Human Skeletal Evidence of Polynesian Presence in South America? Metric Analyses of Six Crania from Mocha Island, Chile

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ABSTRACT

In 2007 the discovery of pre-Columbian chicken bones from Chile provided the first conclusive evidence for prehistoric Polynesian contact with South America. When looking for further commensal data to address the issue of trans-Pacific contacts, we found a museum collection of human remains recovered from Mocha Island, a small island located approximately 30 km off the Chilean coast. The morphology of the crania suggests they may be of Polynesian ancestry. Here we present craniometric analyses for the six complete crania from Mocha Island, Chile and discuss the implications for further research into prehistoric trans-Pacific interaction.

Keywords: craniometric analyses, Polynesian prehistory, voyaging, trans-Pacific contact, South America

INTRODUCTION

The issue of prehistoric trans-Pacific contacts has been a topic of scholarly debate since the first half of the 20th century (MacMillan-Brown 1924, Buck 1938, Emory 1942), but it was the work of the Norwegian adventurer Thor Heyerdahl that brought the issue of contact between Polynesia and the Americas to public attention. As part of research upon identifying population origins, Heyerdahl suggested that Polynesian origins could be found in the Americas and, to prove his point, constructed a balsa wood raft and sailed from Peru to the Tuamotus (Heyerdahl 1952). Archaeological and linguistic research in the second half of the century showed, however, that Polynesian origins were linked to the Lapita cultural complex and the Austronesian expansion which had its origins in the west, in the islands of Near Oceania and further back to Island Southeast Asia (Kirch 2000). At the same time, archaeological theory shifted away from ideas of diffusion and the idea of identifying evidence of contact between Polynesia and the Americas lost favour. Still, compelling evidence for contact exists, most particularly in the presence of not only American plants, the sweet potato (*Ipomoea batatas*) and bottle gourd (*Lagenaria siceraria*), in pre-contact Polynesia (Hather & Kirch 1991, Green 2000, Clarke *et al.* 2005) but more importantly in the use of the South American name for the sweet potato, *kumara*, which relates to the Quechua word, *kumar*, for the same plant (Scaglion 2005).

In 1990, Ramirez (1990, 1992) conducted a formal inventory of Polynesian-like traits which had been described among the Mapuche, a pre-Hispanic culture in central-south Chile located between 32° and 42° south latitude (see Fig 1). While some similarities such as the use of the underground cooking oven (similar to a *hangi* or *umu*) or stone fish weirs are clearly, based on their antiquity, independent inventions, other similarities are much more suggestive of contact–such as the Mapuche hand clubs which are remarkably similar to the Maori *wahaika*, and polished stone adzes called '*toki*' and adze-like pendants called '*toki kura*' – the same name for the same objects in both Maori and Mapuche. Unfortunately all of the examples of these Polynesian like Mapuche artifacts were found and placed in museums prior to the development of modern archaeological practice, so there is no chronological information associated with them which would be necessary to claim that they are evidence of prehistoric Polynesian contact.

In 2007 Storey *et al.* (2007) proposed that the identification and radiocarbon dating of a pre-Columbian chicken bone from the El Arenal site in south-central Chile constituted the first scientific evidence for Polynesian contact with South America. The El Arenal bone possessed a mitochondrial DNA sequence identical to that of some ancient chicken bones from the Pacific. Further analyses identified two more chicken bones from the site with similar DNA and pre-Columbian dates of AD 1300–1450 at 95% probability (Storey *et al.* 2008).

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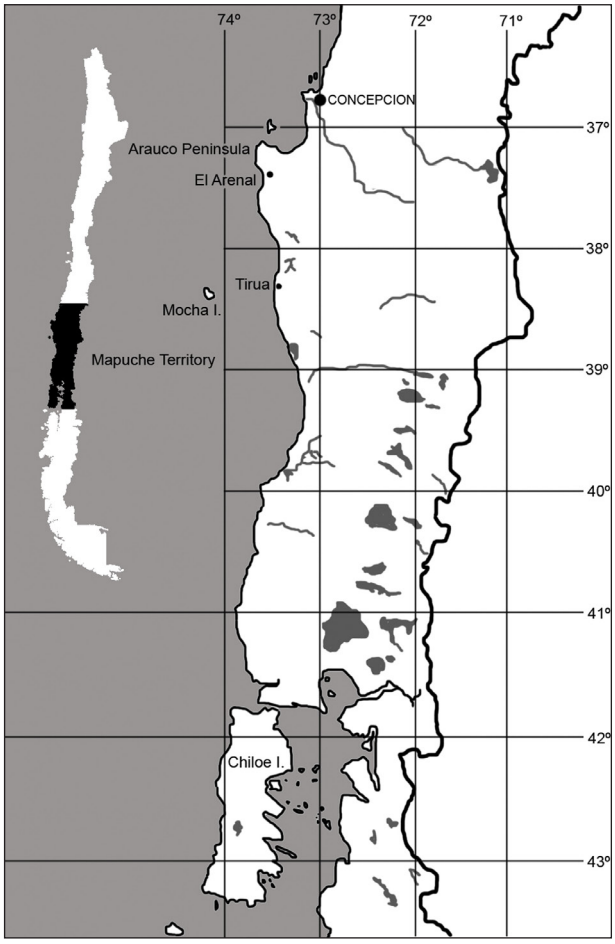

Figure 1. Map of South America with Mapuche region identified.

Initial surveys by Ramirez and Atholl Anderson and Ramirez and Matisoo-Smith of faunal material held in various Chilean museums failed to locate additional chicken bones or other Pacific commensal remains (e.g. *Rattus exulans*) from archaeological sites on the Chilean coast. However, while studying collections at the Concepcion Museum, Ramirez and Matisoo-Smith came across several boxes of human remains recovered from Mocha Island, located only 100 km south of the El Arenal site. A brief look at these remains suggested that they might be of Polynesian origin, as they possessed a number of non-metric traits which, while not exclusive to Pacific populations, are in frequency and combination typical of Pacific and particularly Polynesian populations. These include: an apparent pentagonal shape to the crania when viewed from behind with flattening of the temporal fossae; the presence of a 'rocker jaw', but more specifically the lack of an antegonial arch and the near vertical orientation of the ramus of the mandible; and an oval shaped fovea capitis in the head of the femur (Houghton 1977, 1990, 1996). Metric analyses of the remains were conducted at the museum in 2008. The results of our work are reported here.

