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Ancient DNA analysis of brown bear remains from the Kafukai site on Rebun Island, Hokkaido: On the origin of "bear-sending ceremony" from the Okhotsk Culture

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The brown bear (*Ursus arctos*) is the largest terrestrial mammal in northern Eurasia and North America. Since prehistoric times, this animal has been involved in Northern Hemispheric people's cultures such as ceremonies and rituals. In Japan, the bear-sending ceremony is known as 'Iyomante' in the Ainu Culture (13-20th centuries, A.D.) of Hokkaido, where the brown bear was the god of mountains. Although the origin of this bear ceremony is still unclear, it might be traced to brown bear remains of bones and artifacts excavated from archeological sites of the Okhotsk Culture, which developed around southern coastal areas of the Okhotsk Sea (southern Sakhalin, Rebun and Rishiri Islands, northern and eastern Hokkaido, and southern Kuril Islands) during 6-11th centuries, A.D.

The Kafukai site on Rebun Island (Fig. 1), adjoining the Hokkaido main island, is one of the most famous archeological sites of the Okhotsk Culture, because this site included a lot of faunal remains including brown bears (Oba and Ohyi, 1976; 1981). Meanwhile, currently on Rebun Island, no natural populations of brown bears occur, and there are no records of their fossils naturally formed before the Okhotsk Cultural Period. Therefore, brown bear remains of the Kafukai site are thought to be originated from the outside of Rebun Island. Although ages, dead seasons, and sex of the bear remains were morphologically investigated by Ohyi *et al.* (1980), their original habitats are still unknown.

On the other hand, the Hokkaido main island is currently a brown bear's habitat: one of the southernmost borders in Northern Hemisphere. Matsushashi *et al.* (1999) investigated phylogeographic patterns of the modern population of Hokkaido brown bears based on mitochondrial DNA (mtDNA) control region sequences. They found that there are three

mtDNA lineages which are located separately in north-central Hokkaido (Cluster A), eastern Hokkaido (Cluster B), and southern Hokkaido (Cluster C)(Fig. 1). The three mtDNA lineages could have diverged in the continent and then immigrated into Hokkaido by the last glacial age (approximately 12,000 years ago). This 'triple population structure' of modern brown bears is specific to Hokkaido, compared with other populations of European and North American brown bears.

In order to trace original habitats of brown bear remains from the Kafukai site of Rebun Island, we analyzed ancient DNA from 12 skull remains and investigated their phylogenetic status, compared with modern brown bears (Masuda *et al.* 2001). From the 12 skull remains, partial fragments (approximately 250-360 base pairs) of the mtDNA control region were successfully sequenced. Compared with sequence data of modern brown bears of the Hokkaido main land, ancient mtDNAs of the Kafukai site were phylogenetically classified into either of two lineages of modern mtDNAs: Cluster A (north-central Hokkaido lineage) and Cluster C (southern Hokkaido lineage)(Fig. 2). The southern Hokkaido lineage was identified from three juvenile (less than one year old) ancient bears, while the north-central Hokkaido lineage was mainly from adults (more than three years old)(Fig. 3). Our findings demonstrated that juvenile ancient bears of Rebun Island were originated from southern Hokkaido. In addition, adults were killed in spring while juveniles were done in autumn. This indicates that adult ancient bears were hunted by ancient people around northern Hokkaido in spring just after their hibernation, and that parts of their bodies such as heads were brought to Rebun Island. On the other hand, juvenile ancient bears were likely captured in southern Hokkaido, kept living there from spring to autumn or directly brought to Rebun Island, and then used for the bear ceremony. Archeological findings indicate that this ceremonial system lasted to the end of the Okhotsk Culture. In that time, southern Hokkaido was an outside area of the Okhotsk Culture and belonged to the Epi-Jomon Culture with a close relation to a northern part of the Tohoku district of Honshu. Our results strongly show occurrence of intercultural associations between the ancient people of Rebun Island and those of southern Hokkaido during the Okhotsk Cultural Period. Recently, Inui (1997) reported that an archeological site of the Okhotsk Culture was found on Okushiri Island, which adjoins southern Hokkaido (for the location, see Fig. 1). Gifting juvenile bears could be of importance on the intercultural

