DIACHRONIC DIFFERENCES IN TAIWAN DENTAL MORPHOLOGY

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This paper shows that there are a number of significant differences in the frequencies of maxillary dental crown and root traits in a much-studied ethnographically-derived Taiwan Atayal cranial series when compared with a newly composed archaeologically-derived series. The majority of frequency differences are in the direction of mainland Chinese as represented by crania from the Shang Dynasty site of Anyang. This suggests that the Atayal are genetically admixed. It is our opinion that the Atayal should no longer be used in comparative investigations as representative of aboriginal Taiwan. All previous studies where this series has been employed as representing aboriginal Taiwan should be re-assessed in light of our finding of probable mainland Chinese admixture.

MATERIALS AND METHODS

The Atayal series originated from the Wushe village area (24°02'N, 121°08'E) of the Atayal tribe in north-central Taiwan. The exact age of the collection of 92 crania (of which 48 were dentally usable) is uncertain, although the high organic content of the bone, hemoglobin stain, and bone plasticity suggest an age of less than 100 years. Twenty percent of the skulls possess multiple basal and posterior cut-marks evidencing decapitation with a thin metal blade such as a military sword. The series originally belonged to the Department of Anatomy of Taiwan National University, Taipei, and was subsequently turned over to the Institute of History and Philology, Academia Sinica, Taipei. The whereabouts of the lower jaws was unknown in 1975 when the senior author examined the Atayal along with teeth of the similarly-housed Shang Dynasty Anyang mainland Chinese series excavated by Li Chi and his colleagues.

The Atayal are one of nine or so remaining Taiwan 'tribes' with agricultural and hunting-fishing economies. These tribes are thought not to be descended from the Changpinian chopper-tool users, but from the pottery-making and rice-millet-growing indigenes and immigrants who began to arrive around 6000 BP (Sung, 1980). Classified linguistically and culturally as Indonesian or Malaysian, modern Taiwan aborigines represent the descendants of a complex population history (Chai 1967; Farrell 1969). Since ocean currents trend northward around Taiwan from the South China and Philippine Seas, it is not surprising that Taiwan aboriginal culture lacks significant Jomon influences from Japan, while the southerly

Indonesian and Malaysian cultural influences are numerous.

After AD 1600 population pressure and starvation forced many Fujian Chinese to migrate to Taiwan. These Mongoloid immigrants introduced modern rice agriculture, various metals, writing, water buffalo, goats, and ducks. The Chinese now outnumber the aboriginal Taiwan population, by 15 million individuals.

The Atayal crania have been previously examined by various workers including Chang (1949), Kanaseki (1952), and Tokitsu (1960). Studies on living Atayal are numerous (see Kouchi 1983 for a listing).

The archaeologically-derived Taiwan crania were examined by the senior author in February 1984, using the same observation criteria and methods as in the 1975 work. The scoring procedures are given in the citations at the end of Table 1. Several crania of both series had teeth extracted when alive, particularly upper canines.

The 69 archaeologically-derived individuals with usable dentitions are from seven sites dating at least 1200 years old. The sites are:

Site, Yuan-Shan, Taipei. Excavators, Li, Shih and others, 1952-53. Location, 25° N, 121°3' E. Carbon 14 dates, (all shell) 3860 ± 80 BP, 3540 ± 80 BP, 3190 ± 80 BP. Economy, subtropical agriculture, shellfish, hunting, fishing. Publication, Sung 1980. Crania, 1.

Site, Pei-Nan. Excavator, Sung and Lien, 1980-82. Location, 22°45' N, 121°1' E. Carbon 14 dates, (charcoal) 2818 ± 110 BP. Economy, subtropical agriculture, hunting, and fishing. Publication, Lien 1982; Sung and Lien 1983. Crania, 26.

Site, O-Luan-Pi. Excavators, Sung, Huang, Lien, Li, 1966. Location, 22° N, 121° E. Date c. 3000 BP (typological dating). Economy, subtropical agriculture, shellmound, hunting, fishing and shellfish. Publication, Sung, Huang, Lien, and Li 1967. Crania, 5.

Site, Ma-Tou-Lu, Ta-chia. Excavators, Shih and Sung, 1945. Location, 24°3' N, 120°45' E. Date c. 1200 BP (typological). Publication, Sung and Chang 1945. Crania, 1.

Site, Fan-Tsu-Yuan. Excavators, Shih and Sung, 1955-57. Location, 24°15' N, 120°3' E. Carbon 14 date, 1200 ± 80 BP (shell). Economy, agriculture, hunting and subtropical shellmound (prone burial culture with iron tools). Publication, Shih and Sung 1956; Sung 1962. Crania, 29.

Site, Ken-Ting. Excavators, Japanese scholars, 1930s, and Li, 1977. Location, 22° N, 121° E. Date 3985 ± 145 BP (shell). Economy, subtropical agriculture, hunting, and fishing. Publication, Li, 1981. Crania, 6.