MOCHA ISLAND

Mocha Island is located approximately 35 km off the southern coast of the Arauco region of south central Chile. The island runs in a NW-SE direction and is approximately 13 km long and 5.5 km wide with a total area of 53 km^2. Archaeological survey and excavation indicates that Mocha Island has been sporadically populated for about 3500 years and permanently occupied for approximately 1500 years (Quiroz & Sanchez 1993, 1997, 2004; Quiroz & Vasquez 1996, Vasquez 1997, Sanchez 1997, Goicovich & Quiroz 2008). The indigenous population was removed in 1685 (Sanchez *et al*. 2004) and in 1833 the island was resettled by farmers and cattle ranchers from the mainland. Today, approximately 650 people live on the island and are settled primarily around the coast, which has been divided up into a total of 32 individually owned 'parcelas' or sections. The mountainous interior, which makes up nearly 45% of the island, is part of the Mocha Island National Reserve, which is administered by the Corporacion Nacional Forestal de Chile (CONAF).

Material and Methods

Twenty-seven boxes of human remains from Mocha Island were found in the Concepcion Museum. The material was recovered from a range of contexts, from chance finds made by locals to material recovered during archaeological excavations on the island. Much of the archaeologically recovered material was studied and described by Constantinescu (1997), but she did not conduct any craniometric analyses. The Concepcion Museum collection includes six complete adult crania found in boxes labelled 5, 10, 11, 13, 18 and 24; some of these were associated with post-cranial material, most of which was fragmentary. In addition to the Mocha Island material, we also found another box of skeletal material labelled 'Coronel' which came from a site on the mainland near the town of Tirua, just across from Mocha Island. Unfortunately the Coronel cranium was incomplete, missing a significant amount of the right parietal region so it could not be included in the craniometric analyses conducted on the Mocha material. The complete crania are described and shown below.

Box 5 contained a single cranium, of slightly rounded pentagonal shape when viewed from behind (Figure 2). We noted that there appeared to be a slight flattening of the left posterior portion of the skull. The morphological characteristics suggest it belonged to a female. It was found on Parcela 27, but no other information was available for this sample.

Box 10 included a complete cranium, with some post-cranial material that was recovered from excavations of Parcela 5-1, located on the northeast coast of Mocha. Constantinescu (1997) describes the material as female aged 20–25 years. She noted that it appears to have 'Mongoloid' characteristics and also recorded flattening on the left side

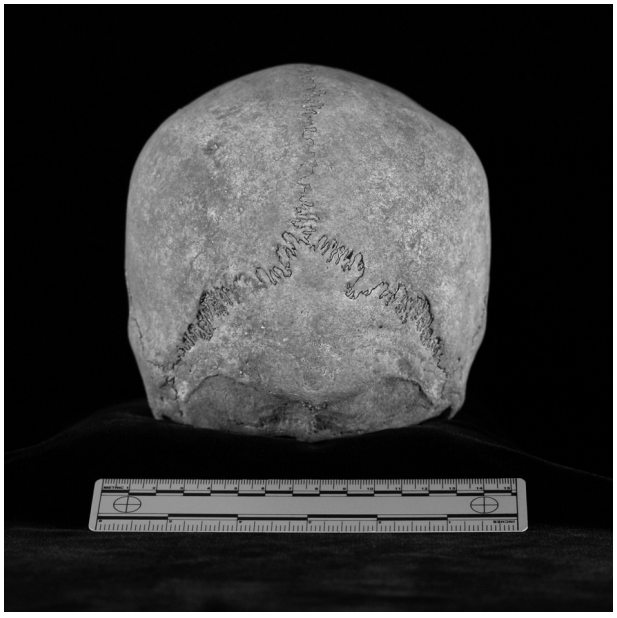

Figure 2. Box 5 cranium, posterior view.

of the skull possibly associated with cradle board deformation. We noted that the cranium was distinctly pentagonal in shape when viewed from behind (see Figure 3a), and that the mandible was of the rocker form (Figure 3b). The head of the femur possessed an oval shaped fovea capitis (on the right of Figure 3c), and the articular surfaces were particularly robust for a female femur. The material is associated with dates from the El Vergel period (1000–1500 AD) of Southern Chilean prehistory (Constantinescu 1997).

Box 11 contained material identified by documentation in the box as belonging to individual 10 recovered from Parcela 10-1 and were apparently found with cultural material belonging to the Pitren complex of Southern Chilean prehistory (Early Ceramic Period: 400–1100 AD). The box included a complete male cranium, mandible and portions of the post-cranial skeleton including vertebrae, a proximal femur and a complete pelvis. All of the material was particularly robust, but this individual also showed signs of anaemia (cribra orbitalia), generalised infection in the maxillary region and had severe osteoarthritis in the vertebral column, particularly in the lumbar region. The cranium was pentagonal in shape (Figure 4a), the fovea capitis was round (see Figure 3c, left side) and though the mandible was not of clear rocker form, it did have a broad and vertical ramus (Figure 4b). The posterior portion of the cranium appeared to be artificially flattened on the right side, which was also recorded by Constantinescu (1997) who determined the remains belonged to a 'Mongoloid' male, aged between 40 and 45 years who stood 1.73 metres tall.