associations. For establishment of systems of capture, keeping, and gift, a common value to juvenile bears must have been shared by ancient people of both the Okhotsk Culture and the Epi-Jomon Culture. Our finding of the southern Hokkaido mtDNA lineage from the Kafukai bears indicates that the ceremony using kept juvenile bears was developed in the Okhotsk Culture, supporting the hypothesis of Watanabe (1974) and Amano (1990) that Iyomante is originated from the Okhotsk Culture. The bear ceremony could have played an important role for strengthening the people's bonds not only within the culture but also between different cultures.

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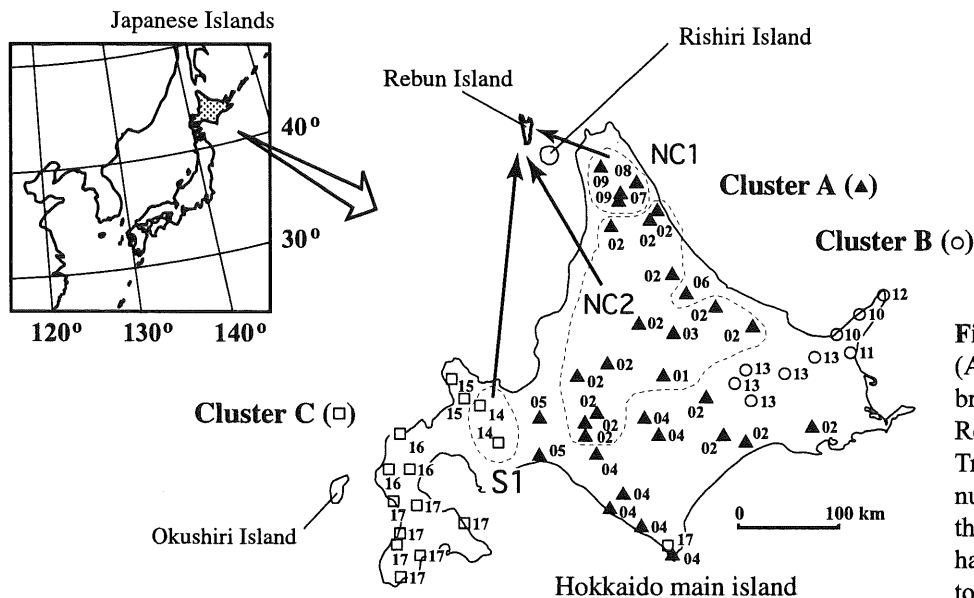


Fig. 1 Estimation of original habitats (Areas NC1, NC2, and S1) of ancient brown bears of the Kafukai site on Reun Island (Masuda *et al.* 2001). Triangles, circles, and squares with numbers indicate the localization on the Hokkaido main island of mtDNA haplotypes (HB01-17) which belong to Clusters A, B, and C, respectively.

