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Frontal and Facial Flatness of Major Human Populations

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ABSTRACT In the present study, the frontal and facial features of 112 populations from around the world are compared in terms of frontal and facial flatness measurements. Univariate analyses and canonical correlation analysis were applied to six indices representing flatness of frontal and facial bones. The deep infraglabellar notch, marked prognathism, and flat frontal bone show distinctive Australian/Melanesian characters among recent populations. Very flat faces in the transverse plane are the most common condition in eastern Asians. Some subSaharan Africans share similar characteristics with Australians in terms of marked prognathism and flat frontal bones in the sagittal plane on the one hand, and with eastern Asians on the other hand, for flat nasal and zygomaxillary regions. These results are not necessarily inconsistent with the evidence for regional continuity. The examination of relationships between frontal and facial flatness through canonical correlation analysis reveals a significant association between morphological features such as a deep infraglabellar notch, prognathism, flat frontal bone, and flat faces in the transverse plane. In this context, together with the generalized features of the late Pleistocene fossil record, the features of Australians having transversely projecting faces and of eastern Asians showing weak infraglabellar notchs, ortho-/mosognathism, and rounded frontal bones can be interpreted as a differential retention of ancestral traits of anatomically modern humans. This may allow us to suppose that the frontal and facial flatness features treated herein can be explained by the hypothesis of a single origin of anatomically modern humans. Am J Phys Anthropol 111:105–134, 2000.

Features relating to facial flatness have often been selected for studies of interpopulation variation (Debets, 1951; Oschinsky, 1962; Alekseev and Debets, 1964; Yamaguchi, 1973, 1980; Alekseev, 1979; Bulbeck, 1981; Rak, 1986; Trinkaus, 1987; Gill et al., 1988; Pope, 1991, 1992; Ishida, 1992).

Recent eastern Asian faces contrast markedly with many European and even New World contemporaries (Woo and Morant, 1934; Yamaguchi, 1973; Brues, 1977; Alekseev, 1979; Ishida, 1992). Eastern Asians exhibit midfaces with more anteriorly situated frontal processes of zygomatic bones and more or less flat nasal bones. Flatness of frontals in the sagittal plane, a deep and narrow infraglabellar notch, and marked prognathism are distinctive traits characterizing Australians and Melanesians (Weidenreich, 1951; Thorne and Wolpoff, 1981; Wolpoff et al., 1984; Baba, 1993, 1995; Lahr, 1996). SubSaharan Africans show, on average, pronounced facial prognathism (in terms

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TABLE 1. Samples used in this study

Sample name	Brief information
Japan	
1 Japanese	Recent people from the central part of Main-Island Japan, around Tokyo, and Tohoku district (Univ. of Tokyo,[1] Tohoku Univ.[2])
2 Ainu	Recent Ainu in Hokkaido, Japan; the majority of individuals examined were collected by Y. Koganei in 1888–1889, but the sample includes specimens collected later (Univ. of Tokyo,[1] Sapporo Medical University[3])
3 Jomon	Prehistoric people in Japan, ca. 5,300–2,300 years B.P. from the eastern part of Main-Island Japan (Univ. of Tokyo)
East Asia	
4 Northern Chinese	Northern part of China, mainly from Liaoning Prefecture (Univ. of Tokyo, Kyoto Univ.,[4] Natural History Museum[4])
5 Southern Chinese	Chinese from south of the Cheng River (Natural History Museum, Musée de l'Homme[6])
6 Koreans	Recent Koreans, mainly from south Korea (Univ. of Tokyo, Kyoto Univ.)
Northeast Asia	
7 Mongolians	Recent people from Mongolia (Musée de l'Homme)
8 Northeast Asians	Recent people from northeast Asia; Buryats, Amur-basin population, Yakut, and other native northeast Siberians (Natural History Museum, Musée de l'Homme)
9 Chukchis	Recent Chukchis from the Arctic region of northeast Asia (Musée de l'Homme)
Mainland Southeast Asia	
10 Vietnamese	Recent Vietnamese from Tonkin District (Musée de l'Homme)
11 Laos-Cambodia	Recent people from Laos and Cambodia (Musée de l'Homme)
12 Thailand	Recent Thailanders from around Bangkok (Natural History Museum, Musée de l'Homme, Univ. of Sydney[7])
13 Myanmar	Recent inhabitants in Burma (now called Myanmar) (Natural History Museum, Univ. of Cambridge[8])
14 Malay	Recent Malayans from Malay Peninsula, not including Sarawak people (Natural History Museum, Univ. of Cambridge, South Australian Museum[9])
15 Early SE Asians	Mesolithic and neolithic Malay from Gua Cha site; neolithic Laos from Abri-Sous Roche de Tam-Nang Anh; neolithic Vietnamese from Tonkin, Lang-Cuom, Dong Thuoc, Keo Phay, Pho Binh Gia (Univ. of Cambridge, Musée de l'Homme)
Island Southeast Asia	
16 Sumatra	Recent inhabitants of Sumatra Island (Natural History Museum)
17 Javanese	Recent inhabitants of Java Island (Natural History Museum, Univ. of Cambridge, Musée de l'Homme)
18 Borneans	Native inhabitants of Borneo Island, mainly the so-called Land Dayaks, but including Iban (Sea Dayaks) (Natural History Museum, Univ. of Cambridge, Musée de l'Homme, Univ. of Sydney, South Australian Museum)
19 Philippines	Recent native inhabitants of the Philippines, Tagalog and other tribes from Luzon and Mindanao Islands (Natural History Museum, Univ. of Cambridge, Musée de l'Homme)
20 Celebes-Molucca	Recent inhabitants of the Celebes and Molucca Islands (Natural History Museum, Univ. of Cambridge)
21 Lesser Sunda	Recent inhabitants of the Lesser Sunda Islands: Timor, Bali, Sumbawa, and Flores Islands (Natural History Museum, Univ. of Cambridge, Musée de l'Homme)
22 Andamanese	Recent inhabitants of the Great Andaman Islands, Jarawa and other tribes (Andaman Negrito groups), including a few sample from Little Andaman Island (Natural History Museum, Univ. of Cambridge Musée de l'Homme)
23 Nicobarese	Recent native people from the Nicobar Islands (Natural History Museum, Univ. of Cambridge, Musée de l'Homme)
24 Philippine Negritos	Recent Philippine Negritos, Aeta, Agta, and other tribes from Luzon Island (Natural History Museum, Musée de l'Homme)
New World	
25 Eskimos	Recent indigenous people from Greenland and northeast Canada (Greenland Eskimos and Canadian Inuit) (Natural History Museum, Univ. of Cambridge, Musée de l'Homme)
26 Subarctic	Native Americans from the subarctic culture area, Canada (Natural History Museum, Univ. of Cambridge)
27 Northwest America	Northwest coast of Canada, Native Americans from the Plateau, Great Basin, and Southwest culture areas (Natural History Museum, Univ. of Cambridge, Musée de l'Homme)
28 California	Native Americans from California (Natural History Museum, Univ. of Cambridge)
29 Northeast America	Native Americans from the Great Plains, Northeast, and Southeast culture areas (Natural History Museum, Univ. of Cambridge)
30 Mesoamerica	Native Americans from Mexico, including a few samples from Colombia and Ecuador (Natural History Museum, Univ. of Cambridge)
31 Caribians	Native Americans from the Carib Islands, including a few samples from Venezuela and Guyana (Natural History Museum, Univ. of Cambridge)
32 Peruvians	Cerro del Oro, Huacho, Pisagua, and other regions (Natural History Museum)
33 Fuegians-Patagonians	Terra del Fuego and Patagonia region, southernmost part of South America (Natural History Museum, Univ. of Cambridge, Musée de l'Homme)

(*continued*)

TABLE 1. (continued)

Sample name	Brief information
Micronesia	
34 Mariana	Recent Chamorros from Guam, Saipan, and Tinian Islands (Musée de l'Homme)
35 Caroline	Recent Ponape Islanders, including a few other Caroline Islanders (Musée de l'Homme, Univ. of Tokyo)
Polynesia	
36 Hawaii	Recent native Hawaiians; mainly from Oahu Island (Natural History Museum, Univ. of Cambridge)
37 Easter	Recent Easter Islanders (Natural History Museum, Univ. of Cambridge, Musée de l'Homme)
38 Marquesas	Early Marquesans from Uahuka Island (ca. 2,000 years B.P.) and recent Marquesas Islanders (B.P. Bishop Museum,[10] Natural History Museum, Musée de l'Homme)
39 Society	Recent Society Islanders, mainly from Tahiti (Natural History Museum, Musée de l'Homme)
40 Cook	Recent Cook Islanders, mainly from Mangaia (Natural History Museum, Kyoto Univ.)
41 Tonga-Samoa	Recent Tongans and Samoans (Australian Museum,[11] Univ. of Sydney, South Australian Museum, Natural History Museum, Univ. of Cambridge, Musée de l'Homme)
42 Maori	Recent aboriginal populations from New Zealand (Australian Museum, Univ. of Sydney, South Museum, Natural History Museum, Univ. of Cambridge)
43 Moriori	Recent aboriginal populations of Chatham Island (Australian Museum, Univ. of Sydney, South Australian Museum, Natural History Museum, Univ. of Cambridge)
Melanesia	
44 Fiji	Recent aboriginal Fijians (Australian Museum, Natural History Museum, Univ. of Cambridge, Musée de l'Homme)
45 New Britain	Recent inhabitants of New Britain Islands (Australian Museum, Univ. of Sydney, South Australian Museum, Natural History Museum, Univ. of Cambridge)
46 Vanuatu	Recent inhabitants of New Hebrides Islands (Australian Museum, Univ. of Sydney, South Australian Museum, Natural History Museum, Univ. of Cambridge)
47 New Caledonia	Recent New Caledonia Islanders (Australian Museum, Univ. of Sydney, South Australian Museum, Natural History Museum, Univ. of Cambridge)
48 New Ireland	Recent New Ireland people (Australian Museum, Univ. of Sydney, South Australian Museum, Natural History Museum)
49 Santa Cruz	Recent inhabitants of Santa Cruz Islands (Australian Museum, Univ. of Sydney, South Australian Museum, Natural History Museum)
50 Solomon	Recent inhabitants of Solomon Islands (Australian Museum, Univ. of Sydney, South Australian Museum, Natural History Museum, Univ. of Cambridge)
51 Torres Strait	Recent inhabitants of the islands of the Torres Strait (Natural History Museum, Univ. of Cambridge, Musée de l'Homme)
52 Papua New Guinea	Purari River delta, Fly River delta, Sepik River delta, and other regions (Australian Museum, Univ. of Sydney, South Australian Museum, Natural History Museum)
Australia	
53 New South Wales	Recent Australian Aborigines from the coastal region of New South Wales (Australian Museum, Natural History Museum, Univ. of Cambridge, Musée de l'Homme)
54 South Australia	Recent Australian Aborigines living near Adelaide (South Australian Museum, Natural History Museum, Univ. of Cambridge, Musée de l'Homme)
55 Murray River	Mainly from the Roonka site, but including a recent sample from Murray River basin, South Australia (South Australian Museum, Natural History Museum, Univ. of Cambridge, Musée de l'Homme)
56 Queensland	Recent Australian Aborigines from Queensland (Natural History Museum, Univ. of Cambridge, Musée de l'Homme)
57 Western Australia	Recent Australian Aborigines from Western Australia (Natural History Museum, Univ. of Cambridge, Musée de l'Homme)
58 Tasmania	Recent Tasmanian Aborigines (Natural History Museum, Univ. of Cambridge, Musée de l'Homme)
Indian Subcontinent	
59 Tibetans	Native Tibetans, mainly from Tibetan soldiers of the late 19th century (Natural History Museum, Univ. of Cambridge)
60 Nepalese	Sunwar and other regions; lowlanders, Nepal (Natural History Museum, Univ. of Cambridge)
61 Assam-Sikkim	Mishme, Naga, Thado, Kuki, Singho, Lepcha, and other tribes; Darjeeling, Assam, Sikkim Districts, Northeast India (Natural History Museum)
62 Bangladesh-Bhutan	Recent inhabitants of Bangladesh and Bhutan (Natural History Museum)
63 Bengal-Bihar	Hindu people, Musselman from the west Bengal District, natives of Patna and other regions of the Province of Bihar, Koa and others from Cuttack, Province of Orissa (Natural History Museum)
64 Punjab-Kashmir	Musselman, Peshwar, Hindu low-caste, Mohammedan, Punjab, and Kashmir Districts, Northwest India and Pakistan (Natural History Museum)
65 Delhi-Northwest India	Native Indians from around Delhi and those from Northwest India (Natural History Museum)
66 Madras	Native Indians from around Madras, Province of Tamil Nadu, mainly Dravidians; Malabar coast of India, Province of Karnataka, including Tamil, southern part of India (Natural History Museum, South Australian Museum)
67 Veddah	Recent Veddahs from Ceylon Island, Sri Lanka (Natural History Museum, South Australian Museum)

(*continued*)

TABLE 1. (*continued*)

Sample name	Brief information
Central-West Asia	
68 Afghanistan	Kelati, Pecheen Valley and other regions, natives of Afghanistan (Natural History Museum)
69 Palestine	Tell Duweir (Lachish), Bronze and Iron Age, ca. 5,000–3,000 years B.P., Palestine, Israel (Natural History Museum)
70 Turkey	Hellenistic and Roman periods, Constantinople and other places, Turkey (Natural History Museum)
71 Cyprus	Hellenistic and Roman period, Cyprus Islands (Natural History Museum)
Europe	
72 Greece	Recent Greece from several locations (Natural History Museum)
73 Ancient Greece	Ancient Greece from Sigeum, Cyrene, Samos, Corfu, Athens, Greece (Natural History Museum)
74 Italians	Frosinone, Rome, Sicily, Otaranto, etc. recent Italian soldiers (Natural History Museum)
75 Ancient Italians	From before the Christian period to 4–5 the century A.D.; Etruria, Naples, Rome, and other places (Natural History Museum)
76 Russians	Recent Russians, Don Cossack soldiers, Odessa (Natural History Museum, Univ. of Cambridge)
77 Hungarians	Ancient Churchyards at Buda-Pest, Magyar, Buda-Pest (Natural History Museum)
78 Czech	Charvaty, Central Moravia, Czechoslovakia (South Australian Museum, Natural History Museum)
79 Finland	Saarijarvi, Birkala, Kides, Carelia (Natural History Museum)
80 Norwegians	Recent Norwegians, probably seamen (Natural History Museum)
81 Swedish	Medieval graves at Stockholm; Calacarlian (Kopperberg, central Sweden) (Natural History Museum)
82 Lapps	Lycksele, on the River Umeå, province of Westerhotten; ancient Lapps found at Mortensuoes, Norway (Natural History Museum, Musée de l'Homme)
83 Holland	Friesland, Province of Groningen, Province of Gelderland, Province of Noord (Natural History Museum)
84 German	München, Hessian soldiers, Holstein, Saxon regiment, Leipzig, Germany (Natural History Museum, Univ. of Cambridge)
85 French	Ouchy, Upnor near Chatham, Lower Brittany, soldiers in the Army of Napoleon, recent French people, France (Natural History Museum, Univ. of Cambridge, Musée de l'Homme)
86 Ancient French	Gaulish, Gallo-Roman, and Frankish Merovingian times (418–752 A.D.) (Natural History Museum)
87 Spain-Portugal	Basque from Zaraus, Province of Guipuscoa, and other regions in Spain, and prehistoric Spanish: Genista cave no. 3, Gibraltar, Albama de Granada, stone age Spain; recent Portuguese from Corunna, Oporto (Natural History Museum)
U.K. series	
88 Ensay	Late medieval to post mediaeval periods, Scotland, excavated at Ensay Island (Natural History Museum)
89 Repton	St. Wystans, Repton, Derbyshire, northeast region of England, medieval era (Natural History Museum)
90 Poundbury	Late Roman period, Poundbury, southwest England (Natural History Museum)
91 Spitalfields-1	Mid-Victorian, Christ Church, Spitalfields, eastern region of London, England (Natural History Museum)
92 Spitalfields-2	Pre-17th century, Spitalfields (Univ. of Cambridge)
93 Neolithic UK	Lan Hill, Skend Leby, Kennet, Littleton Drew, Rodmarton, Rotherham, and other places (Univ. of Cambridge)
North Africa	
94 Badari	Ancient Egyptians from Badari, ca. 5,000–4,000 years B.P. (Univ. of Cambridge)
95 Naqada	Predynastic Egyptians from Naqada, ca. 5,000–4,000 years B.P. (Univ. of Cambridge)
96 Gizeh	26th–30th Dynasty, 664–343 B.C., Gizeh, Egypt (Univ. of Cambridge)
97 Kerma	Dinka near Omdurman, Deruish, 12th–13th Dynasty of Nubia, Kerma (Univ. of Cambridge)
98 Early Nubia	Island of Hesa and Biga, early Christian or Christian date, Nubia (Univ. of Cambridge)
99 Recent Nubia	Recent populations from Sesebi, Nubia (Natural History Museum)
100 Morocco	Tenerife, Orotaua, Guanche, Canary Islands, Morocco (Natural History Museum)
SubSaharan Africa	
101 West Africa	Recent people from west Africa; Senegal, Gambia, Guinea, Sierra Leone, Liberia, and Ivory Coast (Natural History Museum)
102 Nigeria-1	Ibo, northern Nigeria, west Africa (Natural History Museum, Univ. of Cambridge)
103 Nigeria-2	Ashanti, northern Nigeria, west Africa (Natural History Museum, Univ. of Cambridge)
104 Gabon	Fernand Vaz River, recent people from Gabon (Natural History Museum)
105 Congo	Recent people from Congo (Natural History Museum, Univ. of Cambridge)
106 Somalia	Erigavo District, Ogaden Somali, Darod Kuhar, Burao District, Somalia (Univ. of Cambridge)
107 Kenya	Nairobi, Teita Hills, Bantu-speaking people, Kenya (Univ. of Cambridge, Natural History Museum)
108 Tanzania	Haya from Musira Island, Lake Victoria, Kikunga cave, and Ikurunga Cave, Tanzania (Univ. of Cambridge, Natural History Museum)