Box 13, also from Parcela 10-1, was recovered from the same multiple burial as the individual in Box 11, which included at least 3 adults and 6 children. Box 13 contained a cranium, mandible and most of the postcranial skeleton

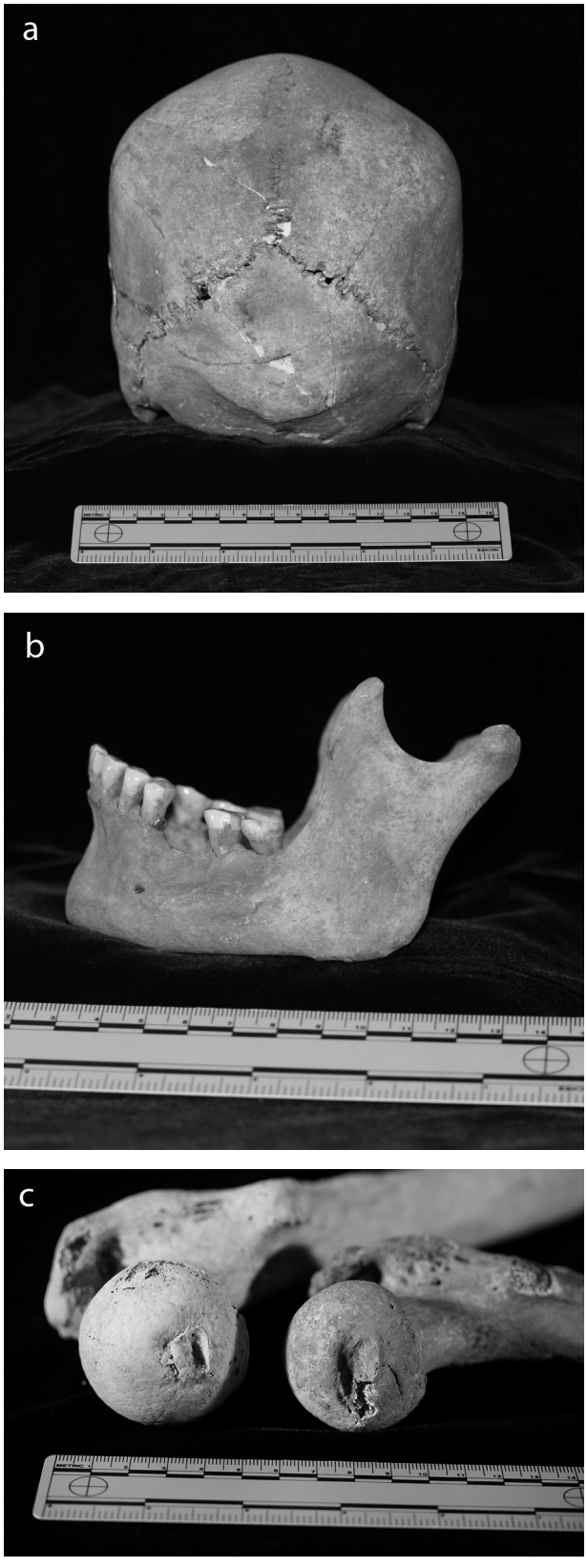

Figure 3. Box 10 material
a) posterior view of cranium; b) lateral view of mandible; c) head of the femur showing oval fovea capitis from box 10 (on right), compared with fovea of box 11 femur.

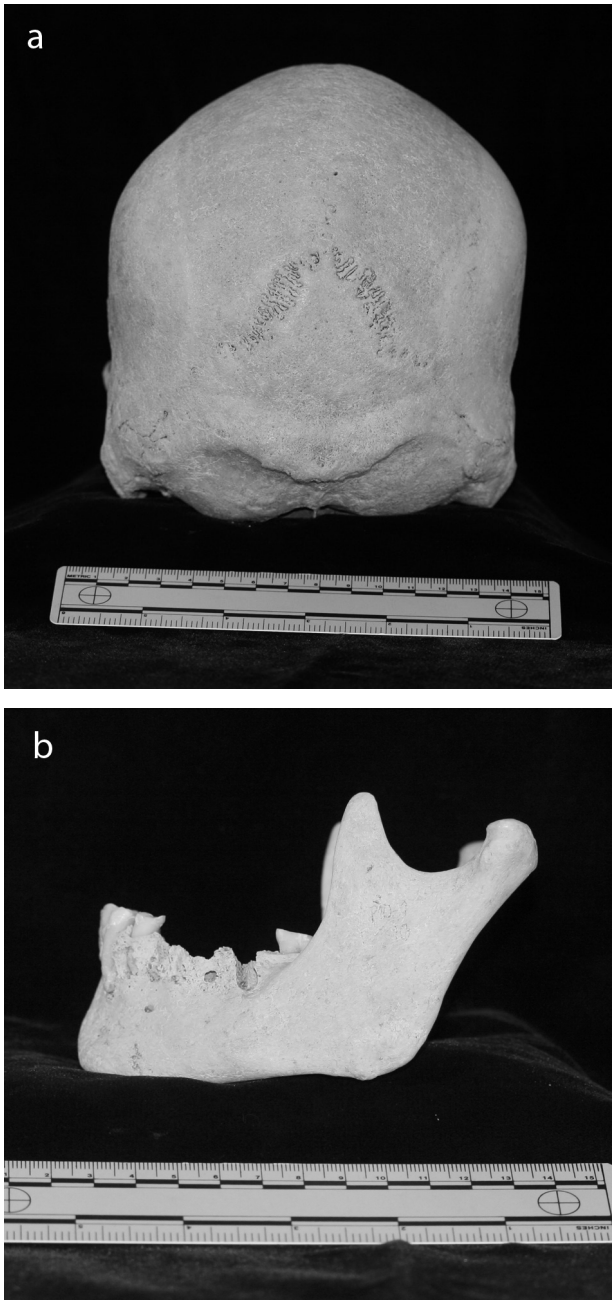

Figure 4. Box 11 material
a) posterior view of cranium; b) lateral view of mandible.

except for a missing left femur. The cranium was pentagonal in shape (Figure 5a), showed flattening on the right posterior portion, and the mandible was not of the rocker form but like the mandible from box 11 was very robust and had a broad, vertical ramus (Figure 5b) . The fovea capitis of the right femur was round in shape. Constantinescu (1997) described that material as coming from a 35 year old male with an estimated stature of 1.63 metres.

Box 18 contained a complete cranium, mandible and portions of a damaged pelvis and femur. The cranium was of pentagonal shape (Figure 6a), and while the mandible did not appear to be rocker in form, it was again quite robust with a vertical ramus (Figure 6b). The tooth wear was extreme with all molars except the left first molar missing. The cranium appeared to have some flattening of the right occipital region. The material was recovered from Parcela 24-1 and based on characteristics of the cranium and the pelvis, probably belonged to a middle-aged or elderly male.

