Ainu, mythic aspects of

Table 2
Tail spine measurements (mm) for four species of ray in northern Japanese waters. Comparisons were made by K Nishida using the collections of the Hokkaido University Fisheries Science Museum and the Osaka Aquarium Kaiyukan Marine Biology Research Laboratory, Iburi Center.

Species	Tail spine length (Schwartz, 2007)	Tail spine length (this study)	Tail spine width (this study)
B. brevicaudata	41–98	85.5–104.9	7.0–8.5
H. akajei	41–42	35.5–93.5	3.5–5.5
M. tobijei	26–42	40.5–52.0	4.5
P. violacea	75–156	127.0–162.0	7.0–8.5

the stingray, *Ai-koro-chiep* in Ainu, are revealed by the belief that it caused earthquakes (Ishikawa, 1963). Even though rarely fatal, it may be that experience of the considerable pain caused by the toxin influenced the choice of stingray spines as armatures for use in conflict. Additional factors may have included the difficulty of extracting the barbed point without causing further soft tissue injury, and the likelihood of the relatively fragile tip breaking off inside the wound and causing subsequent infection.

The potential dating of Uedomari-5 to the first centuries of the Okhotsk culture may be significant. The Okhotsk culture has long been seen as intrusive into Hokkaido via Sakhalin and, prior to that, the Amur River Basin region of mainland northeast Asia (Befu and Chard, 1964; Hudson, 1999; Yamaura, 1998). This has received ample confirmation through analyses of both osteological biological distance measures and

Table 3
Measurements on stingray spines from Kafukai I ([a] – Oba and Ohyi, 1976; [b] – Oba and Ohyi, 1981). See Fig. 7 for images.

Context	Monograph reference	Cat. no.	Fig. 7	Condition	max L (mm)	max W
Layer II	Fig. 147–13[a]	5015	a	complete	78.4	5.6
Layer III	Fig. 267–10[a]	11196	b	broken tip, modified	83.4	11.4
Housepit	Fig. 292–2[a]	6924	c	complete, modified	76.2	9.0
Layer IV	Fig. 385–20[b]	16584	d	complete	126.0	9.2
Layer IV	Fig. 385–21[b]	2294	e	broken base	86.0	7.5
Layer IV	Fig. 385–22[b]	13167	f	broken tip	74.1	7.4
Layer IV (1968)	Fig. 465–2[b]	257	g	tip and base broken	68.4	7.4

Fig. 7. Stingray spines from Okhotsk layers at Kafukai, Rebun Island (Oba and Ohyi, 1976, 1981): 'b' and 'c' have resharpened tips, while 'c' also shows a reworked base.

Fig. 8. Stingray spine from Kafukai (Fig. 7c), worked at both tip and base.

ancient DNA (Matsumura et al., 2009; Sato et al., 2007). Considering the earliest part of its date range, Uedomari-5 could relate to the very earliest appearance of Okhotsk groups from Sakhalin, with the potential for conflict with Epi-Jomon communities then living on Rebun and across northern Hokkaido (having been displaced from the southern tip of Sakhalin; Ono, 2003). Within one to two centuries at most the Okhotsk culture spread across northern Hokkaido but remained coast-bound, not surprisingly given its specialised marine economy.

