VI. INTER AND INTRA TRIBAL MORPHOLOGICAL IDENTITY

Morphological Differences Between Children (Boys) Of Different Bedouin Tribes In South Sinai

In the preceding chapter we emphasized the differences in development between Bedouin boys in South Sinai (Muzeina tribe) and boys of other ethnic and geographic derivations. In the present chapter we shall deal primarily with two central questions, to wit:

(a) Are there morphologic and developmental differences between Bedouin boys of different tribes in South Sinai?

(b) Are there morphologic and developmental differences between Bedouin boys belonging to different sub-tribes of the same tribe?

We have arranged the Bedouin tribes of South Sinai in four groups as follows, according to their origin and ethnic background (see Chapter 1): Group 1, Gebeliya tribe (72 boys); Group 2, Muzeina tribe (269 boys); Group 3, Hamada and Aleigat (66 boys); Group 4, all other tribes (Beni Wassal, Haweitat, Gararsha, Awlad Said and Sawalcha) (158 boys).

We have concentrated mainly on comparisons between Muzeina and Gebeliya boys. In certain instances and mainly in the summarizing chapters, we shall incorporate all the other groups into the results.

In the first stage we carried out comparisons based on raw data, using a two-way analysis of variance where the two independent variables were age and tribal origin.

Results

The means and standard deviations of the distributions of traits in the four Bedouin groups are given in Tables 25 to 66. The differences between the Muzeina and Gebeliya tribes, as indicated in the two-way analysis of variance of the traits and indices are given in Table 67. The final results indicate that in 23 of the 41 traits, there were significant differences between the two tribes. In most cases, as we shall see shortly, the differences were in the breadth measurements or in the indices.

A measurement appearing with an asterisk means that the two tribes differ significantly in the measure. The large spurts in the mean values, as exemplified in the irregularities of the growth data (Tables 30-34; 38-40, 51-52), stem from the small sizes of the samples.

A few words of discussion on the interaction effect may be in order. Ordinarily, in a two-way analysis of variance, one attempts to ascertain the influence of the independent variables on the dependent one (while each time we activate one of the independent variables and keep the other fixed). From the independent variable designated "ethnic origin" we learned about the morphologic differences between the Muzeina and Gebeliya boys. Regarding the second independent variable, age, we assumed that since we were dealing with child populations, most of the traits would show significant changes with age; only 5 traits, most of which were indices rather than direct measurements, failed to show significant changes with age. These were the cephalic index, shoulder (biacromial) breadth/stature index, upper limb (total arm) length/stature index, foot breadth/foot length index, and subcutaneous adipose tissue in the upper arm. Hence we may assume that the body build type, or bodily proportions, are fixed already at an early age, generally 6 years or less. Important information is added by studying the influence of the interaction between both independent variables ("ethnic origin" and "age") on the morphological differences between the groups. In this case the differences are not linked to "ethnic origin" alone or to "age" alone but rather to a combination of both. In developmental terms what we get is not information on the intertribal differences in the trait averages but rather on intertribal differences in the rate of physical development in the tribes, a subject that will be dealt with subsequently.

Hence the pattern of growth between ages 5-13 years of traits which yield a significant interaction effect (age x tribal origin) differs among the tribes. Two traits, morphological facial height and ratio of sitting height to stature, manifested a significant interaction effect.

<u>Head and Face</u> (Tables 25-30)

The ratio between the length and width of the head, or cephalic index, is identical in the Muzeina and Gebeliya tribes, albeit the head in the latter tends to be somewhat narrower than in the Muzeina tribe (Head breadth *). The mean zygomatic face breadth is identical in both tribes. The face as a whole in the Muzeina becomes narrower (Bigonial breadth *) and longer (Morphological facial height *) (* significant difference $p<.05$).

TABLE 25 Mean head length (mm) in South Sinai Bedouin boys, by tribe and age.

TRIBE	Gebeliya		Muzeina		Hamada & Aleigat		Others**		TOTAL	
AGE	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
5	179.00*	8.48	178.94	6.60	175.66*	6.35	178.80	4.31	178.61	5.86
6	180.60	4.32	182.40	5.73	183.72	6.30	181.31	4.92	182.06	5.57
7	181.50	8.35	181.61	5.39	186.00	3.80	183.47	5.64	182.46	6.13
8	184.00	4.39	181.60	5.92	182.33	3.82	180.42	5.04	181.62	5.23
9	181.50	7.42	180.91	4.79	185.50*	2.12	182.75	3.57	182.00	4.81
10	186.00	8.80	185.81	5.43	183.00*	6.32	183.54	3.83	184.67	5.54
11	183.87	3.44	185.46	6.31	191.16	5.63	185.60	7.79	185.02	6.57
12	188.70	7.45	186.60	5.39	188.33*	6.50	189.25	4.53	188.15	5.62
13	186.16	8.44	189.54	5.45	186.27	6.26	187.00	5.39	187.36	6.14

TABLE 26 Mean head breadth (mm) in South Sinai Bedouin boys, by tribe and age.

TRIBE	Gebeliya		Muzeina		Hamada &Aleigat		Others**		TOTAL	
AGE	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
5	136.50*	6.36	134.57	3.70	135.66*	5.59	132.90	5.40	134.29	5.09
6	132.60	3.74	135.71	4.39	134.35	5.04	135.42	4.72	134.88	4.55
7	136.16	5.40	136.04	4.07	136.48	4.37	133.93	3.43	135.76	4.19
8	133.85	4.63	136.41	4.12	134.83	3.65	137.54	4.58	136.33	4.36
9	137.16	3.86	137.00	4.20	137.66*	7.63	134.83	4.56	136.34	4.51
10	136.60	8.26	140.00	3.79	135.00*	4.96	138.81	4.42	138.38	5.09
11	140.00	6.02	137.15	4.89	139.16	4.95	136.46	4.40	137.73	4.98
12	136.00	3.26	138.86	5.06	143.66*	1.52	136.87	5.89	137.81	5.16
13	137.16	3.86	140.42	3.97	137.90	5.57	138.66	4.18	138.90	4.46

* less than 5 cases

** Gararsha, Awlad Said, Sawalcha, Haweitat

TABLE 27: Cephalic index in South Sinai Bedouin boys, by tribe and age

TRIBE	Gebeliya		Muzeina		Hamada &Aleigat		Others**		TOTAL	
AGE	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
5	76.25*	3.05	75.34	4.49	77.36*	3.20	74.36	3.35	75.28	4.34
6	73.47	3.05	74.43	2.20	73.29	2.82	74.74	3.38	74.16	2.77
7	75.21	5.36	74.88	2.87	73.34	2.32	72.71	1.92	74.38	3.33
8	72.75	2.06	75.02	3.54	73.98	2.72	76.50	3.61	75.12	3.49
9	75.64	2.95	76.19	3.27	71.98*	2.72	73.83	3.57	74.94	3.42
10	73.72	4.96	75.41	3.39	73.85*	4.18	75.65	2.79	75.02	4.16
11	76.17	3.85	74.02	3.45	72.81	2.42	73.69	4.75	74.14	3.95
12	72.14	2.47	74.44	2.60	76.32*	1.84	72.34	3.10	73.28	2.96
13	73.78	3.41	74.10	2.96	74.04	2.03	74.21	3.12	74.19	2.84

TABLE 28 Mean bizygomatic breadth (mm) in South Sinai Bedouin boys, by tribe and age.