Site, Shih-san-hang. Excavator, Shih, 1960. Location, 25° N, 121°4' E. Date c. 1145 ± 206 BP (charcoal). Economy, fishing, shellfish (shellmound). Publication, Yang 1961, Sung 1965. Crania, 1.

The mainland Chinese crania were excavated between 1929 and 1937 by Li Chi and associates from the Bronze Age site of Anyang (c. 1384 to 1111 B.C.) in Henan Province (Li 1977). The crania came from the royal tomb area at Xibeigang (Hsi-pei-kang) and are thought to be remains of sacrificial victims (Li 1954).

RESULTS

Table 1 provides frequencies of maxillary dental traits in the archaeologically-derived Taiwan series, the Atayal, and comparative mainland Chinese from Anyang. The Atayal series lacked mandibles, so we are reporting only maxillary dental traits. Table 1 also gives the statistical results of chi-square comparisons between the two Taiwan series.

Trait and expression %	Taiwan archaeological	Atayal ethnographic	Anyang Chinese	X_1^2 Atayal/ Taiwan
Winging I1				
1. Bilateral	20.0	26.1	17.2	2.22
2. Unilateral	0.0	8.7	4.1	P=.2 - .1
3. Straight	80.0	56.5	76.6	
4. Counter-winging	0.0	8.7	2.1	
No. individuals	(15)	(23)	(145)	
Note 1				
Shoveling I1				
0. None	0.0	0.0	0.0	3.03
1. Faint	9.1	0.0	0.0	P=.1 - .05
2. Trace	31.8	17.4	10.1	
3. Semi-shovel	40.9	52.2	33.6	
4. Semi-shovel	18.2	8.7	19.3	
5. Shovel	0.0	17.4	27.7	
6. Shovel	0.0	4.3	9.2	
No. individuals	(22)	(23)	(119)	
Weighted % (D=.143)	.383	.485	.560	
Note 2				
Double-shovel I1				
0. None	33.3	45.4	67.6	1.17
1. Present	66.7	54.6	32.4	P=.3 - .2
No. individuals	(21)	(22)	(142)	
Note 3				

Tuberculum dentale I2				
0. None (smooth)	85.7	15.4	80.3	13.35
1. Weak ridging	0.0	23.1	12.5	P ≤ .001
2. Strong ridging	0.0	0.0	1.4	
3. Small cuspule	14.3	0.0	0.7	
4. Small free cusp	0.0	7.7	0.0	
5. Medium free cusp	0.0	53.8	3.4	
6. Large free cusp	0.0	0.0	0.7	
7. Very large free cusp	0.0	0.0	1.4	
No. individuals	(14)	(13)	(147)	
Weighted % (D=.143)	.061	.462	.063	
Note 4				
Interruption grooves I2				
0. None	46.7	46.1	46.5	0.82
1. Present	53.3	53.9	53.5	P=.8 - .7
No. individuals	(15)	(13)	(114)	
Note 5				
Mesial ridge (Bushman) C				
0. None	100.0	97.1	96.2	0.30
1. T.d. & MLR weak	0.0	2.9	1.5	P=.7 - .5
2. T.d. & MLR medium	0.0	0.0	2.3	
3. T.d. & MLR large	0.0	0.0	0.0	
No. individuals	(10)	(34)	(131)	
Weight % (D = .333)	.000	.01	.02	
Note 6				
Distal accessory ridge C				
0. None	42.9	31.2	28.6	0.29
1. Trace	14.3	0.0	7.9	P=.7 - .5
2. Weak	42.9	25.0	12.7	
3. Moderate	0.0	18.7	20.6	
4. Strong	0.0	18.7	20.6	
5. Very strong	0.0	6.3	9.5	
No. individuals	(7)	(16)	(63)	
Weight % (D = .2)	.200	.425	.450	
Note 7				
Hypocone (cusp 4) M2				
0. None	14.8	27.6	4.8	8.58
1. Weak ridges	0.0	17.2	2.1	P=.01 -.001
2. Cuspule	18.5	3.4	4.8	
3. Small cusp	7.4	20.7	27.7	
3.5 Reduced cusp	59.3	27.6	50.0	
4. Large cusp	0.0	3.4	10.6	
5. Very large cusp	0.0	0.0	0.0	
No. individuals	(27)	(29)	(188)	
Weight % (D = .167)	.495	.356	.581	
Note 8				