The extent to which Okhotsk migrations were contested by existing communities is not known, but there does appear to have been an increase in the prevalence of conflict in the period as a whole. Okhotsk fortifications are known, compared to their apparent absence in the Jomon, and culminating in the ca. 520 Ainu hilltop fortifications, *chasi*, known across Hokkaido (Vasil'evskii and Golubev, 1976, cited in Fitzhugh et al., 2004; Samarin and Shubina, 2007); excavations have shown that comparable sites in Sakhalin have Okhotsk antecedents (Hirakawa, 1994, cited in Hudson, 1999: 216). Yet is clear from skeletal evidence that lethal conflict occurred within both periods. An obsidian projectile point was found embedded in the head of the right femur of an adult male at the Epi-Jomon site of Usu-Moshiri (previously Usu-10) (Matsumura, 1989), while an adult female cranium from the Epi-Jomon site of Minami-Usu 6 exhibits a perimortem injury (Dodo, 1983; Hudson et al., 2020). A stone projectile point was found embedded in the right innominate of an adult male from the Okhotsk site of Ohmisaki 2, with no signs of healing (Yamaguchi, 1967). A number of cases are known from the large, mainly Okhotsk cemetery of Moyoro in eastern Hokkaido. An adult male exhibits an embedded bone projectile fragment in the left innominate, with no signs of healing. More striking is another adult male with an obsidian point fragment in the left proximal tibia, showing a degree of healing consistent with survival for some months at least, as well as three projectile injuries showing no indications of healing. These comprise a bone projectile embedded in a thoracic vertebra (T12), and two embedded obsidian point fragments, one to the right innominate and the other to the head of the left femur (Terazawa, 2006). Additional crania injuries, both ante- and perimortem, have been identified at this site and are currently being prepared for publication.

6. Conclusions

A young adult male skeleton from the site of Uedomari exhibits the broken tip of a stingray spine firmly embedded in the left femur. The injury shows no signs of healing, indicating that the individual died either immediately or soon after. Given that stingray spines are very rarely lethal, particularly when affecting the extremities, we argue that the spine most likely tipped an armature. The skeleton has been broadly dated to the Okhotsk period (cal AD 429–827), with the large range caused by the added uncertainty introduced by the marine reservoir effect. If the individual dated from the earlier part of this range, it is possible that he belonged to an Early Okhotsk community still in the process of establishing its territory. Rebun Island is located in the initial contact zone between Sakhalin (the immediate origin of the Okhotsk population and culture) and Hokkaido, and so would have been at the forefront of Early Okhotsk expansion, as well as possibly acting as a border zone between increasingly differentiated groups on Sakhalin and Hokkaido in the following centuries.

The Uedomari-5 skeleton provides the first example, to our knowledge, of a stingray spine directly embedded in a human bone from an archaeological site. Aside from its intrinsic interest, the finding also contributes to the ongoing debate regarding the prevalence of conflict in hunter-gatherer communities (Allen and Jones, 2014; Bowles, 2009; Fry and Söderberg, 2013; Nakao et al., 2016).

Acknowledgements

This research was made possible by the Baikal-Hokkaido Archaeological Project (Social Sciences and Humanities Research Council of Canada, Major Collaborative Research Initiative Grant no. 412-2011-1001), Core-to-Core Program Advanced Research Network Grant no. PG7E190001, the University of Hokkaido, and the Daiwa Foundation (doctoral studentship to Izumi Braddick). We thank Tetsuya Anamo and Hiroko Ono (Hokkaido University Museum, Sapporo), Fumihito Tashiro (Hokkaido University Museum Fisheries Science Center, Hakodate), and Itsuki Kiyatake (Osaka Aquarium Kaiyukan) for access to their collections, and Gen Suwa (University Museum, University of Tokyo) for CT scanning. The journal's reviewers and associate editor are thanked for their useful comments on the paper.

References

Allen, M.W., Jones, T.L. (Eds.), 2014. Violence and Warfare among Hunter-Gatherers. Left Coast Press, Walnut Creek.

Argüello Menéndez, J.J., 2020. Las fases cronológicas del yacimiento de Sa Galera. Una lectura estratigráfica. In: Argüello Menéndez, J.J. (Ed.), Sa Galera: Más de 4000 Años de Historia. Vessants Arqueologia i Cultura & Amics de Sa Galera., Mallorca, pp. 51–163.

Auerbach, B.M., Ruff, C.B., 2010. Stature estimation formulae for indigenous North American populations. Am. J. Phys. Anthr. 141 (2), 190–207.