Box 24 contained only a cranium and mandible recovered from Parcela 25-1. Documentation with the material indicates it was discovered by a local resident in 1993. The cranium appeared to belong to a female and was not

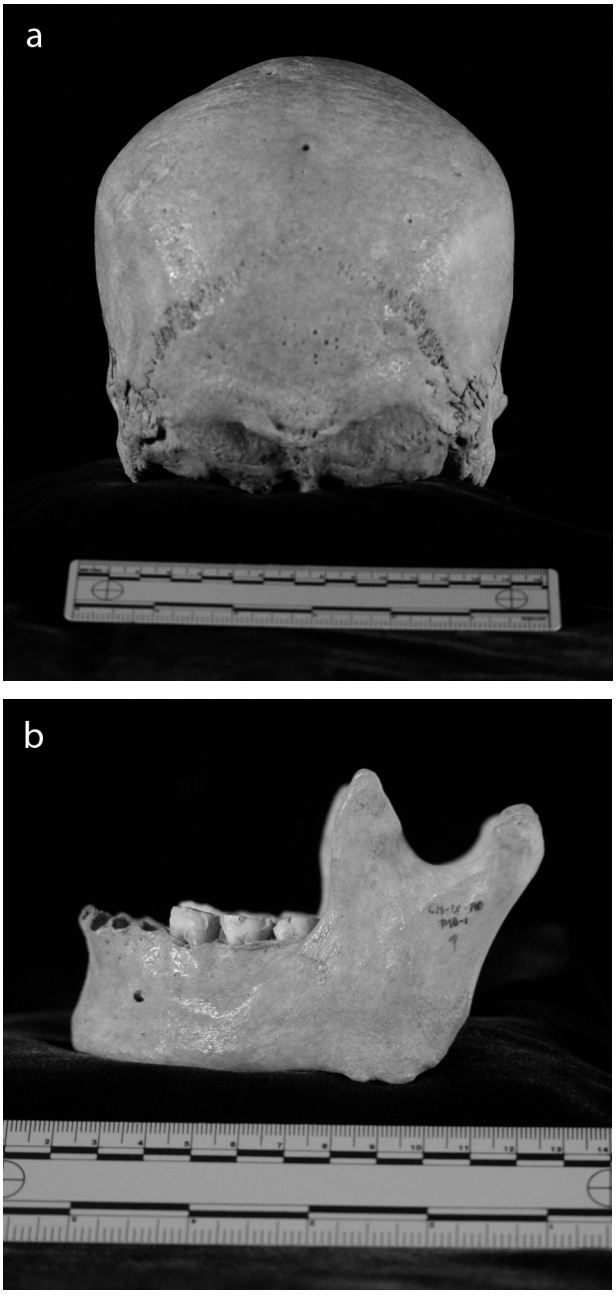

Figure 5. Box 13 material
a) posterior view of cranium; b) lateral view of mandible.

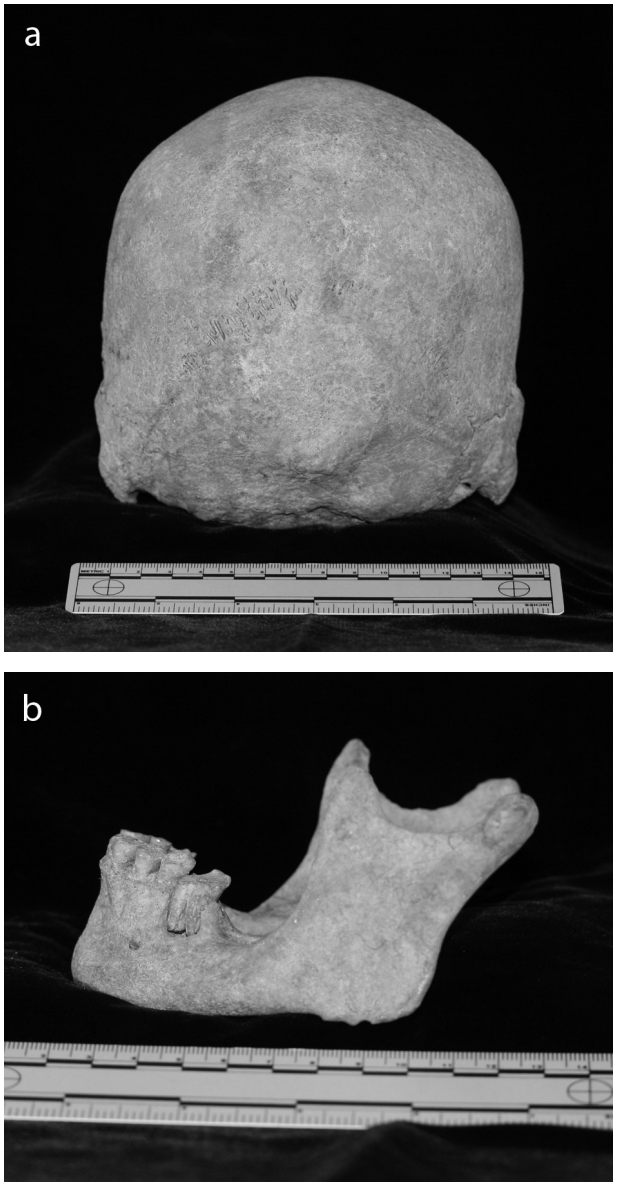

Figure 6. Box 18 material
a) posterior view of cranium; b) lateral view of mandible.

clearly pentagonal in shape (Figure 7a), however the mandible was of the rocker form (Figure 7b). Again, there was some suggestion of artificial deformation resulting in the flattening of the left occipital region.

In addition to the complete crania described above, we also found a particularly unusual skull in box 23. This box contained a cranium and mandible that were recovered by locals from a location on Isla Mocha known as Los Chinos. The cranium was missing the left portion of the face, but it was pentagonal in shape and extremely robust, particularly in the nuccal region – with very large tuberosities located on the occipital and parietal bones (Figure 8).

The Coronel cranium is shown in Figure 9. The material belonged to a middle aged female and both the cranial and post-cranial remains were particularly gracile. The cranium and mandible showed none of the Polynesian-like characteristics seen in the Mocha remains. Figure 10 shows the Coronel mandible (on right), compared to the mandible from Box 10.