(*continued*)

TABLE 1. (continued)

Sample name	Brief information
109 Uganda	Ankole, Basia native, Mt. Elgon (Natural History Museum, Univ. of Cambridge)
110 Malawi	Angoni, Lake Nyasa (Natural History Museum, Univ. of Cambridge)
111 South Africa	Zulu and Kaffir, Pietremanitzburg, Natal, and other places South Africa (Natural History Museum, Univ. of Cambridge)
112 Khoi-San	Recent Bushmen and Hottentots from South Africa (Natural History Museum, Univ. of Cambridge)

[1] Univ. of Tokyo: Department of Anthropology, Faculty of Science, University of Museum; Tokyo, Japan.
[2] Tohoku Univ.: Department of Anatomy, School of Medicine; Sendai, Japan.
[3] Sapporo Medical Univ.: Department of Anatomy, School of Medicine; Sapporo, Japan.
[4] Kyoto Univ.: Department of Zoology, Faculty of Science; Kyoto, Japan.
[5] Natural History Museum: Department of Palaeontology; London, U.K.
[6] Musée de l'Homme: Department of Anthropology; Paris, France.
[7] Univ. of Sydney: Department of Anatomy and Histology, Faculty of Medicine; Sydney, Australia.
[8] Univ. of Cambridge: Department of Biological Anthropology, Duckworth Laboratory; Cambridge, U.K.
[9] South Australian Museum: Department of Anthropology; Adelaide, Australia.
[10] B.P. Bishop Museum: Department of Anthropology; Honolulu, HI.
[11] Australian Museum: Department of Anthropology; Sydney, Australia.

of the gnathic index), with more or less flat faces comparable to some eastern Asians (Bulbeck, 1981; Groves, 1989; Howells, 1989; Stringer, 1989; Lahr, 1996).

Throughout the course of human evolution, craniofacial characters, including frontal and facial flatness, have changed in different groups, and thus differing degrees of these features are observed among recent human populations (Lahr, 1994, 1995, 1996; Lahr and Wright, 1996). According to Lahr (1996), there has been a process of change in craniofacial dimensions in modern humans that has produced the traits identified in most recent groups, although the specific features are not universal either temporally or geographically.

In the present study, following the pioneering studies by Howells (1973, 1989, 1995) and Lahr (1994, 1995, 1996), three aspects of the relationship between levels of frontal and facial flatness are examined: 1) the regional distribution of frontal and facial flatness; 2) possible phylogenetic interpretations of the variation found; and 3) implications for the current debate about modern human origins, as tested by Lahr and Wright (1996).

MATERIALS AND METHODS

The samples used here consist of 112 prehistoric and recent populations from major geographical areas in the world. Table 1 provides sample names and brief background information for each sample. All of the samples are of male crania.

Six indices were calculated to evaluate frontal and facial flatness: 1) glabella-opisthocranion/nasion-opisthocranion (M1/M1d) for evaluating the magnitude of the infraglabellar notch; 2) alveolar index, basion-prosthion/basion-nasion (M40/M5) for prognathism; 3) sagittal-frontal index, sagittal frontal chord/sagittal frontal arc (M29/M26) for frontal flatness in the sagittal plane tentatively; and three facial flatness indices defined by Yamaguchi (1973) as follows: 4) frontal index, nasion subtense/inner biorbital breadth (No. 43c/M43(1)); 5) simotic index, simotic subtense/simotic chord (No. 57a/M57); and 6) zygomaxillary index, zygomaxillary subtense/zygomaxillary chord (No. 46c/No. 46b). Descriptions for each measurement are given under the appropriate Martin (M) number by Bräuer (1988). The subtenses were not measured directly but were calculated from three sides of triangle measured by 0.1 mm, applying trigonometric formulae (Yamaguchi, 1973; see also Hanihara et al., 1999). In this study, frontal flatness represented by the frontal index is called fronto-orbital flatness to avoid confusion with frontal flatness in the sagittal plane.

The relationship between a set of transverse facial flatness variables and the flatness of frontals represented by the glabellar index, frontal index in the sagittal plane, as well as gnathic index was analyzed through canonical correlation analysis. Before applying canonical correlation analysis, the normal distribution of the six indices was examined for four samples having more than 100 individuals. The test for normal distribution was performed using *k*-statistics based on the skewness and kurtosis of the distribu-

TABLE 2. Mean and standard deviation (S.D.) for M1,[1] M1d,[2] and (M1 / M1d) ∗ 100[3]

Sample name	N	M1		M1d		M1/M1d (%)	
		Mean	S.D.	Mean	S.D.	Mean	S.D.
Japanese	131	182.1	5.91	179.3	5.88	101.6	0.68
Ainu	35	187.3	4.86	184.0	4.41	101.8	0.73
Jomonese	33	184.0	7.49	180.9	7.31	101.7	0.77
Northern Chinese	49	181.9	5.39	178.8	5.71	101.4	0.63
Southern Chinese	65	180.6	6.46	178.1	6.31	101.4	0.65
Koreans	23	179.6	6.98	174.8	7.46	101.9	0.80
Mongolians	32	180.9	6.34	178.4	6.08	101.4	0.69
Northeast Asians	17	179.9	5.50	177.7	5.37	101.2	0.56
Chukchis	12	186.2	5.44	183.7	5.12	101.4	0.75
Vietnamese	23	179.0	5.13	176.3	4.96	101.6	0.67
Laos-Cambodia	21	175.6	5.05	172.2	4.64	102.0	0.72
Thailand	18	177.1	6.00	173.4	6.24	102.1	1.05
Myanmar	88	176.6	6.39	173.8	6.11	101.6	0.81
Malay	44	175.3	7.72	172.6	7.57	101.6	0.69
Early-SE Asians	20	186.1	6.39	183.2	6.40	101.9	0.97
Sumatra	12	176.9	5.53	174.3	6.09	101.5	0.71
Javanese	61	176.9	5.56	174.0	5.53	101.7	0.82
Borneans	72	180.3	6.37	177.2	6.16	101.8	0.73
Filipinos	76	178.0	6.09	175.2	5.79	101.6	0.68
Celebes-Molucca	28	175.3	7.70	172.5	7.71	101.7	0.65
Lesser Sunda	9	179.3	6.80	175.8	6.70	102.0	0.77
Andamanese	49	169.1	5.37	167.4	5.00	101.1	0.63
Nicobarese	20	181.7	6.09	176.8	6.08	102.7	0.66
Negritos	17	171.6	6.20	169.4	6.18	101.3	0.40
Eskimos	77	189.6	6.72	185.6	6.42	102.2	0.79
Subarctic	22	186.6	5.34	183.6	5.15	101.7	0.78
Northwest America	20	184.8	8.90	182.5	8.16	101.3	0.93
California	31	181.8	8.74	179.1	8.61	101.5	0.85
East America	24	185.9	4.48	182.6	4.30	101.8	0.59
Mesoamerica	16	178.2	8.55	175.9	8.39	101.3	0.61
Caribians	18	181.1	6.88	178.7	6.82	101.3	0.74
Peruvians	64	174.6	5.73	172.2	5.64	101.4	0.69
Fuegian-Patagonian	37	189.1	6.51	185.1	6.36	102.2	0.71
Mariana	22	182.5	5.53	179.6	5.84	101.6	0.79
Caroline	11	185.2	8.34	181.1	7.58	102.3	0.72
Hawaii	71	183.8	6.53	180.3	5.78	101.9	0.87
Easter	64	192.1	5.61	186.7	5.23	102.9	0.81
Marquesas	56	186.3	6.91	183.0	6.53	101.8	0.80
Society	46	184.9	5.63	181.7	5.39	101.8	0.81
Cook	14	180.8	6.51	177.6	6.46	101.8	0.73
Tonga-Samoa	16	178.3	5.22	174.5	3.45	102.2	0.74
Maori	111	186.7	6.25	183.0	6.04	102.0	0.72
Moriori	70	187.0	5.56	184.1	5.21	101.5	0.75
Fiji	42	189.4	6.59	183.9	7.06	102.5	0.86
New Britain	58	183.5	5.86	178.4	5.76	102.9	0.78
Vanuatu	25	185.7	5.16	181.4	4.91	102.4	0.60
New Caledonia	37	185.0	6.11	181.2	5.74	102.3	0.87
New Ireland	26	182.4	6.44	178.0	6.16	102.5	0.78
Santa Cruz	16	185.3	5.81	181.1	5.06	102.3	0.91
Solomon	57	181.9	5.43	177.4	5.21	102.5	0.86
Torres Strait	55	185.0	6.85	180.9	6.40	102.3	0.73
Papua New Guinea	152	179.7	5.95	176.3	5.70	101.9	0.81
New South Wales	56	187.6	6.12	182.2	5.81	103.0	0.87
South Australia	122	188.5	6.21	182.9	6.01	103.1	0.83
Murray River	45	188.8	7.10	182.7	6.93	103.1	0.86
Queensland	20	183.2	6.94	178.4	6.36	102.7	0.79
Western Australia	22	184.9	7.04	180.4	6.58	102.5	0.70
Tasmania	11	184.5	7.46	178.8	7.28	103.2	0.91
Nepalese	30	179.1	6.30	176.3	5.77	101.6	0.74
Tibetans	56	178.5	8.16	175.9	7.89	101.5	0.68
Bangladesh-Bhutan	26	178.4	5.62	175.5	5.43	101.7	0.78
Assam-Sikkim	37	177.7	5.87	174.8	5.47	101.7	0.67
Bengal-Bihar	76	177.5	6.22	174.6	6.06	101.7	0.67
Punjab	73	184.1	5.86	181.2	5.66	101.6	0.55
Delhi-NW India	33	178.8	7.49	175.6	7.55	101.9	0.72
Madras	97	177.1	6.46	173.6	6.20	102.0	0.70
Veddah	16	177.7	6.61	174.6	6.47	101.8	0.66
Afghanistan	29	183.6	7.22	180.6	6.95	101.7	0.62

(*continued*)

TABLE 2. (continued)

Sample name	N	M1		M1d		M1/M1d (%)	
		Mean	S.D.	Mean	S.D.	Mean	S.D.
Palestine	91	185.8	6.00	183.0	6.01	101.6	0.57
Turkey	19	180.6	5.90	178.1	6.50	101.4	0.64
Cyprus	19	184.4	7.39	182.0	7.46	101.3	0.53
Greece	31	178.4	7.29	175.8	6.88	101.5	0.71
Ancient Greece	18	181.6	5.72	179.3	5.62	101.2	0.45
Italian	100	181.1	7.26	178.1	7.03	101.7	0.69
Ancient Italian	38	184.7	7.71	182.3	7.33	101.3	0.56
Russian	46	182.3	6.52	179.9	6.54	101.7	0.64
Hungary	21	177.4	7.42	174.4	7.07	101.7	0.57
Czechoslovakia	57	175.2	6.26	171.3	5.72	102.1	1.01
Finland	24	185.2	5.95	182.0	6.01	101.8	0.73
Norway	19	184.5	5.66	181.6	5.37	101.6	0.61
Sweden	31	189.2	5.14	186.4	5.26	101.5	0.55
Lapp	25	178.4	6.08	175.5	5.97	101.6	0.74
Holland	36	184.0	7.04	181.4	6.50	101.4	0.61
German	53	184.8	7.98	181.3	8.40	101.9	0.71
French	63	180.6	6.16	177.7	5.74	101.5	0.60
Ancient French	20	187.7	7.77	184.2	7.44	101.9	0.72
Spain	28	186.4	6.84	184.0	6.55	101.3	0.51
Ensay	66	188.1	5.53	184.7	5.25	101.8	0.69
Repton	42	188.5	6.69	185.3	6.47	101.7	0.54
Poundbury	102	190.3	5.54	187.3	5.52	101.6	0.55
Spitalfields-1	76	184.5	4.61	181.7	4.61	101.5	0.66
Spitalfields-2	57	181.3	6.36	178.4	5.98	101.6	0.65
Neolithic UK	24	197.3	6.01	194.3	5.77	101.7	0.53
Badari	41	182.4	5.82	179.9	5.53	101.3	0.59
Naquada	80	184.6	5.39	182.2	5.37	101.3	0.53
Gizeh	100	185.8	5.53	183.8	5.25	101.1	0.51
Kerma	86	186.1	6.17	183.8	6.01	101.3	0.57
Early Nubia	78	183.2	6.70	181.0	6.51	101.2	0.68
Recent Nubia	43	184.7	5.34	182.2	5.12	101.4	0.61
Morocco	19	184.0	6.44	181.3	6.36	101.5	0.62
West Africa	33	182.3	6.17	179.6	6.41	101.5	0.74
Nigeria-1	78	184.4	6.18	182.0	6.14	101.3	0.61
Nigeria-2	74	183.2	6.10	180.7	5.92	101.3	0.65
Gabon	73	179.3	5.96	177.5	6.04	101.0	0.55
Congo	14	178.9	7.18	176.4	7.13	101.5	0.44
Somalia	59	185.2	4.35	183.0	4.29	101.2	0.52
Kenya	75	185.1	6.34	182.9	6.27	101.2	0.58
Tanzania	54	185.1	5.79	182.3	5.53	101.5	0.66
Uganda	19	183.4	4.42	181.1	4.72	101.3	0.79
Malawi	42	184.1	6.11	181.5	5.98	101.5	0.89
South Africa	56	188.3	7.76	185.5	7.60	101.5	0.66
Khoi-San	30	179.2	6.54	176.9	6.30	101.3	0.76

[1] M1, glabella-opisthocranion.
[2] M1d, nasion-opisthoranion.
[3] (M1/M1d) ∗ 100, infraglabellar notch.

tion pattern for each index. Four of the 6 indices are normally distributed. The indices for estimating the depth of the infraglabellar notch and the level of frontal flatness in the sagittal plane are not normally distributed.

RESULTS

Univariate analyses

The basic statistical results of the six indices for each sample are given in Tables 2–7. Figures 1–6 show the principal features of the variations among 112 population samples in the six indices.

