Mi ochondrial DNA Anal i of Ancien Per ian Highlander

K - S [1*] N A [,2] S G [,3] I S [4]

[1]De a e f A h g , Na a a e ca a ed b H a H B agha a d a c d a af che h e a f Pe ha e f Pa ca ca cha, Pa a ac a, a d H a a ea he fa ed de ed e . O d gge a g ge e c I ca a e a e a d a e f Mach P cch a af be ee a ed a e e-H a c d d a a d a a ed b e a e cha eac , a d he e de A dea h gh a de . A e a a f he e e c a ed h a c e a d de DNA f a - Mach P cch e g ca c ec gge ha he e - Ce a A dea a ea e he h he ed d g- de he e e e a ed g f a e f a e h gh a d g . The c a d c d g eg f c a a a d h gh a d eg e ca ed b he I ca a e he ch d a DNA (DNA) f 35 d d a h f a ed e . O e a , d d ca e ha he g e e e ced, a d he ha g f each d- a ed d d a f Pa ca ca cha a d Pa a ac a d a e e de e ed. The f e e c da a f he ha - e e d ge h gh a de h ded e g f he e a e h c ea h e f de ech a a d A a a a he Pe a

in alla ion and oad and i a chi ec al and ce amic le , he hi o of Pa ca cancha da e back o he eign of he Inca king To a Inca (on of he king Pachac i Inca Y an i), a o ima el in he la e 15 h cen (Kendall, 1985). Ba ed on a chi ec e, ce amic , and o he a ifac fo nd in a ocia ion, he b ial ha Bingham e ca a ed a Pa ca cancha and Pa allac a can be a igned o he e iod of he Inca con ol of he U bamba Valle , f om ca. mid-15 h o ea l 16 h cen ie (Bingham, 1913; Kendall, 1985; MacC d , 1923).

O e he a 20 ea , in addi ion o he afo emen- ioned o k led b Kendall, he e ha been m ch effo o el cida e Inca and e-Inca occ a ion along he “Sa-

e_,ed in t he HVR 1 r.egion. F r.t he r. cha r. ac t r. i a t ion of

inde enden l , ing he mono le PCR me hod o ma i-
mi e he ob ne of PCR.

A 1-µl ali o of he PCR od c a e a a ed b elec o ho e i in an 8-cm na i e ol ac lamide gel (10% T, 5% C) con aining 1 × TBE b ffe (H 8.0) i h nning b ffe (0.5 × TBE, H 8.0). DNA band e e de ec ed b l a iole i adia ion af e aining i h e hidi m b omide (Fig. 2).

Da a anal i

Wi h im o ed kno ledge of he global m DNA ee in ecen ea , an nde anding of he c e of m DNA da a and a igning he m DNA e o a lace in he global m DNA ee ha e been im li ed. Con ol-egion mo if e e iden i ed fo a majo i of he majo ha log o and hei bha log o (Al e -Sil a e al., 2000; Bandel e al., 2001; Ki i ild e al., 2002; Kong e al., 2003; Maca la e al., 1999; Ma ama e al., 2003; Q in ana-M ci e al., 1999; Yao e al., 2002, 2003).

The efo e, e a igned each m DNA o ha log o acco ding o he HVR 1, HVR 2, and coding- egion da a, ing he da a and cla i ca ion ee de c ibed abo e, ch ha each am le a alloca ed o he malle named ha log o o hich i belonged. If he ha log o had f he cha ac e i ed bha log o , an a e i k a a ached o he name of he ha log o o indica e ha he ha log o a co ld no be iden i ed f he (Table 3). Since e e al egmen of he ame m DNA e e anal ed inde enden l , me ic lo ca e a aken o a oid a i cial ecombina ion ca ed b o en ial am-le c o o e. Af e a igning he m DNA o ele an ha -log o , e cla i ed hem f he in o ma e nal line , ba ed on he n cleo ide change ob e ed in he con ol and coding egion .