TRIBE	Gebeliya		Muzeina		Hamada &Aleigat		Others**		TOTAL	
AGE	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
5	111.00*	4.24	111.26	3.00	110.33*	2.52	110.70	4.03	111.00	3.22
6	113.30	2.41	113.22	3.84	112.94	4.82	112.83	2.86	113.09	2.63
7	116.58	2.51	115.52	3.64	114.00	4.64	114.53	3.14	115.26	3.54
8	116.86	2.48	116.75	4.69	117.50	2.59	117.00	3.19	116.78	3.80
9	117.50	3.78	117.50	3.48	116.00*	6.56	115.92	2.47	116.83	3.44
10	113.60	3.21	118.09	3.73	115.75*	5.74	119.36	3.93	117.52	4.33
11	120.75	3.99	120.23	5.55	120.83	4.62	119.00	3.46	119.98	4.36
12	119.90	3.63	121.87	6.15	124.00*	1.00	120.06	4.28	120.91	4.80
13	120.33	4.41	124.21	4.95	121.54	4.61	120.08	4.10	121.91	4.71

* less than 5 cases

** Gararsha, Awlad Said, Sawalcha, Haweitat

TABLE 29 Mean bigonial breadth (mm) in South Sinai Bedouin boys, by tribe and age.

TRIBE	Gebeliya		Muzeina		Hamada &Aleigat		Others**		TOTAL	
AGE	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
5	93.00*	9.99	96.26	6.04	95.67*	3.21	96.80	7.50	96.18	6.28
6	99.20	5.55	96.85	5.86	96.67	7.53	99.80	3.90	97.73	5.85
7	101.58	6.93	98.23	5.93	95.30	6.50	97.30	5.80	98.33	6.24
8	103.33	6.74	97.00	4.91	99.33	1.75	101.20	5.10	99.45	5.36
9	104.67	4.50	99.50	8.47	97.67*	1.53	102.00	3.50	101.18	6.07
10	97.80	7.29	101.36	7.21	7.00*	8.91	104.10	3.20	101.19	6.56
11	108.37	3.11	99.09	4.91	98.00	7.77	102.00	6.10	101.88	6.47
12	104.10	8.66	100.80	7.79	105.33*	5.77	104.40	5.70	103.16	7.18
13	101.33	10.2	102.93	6.57	100.70	6.04	102.70	5.10	102.16	6.43

TABLE 30: Mean morphological facial height (mm) in South Sinai Bedouin boys, by tribe and age.

TRIBE	Gebeliya		Muzeina		Hamada &Aleigat		Others**		TOTAL	
AGE	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
5	85.50*	2.12	87.67	3.12	90.00*	2.00	87.10	3.78	87.57	3.24
6	93.10	5.51	93.03	4.18	94.16	4.00	90.74	4.11	92.67	4.38
7	92.83	3.66	95.91	4.32	92.10	3.07	95.23	5.99	94.98	4.64
8	93.67	3.78	98.12	3.86	98.33	4.13	97.59	3.70	97.34	4.07
9	96.33	4.08	99.57	7.40	101.67*	4.04	97.54	5.22	98.47	4.83
10	98.40	2.41	100.54	6.45	97.75*	2.22	98.36	5.02	99.06	4.99
11	100.37	3.29	100.23	3.42	100.33	6.28	98.56	4.49	99.95	4.28
12	103.40	5.01	102.20	3.65	98.33*	1.53	102.82	5.15	102.51	4.48
13	96.83	1.94	104.78	5.01	106.73	4.47	104.08	6.11	104.18	5.77

* less than 5 cases

** Gararsha, Awlad Said, Sawalcha, Haweitat

The Trunk (Tables 31-40)

In the trunk, boys of the two tribes differ markedly.The Muzeina have a longer trunk [trunk length and sitting height (1)*] as well as broader shoulder and hip widths (biacromial and biiliac breadth *), . Also their chest circumference(*) is greater .

The differences in indices relating trunk breadth to overall stature were all statistically significant (Tables 38-40). In sum, both relatively and absolutely, the Muzeina children have a longer and broader trunk than do the Gebeliya children.

TABLE 31 Mean sitting height (1) (cm) in South Sinai Bedouin boys, by tribe and age.

TRIBE	Gebeliya		Muzeina		Hamada &Aleigat		Others**		TOTAL	
AGE	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
5	58.90*	5.23	61.16	2.56	61.76*	2.62	58.76	2.81	60.37	2.90
6	63.38	2.46	64.30	2.16	64.12	2.22	62.58	2.50	63.64	2.41
7	65.89	2.96	66.32	2.05	64.10	2.55	65.23	2.95	65.79	2.49
8	66.25	3.62	68.13	2.25	69.51	2.30	67.19	2.15	67.54	2.74
9	67.83	2.50	68.63	2.88	68.96*	0.25	68.86	2.90	68.61	2.64
10	70.10	1.71	69.80	3.34	68.10*	1.35	69.70	2.48	69.59	2.59
11	70.90	1.67	73.65	2.98	72.48	4.01	72.21	2.07	72.42	2.73
12	73.88	3.20	73.30	3.30	74.13*	3.05	73.07	3.71	73.40	3.33
13	72.05	1.89	75.78	3.06	75.30	3.01	74.46	3.63	74.80	3.20

Note: sitting height (1) - see Chapter on measurement methods.

TABLE 32: Mean biacromial breadth (cm) in South Sinai Bedouin boys, by tribe and age.

TRIBE	Gebeliya		Muzeina		Hamada &Aleigat		Others**		TOTAL	
AGE	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
5	23.10	0.14	23.64	1.13	24.43*	0.37	23.00	1.36	23.48	1.18
6	24.46	1.90	24.67	1.04	25.25	1.61	24.62	0.93	24.73	1.30
7	25.25	1.63	26.22	1.30	25.97	0.90	26.40	1.72	26.08	1.41
8	26.56	2.33	26.65	1.57	28.26	1.08	26.74	1.14	26.80	1.54
9	26.86	1.70	28.10	1.37	27.26*	1.15	27.17	1.48	27.49	1.48
10	27.14	0.76	27.61	1.56	28.32*	1.48	28.50	0.93	27.95	1.28
11	27.93	1.28	28.80	2.13	29.18	1.75	29.60	1.75	28.99	1.84
12	29.40	1.14	29.40	1.81	29.72*	0.57	29.86	1.70	29.59	1.56
13	28.78	0.90	30.84	1.36	31.90	1.63	30.48	1.62	30.76	1.70

* less than 5 cases

** Gararsha, Awlad Said, Sawalcha, Haweitat

TABLE 33 Mean biiliac breadth (cm) in South Sinai Bedouin boys, by tribe and age.