Table 2 and Figure 1 show the mean values of the percentage of the maximum cranial length to naso-occipital length, reflecting the profile of the infraglabellar notch. A deep infraglabellar notch occurs almost exclusively in the Australian and the Melanesian samples. However, a few populations originally derived from eastern Asia, such as the Nicobarese and the Easter Island samples, and to a lesser extent, the Eskimo and the Fuegian-Patagonian samples, show deep infraglabellar notches. The variation of this character is, moreover, very large in the eastern part of the Old World and the New

TABLE 3. Mean and standard deviation (S.D.) for M5,[1] M40,[2] and (M40/M5) ∗ 100[3]

Sample name	N	M5		M40		M40/M5 (%)	
		Mean	S.D.	Mean	S.D.	Mean	S.D.
Japanese	138	101.4	4.64	97.0	5.28	95.8	3.62
Ainu	34	106.0	3.75	102.9	4.89	96.9	3.60
Jomonese	29	103.3	7.20	101.7	8.05	98.1	4.60
Northern Chinese	48	100.2	3.31	96.7	4.64	96.6	4.01
Southern Chinese	64	99.3	4.03	96.0	4.91	96.7	4.32
Koreans	27	99.7	4.40	95.6	4.96	95.5	4.22
Mongolians	32	99.7	4.24	96.8	5.35	97.2	4.72
Northeast Asians	17	99.6	4.65	98.6	4.51	99.0	2.64
Chukchis	12	105.3	4.01	103.4	5.13	98.2	4.36
Vietnamese	23	100.4	3.89	97.2	5.17	96.8	3.05
Laos-Cambodia	42	97.9	3.75	95.8	4.52	98.0	3.84
Thailand	30	99.1	3.84	97.4	4.16	98.4	4.15
Myanmar	102	98.8	4.29	96.7	5.03	98.1	3.74
Malay	50	97.9	4.70	97.6	4.98	99.3	4.22
Early-SE Asians	7	101.0	5.20	97.3	5.94	97.9	2.90
Sumatra	13	99.9	5.81	98.3	4.73	98.6	5.05
Javanese	62	100.0	3.75	99.1	3.89	99.2	3.39
Borneans	67	99.4	3.89	97.4	4.95	97.9	3.97
Filipinos	76	100.3	4.30	98.4	4.52	97.7	4.39
Celebes-Molucca	29	99.0	3.26	99.0	4.41	100.1	3.39
Lesser Sunda	12	98.7	3.23	96.5	4.48	97.9	4.59
Andamanese	49	93.4	3.39	93.2	3.50	100.0	3.65
Nicobarese	19	98.0	3.84	98.3	3.75	101.2	4.23
Negritos	18	95.1	4.85	93.1	6.28	97.9	4.13
Eskimos	77	104.9	4.13	103.2	4.43	98.3	3.63
Subarctic	23	103.9	5.10	101.0	5.35	97.8	3.47
Northwest America	51	99.9	4.50	101.0	5.77	101.2	4.44
California	35	99.7	4.94	99.1	6.08	99.2	3.30
East America	25	103.9	3.89	100.4	5.23	97.1	3.93
Mesoamerica	25	97.2	4.22	97.0	5.07	99.8	4.83
Caribians	20	98.4	4.42	97.5	4.78	99.1	4.25
Peruvians	91	98.8	3.91	98.3	4.55	99.6	3.59
Fuegian-Patagonian	38	104.8	4.16	102.1	4.39	97.5	3.67
Mariana	21	103.5	3.93	99.2	5.17	96.1	3.31
Caroline	11	103.8	5.04	101.9	5.07	98.3	4.42
Hawaii	72	105.2	4.41	101.8	4.50	96.8	3.43
Easter	57	111.1	3.49	106.4	4.39	95.6	3.74
Marquesas	52	103.9	4.22	102.6	4.33	98.9	3.08
Society	42	104.8	4.53	102.3	3.77	97.7	3.63
Cook	13	103.2	4.15	100.7	5.31	97.2	3.23
Tonga-Samoa	17	104.4	4.85	100.5	4.79	96.4	2.95
Maori	108	104.4	3.97	100.9	4.65	96.7	3.72
Moriori	68	104.6	3.66	101.7	4.40	97.2	3.05
Fiji	36	102.4	4.25	102.9	3.51	101.3	3.53
New Britain	57	100.5	3.96	105.3	5.02	104.9	4.00
Vanuatu	25	100.7	3.79	106.0	5.26	105.3	3.91
New Caledonia	38	102.0	3.63	106.0	4.39	103.7	3.18
New Ireland	26	99.7	3.32	102.3	4.74	102.7	4.53
Santa Cruz	16	99.1	3.70	103.6	4.58	105.4	3.80
Solomon	53	99.8	3.75	100.3	3.90	100.5	4.64
Papua New Guinea	147	99.0	3.89	101.2	4.93	102.4	3.86
Torres Strait	56	101.2	3.63	106.3	4.68	105.1	3.53
New South Wales	53	101.6	3.75	103.0	4.15	101.3	4.03
South Australia	98	101.6	4.50	106.2	5.21	104.9	3.82
Murray River	13	100.3	4.96	104.9	4.99	105.0	3.72
Queensland	19	99.8	4.19	101.7	5.30	101.9	3.52
Western Australia	21	99.7	4.66	102.3	3.40	102.4	4.86
Tasmania	10	98.2	4.85	102.3	5.62	104.2	4.35
Nepalese	30	98.1	4.42	95.2	5.34	96.8	3.87
Tibetans	56	97.8	4.19	94.4	6.09	96.5	5.32
Bangladesh-Bhutan	23	99.2	3.64	94.2	3.40	95.3	2.65
Assam-Sikkim	40	97.7	4.05	95.0	4.38	97.3	3.16
Bengal-Bihar	77	99.1	3.95	94.5	4.33	95.4	3.35
Punjab	73	102.8	4.51	97.1	4.62	94.5	3.65
Delhi-NW India	33	98.7	4.33	94.9	4.17	95.9	3.68
Madras	100	98.1	4.59	95.6	4.65	97.5	3.69
Veddah	16	98.7	4.38	94.2	4.53	95.6	3.78
Afghanistan	37	102.9	4.19	100.7	5.45	97.7	3.76

(*continued*)

TABLE 3. (continued)

Sample name	N	M5		M40		M40/M5 (%)	
		Mean	S.D.	Mean	S.D.	Mean	S.D.
Palestine	88	101.8	4.21	97.2	4.93	95.7	3.35
Turkey	20	100.4	3.73	96.9	5.47	96.5	3.38
Cyprus	17	100.8	4.72	94.6	4.30	93.6	2.59
Greece	32	100.5	3.49	95.9	4.11	95.4	3.45
Ancient Greece	17	100.4	4.49	93.9	3.93	93.0	3.92
Italian	100	100.9	4.53	96.2	5.28	95.3	4.54
Ancient Italian	30	101.7	4.70	94.5	4.83	93.0	4.12
Russian	46	101.6	4.64	96.9	5.02	95.3	3.35
Hungary	20	99.2	3.45	95.3	4.72	96.3	3.61
Czechoslovakia	57	98.0	4.51	94.3	4.84	96.0	4.50
Finland	24	101.5	4.64	97.4	4.66	96.1	3.65
Norway	20	100.2	3.64	95.1	4.69	94.9	3.45
Sweden	31	100.7	4.12	95.9	5.11	95.1	3.56
Lapp	28	97.3	3.79	94.7	4.39	97.2	2.92
Holland	36	99.0	4.93	94.5	5.57	95.6	4.05
German	56	99.9	4.04	94.9	5.10	95.0	3.99
French	60	98.7	4.44	93.6	5.07	94.9	3.98
Ancient French	15	101.9	4.73	96.4	6.25	95.1	3.82
Spain	25	102.8	4.10	97.1	4.09	94.5	4.29
Ensay	64	100.0	3.71	93.9	4.40	93.9	3.62
Repton	35	102.2	4.70	97.5	5.27	95.9	3.30
Poundbury	100	101.6	4.88	94.9	5.78	93.4	3.83
Spitalfields-1	77	98.6	3.63	91.6	5.01	92.9	3.79
Spitalfields-2	57	100.6	3.94	96.4	4.65	95.9	3.73
Neolithic UK	14	105.7	4.83	100.3	4.35	94.8	2.81
Badari	39	99.1	4.15	96.6	4.54	97.6	4.50
Naquada	80	101.7	3.83	97.6	4.31	96.0	3.58
Gizeh	100	101.9	3.73	95.4	3.76	93.7	3.61
Kerma	82	101.8	4.04	98.4	4.52	96.7	3.80
Early Nubia	77	100.8	4.29	95.6	5.33	94.8	4.24
Recent Nubia	41	101.9	3.98	100.2	5.99	98.5	5.44
Morocco	18	99.7	4.84	93.7	4.82	93.8	3.93
West Africa	33	101.4	4.49	104.0	6.08	102.6	3.90
Nigeria-1	75	101.8	4.02	101.1	4.46	99.6	3.91
Nigeria-2	71	101.7	4.33	103.9	5.04	102.2	4.45
Gabon	73	99.8	3.99	101.5	4.83	101.8	4.02
Congo	11	98.4	4.82	103.2	4.85	105.0	4.88
Somalia	58	101.8	3.52	95.7	4.69	94.0	3.97
Kenya	69	100.3	4.15	101.1	5.32	100.7	4.24
Tanzania	53	101.3	4.21	105.3	4.53	104.1	4.45
Uganda	18	100.2	3.72	103.4	4.53	103.2	3.15
Malawi	41	101.4	4.47	102.4	5.44	101.0	3.72
South Africa	56	103.2	4.99	103.6	6.84	100.4	4.64
Khoi-San	29	96.2	4.50	95.5	6.68	99.3	5.43

[1] M5, basion-nasion.
[2] M40, basion-prosthion.
[3] (M40/M5) ∗ 100, alveolar index.

World, covering almost all the range of the worldwide samples.

A variation of facial prognathism expressed by the gnathic index is illustrated in Figure 2 (see also Table 3). The greatest prognathism is observed in the Australian/Melanesian samples, followed closely by some of the subSaharan African samples. Regarding the other samples in the world, the samples from the eastern hemisphere of the Old World together with the New World samples are more or less prognathic than those from the western hemisphere. The Southeast Asian samples, especially from the insular part, are relatively prognathic.

The degree of frontal flatness in the sagittal plane was tentatively estimated by the sagittal-frontal index, as shown in Table 4 and Figure 3. Among the 17 regional samples, the Australian samples have, on average, flat frontal bones. However, the Southeast Asian Nicobarese sample shows the flattest frontals, followed by the three samples from subSaharan Africa (the Congo, the Tanzania, and the Khoi-San samples). It should be noted that the South Indian Dra-

TABLE 4. Mean and standard deviation (S.D.) for M26,[1] M29,[2] and (M29/M26) ∗ 100[3]

Sample name	N	M26		M29		M29/M26 (%)	
		Mean	S.D.	Mean	S.D.	Mean	S.D.
Japanese	128	126.6	5.07	110.9	4.10	87.6	1.83
Ainu	35	129.3	4.88	113.1	3.68	87.5	1.31
Jomonese	36	126.3	5.54	111.2	4.66	88.1	1.34
Northern Chinese	50	127.2	5.96	112.7	4.54	88.7	1.74
Southern Chinese	66	126.8	5.70	111.5	4.15	88.0	1.45
Koreans	26	126.9	5.22	111.7	4.15	88.1	1.31
Mongolians	30	127.3	4.66	112.9	3.97	88.7	1.13
Northeast Asians	17	125.9	6.52	111.9	5.23	88.9	1.12
Chukchis	12	125.1	4.48	112.3	4.03	89.8	1.09
Vietnamese	23	127.4	6.42	112.5	5.13	88.4	1.43
Laos-Cambodia	43	125.2	5.72	109.8	3.68	87.8	2.16
Thailand	30	128.0	6.08	112.6	4.55	88.0	1.56
Myanmar	103	127.0	5.99	111.6	4.52	87.9	1.83
Malay	50	126.2	6.28	111.3	4.76	88.2	1.60
Early-SE Asians	21	129.5	7.45	113.1	5.80	87.4	1.74
Sumatra	13	122.6	4.41	108.2	3.89	88.2	1.64
Javanese	62	127.6	5.53	111.8	4.30	87.7	1.58
Borneans	75	127.7	6.77	111.2	4.59	87.1	1.94
Filipinos	77	127.0	5.91	111.9	4.80	88.1	1.20
Celebes-Molucca	29	124.9	6.13	110.1	4.36	88.2	1.38
Lesser Sunda	13	125.3	6.73	110.4	4.84	88.1	1.56
Andamanese	50	121.4	6.21	107.2	4.79	88.4	1.82
Nicobarese	19	127.8	7.04	110.0	4.98	86.1	1.60
Negritos	18	123.7	4.59	108.4	3.43	87.6	1.76
Eskimos	77	130.0	6.20	113.6	4.53	87.5	1.53
Subarctic	23	126.1	4.98	113.0	3.88	89.5	1.57
Northwest America	37	124.9	7.31	113.3	4.66	90.2	1.99
California	42	124.7	6.50	111.5	4.68	89.2	2.23
East America	28	127.9	5.08	113.7	3.54	88.8	1.84
Mesoamerica	25	120.9	6.35	109.0	5.76	89.9	1.28
Caribians	20	124.9	5.06	110.7	3.80	88.7	2.09
Peruvians	84	119.3	5.59	107.4	4.40	90.1	1.71
Fuegian-Patagonian	40	129.9	5.04	115.7	4.04	89.1	1.80
Mariana	25	129.9	6.37	114.2	5.19	87.9	1.59
Caroline	11	128.9	5.91	112.5	4.27	87.3	1.30
Hawaii	72	131.3	5.99	116.1	4.50	88.5	1.53
Easter	65	133.7	5.18	116.6	3.78	87.3	1.42
Marquesas	57	131.5	6.69	116.4	5.22	88.6	1.52
Society	46	129.9	5.49	114.9	3.88	88.5	1.72
Cook	14	129.7	5.57	114.4	5.11	88.1	1.61
Tonga-Samoa	19	129.3	6.42	114.3	5.28	88.4	2.12
Maori	111	130.0	5.73	114.7	4.40	88.2	1.45
Moriori	69	127.0	5.85	114.0	4.41	89.8	1.45
Fiji	42	128.8	6.41	113.6	5.27	88.2	2.15
New Britain	58	124.2	5.51	109.8	4.77	88.4	1.44
Vanuatu	25	124.6	4.48	111.2	3.56	89.3	1.33
New Caledonia	39	128.7	5.19	113.1	4.22	87.9	1.83
New Ireland	26	124.2	7.16	109.7	5.25	88.4	1.83
Santa Cruz	16	126.8	7.91	110.9	6.04	87.5	1.36
Solomon	58	124.9	5.15	109.9	4.05	88.1	1.60
Torres Strait	60	125.7	4.95	111.4	3.62	88.7	1.77
Papua New Guinea	156	123.0	5.76	108.7	4.33	88.4	1.70
New South Wales	57	131.5	5.76	114.0	4.86	86.9	1.62
South Australia	128	128.3	6.31	111.7	4.64	87.2	1.84
Murray River	37	128.5	6.19	111.2	4.86	86.7	1.47
Queensland	20	129.4	6.63	112.3	4.66	86.8	1.31
Western Australia	22	126.6	8.03	111.6	5.69	88.2	1.56
Tasmania	12	126.2	5.37	110.3	4.00	87.4	1.65
Nepalese	31	124.8	6.26	109.6	4.77	87.9	2.42
Tibetans	57	125.4	6.48	109.9	4.76	87.7	1.49
Bangladesh-Bhutan	27	127.7	7.59	111.4	5.89	87.3	1.77
Assam-Sikkim	39	125.1	5.63	109.3	4.25	87.4	1.49
Bengal-Bihar	77	125.7	6.02	109.9	4.37	87.4	1.84
Punjab	73	126.2	6.70	110.9	5.16	87.9	1.66
Delhi-NW India	34	124.9	7.05	108.4	5.52	86.9	2.02
Madras	100	127.4	5.95	110.4	4.61	86.7	1.82
Veddah	16	126.6	5.76	109.9	4.28	86.9	1.91
Afghanistan	38	124.8	5.73	111.1	4.72	89.1	1.42

(*continued*)

TABLE 4. (continued)