Barton, H., Piper, P.J., Rabett, R., Reeds, I., 2009. Composite hunting technologies from the Terminal Pleistocene and Early Holocene, Niah Cave, Borneo. J. Archaeol. Sci. 36 (8), 1708–1714.

Bascom, W.R., 1965. Ponape: a Pacific economy in transition. Anthropological Records. University of California Press, Berkeley, p. 22.

Befu, H., Chard, C.S., 1964. A prehistoric maritime culture of the Okhotsk Sea. Am. Antiq. 30 (1), 1–18.

Bisset, N.G., 1976. Hunting poisons of the North Pacific Region. Lloydia 39 (2–3), 87–124.

de Borhegyi, S.F., 1961. Shark teeth, stingray spines, and shark fishing in ancient Mexico and Central America. J. Anthropol. Res. 17 (3), 273–296.

Bowles, S., 2009. Did warfare among ancestral hunter-gatherer groups affect the evolution of human social behaviors? Science 324, 1293–1298.

Budinoff, L.C., 1991. An osteological analysis of the human burials recovered from Maisabel: an early ceramic site on the north coast of Puerto Rico. In: Robinson, L.S. (ed.), Proceedings of the Twelfth Congress of the International Association for Caribbean Archaeology. Cayenne, pp. 117–133.

Buikstra, J.E., Ubelaker, D.H. (Eds.), 1994. Standards for Data Collection from Human Skeletal Remains. Arkansas Archaeological Survey Research Series, Fayetteville.

Clark, R.F., Girard, R.H., Rao, D., Ly, B.T., Davis, D.P., 2007. Stingray envenomation: a retrospective review of clinical presentation and treatment in 119 cases. J. Emerg. Med. 33 (1), 33–37.

Cook, M.D., Matteucci, M.J., Lall, R., Ly, B.T., 2006. Stingray envenomation. J. Emerg. Med. 30 (3), 345–347.

DeNiro, M.J., 1985. Post-mortem preservation and alteration of in vivo bone collagen isotope ratios in relation to palaeodietary reconstruction. Nature 317, 806–809.

Diaz, J.H., 2008. The evaluation, management, and prevention of stingray injuries in travelers. J. Travel Med. 15 (2), 102–109.

Dodo, Y., 1983. A human skull from the Epi-Jomon period from the Minami-Usu Six site, Date, Hokkaido. J. Anthropol. Soc. Nippon 91 (2), 169–186.

Fenner, P.J., Williamson, J.A., Skinner, R.A., 1989. Fatal and non-fatal stingray envenomation. Med. J. Aust. 151 (11–12), 621–625.

Fitzhugh, B., Moore, S., Lockwood, C.W., Boone, C., 2004. Archaeological paleobiogeography in the Russian Far East: the Kuril Islands and Sakhalin in comparative perspective. Asian Perspect. 43 (1), 92–122.

Forrester, M.B., 2005. Pattern of stingray injuries reported to Texas poison control centers from 1998 to 2004. Hum. Exp. Toxicol. 24 (12), 639–642.

Fry, D.P., Söderberg, P., 2013. Lethal aggression in mobile forager bands and implications for the origins of war. Science 341, 270–273.

Gimlette, J.D., 1915. Malay Poisons and Charm Cures. J&A Churchill, London.

Haddad Jr., V., Costa Cardoso, J.L., Neto, D.G., 2013. Injuries by marine and freshwater stingrays: history, clinical aspects of the envenomations and current status of a neglected problem in Brazil. J. Venom. Anim. Toxins Incl. Trop. Dis. 19, 16.

Haddad Jr., V., Lima, C., Lopes-Ferreira, M., 2016. Venomous marine fish: evolution of the venoms – Chondrichthyes (cartilaginous fish). In: Gopalakrishnakone, P., Haddad, V., Tubaro, A., Kim, E., Kem, W.R. (Eds.), Marine and Freshwater Toxins, Toxinology. Springer, Dordrecht, pp. 421–426.