TRIBE	Gebeliya		Muzeina		Hamada &Aleigat		Others**		TOTAL	
AGE	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
5	16.25*	0.07	17.34	0.96	17.60*	0.40	16.33	1.27	16.98	1.11
6	16.81	1.03	17.88	1.13	17.87	1.32	17.06	0.72	17.53	1.15
7	17.95	0.69	18.41	0.96	18.49	0.89	17.90	1.18	18.25	0.99
8	17.66	0.37	18.85	1.20	19.16	1.19	18.40	1.24	18.56	1.21
9	17.66	0.69	18.90	0.95	20.16*	1.45	18.23	1.09	18.55	1.17
10	18.32	0.73	19.38	1.47	18.97*	0.68	19.46	0.98	19.18	1.15
11	19.01	1.18	19.75	1.74	20.43	1.45	20.14	1.06	19.84	1.41
12	19.92	1.24	20.56	2.07	20.63*	0.90	20.50	1.63	20.40	1.66
13	20.15	1.18	20.61	1.30	21.26	1.82	20.22	1.48	20.63	1.49

TABLE 34 Mean chest circumference (cm) in South Sinai Bedouin boys, by tribe and age.

TRIBE	Gebeliya		Muzeina		Hamada &Aleigat		Others**		TOTAL	
AGE	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
5	53.85*	0.21	56.04	2.32	57.20*	1.70	54.90	2.63	55.62	2.39
6	56.21	3.27	57.80	2.73	58.80	3.30	57.40	2.49	57.70	2.91
7	58.70	2.12	60.04	3.03	59.43	1.89	60.03	2.89	59.75	2.73
8	60.81	3.22	61.36	2.60	64.66	1.83	60.92	2.43	61.40	2.76
9	61.05	3.26	62.14	3.05	62.46*	3.46	61.69	2.43	61.82	2.81
10	61.60	2.74	62.76	4.40	64.25*	2.19	64.16	2.64	63.29	3.26
11	63.47	1.91	65.31	3.22	66.24	3.71	67.23	4.00	65.80	3.58
12	65.45	2.85	67.68	5.40	68.03*	2.61	68.72	4.09	67.60	4.34
13	66.56	2.83	69.29	2.61	71.90	3.57	70.07	3.44	69.83	3.47

* less than 5 cases

** Gararsha, Awlad Said, Sawalcha, Haweitat

TABLE 35 Mean trunk length (cm) in South Sinai Bedouin boys, by tribe and age.

TRIBE	Gebeliya		Muzeina		Hamada &Aleigat		Others**		TOTAL	
AGE	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
5	27.55*	3.32	27.45	1.70	27.63*	2.01	26.66	1.06	27.24	1.62
6	28.50	1.85	29.65	1.53	29.32	1.25	28.43	1.72	29.13	1.61
7	29.46	2.57	30.08	1.56	30.13	2.37	29.37	2.01	29.90	1.92
8	30.94	2.29	30.79	2.34	31.38	1.78	30.31	1.54	30.64	2.00
9	31.40	1.74	32.12	3.08	31.06*	1.68	31.04	2.11	31.52	2.43
10	32.72	1.50	31.93	1.99	31.65*	1.38	32.18	1.69	32.11	1.68
11	31.98	1.56	34.08	2.18	33.81	2.93	33.95	2.09	33.60	2.23
12	34.16	2.63	33.91	2.45	32.93*	2.00	33.48	2.15	33.71	2.28
13	33.66	2.07	34.63	2.08	34.90	1.49	34.43	2.38	34.44	2.02

TABLE 36 Mean sitting height (2) (cm) in South Sinai Bedouin boys, by tribe and age.

TRIBE	Gebeliya		Muzeina		Hamada &Aleigat		Others**		TOTAL	
AGE	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
5	50.65*	2.61	51.20	1.72	52.40*	3.16	50.57	2.12	51.09	1.98
6	53.31	2.76	54.13	1.77	54.38	1.57	52.73	2.03	53.72	1.99
7	54.77	3.03	55.27	2.35	55.71	2.94	54.58	2.72	55.15	2.58
8	56.55	2.95	56.23	2.86	57.90	2.62	56.16	2.03	56.28	2.65
9	57.45	2.46	57.71	2.97	57.86*	1.38	57.43	2.04	57.58	2.39
10	59.26	1.79	57.39	3.36	58.25*	1.59	58.89	2.11	58.33	2.55
11	58.83	1.87	61.54	2.20	61.06	3.63	60.58	2.45	60.61	2.57
12	61.08	2.80	61.27	2.93	60.03*	2.85	61.04	2.56	61.05	2.67
13	60.83	2.37	62.63	2.58	63.29	2.22	62.86	2.99	62.60	2.59

Note: sitting height (2) - see Tests and/or explanations chapter.

* less than 5 cases

** Gararsha, Awlad Said, Sawalcha, Haweitat

TABLE 37 Sitting height (1)/stature index in South Sinai Bedouin boys, by tribe and age.

TRIBE	Gebeliya		Muzeina		Hamada &Aleigat		Others**		TOTAL	
AGE	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
5	52.58*	2.35	55.23	1.23	55.40*	1.63	54.67	1.79	54.93	1.56
6	53.95	1.34	54.74	1.52	53.77	1.04	54.84	1.60	54.46	1.46
7	54.24	1.03	53.61	1.39	52.49	2.07	53.78	0.82	53.60	1.39
8	52.30	1.22	53.43	1.27	53.45	1.01	53.72	1.57	53.36	1.41
9	52.88	0.79	52.51	1.26	52.35*	0.34	53.40	0.72	52.89	1.01
10	52.55	1.03	53.48	1.63	52.02*	0.67	52.51	1.71	52.80	1.53
11	51.71	1.10	52.54	1.42	51.84	1.43	51.63	0.99	51.95	1.24
12	51.46	1.22	51.43	1.49	52.53*	0.46	52.08	2.19	51.75	1.69
13	50.59	0.72	51.73	1.13	50.93	1.35	51.13	1.43	51.16	1.26

TABLE 38 Biacromial breadth/stature index in South Sinai Bedouin boys, by tribe and age.

TRIBE	Gebeliya		Muzeina		Hamada &Aleigat		Others**		TOTAL	
AGE	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
5	20.66*	0.78	21.39	0.82	21.94*	1.26	21.39	0.96	21.40	0.89
6	20.79	1.03	21.00	0.69	21.16	0.92	21.57	0.59	21.15	0.79
7	20.78	1.10	21.19	0.96	21.21	0.25	21.83	1.06	21.25	0.98
8	20.87	1.63	20.96	1.02	21.71	0.66	21.45	0.68	21.20	0.97
9	20.93	0.85	21.40	0.94	20.69*	0.67	21.08	1.02	21.15	0193
10	20.34	0.43	21.17	0.60	21.63*	0.89	21.47	0.43	21.20	0.68
11	20.38	0.98	20.55	1.04	20.87	0.93	21.55	0.48	20.92	0.95
12	20.48	0.77	20.61	0.70	21.09*	0.78	20.95	1.10	20.73	0.87
13	20.21	0.59	21.05	0.63	21.44	0.54	21.16	0.53	21.05	0.66

* less than 5 cases

** Gararsha, Awlad Said, Sawalcha, Haweitat

TABLE 39 Biiliac breadth/stature index in South Sinai Bedouin boys, by and tribe age.