Sample name	N	M26		M29		M29/M26 (%)	
		Mean	S.D.	Mean	S.D.	Mean	S.D.
Palestine	91	128.2	6.54	112.6	4.87	87.9	1.91
Turkey	23	127.7	6.83	113.1	5.60	88.6	1.36
Cyprus	19	127.1	4.34	112.9	3.84	88.8	1.14
Greece	33	125.4	5.61	110.4	4.18	88.1	1.51
Ancient Greece	19	126.5	4.78	111.6	3.22	88.3	1.23
Italian	101	126.4	6.34	110.9	5.18	87.7	1.62
Ancient Italian	38	127.5	5.89	112.3	4.54	88.1	1.75
Russian	47	128.2	6.16	113.0	4.82	88.1	1.61
Hungary	22	123.5	6.32	108.4	4.77	87.9	1.43
Czechoslovakia	57	126.5	7.48	110.3	5.43	87.3	1.72
Finland	24	130.3	5.86	115.9	7.20	88.1	1.47
Norway	19	129.2	6.58	113.5	4.56	87.9	1.43
Sweden	31	131.8	5.88	115.9	4.75	87.9	1.06
Lapp	28	126.4	6.86	110.9	5.22	87.8	1.20
Holland	36	126.9	6.33	111.8	4.82	88.1	1.56
German	52	130.7	6.29	114.1	4.93	87.3	1.76
French	63	126.9	4.75	111.8	4.11	88.1	1.68
Ancient French	23	128.4	8.07	112.5	5.74	87.8	2.29
Spain	28	129.4	6.86	113.8	5.36	87.9	1.71
Ensay	66	128.6	5.82	111.6	4.83	86.9	1.70
Repton	43	127.6	7.25	111.6	5.97	87.5	1.65
Poundbury	102	129.9	5.32	112.8	4.13	86.9	1.79
Spitalfields-1	82	129.6	5.58	112.7	4.45	87.0	1.88
Spitalfields-2	57	127.3	6.25	111.7	4.95	87.8	1.53
Neolithic UK	22	132.0	6.37	115.4	4.82	87.5	1.64
Badari	40	126.4	5.16	110.4	4.11	87.4	1.90
Naquada	80	127.1	5.16	111.2	4.16	87.5	1.32
Gizeh	100	128.7	6.92	113.6	5.15	88.3	1.41
Kerma	86	129.0	6.58	112.9	4.84	87.6	1.48
Early Nubia	78	127.3	5.44	111.3	4.33	87.5	1.44
Recent Nubia	43	128.0	5.54	112.1	3.87	87.7	2.07
Morocco	19	128.0	4.88	111.5	4.03	87.1	1.40
West Africa	34	126.6	6.80	110.8	5.33	87.5	2.20
Nigeria-1	79	128.5	5.70	112.9	4.52	87.9	1.76
Nigeria-2	73	126.4	6.58	110.5	5.13	87.5	1.77
Gabon	73	127.6	6.63	111.7	4.65	87.6	1.73
Congo	15	126.2	3.93	109.0	3.80	86.4	1.26
Somalia	61	130.9	6.66	113.8	4.95	87.0	1.54
Kenya	75	128.4	5.74	111.7	4.88	87.0	1.61
Tanzania	55	128.6	6.35	111.0	4.45	86.4	1.89
Uganda	19	128.4	4.88	111.2	4.26	86.6	1.49
Malawi	42	130.1	6.80	113.1	5.30	86.9	1.66
South Africa	57	131.6	5.92	114.4	4.60	87.0	1.62
Khoi-San	30	128.6	6.44	111.1	5.23	86.4	1.74

[1] M26, sagittal frontal arc.
[2] M29, sagittal frontal chord.
[3] (M29/M26) * 100, sagittal frontal index.

vidian sample together with the Veddah and the northwest Indian samples have flatter frontal bones than many of the Near East, north African, and European samples. The groups with the opposite condition, or rounded frontal bones, are, on average, New World samples except for the Eskimo sample, and the next the northeast Asian samples. In this feature, again, the variation is large in the eastern part of the Old World and the New World.

The next three presentations focus on the transverse flatness of facial skeletons. Zygomaxillary flatness may additionally assess whether the prognathism examined in Figure 2 and Table 3 is associated with the whole face or restricted to the alveolar portion.

Figure 4 shows the variation of fronto-orbital flatness. The northeast Asian samples, and to a lesser degree the east Asian samples except for the Ainu, show the smallest mean values, i.e., the flattest faces in fronto-orbital portion. The degree of fronto-orbital flatness is weaker in the Australian/Melanesian samples than in the east/northeast Asian samples. The series from southeast Asia exhibits intermediate values, indicating a roughly clinal variation. With the

TABLE 5. Frontal measurements (in mm) and indices

Sample name	N	Chord		Subtense		Index	
		Mean	S.D.	Mean	S.D.	Mean	S.D.
Japanese	138	96.2	3.92	15.3	2.28	15.9	2.17
Ainu	35	100.0	3.62	17.9	2.29	17.9	1.98
Jomonese	31	101.7	3.18	16.2	3.35	15.9	3.13
Northern Chinese	56	96.0	3.65	15.2	2.12	15.8	1.92
Southern Chinese	66	96.3	3.88	14.4	2.39	15.0	2.17
Koreans	26	95.7	3.89	14.8	2.22	15.5	2.21
Mongolians	33	97.3	3.68	13.8	2.32	14.1	2.19
Northeast Asians	17	96.9	3.59	13.6	3.02	13.9	2.78
Chukchis	12	101.3	3.48	15.0	2.24	14.8	2.12
Vietnamese	24	96.8	3.70	15.9	2.77	16.4	2.57
Laos-Cambodia	43	96.8	3.18	16.1	1.96	16.6	1.87
Thailand	30	96.9	3.13	15.4	1.81	15.9	1.83
Myanmar	102	97.6	3.67	17.2	2.32	17.6	2.37
Malay	51	96.5	3.61	16.5	2.21	17.1	2.17
Early-SE Asians	14	98.3	5.23	16.1	2.83	16.4	2.62
Sumatra	13	96.9	3.91	17.5	1.97	18.0	1.87
Javanese	62	98.0	3.72	16.8	2.19	17.2	2.06
Borneans	72	96.9	3.80	16.4	2.31	16.9	2.26
Filipinos	76	97.3	3.89	16.2	1.80	16.6	1.59
Celebes-Molucca	28	96.1	3.50	16.0	2.36	16.7	2.21
Lesser Sunda	13	98.0	5.88	17.7	2.08	18.0	1.65
Andamanese	48	92.6	3.29	17.2	2.13	18.5	2.14
Nicobarese	18	95.5	3.63	15.1	2.26	15.8	2.25
Negritos	18	94.4	4.09	15.0	1.84	15.9	1.77
Eskimos	77	99.1	3.03	14.8	2.43	14.9	2.34
Subarctic	23	99.9	4.70	19.3	2.64	19.3	2.18
Northwest America	52	100.6	4.82	18.5	2.46	18.4	2.37
California	42	98.1	3.81	17.6	2.88	18.0	3.00
East America	24	101.2	3.62	19.3	2.42	19.1	2.37
Mesoamerica	30	97.9	4.37	17.0	3.26	17.3	3.15
Caribians	21	99.8	3.43	18.8	2.76	18.8	2.65
Peruvians	92	97.1	3.17	17.9	1.94	18.5	1.87
Fuegian-Patagonian	40	101.7	3.47	18.1	2.25	17.9	2.19
Mariana	24	98.1	3.14	16.3	2.49	16.6	2.41
Caroline	10	98.2	3.04	17.5	3.04	17.8	2.93
Hawaii	72	97.4	3.76	16.1	2.37	16.5	2.20
Easter	59	98.2	3.30	17.9	2.35	18.2	2.20
Marquesas	57	98.3	3.70	16.9	2.51	17.2	2.33
Society	43	97.4	3.61	17.1	2.32	17.6	2.35
Cook	15	99.9	2.98	17.7	2.77	17.7	2.67
Tonga-Samoa	14	100.1	4.75	18.1	2.55	18.0	2.17
Maori	109	98.3	4.10	16.8	2.26	17.1	2.12
Moriori	70	98.2	3.19	17.7	2.33	18.0	2.27
Fiji	32	97.5	4.00	17.6	2.49	18.1	2.28
New Britain	57	100.6	3.44	16.6	2.42	16.5	2.27
Vanuatu	25	100.5	4.06	19.6	2.83	19.4	2.58
New Caledonia	38	99.2	4.55	17.8	2.68	17.9	2.37
New Ireland	27	99.2	3.64	18.9	2.58	19.0	2.79
Santa Cruz	16	98.9	2.58	19.9	1.58	20.2	1.37
Solomon	57	97.8	3.84	18.1	2.56	18.5	2.45
Papua New Guinea	156	96.4	3.86	18.3	2.67	18.9	2.71
Torres Strait	60	101.3	3.56	18.9	2.65	18.7	2.37
New South Wales	55	101.5	4.00	19.2	2.70	18.9	2.46
South Australia	124	101.8	3.71	19.7	2.66	19.3	2.43
Murray River	30	101.1	5.06	19.4	2.64	19.3	2.27
Queensland	20	101.8	3.44	19.4	2.06	19.1	1.99
Western Australia	21	102.1	4.33	19.1	2.94	18.6	2.60
Tasmania	11	100.3	3.97	18.4	3.25	18.3	2.76
Nepalese	31	96.0	2.74	19.3	2.65	20.1	2.79
Tibetans	57	96.6	3.77	17.0	2.28	17.6	2.38
Bangladesh-Bhutan	27	96.1	4.25	19.4	3.12	20.1	2.79
Assam-Sikkim	40	96.8	3.77	16.2	2.67	16.7	2.65
Bengal-Bihar	78	94.9	3.88	18.8	2.19	19.8	2.09
Punjab	71	96.6	3.94	19.9	2.74	20.6	2.59
Delhi-NW India	32	95.6	3.81	18.4	2.67	19.2	2.56
Madras	100	95.5	3.64	18.8	2.39	19.7	2.25
Veddah	16	92.7	4.35	19.3	2.55	20.8	2.34
Afghanistan	38	97.9	4.42	19.7	2.34	20.1	2.05

(*continued*)

TABLE 5. (continued)

Sample name	N	Chord		Subtense		Index	
		Mean	S.D.	Mean	S.D.	Mean	S.D.
Palestine	91	96.5	3.39	18.3	2.42	19.0	2.40
Turkey	22	99.9	2.93	17.7	2.79	17.7	2.71
Cyprus	18	97.2	4.44	18.0	3.51	18.5	3.27
Greece	33	97.5	3.83	18.4	2.97	18.9	2.59
Ancient Greece	17	96.9	3.23	18.5	3.14	19.1	2.94
Italian	100	98.2	3.21	19.2	2.40	19.5	2.30
Ancient Italian	36	98.7	4.57	19.4	2.34	19.6	1.94
Russian	43	98.4	3.81	19.3	2.86	19.5	2.42
Hungary	21	96.8	3.83	18.4	2.91	19.0	2.69
Czechoslovakia	55	97.8	3.28	18.5	2.56	18.8	2.37
Finland	24	100.3	4.08	18.6	2.97	18.5	2.80
Norway	19	97.9	2.95	18.4	1.67	18.8	1.69
Sweden	31	98.9	3.88	19.3	2.36	19.5	2.35
Lapp	27	97.0	4.34	16.3	2.32	16.8	2.26
Holland	35	98.5	3.96	18.4	2.85	18.7	2.47
German	53	99.1	3.81	19.5	2.60	19.7	2.38
French	60	96.9	3.88	18.3	2.59	18.9	2.47
Ancient French	23	99.5	4.23	17.8	2.10	17.8	1.74
Spain	25	96.3	4.28	19.5	2.50	20.2	2.39
Ensay	67	97.6	3.78	17.6	2.10	18.1	2.02
Repton	41	99.3	3.96	17.9	2.61	18.0	2.36
Poundbury	100	99.7	3.69	18.1	2.19	18.2	1.96
Spitalfields-1	73	95.4	3.66	18.7	2.22	19.6	2.14
Spitalfields-2	57	98.8	3.88	18.4	2.08	18.6	1.94
Neolithic UK	20	97.7	3.90	18.7	3.04	19.1	3.04
Badari	38	93.9	2.89	16.9	2.36	18.0	2.28
Naquada	80	95.5	3.78	18.4	2.43	19.3	2.24
Gizeh	100	96.0	3.69	18.8	2.38	19.5	2.23
Kerma	84	97.0	3.36	18.3	2.31	18.9	2.52
Early Nubia	78	95.8	3.71	18.7	2.47	19.5	2.37
Recent Nubia	43	95.9	3.81	18.2	2.25	18.9	2.11
Morocco	19	98.1	4.41	18.5	2.60	18.8	2.36
Western Africa	34	100.5	3.61	19.3	2.12	19.2	1.94
Nigeria-1	77	101.9	3.72	19.1	2.47	18.7	2.20
Nigeria-2	71	99.7	3.65	18.1	2.26	18.2	2.12
Gabon	72	99.6	3.92	18.4	2.53	18.4	2.25
Congo	15	98.0	5.30	18.1	2.76	18.5	2.77
Somalia	59	95.8	3.96	18.9	2.30	19.7	2.13
Kenya	70	99.0	3.72	17.8	2.48	17.9	2.28
Tanzania	50	99.8	4.04	18.3	3.03	18.3	2.81
Uganda	20	99.0	3.92	18.6	2.07	18.8	2.03
Malawi	38	99.7	3.71	17.8	2.28	17.8	2.17
South Africa	56	102.4	4.43	19.1	2.60	18.6	2.36
Khoi-San	29	96.2	3.33	16.0	2.63	16.7	2.56

possible exception of the Eskimo sample, the New World samples show a less flattend fronto-orbital region, comparable to the Australian and the Melanesian samples. In the western hemisphere of the Old World, no significant difference in the degree of fronto-orbital flatness can be detected, showing projecting faces.

The overall range of variation for the simotic index is relatively large (Table 6 and Fig. 5). The subSaharan African samples have very flat nasals, especially the Khoi-San sample. Of all the samples examined, the European samples show the highest nasals, followed by the Indian subcontinent samples, the Oceanian samples, and very significantly, the New World samples and the Ainu sample from Japan. As is well known, the nasal form of Eskimos and, to a lesser extent, Chukchis shows what has been referred to as "pinched nasalia," a condition which is characterized by a narrow nasal chord and high subtense (Table 6).

As in the case of the frontal index, the northeast Asian samples and to a lesser degree the east Asian samples show the smallest mean values of the zygomaxillary index, indicating the flattest faces in the midfacial region (Fig. 6). The Australian and the Melanesian samples exhibit, on average, a high value of the zygomaxillary index, followed by the samples from the western

TABLE 6. Simotic measurements (in mm) and indices

Sample name	N	Chord		Subtense		Index	
		Mean	S.D.	Mean	S.D.	Mean	S.D.
Japanese	136	6.9	2.01	2.2	0.95	32.9	12.53
Ainu	34	8.5	1.79	3.8	0.95	44.9	10.61
Jomonese	30	9.7	1.95	4.0	1.25	41.4	9.23
Northern Chinese	55	7.2	1.59	2.5	1.01	34.8	12.13
Southern Chinese	66	7.5	1.90	2.1	0.95	28.2	10.97
Koreans	26	7.6	1.78	2.3	0.94	30.8	13.02
Mongolians	33	6.9	1.56	2.4	0.75	35.6	8.99
Northeast Asians	17	7.3	2.13	1.8	1.02	24.4	13.60
Chukchis	12	6.3	2.15	2.7	1.14	44.1	12.59
Vietnamese	24	8.1	1.98	2.3	0.75	29.2	10.39
Laos-Cambodia	42	8.1	1.63	2.3	0.76	27.9	7.59
Thailand	30	8.0	1.52	2.8	0.87	35.3	10.13
Myanmar	102	8.5	1.75	3.0	1.02	35.5	10.41
Malay	51	7.9	1.64	2.9	0.94	36.4	10.54
Early-SE Asians	14	8.9	2.16	2.5	0.76	29.1	7.52
Sumatra	13	8.8	2.34	2.8	1.25	32.0	11.27
Javanese	61	8.5	1.83	2.8	1.00	33.8	10.53
Borneans	73	8.0	1.83	2.3	0.84	29.2	9.59
Filipinos	75	8.4	2.11	2.7	1.04	32.3	9.60
Celebes-Molucca	28	8.6	1.95	2.8	0.71	32.8	6.23
Lesser Sunda	13	8.5	1.73	3.2	0.90	38.1	10.36
Andamanese	47	9.1	2.14	2.6	1.04	27.4	8.96
Nicobarese	17	8.9	1.49	2.7	0.96	30.3	11.02
Negritos	18	8.2	1.87	2.2	1.01	27.9	10.80
Eskimos	75	5.5	1.77	2.6	0.84	47.8	11.27
Subarctic	22	8.4	2.14	3.9	1.16	46.4	9.37
Northwest America	52	8.9	1.88	3.5	1.09	39.2	10.61
California	43	8.9	1.73	3.3	0.87	37.5	9.67
East America	26	9.1	2.01	4.3	0.97	47.6	10.88
Mesoamerica	33	9.5	1.57	3.6	0.97	38.0	8.70
Caribians	20	9.3	1.89	3.8	1.01	41.5	9.19
Peruvians	91	9.4	1.62	4.0	0.88	43.1	10.44
Fuegian-Patagonian	38	8.1	1.56	3.6	0.95	45.6	11.21
Mariana	23	9.0	2.02	2.8	1.04	31.8	10.09
Caroline	9	7.8	1.28	2.7	1.14	34.6	13.28
Hawaii	71	7.2	1.62	2.5	0.91	34.6	11.72
Easter	64	7.6	1.59	3.2	0.86	41.7	8.60
Marquesas	57	7.1	1.71	2.9	0.93	41.2	10.13
Society	44	7.6	1.33	3.1	0.89	41.1	11.03
Cook	12	8.1	2.01	3.1	0.96	39.6	11.27
Tonga-Samoa	13	8.0	1.48	3.6	0.71	45.6	10.24
Maori	109	6.9	1.45	2.9	0.94	41.7	12.02
Moriori	68	6.7	1.41	2.6	0.84	38.5	9.97
Fiji	30	8.1	2.16	3.4	1.13	42.7	10.75
New Britain	58	8.2	1.96	2.7	1.05	33.5	12.33
Vanuatu	24	8.2	1.79	3.3	0.76	41.1	11.10
New Caledonia	34	9.2	2.21	3.1	0.93	34.1	9.91
New Ireland	25	7.4	2.18	3.4	0.94	46.8	12.23
Santa Cruz	16	8.1	1.31	3.4	1.14	41.8	13.01
Solomon	57	7.8	1.79	3.4	1.06	42.9	10.45
Papua New Guinea	154	8.4	1.82	3.3	0.93	40.3	11.70
Torres Strait	59	8.9	1.88	3.7	1.01	42.0	11.28
New South Wales	54	9.3	1.98	3.8	0.86	42.3	12.38
South Australia	98	9.9	1.77	4.0	0.95	41.5	9.11
Murray River	17	9.3	2.30	3.5	1.04	38.2	11.62
Queensland	19	10.0	2.37	3.6	0.86	37.3	10.29
Western Australia	21	9.6	2.16	4.1	0.91	44.2	10.57
Tasmania	12	8.0	1.45	3.7	1.30	44.6	11.52
Nepalese	31	8.5	1.96	3.7	1.24	42.8	11.47
Tibetans	56	7.3	1.78	2.7	0.88	38.0	11.46
Bangladesh-Bhutan	27	8.6	1.98	3.6	0.97	42.8	9.99
Assam-Sikkim	39	7.6	1.76	2.5	1.04	32.9	12.17
Bengal-Bihar	77	8.4	1.66	3.5	0.90	42.3	10.89
Punjab	72	9.0	1.80	4.0	1.10	45.1	10.86
Delhi-NW India	32	8.5	1.63	3.5	1.14	42.3	13.20
Madras	100	8.6	1.71	3.5	0.98	40.6	10.13
Veddah	16	8.2	1.63	3.2	0.64	39.7	7.01
Afghanistan	37	9.7	1.93	4.3	1.14	44.9	10.57