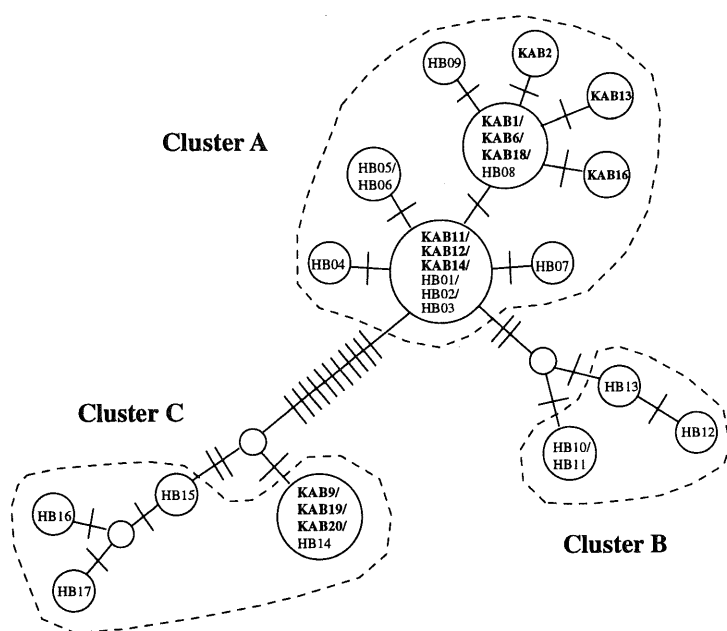


Fig. 2 Parsimonious networks among mtDNA haplotypes (254 bp) from 12 ancient brown bears of Reun Island and modern brown bears of the Hokkaido main island (Masuda *et al.* 2001). Open circles show presumed sequences. One slash means a nucleotide substitution shown.

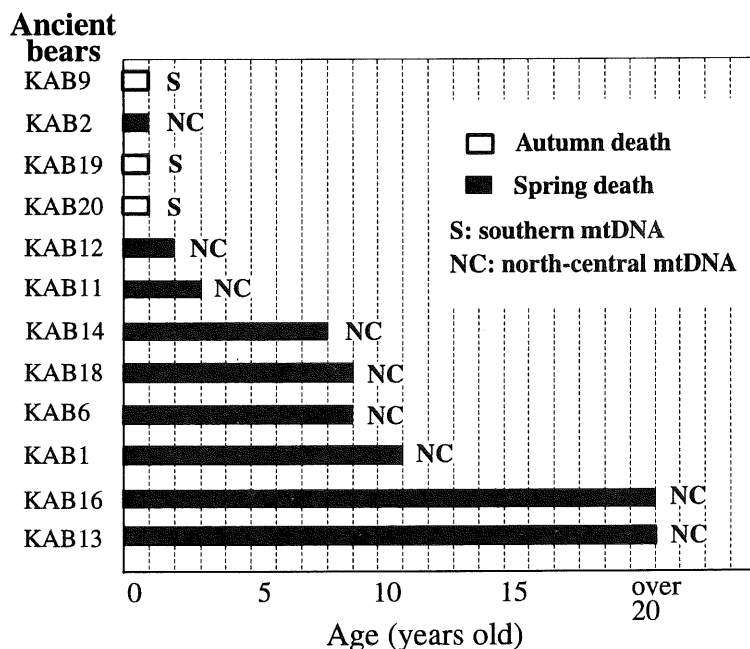


Fig. 3 The relationships between ages, dead seasons, and mtDNA lineages of ancient brown bears of Reun Island (Masuda *et al.* 2001). The southern Hokkaido mtDNA was identified from juvenile (less than one year old) ancient bears which died in autumn, while the north-central Hokkaido mtDNA was from most of adults which died in spring.

Ancient DNA analysis of brown bear remains from the Kafukai site on Rebun Island, Hokkaido: On the origin of "bear-sending ceremony" from the Okhotsk Culture

(北海道礼文島香深井遺跡出土のヒグマ遺存体に関する古代DNA分析：オホーツク文化のクマ送り儀礼の起源について)

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北半球に広く分布するヒグマ (*Ursus arctos*) は、北東ユーラシアを中心とする北方民族の文化と深い関わりをもってきた。わが国ではその一例として、アイヌ文化におけるクマ送り儀礼 (イヨマンテ) があげられる。この儀礼では、ヒグマは山の神として動物崇拝の対象とされてきた。クマ送り儀礼の起源は、紀元後 6-12 世紀頃にかけて北海道・サハリン南部・南千島において栄えた狩猟・漁労民族によるオホーツク文化の遺跡から発掘されるヒグマ遺存体にさかのぼることができる。たとえば、日本列島の最北端に位置する北海道礼文島の香深井 A 遺跡からはオホーツク文化期の遺物が数多く出土しており、竪穴式住居跡からは儀礼に使われた形跡の見られる頭骨などのヒグマ遺存体が発掘されている。現在の礼文島およびその隣に浮かぶ利尻島にはヒグマは自然分布していないため、香深井 A 遺跡に眠っていたヒグマ遺存体は、オホーツク文化期において頭骨の状態または生きたクマとして礼文島以外の地域から持ち込まれたものに由来すると考えられる。私たちはまず礼文島の古代ヒグマが生前に分布していた地域を同定することを目的として、ミトコンドリア DNA (mtDNA) に注目した古代 DNA 分析を開始した。そして、得られた古代 DNA 情報と現生ヒグマ集団の遺伝情報とを分子系統学的に比較解析することにより、礼文島古代ヒグマの起源地を推定することができた (Masuda *et al.* 2001; 増田&天野 2001)。