Analysis

A total of 29 standard craniometric measurements were taken on the six complete adult crania from Mocha Island (from boxes 5, 10,11,13,18 and 24) with spreading, sliding and modified coordinate callipers (as described by Wright 2007). The measurements taken and values recorded are shown in Table 1. Each measurement was taken three times to check for consistency.

Linear discriminant (LDA) and nearest neighbour discriminant analyses (NNDA) were conducted on the

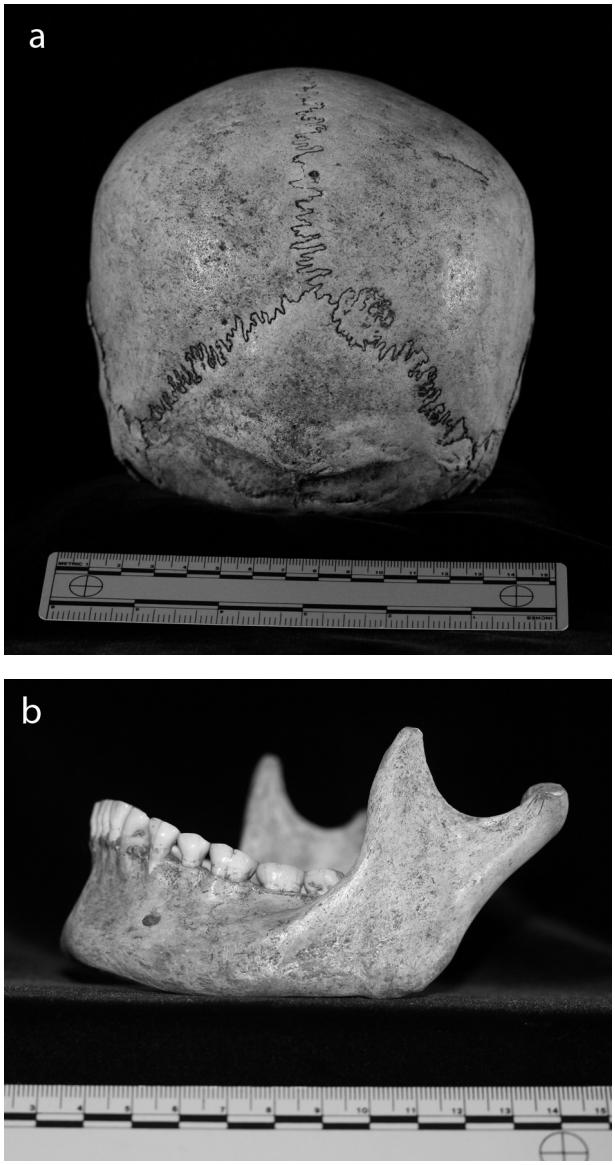

Figure 7. Box 24 material
a) posterior view of cranium; b) lateral view of mandible.

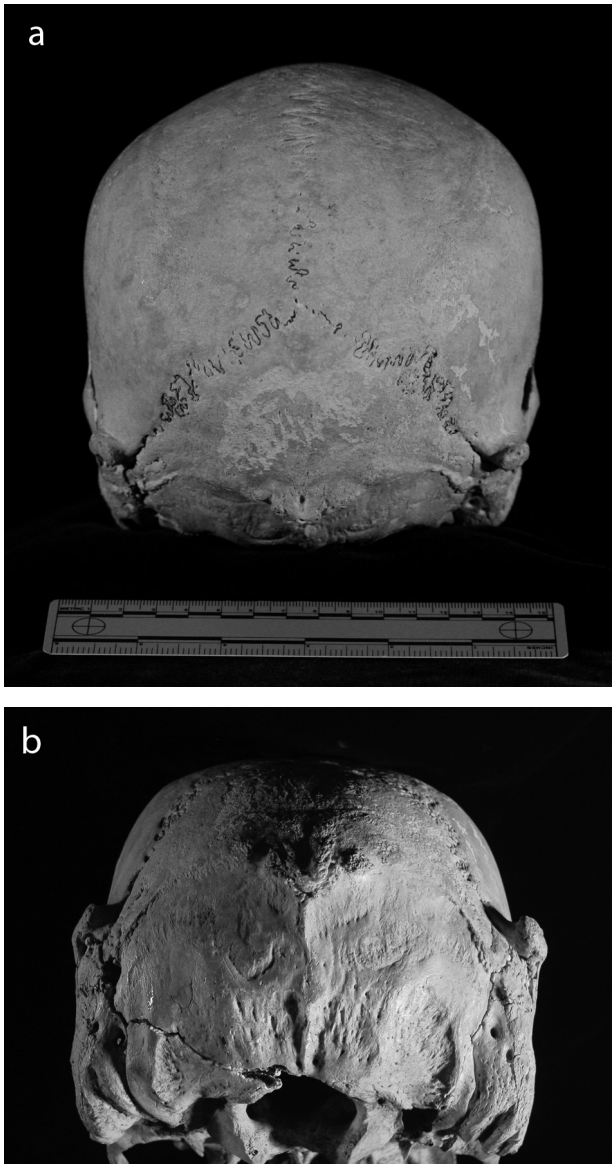

Figure 8. Box 23
a) 'Los Chinos' posterior view of cranium;
b) Note large tuberosities, inferior posterior view.

craniometric data using the CRANID programme (Wright 2007). CRANID6 uses the database of W. W. Howells (1973) combined with additional data (most importantly for this study is the inclusion of Patagonian samples) resulting in a database consisting of 3,163 crania from 74 sample populations from around the world. The program evaluates morphological similarity of an unknown skull to those in the database to help determine likely ancestry (Wright 2008).

The LDA method for data reduction was applied to both size and shape and shape only to examine the likely ancestry of the six crania. In addition, NNDA was applied to data to determine which of the 3163 individual crania in the database is the actual nearest neighbour of the unknown skull, again based on both size and shape and shape only. A final analysis using only the first two canonical variants was also conducted and the position of each of the six crania was compared to the database. Additional metric data were collected for some of the post-cranial material. In particular we measured the characteristics of the complete femora in boxes 10 and 11 and the from Coronel material.

Results

According to the CRANID analyses, the morphology of the crania contained in boxes 11, 13 and 18 could all be classified with high probability (above 0.5) as South American, specifically Patagonian, based on both the LDA and NNDA of size and shape. The box 24 cranium was most closely related to Peruvian samples based on LDA of size and shape and shape only, but its nearest neighbour in both size and shape and shape alone was with female crania from the Santa Cruz Islands in California (distance from its nearest neighbour = 5.498; mean for the database = 5.155).