To el cida e biological ela ion hi he4420-1..,4493a

TABLE 3. N ce de cha ge b e ed a ce Pe a h gh a de a a ed e e d

Si e and ecimen n mbe	Ha log o	Ma e nal line	M a ion in egmen t [1]			APLP anal i [3]			
			16209–16402 (16000+)	128–267[2]	10382–10465 (10000+)	5178	8794	14318	9 b
Pa ca cancha									
195	A*	A*-1	223 ***290 319*** 362	146 ***235***	CRS	·	***T***	·	2
208	A*	A*-1	223 ***290 319*** 362	146 ***235***	CRS	·	***T***	·	2
216	A*	A*-2	217 223 266 ***290 319*** 343T 362	146 153 ***235*** 260	CRS	·		·	2
192	B4*	B4*-1	***217*** 272 362	CRS	CRS	·	·	·	***1***
213	B4*	B4*-2	***217*** 289	143	CRS	·	·	·	***1***
198	B4*	B4*-2	***217*** 289	143	ND	·	·	·	***1***
203	B4*	B4*-3	***217***	146 215	CRS	·		·	***1***
210	B4*	B4*-4	***217*** 228 379N	214	CRS	·	·	·	***1***
212	B4*	B4*-5	214 ***217*** 262	231N	CRS	·	·	·	***1***
214	B4*	B4*-6	***217*** 278	146 215	CRS	·	·	·	***1***
227	B4*	B4*-7	***217*** 357	143	CRS	·	·	·	***1***
233	B4*	B4*-8	***217*** 362	CRS	CRS	·	·	·	***1***
230	B4a	B4a-1	***217 261*** 319	CRS	CRS	·	·	·	***1***
193	C*	C*-1	223 ***298*** 325 ***327***	146 ***249d***	398 ***400***	·	·	***C***	2
204	C*	C*-1	223 ***298*** 325 ***327***	146 ***249d***	398 ***400***	·	·	***C***	2
211	C*	C*-2	223 ***298*** 325 ***327***	***249d***	ND	·	·	***C***	2
Pa allac a									
680	B4*	B4*-2	***217*** 289	143	CRS	·	·	·	***1***
978	B4*	B4*-3	***217***	146 215	CRS	·	·	·	***1***
681	B4*	B4*-9	***217*** 296N 321 363 390	214 234	CRS	·	·	·	***1***
686	B4*	B4*-10	***217***	152	CRS	·	·	·	***1***
689	B4*	B4*-10	***217***	152	CRS	·	·	·	***1***
687	B4*	B4*-11	***217***	CRS	CRS	·	·	·	***1***
974	B4*	B4*-11	***217***	CRS	CRS	·	·	·	***1***
981	B4*	B4*-12	***217*** 268 348 378 379		CRS	·	·	·	***1***
989	B4*	B4*-13	***217*** 294	143 210	CRS	·	·	·	***1***
677	B4*	B4*-14	***217***	152, 204	CRS	·	·	·	***1***
683	B4a	B4a-2	***217 261***	CRS	CRS	·	·	·	***1***
976	B4a	B4a-3	***217 261N*** 357	143	CRS	·	·	·	***1***
678	B*	B*-1	***217*** 381	CRS	***398***	·	·	·	***1***
682	C*	C*-1	223 ***298*** 325 327	146 195 ***249d***	398 ***400***	·	·	***C***	2
975	C*	C*-3	223 246N ***298*** 325 327 373		398 ***400***	·	·	***C***	2
676	C*	C*-1?	223 ***298N*** 325N 327		398 ***400***	·	·	***C***	2
977	D*	D*-1	325 362N	CRS	398 ***400***	***A***	·	·	2
H a a									
899	C*	C*-1	223 ***298*** 325 ***327***		398 ***400***	·	·	***C***	2
897	C*	C*-4	223 ***298*** 325 ***327***		392 ***400***	·	·	***C***	2

[1] All ol mo hic i e a e n mbe ed acco ding o e i ed CRS (And e e al., 1999). CRS deno e ha e ence of egmen i iden ical o e i ed CRS, and N indica e no de e mined. S f T indica e an e ion, and d indica e dele ion. Dele ion a e eco ded a la o ible i e. indica e ha PCR od c a no ob ained a egion. Diagno ic ol mo hi m a e indica ed b bold i alic e.

[2] N cleo ide change a o i ion 263 in egmen 128–267 a ob e ed in all ecimen , and he efo e i omi ed.

[3] Diagno ic ol mo hi m a e em ha i ed b bold i alic e. Do indica e ha no n cleo ide change a ob e ed. indica e ha PCR od c a no ob ained in egion.

eco e and e encing a e of 61.5% and 70.8%, e- ec i el . In con a of e en indi id al f om he H a a, onl o (o 28.6%) e e cce f ll e enced.

Ha log o di ib ion fo he o al am le a a follo : 8.6% A, 65.7% B, 22.9% C, and 2.9% D. Ha - log o f e encie of con em o a Ame indian o la- ion and ancien no h coa am le a e al o ho n in Table 4. F- a i ic f om ha log o f e encie among egional o la ion a e ho n in Table 5. An e ac e of diffe en ia ion be een each ai of o la ion e ealed a i icall igni can diffe ence e ce be- een he ancien highlande and con em o a cen al Andean o la ion (igni can F $P = 0.180 \pm 0.054$).

To in e iga e he ela ion hi among he a elli e comm ni ie of he o al e a e of Mach Picch , m DNA e ence of Pa ca cancha and Pa allac a e e com a ed. Ha log o f e encie of Pa ca cancha and Pa allac a a e ho n in Table 6. Gene ic di e i e l fo he e o i e a e ho n in Table 7. Mean n mbe of ai i e diffe ence and n cleo ide di e i a e ligh l la ge in he Pa ca cancha.

DISCUSSION

Haplogro p pro le of indi id al e amined in he pre en d

We fo nd ha ha log o B a he mo f e en among kele al am le anal ed in he Inca- e iod e i- den of he U bamba Valle , follo ed b ha log o C, A, and nall D. The mo di inc i e fea e of he ha log o o le of indi id al e amined in he e - en d i he high f e enc of ha log o B (65.7%; 23 of 35 indi id al ; Table 3 and 4). Cla if ing indi id- al in o ma e nal line e l ed in ha log o B ha ing a lea 18 diffe en line in 23 indi id al . In o he o d , he high f e enc of ha log o B i no ca ed b he concen a ion of indi id al on a eci c ma e nal line.