Carabelli trait M1				
0. None (smooth)	40.0	45.9	63.1	0.21
1. Line or furrow	26.7	27.0	7.0	P=.7 - .5
2. Pit	13.3	5.4	8.9	
3. Double line	0.0	2.7	3.8	
4. Y-form	0.0	5.4	3.8	
5. No contact w/ groove	20.0	8.1	5.1	
6. Small contact	0.0	5.4	4.5	
7. High cone	0.0	0.0	3.8	
No. individuals	(15)	(37)	(157)	
Weight % (D = .143)	.219	.201	.187	
Note 9				
Cusp 5 M1				
0. None	77.8	81.3	67.9	0.54
1-5 Present	22.2	18.7	32.1	P=.5 - .3
No. individuals	(9)	(32)	(106)	
Note 10				
Enamel extension M1				
0. None (and reversed)	35.7	0.0	19.6	8.58
1. Slight (1.5mm)	14.3	15.1	22.8	P=.01 -.001
2. Medium (1.5mm)	7.1	6.1	15.6	
3. Marked (1.5mm)	42.9	78.8	42.0	
No. individuals	(28)	(33)	(224)	
Weighted % (D = .333)	.524	.879	.600	
Note 11				
Root number P1				
1. 1 root	81.8	52.9	70.1	4.85
2. 2 roots	18.2	41.2	27.8	P=.05 - .02
3. 3 roots	0.0	5.9	2.1	
No. individuals	(22)	(34)	(144)	
Note 12				
Root number M2				
1. 1 root	13.3	0.0	11.3	3.30
2. 2 roots	20.0	10.7	8.3	P=.10 - .05
3. 3 roots	66.7	89.3	80.4	
No. individuals	(15)	(28)	(133)	
Note 13				
Molar occurrence M3				
1. L and R M3 +	84.6	54.7	71.9	3.75
2. L and/or R M3 -	15.4	45.3	28.1	P=.10 - .05
No. individuals	(13)	(42)	(217)	
Note 14				
Palatine torus				
0. None (smooth)	42.9	41.6	20.0	0.00

1. Trace	57.1	52.1	55.3	P ≫ .9
2. Medium	0.0	4.2	21.4	
3. Marked	0.0	2.1	3.3	
4. Very Marked	0.0	0.0	0.0	
No. individuals	(7)	(48)	(215)	
Weighted % (D = .25)	.143	.167	.270	
Note 15				

Table 1. Dental morphology[1]

Inspection of Table 1 reveals a greater than chance frequency of significant differences between the two Taiwan series. Four out of 15 traits (26.7%) have significantly different frequencies. These are the hypocone, enamel extension, premolar root number, and tuberculum dentale. However, the latter has such a marked difference that we suspect possible sampling or observation error of some sort. Even 3/15 (20.0%) significant trait frequency differences is too great to be due solely to chance, so we conclude that the two Taiwan series are meaningfully different.

When the Atayal are compared with the Anyang Chinese the majority of the traits (11/15; 73.3%) reveal shifts towards the Anyang condition. These traits are shoveling, double-shoveling, canine mesial ridge, canine distal accessory ridge (this trait has some sex dimorphism according to Scott 1973, which we cannot evaluate with only crania), Carabelli's trait, second molar root number, third molar occurrence, enamel extension, premolar root number, winging, and palatine torus. Only four traits (26.7%) show no substantial difference between the two Taiwan series or show a shift away from the Chinese condition. These traits are incisor interruption groove, hypocone, first molar cusp 5, and tuberculum dentale. The difference in the ratio of traits shifted towards the Chinese and those that are not is significant ($x^2{}_1$= 6.53; P=.02 - .01).

DISCUSSION

Both the magnitude of the differences between the two Taiwan series, and the overwhelming shift of the Atayal towards the Anyang Chinese dental characteristics can be explained by gene flow from the mainland into the aboriginal populations after 4000 to 1000 BP. With a larger archaeologically-derived, regionally representative, and temporally stratified series we could possibly pinpoint where and when this gene flow started.

Relative to what is known about the rate of dental microevolution in the genetically-isolated prehistoric Americas (Turner 1983), we feel certain that the trait frequency differences in the two Taiwan series are not due chiefly to natural selection, mutation, or gentic drift. The most parsimonious explanation, in light of Taiwan prehistory (Chang 1969; Sung 1980), is that significant admixture has occurred between the aboriginal population and later immigrants from the Chinese mainland.

We consider this biological conclusion to be useful for culture prehistorians and archaeologists as well as physical anthropologists and geneticists concerned with the present and past human populations of Taiwan. Simply put, the Atayal, and possibly all other Taiwan aborigine tribes, have been significantly changed according to our diachronic study. We feel the Atayal are not representative of Taiwanese population genetics of late Pleistocene and most of Holocene time.

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FOOTNOTE

1. Observation procedures and trait descriptions can be found in the following citations:
1, Enoki and Dahlberg (1958). 2, Scott (1973); this scale approximates that of Hrdlicka (1920) as 0 = none, 1-2 = trace, 3-4 = semi, 5-6 = shovel. 3, modified from Dahlberg (1951). 4, Turner (n.d.). 5, Turner (1967). 6, modified after Morris (1975). 7, Scott (1973). 8, Larson, Scott, and Turner, in Scott (1973). 9, Dahlberg 1963). 10, Turner (1967). 11, modified after Lasker (1950). 12, Turner (1967). 13, Turner (1967). 14, no sign of tooth for absence score. 15, Turner (n.d.). See Turner (1979) for full citations of these scoring and observation precedures.

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