TRIBE	Gebeliya		Muzeina		Hamada &Aleigat		Others**		TOTAL	
AGE	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
5	14.53*	0.57	15.69	0.76	15.83*	1.41	15.19	0.99	15.47	0.92
6	14.30	0.60	15.22	0.87	14.97	1.03	14.93	0.84	14.99	0.89
7	14.79	0.70	14.86	0.74	15.10	0.50	14.81	0.80	14.86	0.71
8	13.90	0.80	14.82	0.89	14.58	0.69	14.70	0.82	14.66	0.85
9	13.79	0.77	14.39	0.55	15.30*	0.98	14.14	0.79	14.28	0.78
10	13.72	0.24	14.75	0.66	14.49*	0.49	14.66	0.67	14.49	0.67
11	13.87	0.92	14.08	0.86	14.63	1.14	14.34	0.77	14.21	0.88
12	13.86	0.42	14.39	0.95	14.62*	0.08	14.61	0.91	14.37	0.85
13	14.14	0.69	14.08	0.92	14.39	0.85	13.88	0.84	14.12	0.84

TABLE 40 Chest circumference/stature index in South Sinai Bedouin boys,by tribe and age.

TRIBE	Gebeliya		Muzeina		Hamada &Aleigat		Others**		TOTAL	
AGE	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
5	48.16*	1.94	50.75	2.19	51.53*	4.98	51.09	1.95	50.77	2.41
6	47.80	0.93	49.22	2.42	49.45	2.09	50.31	2.02	49.40	2.21
7	43.37	2.12	48.66	2.24	48.56	1.21	49.71	2.03	48.79	2.09
8	47.76	0.81	48.20	1.49	49.82	1.43	48.75	1.50	48.53	1.49
9	47.57	1.26	47.32	1.52	47.41*	2.60	47.90	2.67	47.58	2.00
10	46.17	1.67	47.92	2.08	49.06*	1.26	48.33	1.75	47.93	1.92
11	46.29	0.73	46.62	1.55	47.64	2.24	48.79	1.71	47.47	1.87
12	45.59	1.39	47.78	2.07	48.22*	1.15	48.73	2.04	47.66	2.18
13	46.73	1.50	47.31	1.61	48.73	1.56	48.11	1.24	47.82	1.57

* less than 5 cases

** Gararsha, Awlad Said, Sawalcha, Haweitat

The Limbs

In neither the upper limb (Tables 41-45) nor lower limb (Tables 46-49) was there any significant difference between the Muzeina and Gebeliya boys.

The Foot

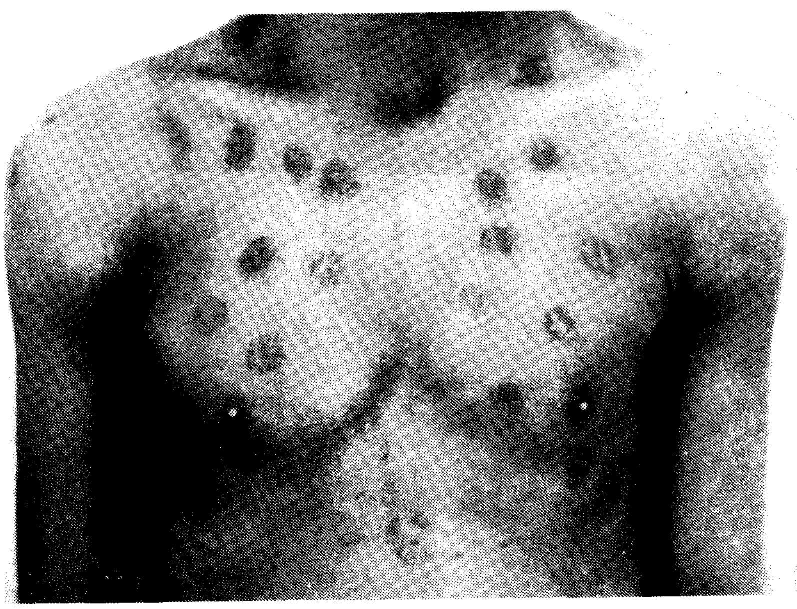
Mean foot length was the same in both the Muzeina and Gebeliya boys, but foot width was significantly greater in the Muzeina (Tables 50-52). Hence the ratio between foot length and foot width was significantly different, the Muzeina boys having feet broader both absolutely and relatively.

TABLE 41 Mean upper arm length (cm) in South Sinai Bedouin boys, by tribe and age.

TRIBE	Gebeliya		Muzeina		Hamada &Aleigat		Others**		TOTAL	
AGE	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
5	20.10*	1.13	19.89	1.53	19.60	2.85	18.96	1.60	19.60	1.64
6	20.93	1.39	21.08	1.84	21.02	1.09	20.50	1.27	20.90	1.50
7	21.96	0.97	21.89	1.69	21.85	1.02	21.70	1.35	21.87	1.45
8	22.90	1.93	23.31	1.93	23.33	1.69	23.16	2.78	23.16	2.22
9	22.36	1.43	23.57	1.92	23.03*	0.66	23.23	1.41	23.22	1.59
10	24.28	1.46	23.00	2.35	22.97*	0.09	24.32	0.94	23.67	1.69
11	24.53	0.86	25.74	1.49	25.23	1.75	24.83	1.50	25.10	1.46
12	26.62	1.50	26.20	1.51	25.26*	1.36	25.66	1.76	26.02	1.61
13	26.06	1.84	26.44	1.12	26.80	1.65	26.20	1.43	26.44	1.42

* less than 5 cases

** Gararsha, Awlad Said, Sawalcha, Haweitat



Cauterization, a popular 'medical' treatment among the Bedouins of South Sinai.

TABLE 42 Mean lower arm length (cm) in South Sinai Bedouin boys, by tribe and age.

TRIBE	Gebeliya		Muzeina		Hamada &Aleigat		Others**		TOTAL	
AGE	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
5	15.90*	0.42	16.24	1.62	16.86*	0.89	15.17	0.93	15.99	1.43
6	16.61	1.89	16.56	1.72	16.87	1.43	16.09	1.44	16.48	1.61
7	17.23	1.19	17.80	1.31	18.42	1.22	17.52	1.35	17.75	1.30
8	18.50	1.40	18.47	1.57	19.90	1.35	17.86	1.66	18.42	1.62
9	19.40	1.32	19.35	1.55	18.76*	0.32	18.66	1.15	19.05	1.31
10	19.96	0.72	19.40	1.82	19.25*	1.41	19.75	1.08	19.60	1.33
11	20.80	0.99	20.39	0.71	21.28	2.82	20.75	1.29	20.74	1.41
12	20.81	1.37	20.82	1.47	20.50*	0.78	20.85	1.21	20.81	1.28
13	21.05	1.24	21.82	1.43	22.58	1.06	21.89	1.42	21.92	1.34

TABLE 43 Mean hand length (cm) in South Sinai Bedouin boys, by tribe and age.