Ha log o B i he common ha log o in con em o- a Cen al Andean o la ion . When he ha log o o le of he e ancien e iden of he U bamba Valle a com a ed i h ha of o he So h Ame ican o - la ion , he fo me ho ed a clea o imi o he mode n Cen al Andean o la ion ha a e di ib ed ima il in he Pe ian and Boli ian highland (Table 4). Thi nding i no i ing, con ide ing he highland loca ion of he d a ea.

On he o he hand, he ancien highlande con ide - abl diffe f om indi id al of he ancien no h coa comm ni in e m of m DNA ha log o f e enc . Va io line of a chaeological e idence indica e in ima e c l al in e ac ion be een he ancien no h coa al o la ion and con em o aneo Ec ado ian and Co- lombian o la ion (Shimada, 1995, 1999; Shimada e al., 1997, 2000). Rela i el high f e encie of ha -

A eologia e Hi o ia del Pe) and Ja ane e ho og a- he Y aka Yo hii fo hei a i ance in he collec ion of o h am le ed in he m DNA anal i . Re ea ch b K.-I.S. fo hi d a o ed b G an in-Aid fo Scien i c Re ea ch 13575017 f om he Mini of Ed ca ion, Science, S o and C l e, Ja an.

LITERATURE CITED

Adachi N, Dodo Y, Oh hima N, Doi N, Yoneda M, Ma m a H. 2003. Mo hologic and gene ic e idence fo he kin hi of j enile kele al ecimen f om a 2,000 ea -old do ble b - ial of he U -Mo hi i e, Hokkaido, Ja an. An h o ol Sci 111:347–363.

Adachi N, Ume K, Takiga a W, Saka e K. 2004. Ph loge- ne ic anal i of he h man ancien mi ochond ial DNA. J A chaeol Sci 31:1339–1348.

Al e -Sil a J, San o MDS, G ima ae PEM, Fe ei a ACS, Bandel HJ, Pena SDJ, P ado VF. 2000. The ance of B a ilian m DNA linage . Am J H m Gene 67:444–461.

And e RM, K backa I, Chinne PF, Ligh o le RN, T n- b ll DM, Ho ell N. 1999. Reanal i and e i ion of he Cam- b idge efe ence e ence fo h man mi ochond ial DNA. Na Gene 23:147.

Baillie G, Ro hhamme F, Ca ne e FR, B a i CM, Bianchi NO. 1994. Fo nde mi ochond ial ha lo e in Ame indian o - la ion . Am J H m Gene 55:27–33.

Bandel HJ, Lahe mo P, Richa d M, Maca la V. 2001. De ec - ing e o in m DNA da a b h logene ic anal i . In J Legal Med 115:64–69.

Ba i a O, Kolman CJ, Be mingham E. 1995. Mi ochond ial DNA di e i in he K na Ame ind of Panama. H m Mol Gene 4:921–929.

Bingham H. 1912. P elimina e o of he Yale Pe ian e- di ion. B ll Am Geog Soc 44:20–26.

Bingham H. 1913. In he onde land of Pe . Na l Geog Mag 24:387–573.

Bingham H. 1916. F he e lo a ion in he land of he Inca . Na l Geog Mag 29:431–473.

Bingham H. 1930. Mach Picch , a ci adel of he Inca . Re o of he e lo a ion and e ca a ion made in 1911, 1912 and 1915 nde he a ice of Yale Uni e i and he Na ional Geog a hic Socie . Ne Ha en: Yale Uni e i P e .

B ge RL, Sala a LC. 2003. P eface. In: B ge R, Sala a LC, edi o . The 1912 Yale Pe ian cien i c e edi ion col- lec ion f om Mach Picch : h man and animal emain , Yale Uni e i blica ion in an h o olog 85. Ne Ha en: Peabod M e m of Na al Hi o , Yale Uni e i . iii– .

Ea on GF. 1916. The collec ion of o ological ma e ial f om Mach Picch . Memoi of he Connec ic Academ of A and Science 5. Ne Ha en: T le, Mo eho e and Ta lo .

Fa ing on IS. 1995. The m mm , e a e and alace of Inka H a na Ca ac a Q i eg anca. Ta an in 1:55–65.

Gin he C, Co ach D, Penacino GA, Re JA, Ca ne e FR, H MH, Ande on A, J J, Sal ano FM, King MC. 1993. Gene ic a ia ion among he Ma che Indian f om he Pa a- gonian egion of A gen ina: mi ochond ial DNA e ence a ia ion and allele f e encie of e e al n clea gene . EXS 67:211–219.

Ho ai S, Kondo R, Nakaga a-Ha o i Y, Ha a hi S, Sonoda S, Tajima K. 1993. Peo ling of he Ame ica , fo nded b fo majo lineage of mi ochond ial DNA. Mol Biol E ol 10:23–47.

Kendall A. 1974. A chi ec e and lanning a he Inca i e in he C ichaca a ea. Bae le A chi 22:73–137.