(*continued*)

TABLE 6. (continued)

Sample name	N	Chord		Subtense		Index	
		Mean	S.D.	Mean	S.D.	Mean	S.D.
Palestine	90	10.3	1.93	4.7	1.14	46.1	8.67
Turkey	22	9.4	2.51	4.0	1.19	43.3	6.88
Cyprus	17	9.8	1.15	4.7	1.01	47.8	8.70
Greece	32	9.5	2.37	4.3	1.08	46.2	9.20
Ancient Greece	17	9.5	1.76	4.8	1.23	50.2	11.41
Italian	101	9.4	1.92	4.2	1.07	45.1	10.16
Ancient Italian	36	9.7	1.63	4.9	1.05	50.6	7.33
Russian	44	9.3	1.87	4.5	1.12	48.8	7.56
Hungary	22	9.1	1.50	4.2	0.92	46.8	8.88
Czechoslovakia	54	9.5	1.71	4.3	0.91	45.5	9.72
Finland	24	10.1	1.42	4.3	1.17	42.8	9.78
Norway	20	9.0	1.36	4.7	1.17	52.0	10.20
Sweden	30	8.8	1.78	4.2	1.06	48.6	10.63
Lapp	26	8.7	1.89	3.5	0.88	41.3	10.67
Holland	36	8.6	1.91	4.2	1.09	48.5	9.00
German	53	9.4	1.70	4.5	1.20	47.9	11.32
French	58	9.2	1.92	4.4	1.10	47.7	8.60
Ancient French	21	9.3	2.15	4.4	1.06	48.0	7.06
Spain	27	9.7	2.05	4.6	1.06	47.9	9.91
Ensay	63	9.0	1.64	3.9	1.01	42.7	9.50
Repton	35	8.9	1.81	4.4	1.02	49.3	9.24
Poundbury	102	9.3	1.89	4.2	1.03	45.4	8.73
Spitalfields-1	77	8.4	1.61	4.5	1.15	53.5	11.40
Spitalfields-2	57	8.8	1.89	3.9	1.20	44.8	12.08
Neolithic UK	20	9.6	1.57	4.6	0.78	47.8	6.66
Badari	36	10.6	1.87	3.8	0.97	36.2	9.06
Naquada	79	10.0	1.67	3.9	1.03	38.8	8.83
Gizeh	100	10.3	2.00	4.4	0.98	43.3	8.82
Kerma	83	10.3	1.98	3.7	1.11	36.0	9.98
Early Nubia	77	9.8	1.65	4.1	1.14	41.9	11.22
Recent Nubia	44	10.3	1.94	3.7	1.10	35.3	7.70
Morocco	19	10.0	1.78	4.3	1.31	43.2	9.96
West Africa	33	9.3	2.06	2.9	0.80	32.1	9.53
Nigeria-1	72	9.7	2.15	3.1	0.85	32.4	8.91
Nigeria-2	72	9.2	2.19	2.7	1.01	29.6	9.36
Gabon	71	8.8	2.33	2.7	1.00	30.4	9.15
Congo	12	8.7	2.19	2.8	1.27	31.2	11.73
Somalia	60	9.7	1.87	3.4	1.11	35.7	10.15
Kenya	70	9.2	2.41	2.3	1.11	25.4	10.77
Tanzania	54	9.1	2.23	2.7	0.78	30.3	6.49
Uganda	20	9.0	2.12	2.3	0.89	25.7	8.92
Malawi	41	9.1	2.94	2.7	1.18	30.3	10.63
South Africa	56	8.8	2.40	2.8	1.05	32.4	10.25
Khoi-San	28	7.1	2.30	1.4	1.03	17.5	10.77

hemisphere of the Old World. Coon (1967) pointed out that the zygomaxillary index is influenced by prognathism. In a previous study, the influence of prognathism on the degree of zygomaxillary flatness was estimated using linear regression analysis between the gnathic and zygomaxillary indices (Hanihara and Ishida, 1995). In that study, the expected prognathism-free values of Australians and Melanesians were quite comparable to those of Europeans. On the other hand, the values of the subSaharan African samples fall within the range of samples from Europe to the Indian subcontinent through north Africa and the Near East, even though they indicate marked prognathism, as shown in Figure 2. As described above, the eastern Asian samples have a quite flat zygomaxillary portion in spite of their weak prognathism (Fig. 2). This suggests that the prognathism of the eastern Asian samples may be more or less attributed to alveolar prognathism. The degree of zygomaxillary flatness of the New World samples, together with that of the Polynesian samples, is again comparable to those of the western part of the Old World, except for the Eskimo sample.

Canonical correlation analysis

Correlation and covariance matrices used in the canonical correlation analysis are

TABLE 7. Zygomaxillary measurements (in mm) and indices

Sample name	N	Chord		Subtense		Index	
		Mean	S.D.	Mean	S.D.	Mean	S.D.
Japanese	133	98.1	5.01	22.8	2.81	23.2	2.89
Ainu	35	101.9	5.05	22.5	2.47	22.1	2.18
Jomonese	24	100.2	4.95	22.2	2.90	22.2	2.89
Northern Chinese	55	98.1	4.12	22.0	3.33	22.4	3.21
Southern Chinese	63	98.6	4.82	21.1	3.06	21.4	2.93
Koreans	25	99.4	4.49	20.2	3.04	20.3	2.99
Mongolians	31	100.8	3.86	18.7	2.69	18.5	2.44
Northeast Asians	17	96.8	5.85	18.5	2.96	19.1	3.09
Chukchis	12	99.6	5.14	20.0	2.62	20.0	2.48
Vietnamese	22	100.5	4.02	22.0	3.57	21.8	3.37
Laos-Cambodia	43	99.8	4.86	21.7	2.73	21.8	2.80
Thailand	30	100.6	4.66	22.0	2.71	21.9	2.44
Myanmar	97	99.4	5.38	22.2	2.78	22.4	2.88
Malay	49	98.1	4.67	22.6	2.92	23.0	2.99
Early-SE Asians	10	99.2	7.93	21.3	2.56	21.6	3.67
Sumatra	13	99.6	5.06	21.4	1.74	21.5	2.12
Javanese	59	100.9	4.63	22.3	2.83	22.1	2.65
Borneans	69	99.0	5.07	22.5	2.53	22.7	2.64
Filipinos	74	99.5	5.63	21.3	2.69	21.5	2.56
Celebes-Molucca	27	100.3	3.92	21.3	2.58	21.3	2.60
Lesser Sunda	13	96.5	5.19	21.9	3.62	22.6	3.58
Andamanese	48	95.1	4.19	23.8	2.72	25.1	2.75
Nicobarese	17	99.2	4.59	22.1	3.35	22.3	2.97
Negritos	18	94.8	4.29	19.3	2.35	20.3	2.14
Eskimos	76	100.7	5.63	19.4	2.88	19.3	2.85
Subarctic	20	100.9	5.35	23.9	3.56	23.7	3.35
Northwest America	50	101.4	5.11	24.0	3.05	23.7	2.74
California	38	100.3	5.95	23.2	2.79	23.2	2.74
East America	19	100.2	5.99	23.7	3.19	23.8	3.88
Mesoamerica	26	99.8	5.73	23.2	2.89	23.3	2.75
Caribians	19	102.5	5.90	25.6	3.07	25.0	3.06
Peruvians	91	98.9	4.32	24.2	2.57	24.5	2.38
Fuegian-Patagonian	38	103.0	4.18	24.6	2.41	23.9	2.22
Mariana	21	100.2	5.18	20.7	3.58	20.6	3.08
Caroline	11	98.1	2.89	23.8	3.07	24.3	3.29
Hawaii	72	96.5	5.20	24.2	2.58	25.1	2.53
Easter	54	97.4	4.88	25.4	3.25	26.1	2.96
Marquesas	57	99.0	4.52	25.1	2.93	25.4	2.69
Society	42	95.9	5.25	24.8	3.44	25.9	3.46
Cook	13	99.1	4.85	23.2	3.67	23.5	3.82
Tonga-Samoa	12	100.6	6.89	24.6	2.86	24.4	2.36
Maori	108	97.3	5.82	25.7	2.88	26.5	2.80
Moriori	67	97.5	4.47	26.8	3.04	27.4	2.87
Fiji	28	96.0	4.58	26.0	2.46	27.1	2.52
New Britain	56	96.5	4.31	25.6	2.91	26.5	2.74
Vanuatu	24	96.8	3.94	25.9	2.90	26.8	3.27
New Caledonia	35	98.5	5.64	25.8	2.86	26.2	2.50
New Ireland	24	95.8	4.91	26.4	3.21	27.6	3.87
Santa Cruz	16	96.0	2.96	29.0	3.23	30.2	3.08
Solomon	53	96.4	5.08	25.7	3.17	26.7	3.03
Papua New Guinea	152	95.3	5.00	26.5	3.21	27.8	3.68
Torres Strait	58	97.4	5.09	26.6	2.88	27.3	2.88
New South Wales	50	95.3	4.92	25.0	2.46	26.2	2.78
South Australia	92	96.6	5.02	26.0	3.11	27.0	3.12
Murray River	23	95.4	4.53	24.6	2.16	25.8	2.50
Queensland	19	94.7	5.94	23.4	2.68	24.8	3.43
Western Australia	20	95.1	5.08	26.3	2.60	27.7	2.54
Tasmania	10	95.2	5.66	27.3	3.18	28.7	3.50
Nepalese	31	95.7	4.69	22.8	3.34	23.9	3.65
Tibetans	56	97.9	5.36	21.4	2.48	21.9	2.73
Bangladesh-Bhutan	27	94.1	5.11	24.0	2.87	25.5	2.75
Assam-Sikkim	40	97.8	5.48	22.4	2.79	22.9	3.00
Bengal-Bihar	76	93.8	4.44	23.6	2.84	25.2	3.01
Punjab	72	94.4	4.91	24.7	2.98	26.2	2.98
Delhi-NW India	31	94.2	4.90	22.7	2.59	24.1	2.68
Madras	96	93.8	5.10	23.3	2.95	24.9	3.00
Veddah	15	90.1	5.08	22.6	3.66	25.1	3.55

(*continued*)

TABLE 7. (continued)

Sample name	N	Chord		Subtense		Index	
		Mean	S.D.	Mean	S.D.	Mean	S.D.
Afghanistan	38	95.0	5.21	24.5	3.00	25.8	2.98
Palestine	83	94.8	4.78	23.8	2.69	25.1	2.77
Turkey	20	96.7	4.61	22.9	3.39	23.7	3.31
Cyprus	17	94.8	4.36	22.9	2.65	24.2	2.86
Greece	30	93.9	5.72	23.6	3.14	25.2	3.00
Ancient Greece	16	94.7	3.92	22.4	3.42	23.7	3.80
Italian	99	93.7	5.15	23.9	2.55	25.6	2.76
Ancient Italian	33	94.2	4.87	22.8	2.58	24.2	2.69
Russian	42	94.1	6.62	23.3	2.58	24.9	3.13
Hungary	21	92.7	4.58	22.6	1.48	24.4	1.95
Czechoslovakia	55	93.2	4.85	22.8	2.93	24.5	2.91
Finland	24	97.9	4.69	23.6	2.29	24.1	2.26
Norwegian	18	93.6	5.20	24.8	1.60	26.5	1.37
Sweden	29	94.9	6.14	23.3	3.66	24.5	3.54
Lapp	26	94.6	5.39	21.7	2.75	22.9	2.40
Holland	35	92.0	4.87	23.0	2.66	25.0	2.34
German	52	94.0	3.89	23.5	3.24	24.9	3.46
French	55	92.3	5.69	22.9	2.33	24.8	2.56
Ancient French	18	96.5	7.47	22.7	3.73	23.5	2.88
Spain	23	94.1	5.86	24.8	2.58	26.4	2.60
Ensay	64	92.9	4.23	23.2	2.73	25.0	2.53
Repton	30	94.0	4.75	23.6	2.81	25.1	2.61
Poundbury	94	94.3	5.25	23.3	3.12	24.7	2.95
Spitalfields-1	72	88.4	4.87	22.4	2.22	25.3	2.24
Spitalfields-2	57	94.3	4.40	22.7	1.92	24.1	2.21
Neolithic UK	12	92.7	3.99	23.6	2.98	25.4	3.08
Badari	36	93.3	5.05	22.9	3.26	24.5	2.92
Naquada	76	94.7	4.89	23.2	2.75	24.5	2.57
Gizeh	100	93.8	4.78	23.3	2.57	24.8	2.60
Kerma	82	95.7	4.70	21.3	3.67	22.5	3.24
Early Nubia	76	93.9	4.73	23.0	2.48	24.5	2.43
Recent Nubia	37	94.8	4.74	23.1	2.79	24.4	2.83
Morocco	18	93.0	6.33	21.0	2.71	22.6	2.82
West Africa	34	98.0	5.62	23.5	2.46	24.0	2.55
Nigeria-1	69	98.5	4.47	21.4	2.40	21.7	2.24
Nigeria-2	70	96.5	4.16	23.2	2.64	24.0	2.93
Gabon	72	96.4	4.44	24.5	2.71	25.4	2.91
Congo	13	95.6	5.30	24.6	2.70	25.9	3.27
Somalia	50	92.8	5.19	22.2	3.14	23.9	3.13
Kenya	62	97.2	5.16	21.4	3.07	22.0	3.11
Tanzania	47	95.8	5.22	24.5	3.06	25.5	2.88
Uganda	17	95.8	5.14	23.2	3.66	24.2	3.81
Malawi	32	96.8	5.21	23.3	2.47	24.1	2.76
South Africa	53	97.5	4.71	23.9	3.02	24.6	3.10
Khoi-San	28	92.2	5.30	20.7	2.99	22.4	2.77

based on the combined sum of squares calculated separately in the 112 population samples. Table 8 gives the basic results of this canonical correlation analysis, using the first variable group (glabellar, gnathic, and sagittal frontal indices) and a set of transverse flatness measurements of the face (second variable group). The canonical correlation of the first factor is statistically significant (chi-square = 16.975; $P < 0.05$), but not so in the second and third factors.