TRIBE	Gebeliya		Muzeina		Hamada &Aleigat		Others**		TOTAL	
AGE	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
5	11.90*	0.98	12.58	1.58	12.83*	1.40	12.63	0.75	12.57	1.32
6	13.02	1.14	13.38	1.21	13.18	1.37	12.83	0.97	13.15	1.17
7	14.08	0.87	13.86	1.15	14.38	0.82	13.92	0.84	13.97	1.01
8	14.18	1.70	14.50	1.31	14.30	1.11	14.14	1.20	14.27	1.30
9	14.12	1.26	14.75	0.71	14.83*	0.75	14.70	1.73	14.65	1.23
10	15.28	0.93	15.07	0.76	14.75*	0.56	15.34	1.11	15.16	0.89
11	14.73	1.15	15.81	1.63	16.86	0.93	16.00	1.12	15.82	1.39
12	16.13	1.19	15.92	1.02	14.23*	0.50	15.30	1.05	15.62	1.14
13	15.45	0.95	16.40	0.83	17.40	1.39	16.35	1.11	16.52	1.21

* less than 5 cases

** Bararsha, Awlad Said, Sawalcha, Haweitat

TABLE 44 Mean total arm length (cm) in South Sinai Bedouin boys, by tribe and age.

TRIBE	Gebeliya		Muzeina		Hamada &Aleigat		Others**		TOTAL	
AGE	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
5	47.90*	0.56	48.72	2.94	49.30*	4.47	46.75	2.60	48.15	2.94
6	50.44	4.08	51.03	2.75	51.10	2.44	49.36	2.53	50.51	2.83
7	53.30	1.58	53.52	2.27	54.65	1.90	52.82	2.93	53.50	2.29
8	55.58	4.20	56.11	3.00	57.53	3.63	54.73	3.39	55.62	3.40
9	55.11	3.11	57.67	3.30	56.63*	0.47	56.60	3.16	56.77	3.11
10	59.52	1.43	57.06	4.63	56.97*	1.41	59.42	2.41	58.28	3.33
11	60.07	1.79	61.94	3.78	63.38	4.35	61.59	2.55	61.66	3.19
12	63.56	3.39	62.44	4.03	60.00*	2.32	61.81	3.10	62.30	3.48
13	62.56	2.13	64.67	1.78	66.80	2.86	64.45	3.17	64.89	2.78

TABLE 45 Mean total arm length/stature index in South Sinai Bedouin boys, by tribe and age.

TRIBE	Gebeliya		Muzeina		Hamada &Aleigat		Others**		TOTAL	
AGE	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
5	42.83*	1.38	43.98	1.51	44.16*	2.70	43.47	0.98	43.78	1.46
6	42.84	1.53	43.43	1.41	42.87	0.99	43.24	1.49	43.23	1.36
7	43.38	1.31	43.39	1.52	44.30	1.32	43.65	1.61	43.54	1.47
8	43.84	1.41	44.12	1.52	43.49	1.23	43.64	1.18	43.87	1.34
9	42.95	1.48	43.90	1.24	42.99*	0.38	43.88	1.49	43.66	1.35
10	44.62	1.00	43.65	1.67	43.54*	1.68	44.76	1.47	44.18	1.54
11	43.83	1.56	44.18	1.40	45.30	1.16	44.34	1.39	44.33	1.41
12	44.25	1.14	43.80	2.13	42.52*	0.93	44.03	1.21	43.90	1.57
13	43.93	1.27	44.16	0.76	45.17	0.92	44.24	1.08	44.39	1.04

* less than 5 cases

** Gararsha, Awlad Said, Sawalcha, Haweitat

TABLE 46 Mean iliospinal anterior height (cm) in South Sinai Bedouin boys, by tribe and age.

TRIBE	Gebeliya		Muzeina		Hamada &Aleigat		Others**		TOTAL	
AGE	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
5	61.25*	2.33	59.58	4.35	59.23*	4.90	57.00	4.34	58,89	4.33
6	64.26	3.86	63.35	3.52	64.76	3.52	60.89	3.57	63.04	3.86
7	66.67	2.53	68.25	2.81	66.72	3.90	66.35	3.15	67.46	3.03
8	70.12	4.14	70.91	3.38	71.28	1.09	69.18	3.91	70.10	3.63
9	70.83	3.61	73.63	4.47	73.86*	1.90	71.50	3.58	72.41	3.92
10	74.18	3.70	73.21	5.22	72.65*	1.04	73.87	3.05	73.53	3.79
11	78.27	2.07	78.59	4.75	78.81	4.78	78.36	3.69	78.48	3.85
12	79.85	6.44	80.58	3.37	81.06*	2.84	79.22	4.30	79.94	4.43
13	81.56	2.72	83.84	2.80	84.25	4.02	82.80	3.89	83.46	3.54

TABLE 47 Mean tibial height (cm) in South Sinai Bedouin boys, by tribe and age.

TRIBE	Gebeliya		Muzeina		Hamada &Aleigat		Others**		TOTAL	
AGE	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
5	29.25*	1.90	28.68	2.44	28.66*	2.01	26.93	2.50	28.20	2.45
6	31.04	1.92	30.69	1.88	31.50	1.90	29.44	1.70	30.56	1.96
7	32.00	1.43	33.33	1.83	32.63	2.16	31.80	1.69	32.78	1.88
8	34.57	2.40	34.44	1.87	35.01	1.69	33.04	2.37	33.92	2.24
9	34.23	2.41	36.20	2.53	35.80*	1.90	34.74	2.08	35.31	2.36
10	36.26	1.09	36.17	2.94	35.37*	1.45	36.08	1.72	36.05	2.08
11	37.93	1.60	38.27	2.08	38.46	2.07	38.58	1.86	38.35	1.86
12	40.10	2.13	39.46	2.03	38.96*	0.66	38.54	2.42	39.22	2.18
13	40.46	1.03	41.12	1.27	41.74	2.08	40.51	2.32	41.07	1.84

* less than 5 cases

** Gararsha, Awlad Said, Sawalcha, Haweitat

TABLE 48 Mean upper leg length (cm) in South Sinai Bedouin boys, by tribe and age.