Two crania, those from boxes 5 and 10, produced unusual results given their geographic location. The cranium in box 5, in terms of both LDA size and shape, and by shape alone, produced a high probability of belonging to the Buriat sample from Siberia (probability = 0.898 and 0.97 respectively). Its nearest neighbour is also a female Buriat skull (distance to nearest neighbour 5.97, which is between plus 1 and 2 standard deviations for the mean). The results for the analysis of the box 10 crania were particularly interesting. Based on LDA of size and shape, the highest probability (0.509) placed it with a Latte period female sample from Guam which according to Howells (1995: 5) dates to about 1000 AD, but is certainly pre-Spanish. The

Figure 9: 'Coronel' cranium posterior view.

Figure 10. Lateral view of Coronel mandible (on right) compared with mandible from box 10. Both belong to females.

Table 1. *Values for the 29 standard craniometric measurements taken on the six complete adult crania from Mocha Island. All measurements are in millimetres.*

Measurement	Code	Box 5	Box 10	Box 11	Box 13	Box 18	Box 24
Glabello-occipital length	GOL	160	176	175	170	168	165
Nasio-occipital length	NOL	160	174	168	165	163	162
Basion-nasion length	BNL	95	99	103	105	103	90
Basion-Bregma height	BBH	130	140	140	145	145	130
Maximum cranial breadth	XCB	141	135	138	145	142	144
Maximum frontal breadth	XFB	122	110	108	116	118	120
Biauricular breadth	AUB	121	120	124	128	134	125
Biasterionic breadth	ASB	105	110	110	110	107	105
Basion-prosthion length	BPL	98	96	103	107.8	102	95
Nasion-prosthion length	NPH	65.7	64.3	65.9	69.5	66.4	68.4
Nasal height	NLH	48	47.3	44.8	48	46.4	48
Orbital height	OBH	34.4	38	32	34	33	35.8
Orbital breadth	OBB	37.8	41	39	41	40	38
Bijugal breadth	JUB	105	120	123	125	120	112
Nasal breadth	NLB	24	24.2	24.7	26.3	24.1	22
Palate breadth, external	MAB	62	60	63.8	68	63.8	65
Bimaxillary breadth	ZMB	84	101.6	101	102	106	92
Zygomaxillary subtense	SSS	17	22	28	25	24	17
Bifrontal breadth	FMB	93.8	106.2	105	110	103	96
Nasio-frontal subtense	NAS	15	17	17	20	15	15
Biorbital breadth	EKB	90.7	102.7	102	106	101	93.5
Interorbital breadth	DKB	17.6	22	27.9	25.8	25	18.7
Cheek height	WMH	21.7	21.4	22.5	21.4	21	20.3
Frontal chord	FRC	109.6	108.5	109.9	116.3	106.7	105.5
Frontal subtense	FRS	24	25	20	24	19	25
Parietal chord	PAC	98.3	108.5	98	107.7	108.7	109
Parietal subtense	PAS	22	25	20	23	27	29
Occipital chord	OCC	93	100	102	98.5	97.3	92.3
Occipital subtense	OCS	22	31	32	27	26	25

two highest scores for NNDA using size and shape were again a female cranium from Guam but also a male Maori cranium (distance from nearest neighbour = 6.124). When considering shape only, the cranium was closest to Santa Cruz Island crania (probability 0.526).

A scattergram showing the estimated canonical variate scores for the six complete crania analyzed from Isla Mocha is shown in Figure 11. Where the LDA and NNDA results used 100% of the variance in the 29 dimensional canonical variate space, the scattergram uses only the first two canonical variates. These account for 36.2% of the variance (R. Wright, unpublished report provided to the authors). As can be seen, the crania fall into two clusters. The crania from boxes 5, 18 and 24 cluster with American samples while those from boxes 10, 11 and 13 fall with Pacific and East Asian populations.

Discussion

Vergara (1903) was the first to note the similarity between skulls from Mocha Island and Polynesian crania in his study of three skull from the island. The results of the LDA and NNDA provided some general support for our initial reaction when viewing the Mocha Island human remains in 2007, identifying one cranium (box 10) as most likely belonging to a Pacific population. Interestingly, the Mocha crania were not unusual by the standards of the CRANID6 database in that they generally had little difficulty in finding a nearest neighbour. However, they did provide some inconsistent geographic results. Based on the geographic location of Mocha Island, the crania found there could be expected to relate most closely to other South American material from the comparative dataset – and, in particular, most similar to the Patagonian material, if not the Peruvian sample. Indeed several of the crania, specifically those from boxes 11, 13 and 18, did clearly fit most closely with the Patagonian sample. Individuals in Boxes 11 and 13 were members of a multiple burial associated with the Early Ceramic Period, dated before 1000 AD, and the skull from Box18 was not associated with any dates.

Three of the six crania, however, provided results that were geographically inconsistent with their Mocha Island location in at least one or more of the analyses.According to Wright (2008) geographically inconsistent results could be the result of incorrect measurement of the skull in question; poor representation in the comparative database of the region from which the sample came; atypical morphological characteristics of the individual due to unusual growth or artificial deformation; or mixed ancestry of the skull in question. Several of these possibilities can be dismissed. The issue of incorrect measurement was considered at the time of study and that is why the measurements were taken several times for each skull. Looking at the populations included in the CRANID6 dataset, poor