Haddon, A.C., 1890. The ethnography of the western tribe of Torres Straits. J. Anthropol. Inst. 19, 297–440.

Heaton, T.J., Kohler, P., Butzin, M., Bard, E., Reimer, R.W., Austin, W.E.N., Bronk Ramsey, C., Grootes, P.M., Hughen, K.A., Kromer, B., Reimer, P.J., Adkins, J., Burke, A., Cook, M.S., Olsen, J., Skinner, L.C., 2020. Marine20–the marine radiocarbon age calibration curve (0–55,000 cal BP). Radiocarbon 62 (4), 779–820.

Hudson, M.J., 1999. Ruins of Identity: Ethnogenesis in the Japanese Islands. University of Hawai'i Press, Honolulu.

Hudson, M.J., Schulting, R.J., Gilaizeau, L., 2020. The origins of violence and warfare in the Japanese Islands. In: Fagan, G.G., Fibiger, L., Hudson, M., Trundle, M. (Eds.), The Cambridge World History of Violence, Vol. I: The Prehistoric and Ancient Worlds. Cambridge University Press, Cambridge, pp. 160–177.

Ishikawa, M., 1962. Poisons and venoms used for hunting by the Ainu. J. Anthropol. Soc. Nippon 69 (3–4), 141–153.

Ishikawa, M., 1963. Poisonous fish "Akaei" (stingray): its ethnological investigation. J. Anthropol. Soc. Nippon 70 (3–4), 149–162.

Junno, A., Dury, J., Leipe, C., Wagner, M., Tarasov, P.E., Hirasawa, Y., Jordan, P.D., Kato, H., 2020. Building a high-resolution chronology for northern Hokkaido – a case study of the Late Holocene Hamanaka 2 site on Rebun Island, Hokkaido (Japan). J. Archaeol. Sci. Rep. 36, e102867.

Kaneko, H., Oshizawa, N., 1986a. Kokkakuki no kenkyu: Jomon-hen Part I. Keiyūsha, Tokyo.

Kaneko, H., Oshizawa, N., 1986b. Kokkakuki no kenkyu: Jomon-hen Part II. Keiyūsha, Tokyo.

Kawazoe, K., 2009. Tokai chiiki Jomon jidai koubannki no kokkakuki-sei tenjo-shitotsugu-rui ni tsuite: yasu yajiri hari no bunseki. Kenkyu Kiyou. Res. Bull. Aichi Prefect. Cent. Archaeol. Oper. 10, 1–22.

Keegan, W.F., Carlson, L.A., 2008. Talking Taino: Caribbean Natural History from a Native Perspective. University of Alabama Press, Tuscaloosa.

Kodama, S., Oba, T., 1952. Rebunto Funadomari Sakyu Iseki no Hakkutsu nitsuite [On the excavation at the Funadomari sand dune site on Rebun Island]. Hoppo Bunka Kenkyu Hokoku 7, 167–270.

Kudaka, M., Fukase, H., Kimura, R., Hanihara, T., Matsumura, H., Saso, A., Fukumine, T., Ishida, H., 2013. Metric characteristics of human limb bones in Asian and Japanese populations. Anthropol. Sci. 121 (1), 49–62.

Last, P.R., Naylor, G.J.P., Manjaji-Matsumoto, B.M., 2016. A revised classification of the family Dasyatidae (Chondrichthyes: Myliobatiformes) based on new morphological and molecular insights. Zootaxa 4139, 345–368.

Lippmann, J., Walker, D., Lawrence, C., Fock, A., Wodak, T., Jamieson, S., 2011. Provisional report on diving-related fatalities in Australian waters 2006. Diving Hyperb. Med. 41 (2), 70–84.

Lothrop, S.K., 1937. Cocli: An Archaeological Study of Central Panama, Part I. Peabody Museum of American Archaeology and Ethnology, Harvard University, Memoirs, Cambridge, MA.