The standardized coefficients for the variables of the first factor indicate the relationship between the prominence of the infraglabellar notch, prognathism, and frontal flatness in the sagittal plane and frontoorbital flatness and, to a lesser extent, nasal flatness. The plots of the samples on the first canonical variates, based on the scores of the canonical variables in each sample, are presented in Figures 7a,b. The first variable group (Fig. 7a) opposes the Australian/Melanesian samples to the east/northeast Asian samples. The positive, or Australian/Melanesian end, reflects a relatively prominent infraglabellar notch and marked prognathism with a sagittally flat frontal bone.

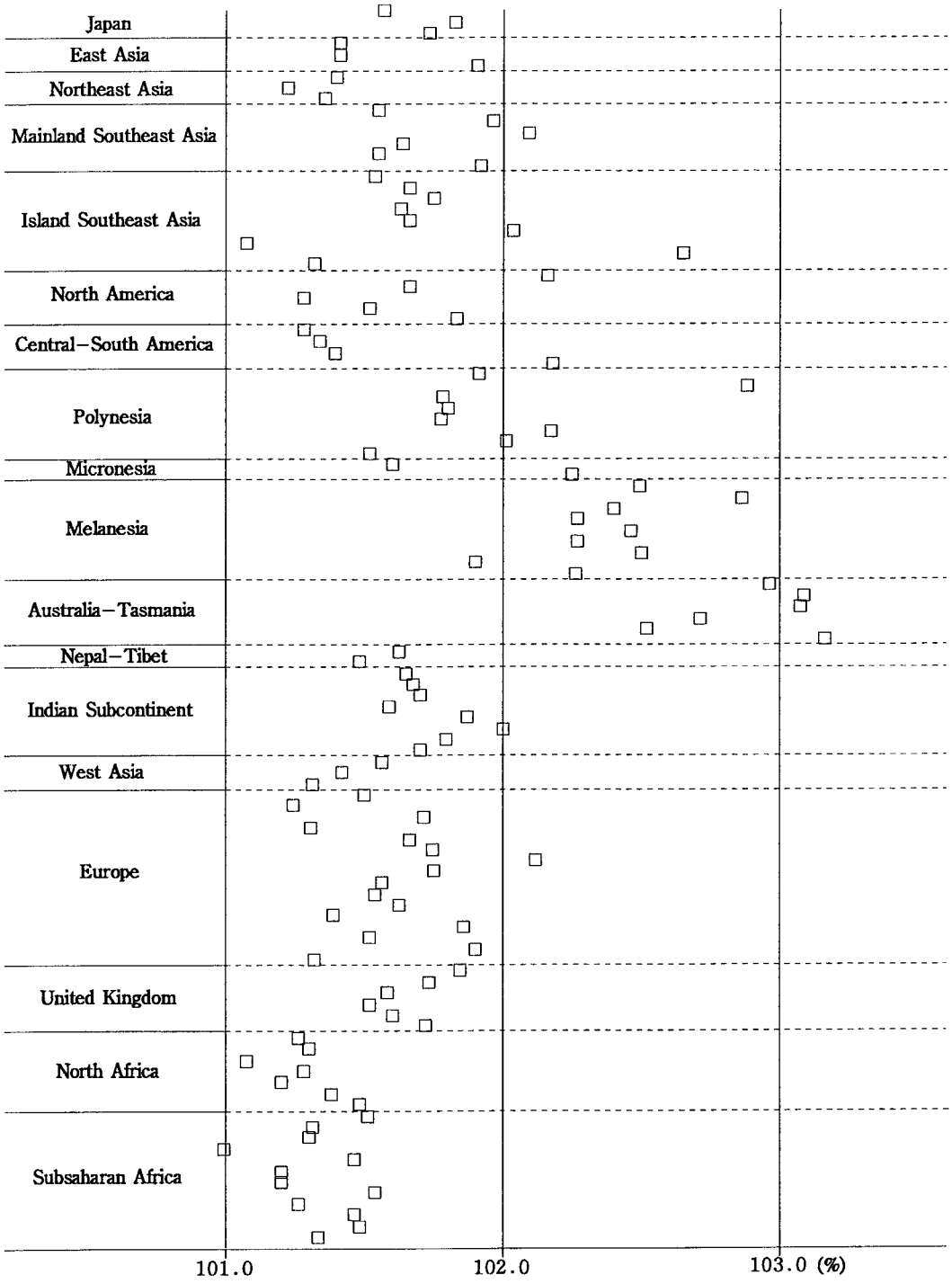

Fig. 1. Graphic display of regional variation in the depth of the infraglabellar notch evaluated by M1/M1d. The order of squares corresponds to the sample number given in Table 1.

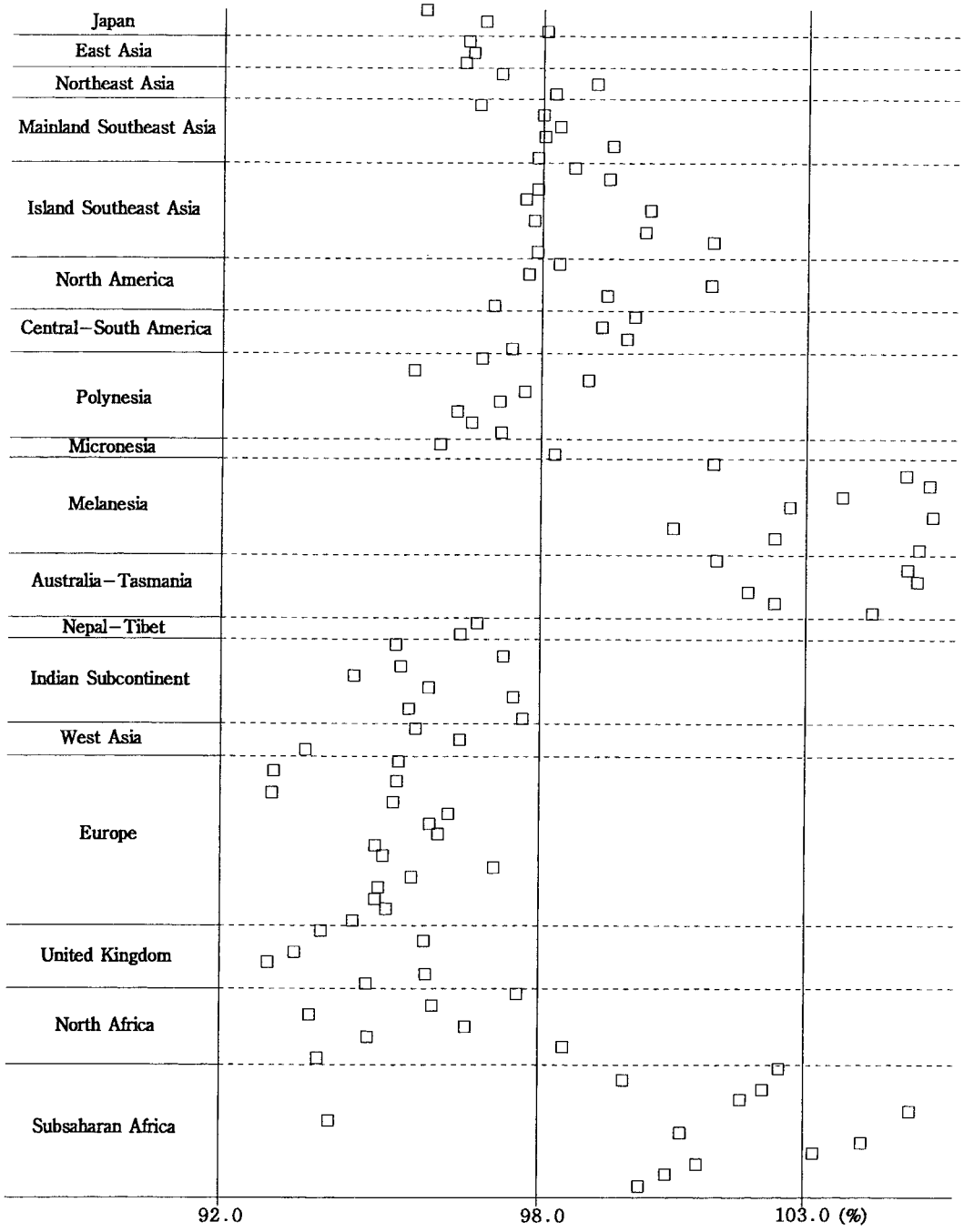

Fig. 2. Graphic display of regional variation in prognathism (M40/M5).

Some of subSaharan African samples are plotted on the positive or Australian/Melanesian side. On the other hand, the European samples, together with the north African, west Asian, and Indian subcontinent samples, are scattered on the opposed side. Figure 7b indicates the magnitude of the projection of midfacial region in the trans-

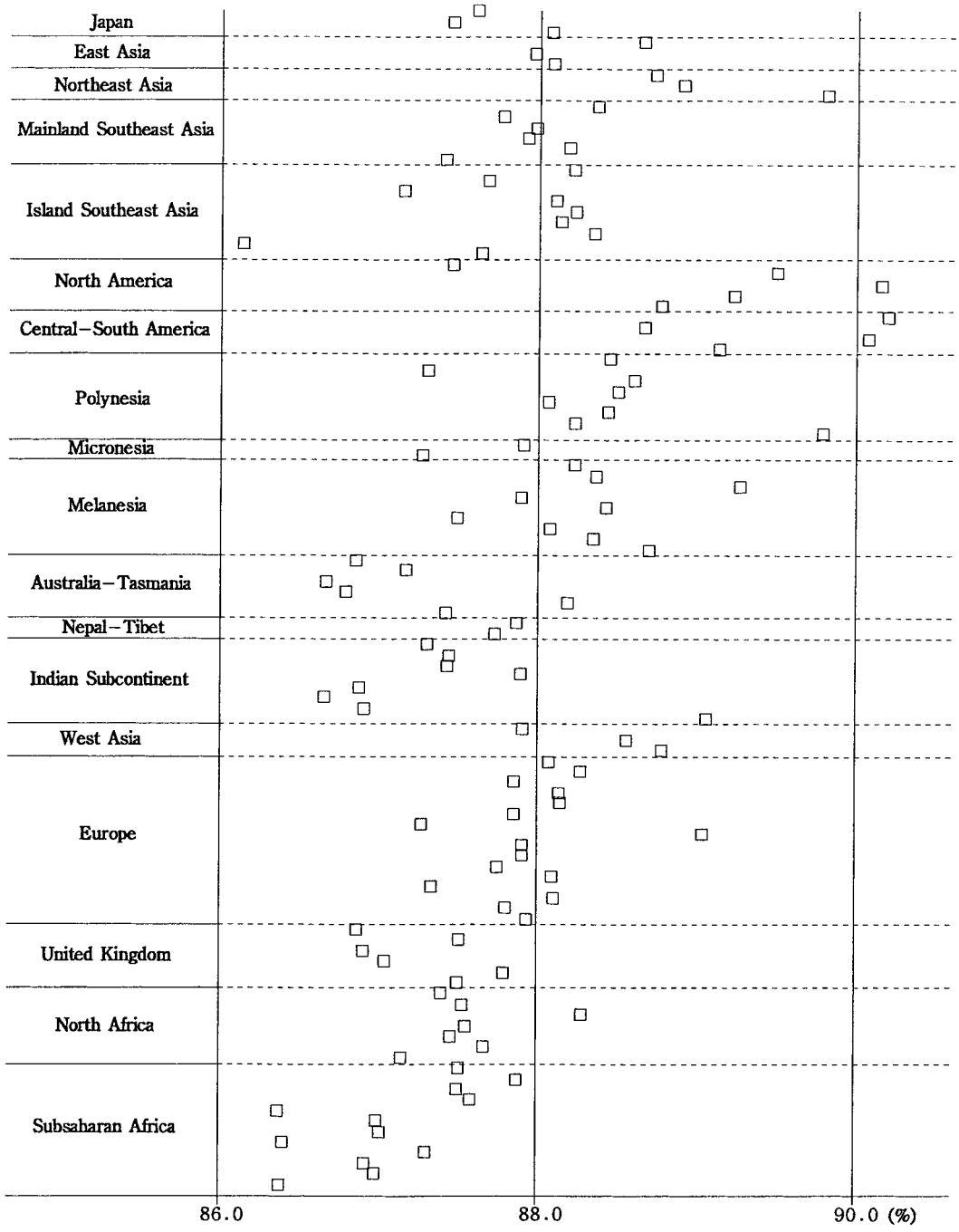

Fig. 3. Graphic display of regional variation in sagittal frontal flatness tentatively measured by M29/M26.

verse plane without prognathism. The positive end, reflecting flat fronto-orbital and nasal portions, signals a decided eastern Asian and Pacific configuration together with some subSaharan African samples. The degree of facial projection of some New World samples and Australian samples is comparable to those of samples from south

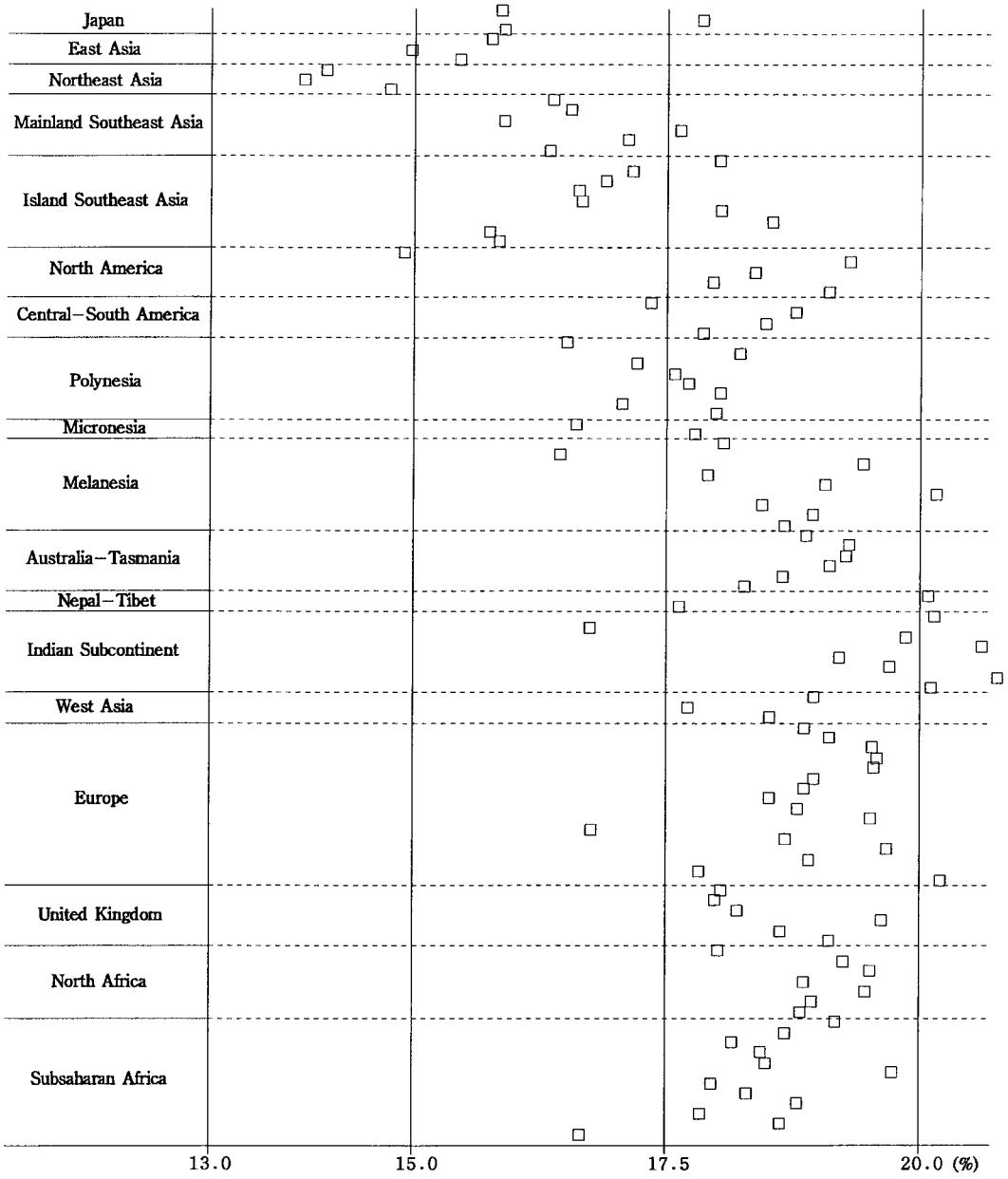

Fig. 4. Graphic display of regional variation in the frontal index of facial flatness measurements.