古代 DNA 分析の結果を紹介する前に、これまでに私たちが調査研究してきた北海道本島における現生ヒグマ集団の遺伝的特徴 (Matsushashi *et al.* 1999; 増田 2000) について少しお話をしたい。私たちは、mtDNA の分子系統解析により、北海道の現生ヒグマ集団には系統の異なる 3 つの系列が存在し、それらが北海道南部 (渡島半島を中心とした道南地方)、北部-中央部 (道北-道央地方)、東部 (知床半島を中心とした道東地方) に明瞭に分かれて分布していることを明らかにした (図 1)。このような明瞭な境界をもつ分布パターンは、オスグマの行動圏 (半径数十 km) に比べて遥かに行動範囲の狭い (半径数 km) メスグマによってもたらされる mtDNA の母性遺伝様式をよく反映しているものと考えられる。さらに、ユーラシア大陸の現生ヒグマ集団と北海道産との比較分析および分子時計による計算に基づくと、北海道に分布する 3 つの mtDNA 系列は約 30 万年以上前にユーラシア大陸において分岐し、各々の系列は異なる時代または異なる

ルート（氷期に形成された陸橋）を経て北海道へ渡来したと理解される。このような mtDNA 系列の分布様式を「北海道ヒグマ集団の三重構造」とよぶこともできよう。

そこで、本研究により解読に成功した古代ヒグマの DNA 情報を上述のような北海道本島の現生ヒグマ集団の遺伝的データと比較検討したところ（図 2）、礼文島古代ヒグマは少なくとも道北-道央地方（図 1 の NC1 および NC2）および道南地方（図 1 の S1：積丹半島の付け根付近から支笏湖の周辺域）から持ち込まれたと推定された。さらに興味深いことに、既報の犬歯年輪分析による年齢・死亡時期データ（大井ほか，1980）と照合すると、道南型 mtDNA をもつ古代ヒグマはすべて秋に死亡した 1 歳未満の仔グマであった（図 3）。それに対して、道北-道央型 mtDNA をもつ古代ヒグマのほとんどは春に死亡した 3 歳以上の成獣であった。道南型 mtDNA をもつ古代仔グマはおそらく春グマ猟で捕獲された後、半年余り飼育され儀礼に使われたと考えられる。その飼育がオホーツク文化圏外である道南地方の続縄文人（6-7 世紀北大期）、または道北地方のオホーツク人のいずれによって行われたか、という問いは今後に残された課題である。しかし、もし礼文島外において秋まで飼育されていたとしても、死んだ仔グマあるいはその頭蓋骨のみを礼文島人へ贈ることはまず考えられないから、生きた状態の仔グマの授受が文化の交流に重要な役割を果たした可能性が高いと思われる。このような仔グマの捕獲、飼育、およびギフトのシステムが成立するためには、仔グマに対する価値観がオホーツク文化圏と続縄文文化圏の古代人集団によって共有されていたことが前提となる。

おそらくこの価値観は、当時、北海道を含めた極東諸民族の間にすでに広く普及していたのであろう。礼文島香深井 A 遺跡の仔グマ遺存体からの道南型 mtDNA の発見により、飼いグマ送り儀礼が従来強調されてきた集団内だけでなく、異集団間の絆を強める機能をも果たしたことが示唆された。これはアイヌ民族が本州の南部藩主にツルを献上したことや現代における国際間のパンダやトキなどの動物ギフトに通じる思想といえるかもしれない。