Martin, J., 1991. [1817]. Tonga Islands: William Mariner's Account. Vava'u Press, Tonga.

Matsumoto, N., 2011. Cognitive foundation of long-distance interaction and its relation to social contexts. In: Matsumoto, N., Bessho, H., Tomii, M. (Eds.), Coexistence and Cultural Transmission in East Asia. Routledge, London, pp. 31–47.

Matsumura, H., 1989. A human femur from prehistoric Hokkaido penetrated by a stone arrowhead. J. Anthropol. Soc. Nippon 97 (1), 129–132.

Matsumura, H., Ishida, H., Amano, T., Ono, H., Yoneda, M., 2009. Biological affinities of Okhotsk-culture people with east Siberians and Arctic people based on dental characteristics. Anthropol. Sci. 117 (2), 121–132.

Miyata, Y., Horiuchi, A., Kondo, M., Onbe, S., Yoshida, K., Nagao, S., Paleo Labo AMS Dating Group, Nishimoto, T., 2016. Marine reservoir effects deduced from ^{14}C dates on pottery residues, bones, and molluskan shells from the Hamanaka 2 archaeological site, Rebun Island, Hokkaido, Japan. Radiocarbon 58 (4), 755–770.

Myatt, T., Nguyen, B.J., Clark, R.F., Coffey, C.H., O'Connell, C.W., 2018. A prospective study of stingray injury and envenomation outcomes. J. Emerg. Med. 55 (2), 213–217.

Nagao, T., Kawai, T., Matsubara, H., Suzuki, A., 2011. Record of pitted stingray *Dasyatis matsubarai* (Myliobatiformes: Dasyatidae) collected from the Sea of Okhotsk, Abashiri, Hokkaido, Japan. Bull. Shire Mus. 32, 31–34.

Nakao, H., Tamura, K., Arimatsu, Y., Nakagawa, T., Matsumoto, N., Matsugi, T., 2016. Violence in the prehistoric period of Japan: the spatio-temporal pattern of skeletal evidence for violence in the Jomon period. Biol. Lett. 12, e20160028.

O'Malley, G.F., O'Malley, R.N., Pham, O., Randolph, F., 2015. Retained stingray barb and the importance of imaging. Wilderness Environ. Med. 26, 375–379.

Oba, T., 1955. Moyoro kaizuka shutudo no kokkakuki. Hoppou Bunka Kenkyu Hokoku 10, 173–249.

Oba, T., 1968. The Okhotsk culture in and near Hokkaido Part II: Rebun and Rishiri Inlets. Research of Northern Culture. Hoppou Bunka Kenkyu 3, 1–43 (in Japanese).

Oba, T., Ohyi, H., 1976. Studies on the Okhotsk Culture 2: The Kabukai Sites, Part I. University of Tokyo Press, Tokyo (in Japanese).

Oba, T., Ohyi, H., 1981. Studies on the Okhotsk Culture 3: The Kabukai Sites, Part II. University of Tokyo Press, Tokyo.

Ohnuki-Tierney, E., 1976. Regional variations in Ainu culture. Am. Ethnol. 3 (2), 297–329.

Okamura, M., 1984. Shika no kenkoukotsu ni sasatta ei-bikyoku-sei no yajiri. Tohoku Rekishi Shiryoukanpou 13, 2 (in Japanese).

Ono, H., 2003. Relationship between the Susuya Culture and the Aniwa Culture: 1. analysis of the Yuzhnaya II site. Bull. Hokkaido Univ. Mus. 1, 19–31.

Purdy, B.A., 1977. Weapons, strategies, and tactics of the Europeans and the Indians in sixteenth- and seventeenth-century Florida. Fla. Hist. Quart. 55 (3), 259–276.

Rathjen, W.F., Halstead, B.W., 1969. Report on two fatalities due to stingrays. Toxicon 6, 301–302.