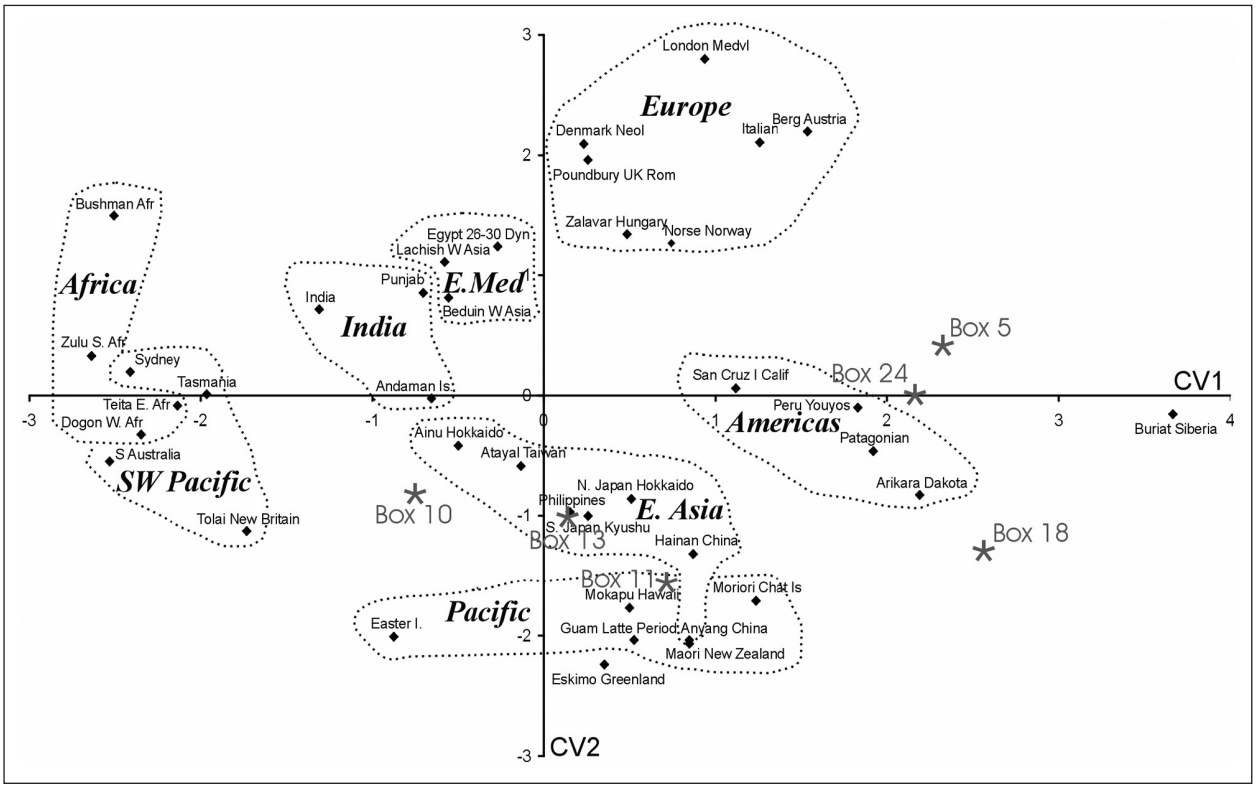

Figure 11. Scatterplot diagram of the six crania from Mocha Island compared to the CRANID database, plotted in the space of the first two canonical variates (discriminant functions).

representation does not seem to be a likely problem, with both Peruvian and Patagonian samples included.

This then leaves us with deformation and/or admixture as possible explanations for our CRANID results. Indeed, as noted by ourselves and Constantinescu (1997) there does seem to be some evidence of artificial deformation in much of the material we studied. We noted that there was some clear flattening of the posterior region on many of the crania which Constantinescu ascribes to cradle board deformation. We do not think, however, that the possible artificial deformation of the crania explains the results presented here. The possibility of admixture of the Mocha Island samples is particularly interesting and we suggest that admixture between indigenous Mapuche populations and Polynesian voyagers is worthy of consideration. In addition to the CRANID analyses, most notably those results for the cranium in box 10, there were also other indicators that might suggest Pacific connections including discrete traits and post-cranial characteristics.

One of the striking observations made when looking at both crania and post-cranial material from Mocha was the extreme robusticity. This characteristic is not unique to Pacific populations, and it has indeed been a noted characteristic of Patagonian and other southern South American populations (Lahr 1995, Perez *et al.* 2007), but it has not been recorded in Mapuche material from La Pampa, Argentina. The robusticity of the Mocha material was particularly marked when we compared the female Mocha material to the female skeleton from Coronel, close to Mocha. Figure 12 shows the distal femur from box 10 compared to the Coronel femur (both belong to females). The condylar breadth for the femur from box 10 of 73.6 mm is very close to the mean Maori female condylar breadth (73.7 mm) recorded by Houghton (1996: 50). This can be compared to a measurement of 61.19 mm for the Coronel femur. The only other complete and undamaged femur from Mocha that we could measure, from box 11, had a condylar breadth of 84 mm, also within the range Houghton (1996) recorded for Maori males (mean 82.1 SD 4.0 mm).

In addition to the general robusticity, we also noted a high degree of cranial robusticity and evidence of strong muscle attachments on most of the Mocha material – again, a characteristic often noted in skeletal material from the most southern populations of South America, and a trait associated with adaptation to cold or high latitude environments generally (Churchill 1998, Bulbeck 2001) and in southern South America (Bernal *et al.* 2006, Perez *et al.* 2007), and Polynesia (Houghton 1990) in particular. Thus climate or other shared non-genetic factors could be an explanation for the similarities between the Mocha crania and Polynesian populations observed in our CRANID results. However, the extreme tuberosities located on the

Figure 12: Distal femora from Coronel (on left) and Mocha Box 10. Both belong to females.

occipital of the cranium in box 23 and shown in Figure 8 are identical to those identified by Heathcote (1996: 286) on skeletal remains from the Marianas Islands. In describing these features he states:

> These hyperostotic traits, associated with attachments of neck, shoulder girdle and thoracic cage muscles, are distinctive in their relatively high frequencies and remarkable in their strong degrees of development in archaeologically-recovered Mariana Islander skeletal remains….Currently, these superstructures are enigmatic in origin and somewhat obscure in geographic patterning, though markedly strong expression of them *appears* to be virtually restricted to Oceania. So again, we have indications of possible Pacific contacts on Mocha Island.

One of the major questions, of course, if the results presented here are indeed evidence of Polynesian contact with Mocha, is when that might have occurred. The history of Mocha includes a large amount of European contact as it was often visited by whalers, traders and pirates. While 'blackbirding' activities from the mid 19th through to the early 20th centuries transported many Polynesian and other Pacific populations to Australia and South America, in particular to Peru, there is no record of them being taken to Mocha or any nearby location in Chile. Polynesians were often picked up as crew on European sailing ships – so evidence of admixture on Mocha could be related to arrivals on the island during the historic period. While we have little information regarding the context or dating of some of the Mocha material, much of it does come from archaeological contexts that strongly suggest that the material is pre-Columbian. So, is it possible that we might be seeing evidence of prehistoric Polynesian contact with Mocha that resulted in admixture with the indigenous Mapuche community?