Asia to Europe through west Asia and north Africa.

DISCUSSION

The results presented herein suggest that the features relating to frontal and facial flatness are largely confined to populations from differing world regions: 1) the considerable flatness of the faces of east/northeast Asians, and to a lesser extent, of southeast Asians; 2) morphological complexes such as a deep infraglabellar notch and sagittally flat frontal bone with facial prognathism in Australians and Melanesians; 3) rounded forehead comparable to that in northeast Asians and transversely projecting faces as

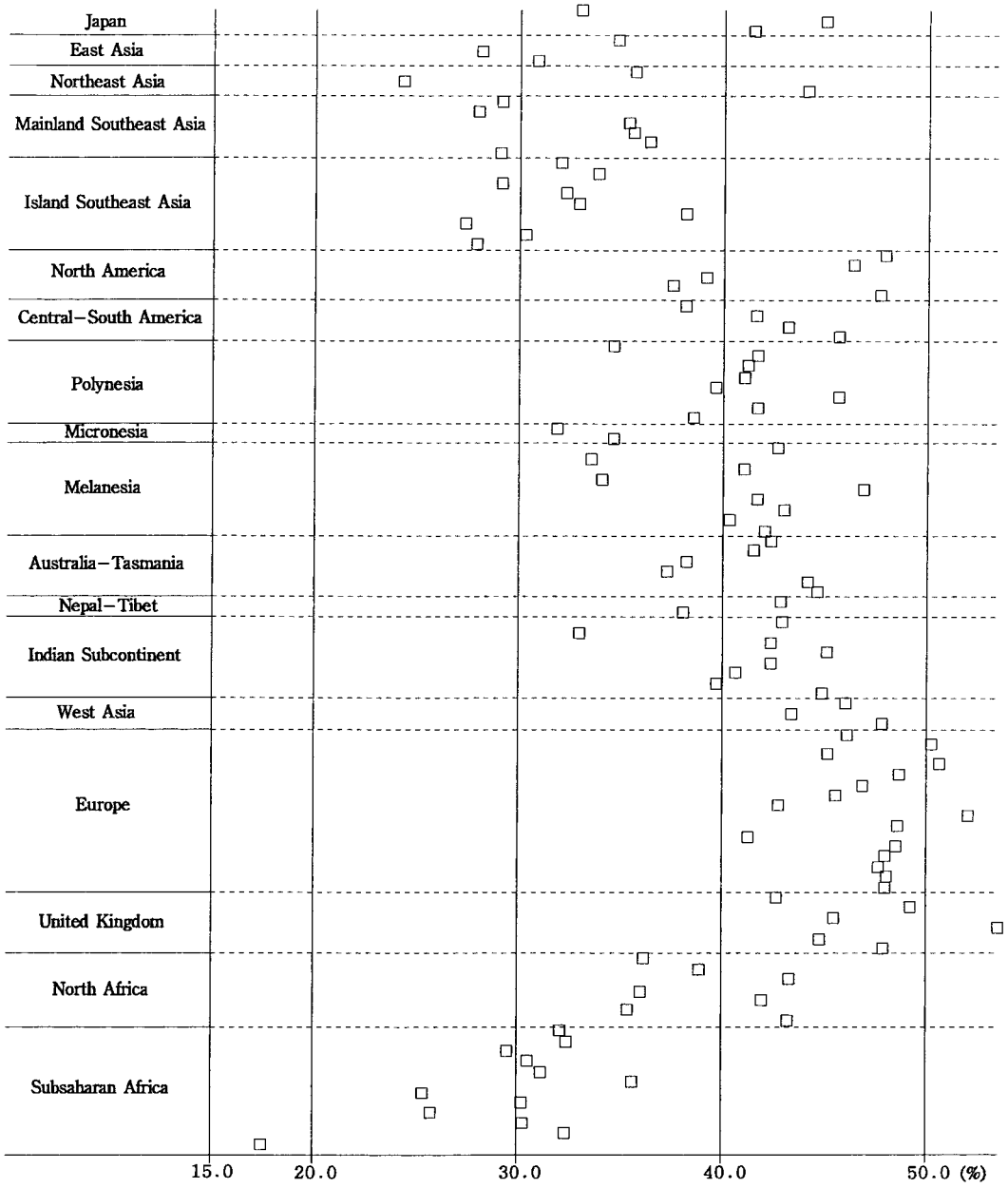

Fig. 5. Graphic display of regional variation in the simotic index of facial flatness measurements.

in Europeans found in the New World populations; 4) eastern Asian-like features in Polynesians and Micronesians, except for a projecting zygomaxillary region; 5) midfacial projection without prognathism in Europeans and related populations such as south and west Asians as well as north Africans; and 6) remarkable prognathism and very flat nasal bones in SubSaharan Africans.

East/northeast Asians are quite different from other geographical populations in their front-orbital and zygomaxillary indices. This is consistent with the fact that they exhibit a more horizontally oriented zygomatic bone, characterized by a more acute and anteri-

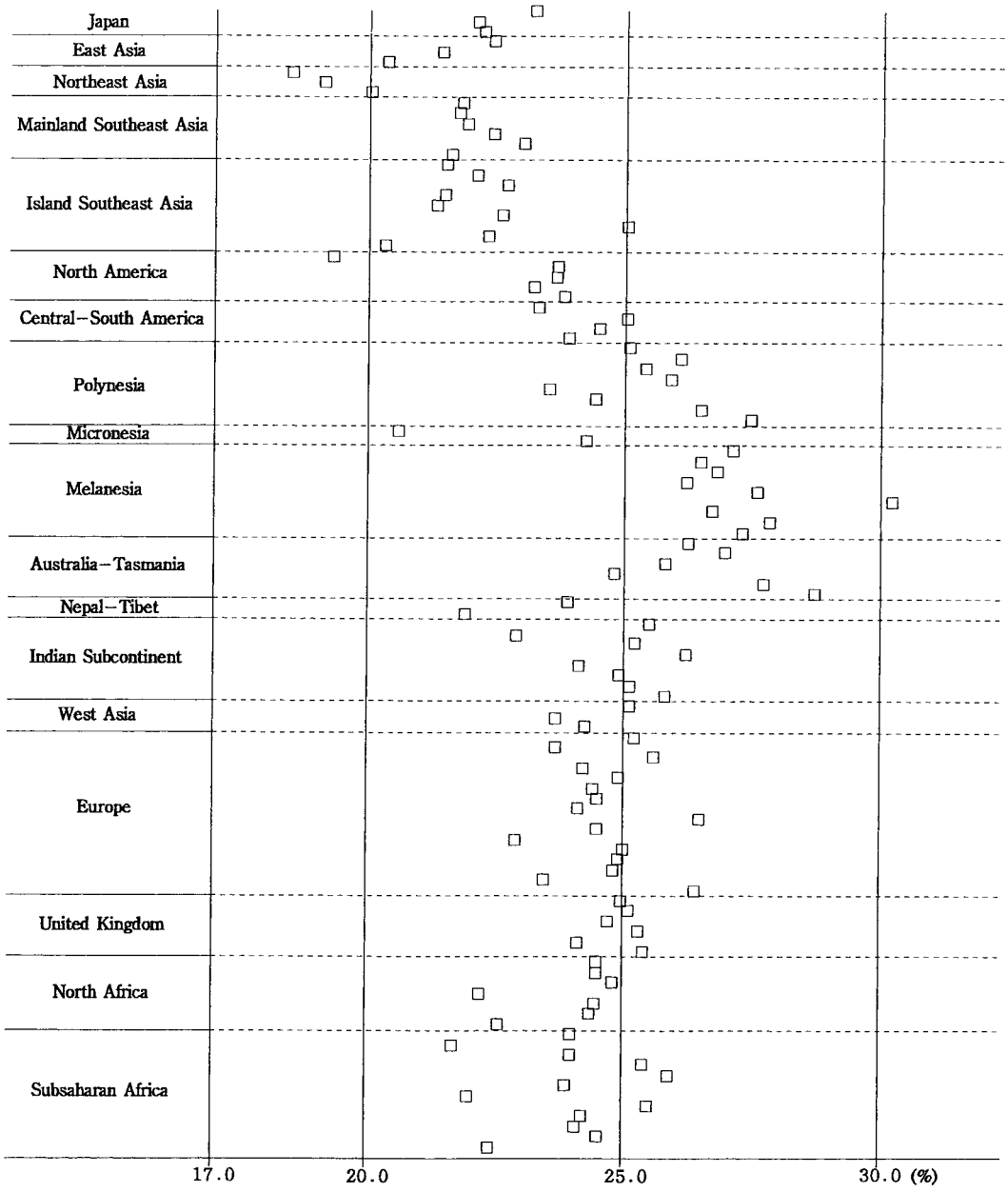

Fig. 6. Graphic display of regional variation in the zygomaxillary index of facial flatness measurements.

orly situated zygomaxillary angle. The faces of Asian fossil hominids also show the same characteristics and contrast markedly with a good number of European and African contemporaries (Weidenreich, 1943; Coon, 1967; Wolpoff, 1985, 1989, 1992; Wu and Wu, 1985; Wu and Zhang, 1985; Smith et al., 1989; Pope, 1991). In Australasia, the distinctive characteristics of Australians among current human populations, and the firm links between the middle and late Pleistocene fossil hominids in this region and living Australians, have been emphasized with features that include a deep infraglabellar notch, marked prognathism, and a flat forehead (Weidenreich, 1951; Larnach and

TABLE 8. Canonical correlation coefficients and canonical vectors

Axis	First	Second	Third
Canonical correlation	0.36962	0.15915	0.06535
Standardized coefficients in each index			
Grabellar	0.25993	1.04517	−0.15985
Gnathic	0.85186	−0.33174	−0.40914
Frontal-sagittal	−0.34729	0.38572	−0.95583
Frontal	−0.97032	−0.37676	−0.01051
Simotic	−0.28632	0.84430	−0.49207
Zygomaxillar	0.50407	−0.49963	−0.78118

Macintosh, 1974; Jacob, 1976; Pope, 1988; Wolpoff, 1992).

The results obtained in the univariate analysis generally fit the definition of "regional character" in eastern Asia and Oceania proposed by Wolpoff (1980, 1985, 1989, 1992), Thorne and Wolpoff (1981), Wolpoff et al. (1984), and others in their multiregional hypothesis for the origin of anatomically modern humans.

If, on the other hand, a single origin for modern humans in subSaharan Africa is assumed, how can the regional morphological variation be explained? Lahr (1996), in her excellent study of craniofacial features, pointed out that early anatomically modern humans as represented at Klasies River Mouth, and by Florisbad, Skhul 5, Qafzeh 9, and other late Pleistocene fossil crania, present a morphological pattern characterized by features such as a deep infraglabellar notch, facial prognathism, and a flat frontal bone in the sagittal plane. The flat faces are, moreover, regarded as a generalized character in anatomically modern humans, based on the fact that a transversely flat face occurred commonly in not only middle Pleistocene hominids but also in late Pleistocene anatomically modern humans (Bulbeck, 1981; Groves, 1989; Habgood, 1989, 1992; Smith and Paquette, 1989; Stringer, 1989, 1992).

Stringer (1989) provides naso-frontal and zygomaxillary angles defined by Howells (1973) for a series of cranial samples from the late Pleistocene. Figure 8 illustrates the fronto-orbital and zygomaxillary indices of the samples used in the present study, together with several late Pleistocene fossil remains reported by Stringer (1989). The late Pleistocene anatomically modern samples show generally flat faces, comparable to present eastern Asian samples in at least fronto-orbital flatness. Moreover, the variation of facial flatness in anatomically modern humans in the late Pleistocene falls within the range of facial flatness in current human groups from around the world.

The results obtained from canonical correlation analysis indicate that two different anatomical circumstances can be recognized in crania with deep infraglabellar notches, sagittally flat frontal bones, and marked prognathism: transversely flat faces and projecting ones. As described above, the proportion of frontal and facial flatness in the late Pleistocene among anatomically modern humans roughly combines a deep infraglabellar notch, sagittally flat frontal bones, and marked prognathism with more or less flat faces. Taking this into consideration, it may be possible to interpret the frontal and facial form of Australians as presenting both generalized and specialized features. In a cladistic sense, the distinctive anatomical combination seen in Australian cranial series does not retain a plesiomorphic state. Stated another way (Lahr and Wright, 1996), Australian faces do not reflect the retention of ancestral traits. At the same time, it may be possible to regard east/northeast Asians as having specialized craniofacial features, because of their considerably flat faces without a deep infraglabellar notch, sagittally flat frontals, and prognathism.

Several investigators regard the flat faces of current northeast Asians as the result of cold adaptation and/or biomechanical efficiency (Coon et al., 1950; Brues, 1977; Hylander, 1977; Szathmary, 1984; Rak, 1986; Smith and Paquette, 1989; Pope, 1991; Ishida, 1992). Some subSaharan Africans have, on the other hand, high canonical scores in both the first and second canonical variates. Except possibly for the gracilization of the infraglabellar region, therefore, cranial series of some subSaharan Africans, e.g., Congolese, Tanzanians, and others, show the remnants of generalized features, suggesting the occurrence of gracilization without marked intensification of specialized features. At the same time, the possible outliers of the predominant eastern Asians and their derived populations, such as the

TABLE 9. Scores of the first canonical variables

Population name	First	Second
1 Japanese	−0.51534	0.96573
2 Ainu	−0.13663	−0.41083
3 Jomonese	−0.04313	0.53295
4 Northern Chinese	−0.61215	0.80573
5 Southern Chinese	−0.44283	1.15497
6 Korean	−0.54027	0.68175
7 Mongolians	−0.49789	0.78355
8 Northeast Asians	−0.19624	1.29493
9 Chukchis	−0.51400	0.54450
10 Vietnamese	−0.45913	0.60363
11 Laos-Cambodia	0.08152	0.54883
12 Thailand	0.17005	0.65129
13 Myanmar	−0.05769	0.00375
14 Malay	0.13889	0.30324
15 Early southeast Asians	0.12666	0.58224
16 Sumatra	−0.02390	−0.23001
17 Javanese	0.26509	0.18998
18 Borneo	0.12446	0.53977
19 Filipino	−0.16207	0.34300
20 Celebes-Molucca	0.33318	0.28610
21 Lesser Sunda	0.00553	−0.20532
22 Andamanese	0.07203	0.31296
23 Nicobarese	1.40590	0.92079
24 Negritos	−0.14795	0.59819
25 Eskimo	0.29879	0.25451
26 Subarctic	−0.43647	−0.80032
27 Northwest America	0.03988	−0.18696
28 California	−0.12198	−0.05132
29 East America	−0.37432	−0.71348
30 Mesoamerica	−0.28720	0.21235
31 Caribians	−0.08919	−0.19096
32 Peruvians	−0.24755	−0.20220
33 Fuegians-Patagonians	−0.23735	−0.11717
34 Mariana	−0.49870	0.21201
35 Caroline	0.35698	0.28340
36 Hawaii	−0.33028	0.96503
37 Easter	0.00139	0.22937
38 Marquesas	0.04121	0.55167
39 Society	−0.18568	0.47860
40 Cook	−0.21879	0.03707
41 Tonga-Samoa	−0.32261	−0.09316
42 Maori	−0.28640	0.78459
43 Moriori	−0.67361	0.66060
44 Fiji	0.91111	0.45223
45 New Britain	1.81894	0.12679
46 Vanuatu	1.55095	−0.14166
47 New Caledonia	1.43624	0.06090
48 New Ireland	1.17431	0.01420
49 Santa Cruz	1.89423	0.13373
50 Solomon	0.77793	0.19882
51 Torres Strait	1.57422	0.25476
52 Papua New Guinea	0.92669	0.27432
53 New South Wales	1.38151	−0.04218
54 South Australia	2.16836	−0.06955
55 Murray River	2.29469	−0.17078
56 Queensland	1.43997	−0.25901
57 Western Australia	1.18973	−0.26158
58 Tasmania	1.98920	0.59108
59 Nepalese	−0.31678	−0.97112
60 Tibet	−0.41049	−0.16373
61 Bangladesh-Bhutan	−0.52885	−0.72377
62 Assam-Sikkim	−0.09922	0.53755
63 Bengal-Bihar	−0.51980	−0.63246
64 Punjab	−0.85010	−0.86144
65 Delhi-NW India	−0.22099	−0.55812
66 Madras	0.23024	−0.57761
67 Veddah	−0.33035	−0.97807
68 Afghanistan	−0.33998	−0.71406
69 Palestine	−0.60440	−0.38463
70 Turkey	−0.60357	−0.03958
71 Cyprus	−1.33885	−0.40451
72 Greece	−0.72897	−0.33236
73 Ancient Greece	−1.38628	−0.81026
74 Italian	−0.61754	−0.50710
75 Ancient Italian	−1.34607	−0.92719
76 Russian	−0.70826	−0.74796
77 Hungary	−0.39161	−0.52312
78 Czechoslovakia	−0.20074	−0.42524
79 Finland	−0.68235	−0.28345
80 Norwegian	−0.77253	−0.23834
81 Sweden	−0.75123	−0.78963
82 Lapp	−0.22060	0.29419
83 Holland	−0.71893	−0.35226
84 German	−0.53106	−0.76893
85 French	−0.83406	−0.45422
86 Ancient French	−0.56970	−0.25131
87 Spain	−0.95937	−0.73688
88 Ensay	−0.67296	0.07539
89 Repton	−0.41484	−0.06564
90 Poundbury	−0.89128	−0.11478
91 Spitalfield-1	−1.05172	−0.83478
92 Spitalfield-2	−0.52416	−0.37871
93 Neolithic UK	−0.66419	−0.44459
94 Badari	−0.17757	0.19263
95 Naquada	−0.54847	−0.41016
96 Gizeh	−1.30567	−0.59570
97 Kerma	−0.41847	−0.56340
98 Early Nubia	−0.84130	−0.60036
99 Recent Nubia	0.00308	−0.19127
100 Morocco	−0.88181	−0.69076
101 West Africa	0.97986	−0.28247
102 Nigeria-1	0.17861	−0.48442
103 Nigeria-2	0.82602	0.22732
104 Gabon	0.60916	0.33746
105 Congo	1.74754	0.36976
106 Somalia	−0.91061	−0.63282
107 Kenya	0.55730	0.08282
108 Tanzania	1.56967	0.41645
109 Uganda	1.07217	0.09828
110 Malawi	0.74199	0.36025
111 Zulu-Kaffir	0.60181	0.04403
112 Khoi-San	0.43738	0.92141