Reimer, P.J., Austin, W.E.N., Bard, E., Bayliss, A., Blackwell, P.G., Bronk Ramsey, C., Butzin, M., Cheng, H., Edwards, R.L., Friedrich, M., Grootes, P.M., Guilderson, T.P., Hajdas, I., J Heaton, T., Hogg, A.G., Hughen, K.A., Kromer, B., Manning, S.W., Muscheler, R., Palmer, J.G., Pearson, C., van der Plicht, J., Reimer, R.W., Richards, D.A., Scott, E.M., Southon, J.R., Turney, C.S.M., Wacker, L., Adolphi, F., Büntgen, U., Capano, M., Fahrni, S.M., Fogtmann-Schulz, A., Friedrich, R., Köhler, P., Kudsk, S., Miyake, F., Olsen, J., Reinig, F., Sakamoto, M., Sookdeo, A., Talamo, S., 2020. The IntCal20 Northern Hemisphere radiocarbon age calibration curve (0–55 cal kBP). Radiocarbon 62 (4), 725–757.

Reimer, R.W., Reimer, P.J., 2017. An online application for ΔR calculation. Radiocarbon 59 (5), 1623–1627.

Roth, W.E., 1909. North Queensland ethnography. Bulletin No. 13. Fighting weapons. Rec. Aust. Mus. 7 (4), 189–211.

Russell, F.E., 1953. Stingray injuries: a review and discussion of their treatment. Am. J. Med. Sci. 226, 611–622.

Russell, F.E., Panos, T.C., Kang, L.W., Warner, A.M., 1958. Studies on mechanisms of death from stingray venom. A report of two fatal cases. Am. J. Med. Sci. 235 (5), 566–584.

Samarin, I.A., Shubina, O.A., 2007. Fortified settlements of the chasi type on Kunashir Island: Kurile Isles of the Russian Far East. North Pac. Prehist. 1, 163–190.

Sato, T., Amano, T., Ono, H., Ishida, H., Kodera, H., Matsumura, H., Yoneda, M., Masuda, R., 2007. Origins and genetic features of the Okhotsk people, revealed by ancient DNA analysis. J. Hum. Genet. 52, 618–627.

Schwartz, F.J., 2007. Tail spine characteristics of stingrays (order Myliobatiformes) frequenting the FAO Fishing Area 61 (20°N 120°E - 50°N 150°E) of the Northwest Pacific Ocean. Raffles Bull. Zool. 14, 121–130.

Smarrito, S., Smarrito, F., Leclair, O., Labbe, J.L., 2004. Surgical management of stingray injuries. About two clinical cases. Ann. Chir. Plast. Esthet. 49 (4), 383–386.

Srinivasan, S., Bosco, J.I.E., Lohan, R., 2013. Marine stingray injuries to the extremities: series of three cases with emphasis on imaging. J. Postgrad. Med. 59 (4), 309–311.

Terazawa, K., 2006. Medico-legal observation of archaeological specimens (human skeletal remains). In: Amano, T. (Ed.), Abstracts of the International Symposium Life and Roots of the Okhotsk People, studied in Physical Anthropology and Genetic Science. Hokkaido University Museum, Sapporo, pp. 58–64.

Tsutaya, T., Naito, Y.I., Ishida, H., Yoneda, M., 2014. Carbon and nitrogen isotope analyses of human and dog diet in the Okhotsk culture: perspectives from the Moyoro site, Japan. Anthropol. Sci. 122 (2), 89–99.

Wilbert, J., 1972. Survivors of Eldorado: Four Indian Cultures of South America. Praeger, New York.

Yamaguchi, B., 1967. A human skeleton penetrated by a stone arrowhead. Cult. Hokkaido 12, 32–34 (in Japanese).

Yamaura, K., 1998. The sea mammal hunting cultures of the Okhotsk Sea with special reference to Hokkaido prehistory. Arct. Anthropol. 35 (1), 321–334.