TRIBE	Gebeliya		Muzeina		Hamada &Aleigat		Others**		TOTAL	
AGE	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
5	32.00*	0.42	30.90	2.25	30.56*	3.16	30.07	2.24	30.69	2.23
6	33.22	2.07	32.65	1.90	33.26	1.85	31.52	2.12	32.48	2.15
7	34.66	1.49	34.92	1.79	34.09	2.00	34.55	1.95	34.68	1.79
8	35.55	1.87	36.47	2.09	36.88	0.98	36.00	1.93	36.18	1.93
9	36.60	1.72	37.43	2.16	38.06*	0.28	36.76	2.00	37.10	1.94
10	37.92	3.14	37.91	2.04	37.27*	0.81	37.79	1.76	37.78	1.96
11	40.33	0.89	40.96	1.82	40.35	2.85	39.78	2.39	40.31	2.07
12	41.66	2.24	41.12	1.84	42.10*	2.45	40.68	2.25	41.12	2.10
13	41.10	2.15	42.72	2.21	42.71	2.53	42.28	2.03	42.45	2.27

TABLE 49 Leg length/stature index in South Sinai Bedouin boys, by tribe and age.

TRIBE	Gebeliya		Muzeina		Hamada &Aleigat		Others**		TOTAL	
AGE	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
5	54.74*	0.33	53.73	1.38	53.03*	0.94	52.93	1.39	53.49	1.37
6	54.64	1.09	53.89	1.14	54.33	1.06	53.56	1.39	53.96	1.24
7	54.91	1.45	55.25	1.27	54.48	2.11	54.86	0.67	55.01	1.33
8	55.34	0.96	55.77	1.47	55.19	1.33	55.17	1.03	55.45	1.25
9	55.20	1.22	56.04	1.66	56.07*	1.13	55.44	1.25	55.68	1.40
10	55.57	1.28	56.03	1.71	55.50*	0.58	55.63	1.51	55.74	1.43
11	57.08	0.91	56.04	1.35	56.34	0.40	56.38	0.98	56.41	1.08
12	56.84	1.53	56.54	1.21	47.46*	0.68	56.46	0.97	56.63	1.17
13	57.27	1.51	57.24	1.05	57.08	0.89	56.84	0.78	57.13	1.02

* less than 5 cases

** Gararsha, Awlad Said, Sawalcha, Haweitat

TABLE 50 Mean foot length (cm) in South Sinai Bedouin boys, by tribe and age.

TRIBE	Gebeliya		Muzeina		Hamada &Aleigat		Others**		TOTAL	
AGE	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
5	18.45*	0.77	18.18	1.10	18.30*	0.88	17.66	0.74	18.05	0.97
6	18.97	1.14	19.10	0.94	19.47	1.17	18.66	0.80	19.02	1.05
7	19.83	0.70	19.94	1.03	19.75	0.80	19.70	0.81	19.83	0.93
8	20.13	1.32	20.59	1.13	21.35	0.60	20.24	1.13	20.45	1.17
9	20.71	1.06	21.34	0.89	21.56*	0.70	20.77	0.95	21.05	0.95
10	21.74	0.79	21.32	1.16	21.60*	0.68	21.67	0.97	21.55	0.96
11	21.91	0.45	22.38	1.26	22.90	1.77	22.68	1.09	22.47	1.18
12	23.15	1.00	22.94	1.48	22.36*	1.02	22.76	1.04	22.88	1.18
13	23.45	0.68	23.45	0.85	23.96	1.10	23.55	1.21	23.62	0.98

TABLE 51 Mean foot breadth (cm) in South Sinai Bedouin boys, by tribe and age.

TRIBE	Gebeliya		Muzeina		Hamada &Aleigat		Others**		TOTAL	
AGE	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
5	6.95*	0.77	7.06	0.33	7.10*	0.30	6.96	0.29	7.03	0.33
6	7.15	0.45	7.47	0.46	7.72	0.44	7.37	0.35	7.45	0.46
7	7.50	0.43	7.73	0.43	7.73	0.30	7.66	0.37	7.69	0.40
8	7.61	0.34	7.95	0.41	8.01	0.14	7.83	0.57	7.87	0.46
9	8.11	0.65	8.15	0.56	8.63*	0.35	7.83	0.35	8.07	0.52
10	7.90	0.48	8.17	0.51	8.10*	0.18	8.22	0.44	8.13	0.45
11	7.85	0.42	8.53	0.43	8.30	0.46	8.70	0.57	8.44	0.57
12	8.63	0.45	8.90	0.64	8.60*	0.26	8.72	0.40	8.75	0.50
13	8.78	0.51	9.02	0.45	9.22	0.30	8.83	0.38	9.01	0.44

* less than 5 cases

** Gararsha, Awlad Said, Sawalcha, Haweitat

TABLE 52 Foot breadth/length index in South Sinai Bedouin boys, by tribe and age.

TRIBE	Gebeliya		Muzeina		Hamada &Aleigat		Others**		TOTAL	
AGE	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
5	37.61*	2.63	39.04	2.75	38.82*	1.34	39.44	1.61	39.05	2.29
6	37.73	1.96	39.14	1.96	39.69	1.99	39.55	1.81	39.18	1.98
7	37.87	2.07	38.83	1.80	39.16	1.48	38.93	2.01	38.80	1.93
8	37.88	1.21	38.71	2.29	37.58	1.46	38.46	2.22	38.45	2.10
9	39.13	1.39	38.15	1.46	40.03*	1.37	37.74	1.35	38.33	1.51
10	36.36	2.28	38.31	1.12	37.51*	0.78	37.96	1.39	37.77	1.51
11	35.80	1.31	38.13	1.04	37.18	1.68	38.77	1.27	37.79	1.64
12	37.27	0.83	38.42	1.04	36.82*	0.64	37.81	0.99	37.81	1.05
13	37.43	1.28	38.57	1.10	38.21	1.14	37.56	1.55	38.04	1.30

Subcutaneous Adipose Tissue

In the upper arm and the subscapular area there were significant differences between the Muzeina and Gebeliya boys in thickness of the subcutaneous fat layer (Tables 53-54). Muzeina boys had more subcutaneous adipose tissue than Gebeliya boys, especially in the subscapular region .

TABLE 53 Mean upper arm skinfold (mm) in South Sinai Bedouin boys, by tribe and age.

TRIBE	Gebeliya		Muzeina		Hamada &Aleigat		Others**		TOTAL	
AGE	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
5	5.75*	1.06	5.57	1.80	4.38*	2.75	6.50	0.86	5.78	1.65
6	3.76	1.47	5.09	1.19	5.40	1.73	5.28	1.56	5.05	1.50
7	4.60	1.45	5.28	1.61	4.83	1.60	4.05	0.97	4.93	1.56
8	5.28	1.31	4.96	1.03	6.45	1.43	4.86	1.50	5.12	1.34
9	4.66	0.98	5.41	1.35	6.50*	3.53	4.57	1.61	5.03	1.55
10	4.96	1.57	5.24	1.59	5.40*	2.40	4.59	1.17	4.98	1.52
11	5.87	2.09	6.10	1.82	6.07*	1.37	4.93	1.96	5.60	1.91
12	5.80	2.03	5.41	1.92	4.66*	1.15	5.26	1.87	5.39	1.85
13	4.68	1.08	5.99	1.93	5.46	2.78	5.20	2.08	5.43	2.07

* less than 5 cases

** Gararsha, Awlad Said, Sawalcha, Haweitat

TABLE 54 Mean subscapular skinfold (mm) in South Sinai Bedouin boys, by tribe and age.