There has yet to be any evidence from molecular studies of South American populations suggesting admixture with Pacific populations (other than in locations such as Rapa Nui where historic admixture is to be expected). Similarly the archaeological evidence of Polynesian contact with the Americas is limited though a topic of much recent debate (Jones & Klar 2005, 2006; Anderson 2006; Storey *et al*. 2007, 2008; Gongora *et al* 2008). The lack of such evidence however could be easily explained if prehistoric Pacific contact was minor and/or limited in time and space. But if such limited contact did happen, when, where and how might we expect to find evidence of it?

The dating of the settlement of central and east Polynesia has been a topic of debate in recent years, but a consensus is beginning to appear indicating earliest eastward expansion from West Polynesia within the last 1200 years, beginning around 800 AD (Anderson & Sinoto 2002, Kirch & Kahn 2007). It has been suggested that the colonization of the extremes of the Polynesian Triangle, specifically the settlement of Rapa Nui and New Zealand, occurred as late as 1200 AD (Hunt & Lipo 2006, Wilmshurst *et al*. 2008). These dates provide some indication of the periods during which there might have been contact with South America. Contact is unlikely to be dated to before 800–900 AD but it could have been made at any time up until European arrival in the Pacific when long distance voyaging was no longer practiced by most Polynesian societies (Rolett 2002). The dating of the pre-Columbian chicken bones from the El Arenal site fit into this later period (calibrated dates at 2 SD range from AD 1304 to 1459). Interestingly, the cranium that shows the strongest affiliations with Pacific populations is the one from box 10, which corresponds to El Vergel period (1000–1500 AD).

Computer voyaging simulations conducted by a number of researchers in the 1990s (Irwin *et al*. 1990, Finney 1994) demonstrated that voyaging from Polynesia to the Americas was feasible and during an El Niño event such a trip could be much faster. Voyaging simulations indicate that canoes leaving from central Polynesia or Rapa Nui could arrive on the coast of south-central Chile (Finney 1994), in the middle of the area occupied by the Mapuche.

Islands such as Mocha might have been targeted for occupation by Polynesians arriving in South America – the Lapita ancestors of Polynesians often settled small offshore islands near larger landmasses and the Polynesian back migration into Melanesia also resulted in Polynesians often settling small, offshore islands. Such islands, off the coast of the Americas, are also one of the few places where Polynesian contact or a settlement might be archaeologically visible as the arrival of a boat load of Polynesian traders or settlers would be likely to have a more significant impact culturally and biologically on a small island population than on the mainland. There is no indication that archaeological research on Mocha Island has considered the possibility of Polynesian contact. We suggest that given the results presented here, further research on the island should take place, specifically to address this issue.

The possibility of Polynesian contact with North America, particularly in the area occupied by the Chumash tribe near what is today Santa Barbara, California, has been raised by archaeologist Terry Jones and linguist Kathryn Klar and has been the topic of significant debate (Klar & Jones 2005, Jones & Klar 2005, 2006, 2009, Anderson 2006, Arnold 2007). We will not elaborate on the debate here but simply note that, in the NNDA studies of the Mocha crania, samples from Santa Cruz Island (one of the Channel Islands), which also happen to be identified as Chumash (Howells 1995), were identified as being a nearest neighbour. This was particularly the case for the cranium from box 24, but also for the box 10 sample in the analyses of shape alone. It could be that this similarity is due to the limited number of coastal American populations in the dataset, or the result of adaptations to similar environmental conditions, but it could also perhaps indicate a similarity based on admixture with Polynesians in both the Santa Cruz and the Mocha Island crania.

In addition to further archaeological investigation of Mocha Island and similar locations, we also suggest there is a need for further study of archaeologically recovered human and faunal remains from both Mocha and the general coastal region. As was demonstrated by the discovery of the pre-Columbian chicken bones found in a site less than 100 km north of Mocha, the use of ancient DNA evidence is one way of identifying pre-historic trans-Pacific interactions. However, as debates regarding that topic (Gongora *et al*. 2008, Storey *et al*. 2008) have shown, evidence for a Polynesian presence based on radiocarbon dated commensal animal bones can be questioned, in part because the origin of the humans who undertook the translocation has to be assumed. The identification of pre-Columbian Polynesian human DNA however would provide a much stronger case.

To date there is very limited ancient DNA data for South American coastal populations, and what has been identified does not contradict indications based on modern DNA analyses of South American populations, with all four South American mitochondrial DNA (mtDNA) haplotypes, A, B, C and D, present (Moraga *et al*. 2005, Fehren-Schmitz 2009). No evidence of the Pacific B4 lineages has been reported. Most genetic studies (of both modern and ancient populations) addressing population origins however have focused on mtDNA – which is maternally inherited. The most likely source of contact and resulting admixture, particularly if it was accidental, or the result of voyages of exploration and/or limited or sporadic trade, would be by Polynesian/Pacific men. Such contact would be invisible from a mitochondrial perspective (given that mtDNA is passed down through the maternal line). However, recent developments in DNA sequencing technologies (see Green *et al*. 2006, Mardis 2008, Millar *et al*. 2008) may provide a solution to this problem by allowing for the sequencing of nuclear DNA, including Y chromosome data, from ancient remains.

We suggest that the results presented here, along with the evidence based on archaeological chicken remains and the similarities between Polynesian and Mapuche cultural traits, indicate the need for further investigation of the evidence and impact of trans-Pacific contact. Some archaeological survey and environmental studies have begun focusing on the islands off of the South American coast (Anderson *et al*. 2002, Flett & Haberle 2008), and we look forward to seeing more of this work. We are now developing a research project to undertake archaeological investigations and ancient DNA analyses of human and other commensal animals recovered from Mocha and similar sites in south central Chile in order to address questions of Polynesian contact in the Americas and the impact of such contact for both American and Pacific prehistory.

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