(*continued*)

Nicobarese and Tasmanians, do not show any distinctive morphological differentiation from the expected generalized or the subSaharan African form. According to Lahr (1995), it is possible that these peripheral groups maintained, at least in part, their distinctiveness because of limited gene flow from neighboring groups, which would have allowed the retention of certain morphological traits.

The results in this study are consistent with the definition of "regional characters" summarized by Wolpoff (1992). However, in a cladistic sense, it may also be possible to explain regional morphological variation in frontal and facial flatness under the assumption of a single origin for anatomically mod-

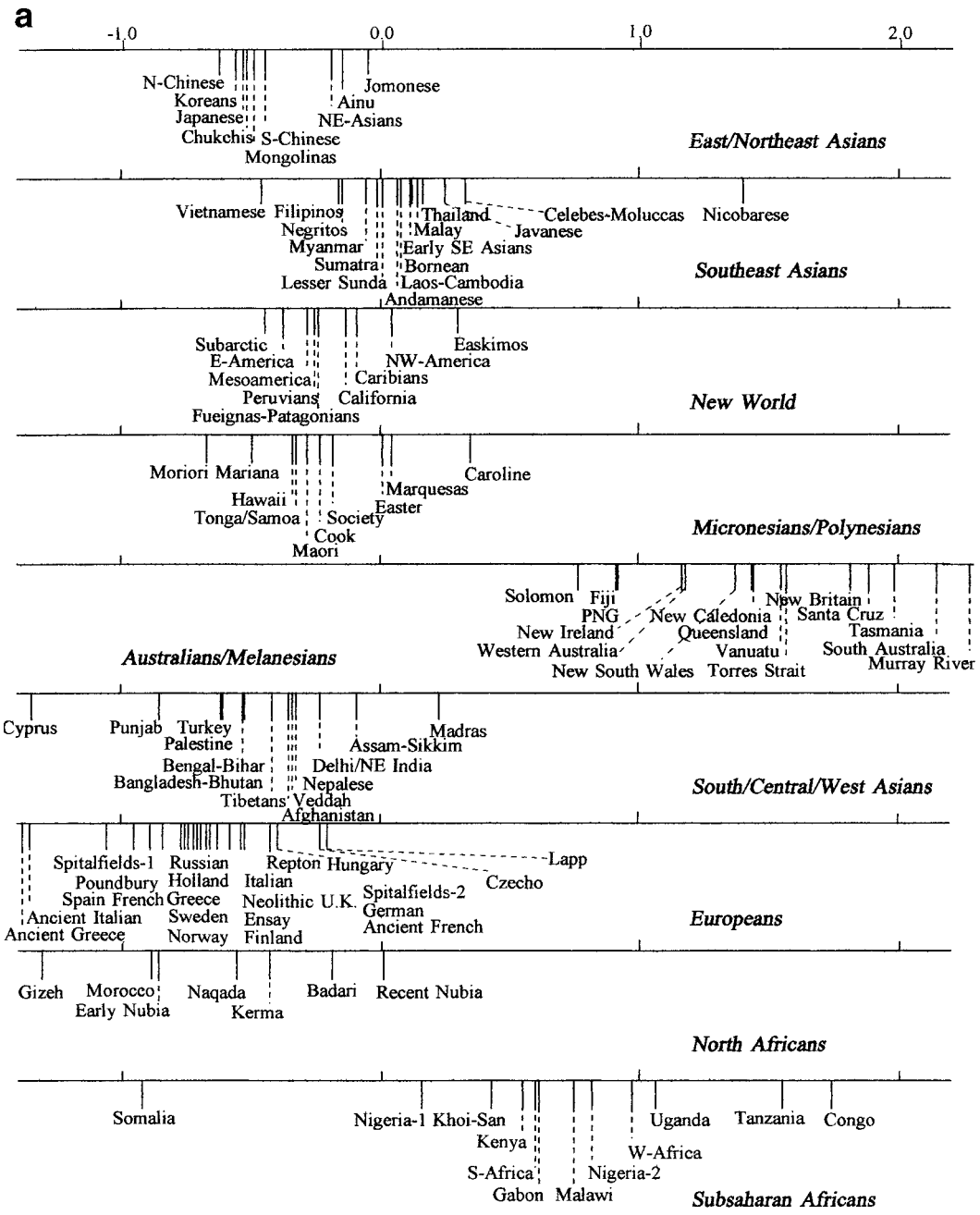

Fig. 7. **a:** Scores of the first canonical vector of the first canonical variates. **b:** Scores of the second canonical vector of the first canonical variates.

ern humans in subSaharan Africa. It is worth noting that this study is not a test of competing models of modern human origins. The proper conclusion is, therefore, that the data on recent craniofacial variation in worldwide populations are compatible with not only a multiregional interpretation but also a single-origin interpretation.

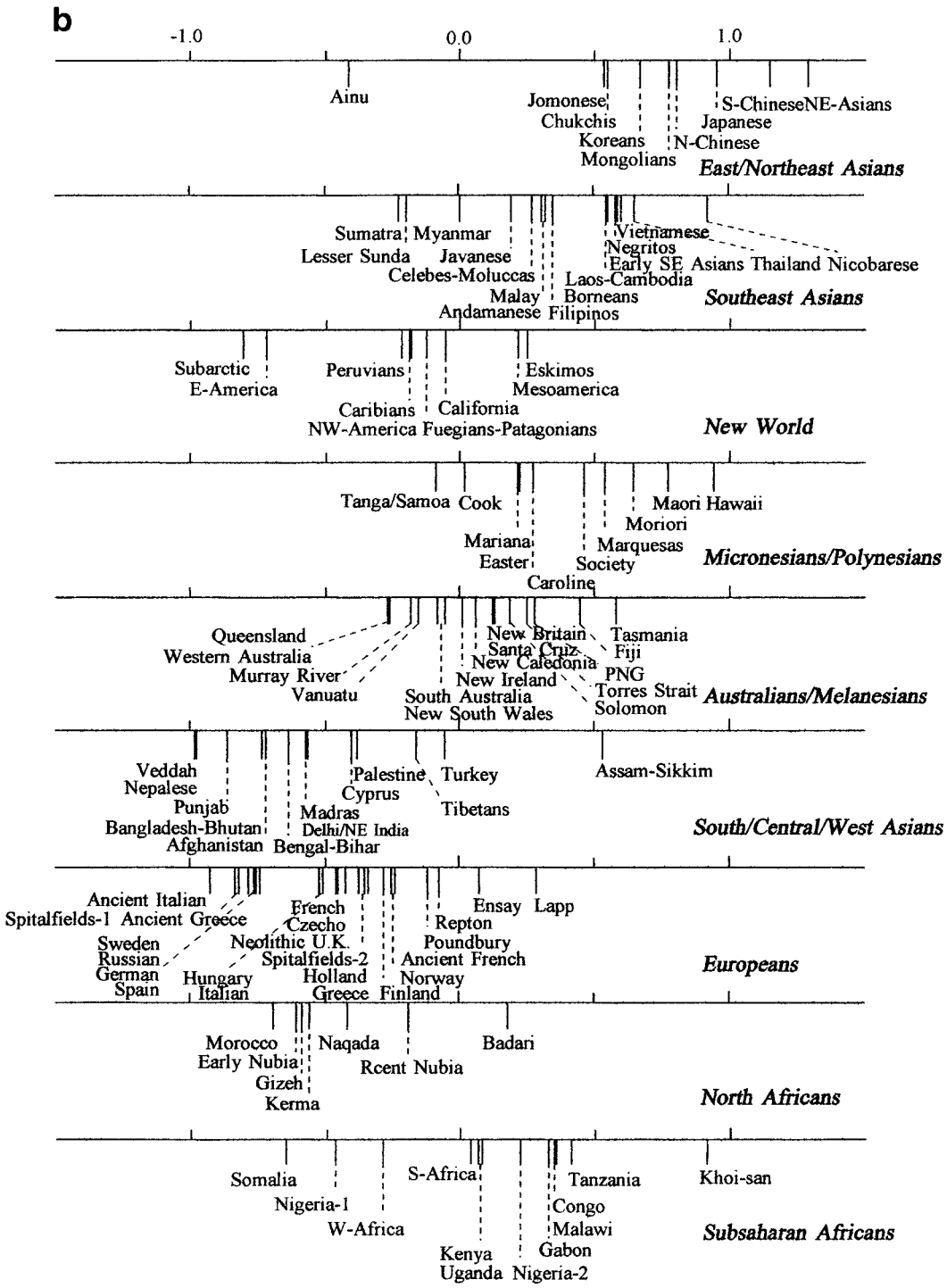
b
-1.0
0.0
1.0
Ainu
Jomonese
Chukchis
Koreans
Mongolians
S-ChineseNE-Asians
Japanese
N-Chinese
East/Northeast Asians
Sumatra
Myanmar
Lesser Sunda
Javanese
Celebes-Moluccas
Malay
Andamanese
Filipinos
Vietnamese
Negritos
Early SE Asians
Thailand
Nicobarese
Laos-Cambodia
Borneans
Southeast Asians
Subarctic
E-America
Peruvians
Caribians
NW-America
California
Fuegians-Patagonians
Eskimos
Mesoamerica
New World
Tanga/Samoa
Cook
Mariana
Easter
Society
Caroline
Marquesas
Moriori
Maori
Hawaii
Micronesians/Polynesians
Queensland
Western Australia
Murray River
Vanuatu
South Australia
New South Wales
New Britain
Santa Cruz
New Caledonia
New Ireland
Tasmania
Fiji
PNG
Torres Strait
Solomon
Australians/Melanesians
Veddah
Nepalese
Punjab
Bangladesh-Bhutan
Afghanistan
Madras
Delhi/NE India
Bengal-Bihar
Palestine
Cyprus
Turkey
Tibetans
Assam-Sikkim
South/Central/West Asians
Ancient Italian
Spitalfields-1
Ancient Greece
Sweden
Russian
German
Spain
Hungary
Italian
French
Czecho
Neolithic U.K.
Spitalfields-2
Holland
Greece
Finland
Repton
Poundbury
Ancient French
Norway
Ensay
Lapp
Europeans
Morocco
Early Nubia
Gizeh
Kerma
Naqada
Rcent Nubia
Badari
North Africans
Somalia
Nigeria-1
W-Africa
S-Africa
Kenya
Uganda
Nigeria-2
Tanzania
Congo
Malawi
Gabon
Khoi-san
Subsaharan Africans

Fig. 7.

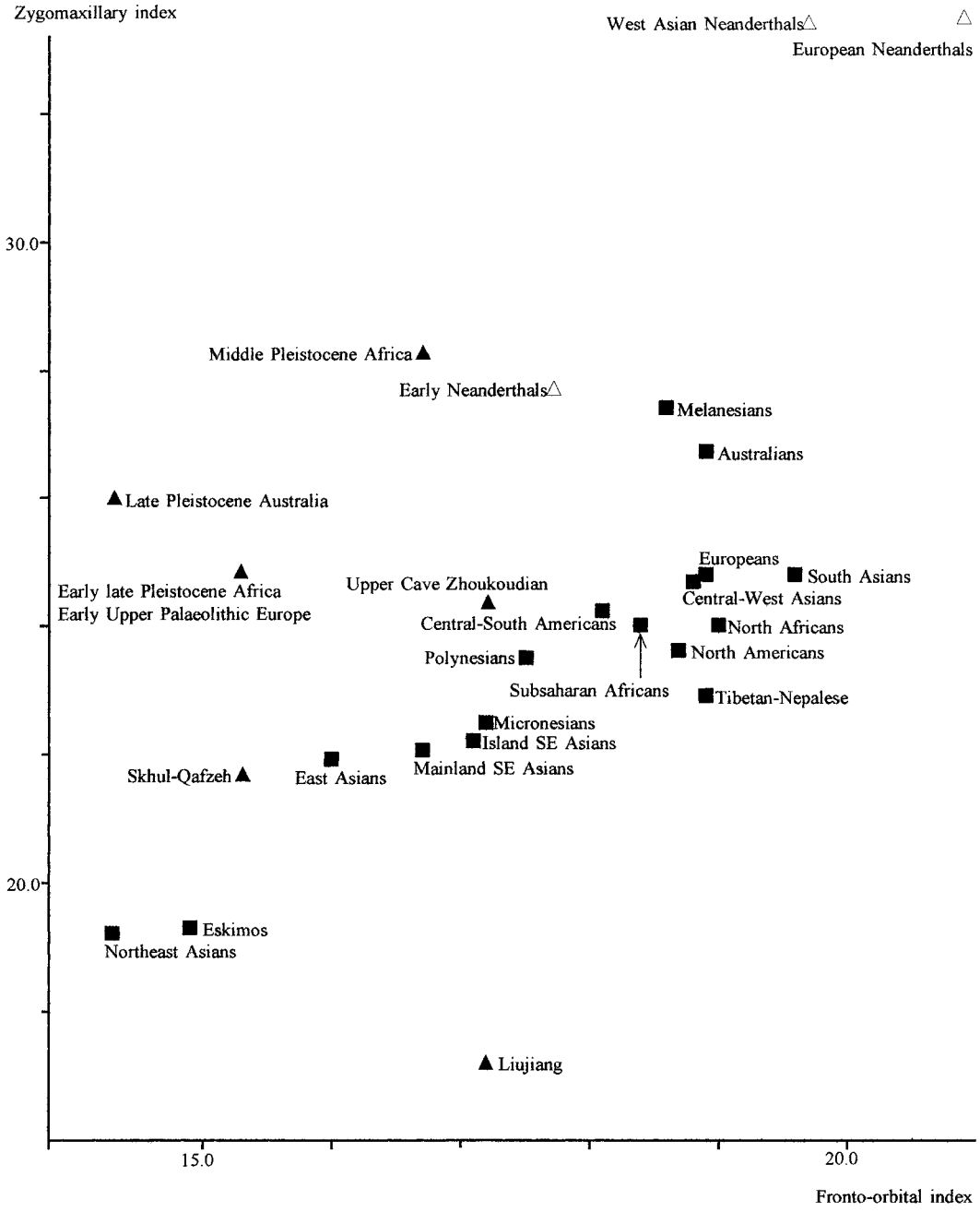

Fig. 8. Scatter diagram of fronto-orbital and zygomaxillary indices of facial flatness, including samples from late Pleistocene fossil remains (Stringer, 1989).

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