TRIBE	Gebeliya		Muzeina		Hamada &Aleigat		Others**		TOTAL	
AGE	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
5	3.85*	0.49	3.60	0.75	3.43*	0.92	3.37	0.64	3.53	0.70
6	2.94	0.50	3.96	1.36	3.75	0.69	3.48	0.68	3.64	1.04
7	3.58	0.47	3.96	0.95	3.25	0.48	3.43	0.57	3.72	0.81
8	3.78	0.31	4.46	0.90	4.70	0.78	3.30	0.44	3.94	0.89
9	3.51	0.84	4.22	1.09	4.00*	1.41	3.66	0.84	3.88	0.98
10	3.62	0.71	4.96	1.19	3.65*	0.43	3.35	0.46	3.94	1.04
11	4.28	0.94	4.66	1.04	4.25	0.95	3.73	0.71	4.18	0.94
12	4.10	0.53	4.56	1.03	4.00*	0.00	4.10	0.82	4.25	0.83
13	3.98	0.67	4.94	1.05	4.52	0.76	4.00	0.79	4.43	0.92

Hand Strength

There were no significant differences in hand strength between the boys of the Muzeina and Gebeliya tribes (Tables 55, 56).

TABLE 55 Mean hand strength (L) (kg) in South Sinai Bedouin boys, by tribe and age.

TRIBE	Gebeliya		Muzeina		Hamada &Aleigat		Others**		TOTAL	
AGE	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
5	8.50*	3.54	9.95	2.46	10.33*	3.51	9.50	2.07	9.76	2.40
6	11.78	3.19	11.76	2.15	11.76	1.85	10.28	2.52	11.35	2.37
7	14.33	2.64	13.80	2.23	13.67	2.78	14.06	2.86	13.90	2.41
8	15.14	3.08	14.43	2.37	15.83	2.23	14.59	2.04	14.64	2.37
9	15.67	1.97	16.00	3.37	16.00*	1.41	15.92	2.90	15.91	2.82
10	16.20	1.92	16.44	2.51	16.00*	2.16	16.60	2.72	16.39	2.33
11	16.50	1.60	16.92	2.27	19.00*	1.41	19.00	3.42	17.87	2.81
12	18.80	2.39	19.67	3.77	18.33*	1.53	18.47	2.76	18.93	2.96
13	20.50	3.45	19.42	1.78	20.50	3.41	20.08	2.19	20.19	2.71

* less than 5 cases

** Gararsha, Awlad Said, Sawalcha, Haweitat

TABLE 56 Mean hand strength (R) (kg) in South Sinai Bedouin boys, by tribe and age.

TRIBE	Gebeliya		Muzeina		Hamada &Aleigat		Others**		TOTAL	
AGE	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
5	8.50*	2.12	9.94	2.13	9.00*	3.46	10.00	2.45	9.79	2.27
6	12.67	3.54	12.31	2.65	12.70	2.49	10.65	1.93	11.97	2.67
7	14.58	2.61	14.11	2.31	14.00	3.64	14.50	2.56	14.23	2.49
8	16.00	3.56	14.25	3.00	16.33	2.73	14.73	2.37	14.78	2.86
9	14.50	1.38	16.78	3.40	16.00*	1.41	16.31	3.84	16.17	3.26
10	16.00	2.55	17.10	3.35	17.50*	2.08	16.70	4.03	16.83	3.23
11	17.75	1.75	18.64	3.04	19.50*	4.20	19.87	3.38	19.05	3.10
12	19.80	2.44	20.93	3.86	20.67*	1.53	20.00	2.45	20.31	2.91
13	20.67	3.39	21.50	2.91	21.50	3.41	21.67	2.96	21.63	3.27

The two tribes did not differ significantly in stature , or in other height dimensions. In contrast, there was a significant difference in weight (*) at all ages and in the ratio of weight to stature (*) .

TABLE 57 Mean stature (cm) in South Sinai Bedouin boys, by tribe and age.

TRIBE	Gebeliya		Muzeina		Hamada &Aleigat		Others**		TOTAL	
AGE	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
5	111.90*	4.94	111.84	5.60	111.63*	7.88	107.57	6.09	110.73	5.94
6	117.57	6.13	117.02	4.77	119.14	4.65	114.20	5.28	116.71	5.26
7	121.45	4.38	123.72	4.11	122.43	4.37	120.94	5.65	122.79	4.56
8	126.68	6.67	126.91	4.60	129.18	2.30	125.34	5.50	126.41	5.17
9	128.28	5.15	131.37	5.41	131.73*	1.30	128.93	4.73	130.32	5.09
10	133.44	4.46	131.93	6.55	130.90*	2.31	132.76	3.21	132.26	5.06
11	137.11	3.07	139.85	5.73	139.88	8.34	138.95	5.50	139.05	5.59
12	143.58	5.69	141.89	5.91	141.10*	5.40	140.27	6.37	141.63	5.95
13	142.40	2.65	146.21	4.25	147.88	5.54	145.66	6.48	146.12	5.19

* less than 5 cases

** Gararsha, Awlad Said, Sawalcha, Haweitat

TABLE 58 Mean acromion height (cm) in South Sinai Bedouin boys, by tribe and age.

TRIBE	Gebeliya		Muzeina		Hamada &Aleigat		Others**		TOTAL	
AGE	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
5	89.30*	5.23	86.73	5.41	88.03*	6.64	84.06	5.40	86.21	5.46
6	91.67	6.10	92.41	4.22	93.70	4.40	89.62	4.03	91.77	4.66
7	96.59	4.22	98.09	4.28	96.66	4.16	95.59	4.83	97.27	4.42
8	101.30	5.51	101.09	4.66	104.65	4.48	99.71	5.24	100.84	5.13
9	102.30	4.08	104.46	4.90	104.43*	1.35	103.08	4.71	103.60	4.44
10	107.16	3.69	104.02	7.45	102.85*	2.48	106.68	2.75	105.32	5.11
11	110.26	3.34	111.70	5.31	112.31	6.92	111.67	4.53	111.50	4.84
12	116.08	5.09	114.34	6.10	113.60*	4.08	112.67	6.28	114.05	5.83
13	114.71	2.15	117.51	3.85	119.15	5.72	117.43	5.63	117.65	4.83

TABLE 59 Mean upper body segment length (cm) in South Sinai Bedouin boys, by tribe and age.

TRIBE	Gebeliya		Muzeina		Hamada &Aleigat		Others**		TOTAL	
AGE	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
5	23.10*	0.70	23.75	0.99	24.76*	1.25	23.91	1.36	23.85	1.12
6	24.81	1.47	24.47	1.50	25.05	0.91	24.45	1.11	24.61	1.29
7	24.74	2.20	25.10	1.31	25.06	1.25	25.21	1.01	25.06	1.37
8	25.61	1.10	25.42	1.12	26.52	1.08	25.84	0.91	25.64	1.15
9	26.05	0.96	26.25	1.39	26.80*	0.69	26.38	0.92	26.31	1.08
10	26.54	0.66	26.00	1.44	26.60*	0.66	26.70	1.30	26.41	1.21
11	26.85	1.50	27.46	1.21	27.25	0.84	27.00	1.06	27.15	1.16
12	27.23	1.23	27.52	1.26	27.10*	0.85	27.55	1.09	27.44	1.14
13	27.16	0.80	28.00	0.97	28.36	0.95	28.43	1.10	28.15	1.10

* less than 5 cases

** Gararsha, Awlad Said, Sawalcha, Haweitat

TABLE 60 Mean body weight (kg) in South Sinai Bedouin boys, by tribe and age.

TRIBE	Gebeliya		Muzeina		Hamada &Aleigat		Others**		TOTAL	
AGE	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
5	16.15*	2.33	17.70	1.71	17.00*	1.00	15.95	1.93	17.12	1.87
6	17.90	2.36	19.30	2.03	20.21	2.89	17.86	1.19	18.95	2.27
7	20.45	2.03	21.87	2.28	20.83	2.53	20.62	2.88	21.37	2.42
8	22.57	3.64	23.05	2.74	25.66	2.06	22.10	2.15	22.85	2.80
9	22.91	4.27	25.54	2.87	23.50*	2.12	23.30	2.50	24.47	3.09
10	24.60	2.60	25.82	3.49	24.50*	2.27	25.45	1.57	25.40	2.75
11	26.25	2.13	29.77	3.75	30.37*	6.62	29.59	3.42	29.08	3.84
12	30.05	3.86	32.07	4.91	29.83*	2.75	30.14	3.44	30.85	4.13
13	29.38	2.88	33.97	3.43	34.77	2.68	33.04	5.21	33.38	4.04

TABLE 61 Weight/stature index in South Sinai Bedouin boys, by tribe and age.

TRIBE	Gebeliya		Muzeina		Hamada &Aleigat		Others**		TOTAL	
AGE	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
5	14.40*	1.44	15.80	0.92	15.24*	0.71	14.78	1.17	15.42	1.08
6	15.10	1.20	16.47	1.33	17.04	1.96	15.72	0.86	16.22	1.48
7	16.83	1.39	17.57	1.35	17.02	1.58	16.99	1.65	17.32	1.43
8	17.73	1.97	18.12	1.63	19.34	0.84	17.64	1.16	17.98	1.57
9	17.78	2.66	19.39	1.54	17.94*	1.67	18.05	1.57	18.74	1.82
10	18.44	1.96	19.46	1.88	18.69*	1.41	19.17	1.05	19.15	1.61
11	19.12	1.17	21.20	1.81	21.63*	3.09	21.24	1.75	20.85	1.96
12	20.88	2.09	22.42	2.72	21.11*	1.18	21.44	1.79	21.69	2.26
13	20.61	1.70	23.20	1.79	23.79	1.49	22.59	2.65	22.86	2.15

* less than 5 cases

** Gararsha, Awlad Said, Sawalcha, Haweitat

Relationship Between Size and Shape of Body (Tables 62-65)

There is a significant difference between the Muzeina and Gebeliya boys in the relationship between body size and shape. This fact became apparent in the preceding, where a relationship was found between the limbs and the trunk, and is corroborated in the significant difference in body surface area between the two tribes. Similar significant differences were recorded also regarding the ratio of body surface area to body weight (Tables 62-65).

TABLE 62 Weight/stature^3 index in South Sinai Bedouin boys, by tribe and age.

TRIBE	Gebeliya		Muzeina		Hamada &Aleigat		Others**		TOTAL	
AGE	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
5	1.14*	0.01	1.26	0.09	1.23*	0.20	1.28	0.09	1.26	0.10
6	1.08	0.05	1.20	0.10	1.20	0.10	1.22	0.12	1.19	0.11
7	1.14	0.10	1.15	0.08	1.14	0.06	1.16	0.07	1.15	0.08
8	1.10	0.06	1.12	0.06	1.15	0.04	1.12	0.08	1.12	0.07
9	1.07	0.10	1.12	0.07	1.04*	0.10	1.08	0.10	1.10	0.08
10	1.04	0.14	1.11	0.08	1.09*	0.04	1.08	0.07	1.09	0.08
11	1.01	0.03	1.08	0.04	1.11*	0.10	1.10	0.06	1.07	0.06
12	1.01	0.09	1.09	0.09	1.06*	0.03	0.09	0.09	1.07	0.09
13	1.01	0.06	1.08	0.05	1.11	0.06	1.06	0.07	1.07	0.06

TABLE 63 Weight/stature^2 index in South Sinai Bedouin boys, by tribe and age.

TRIBE	Gebeliya		Muzeina		Hamada &Aleigat		Others**		TOTAL	
AGE	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
5	1.28	0.07	1.41	0.06	1.37*	0.14	1.37	0.07	1.39	0.07
6	1.27	0.05	1.40	0.10	1.43	0.13	1.38	0.09	1.39	0.11
7	1.38	0.10	1.42	0.09	1.39	0.09	1.40	0.09	1.41	0.09
8	1.39	0.09	1.42	0.09	1.49	0.05	1.40	0.07	1.42	0.09
9	1.38	0.16	1.47	0.08	1.36*	0.13	1.40	0.11	1.43	0.11
10	1.38	0.16	1.47	0.10	1.42*	0.08	1.44	0.08	1.44	0.10
11	1.39	0.06	1.51	0.07	1.54*	0.13	1.52	0.08	1.49	0.09
12	1.45	0.12	1.56	0.15	1.49*	0.03	1.52	0.10	1.52	0.13
13	1.44	0.10	1.58	0.09	1.62	0.09	1.54	0.13	1.56	0.11

* less than 5 cases

** Gararsha, Awlad Said, Sawalcha, Haweitat

TABLE 64 Body surface area (sq cm) in South Sinai Bedouin boys, by tribe and age.

TRIBE	Gebeliya		Muzeina		Hamada &Aleigat		Others**		TOTAL	
AGE	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
5	7162.61*	670.16	7448.12	560.97	7310.94*	529.82	6924.91	627.97	7288.77	601.84
6	7783.02	726.45	7981.52	554.21	8251.89	721.59	7560.71	395.91	7896.18	621.71
7	8402.70	518.22	8741.86	546.79	8501.11	646.88	8405.28	766.07	8613.24	606.78
8	9031.41	950.81	9125.96	683.13	9572.95	337.90	8895.98	632.88	9056.31	710.86
9	9162.78	976.07	9775.94	737.68	9415.76*	339.53	9274.39	613.87	9538.56	755.05
10	9725.08	513.18	9865.27	903.99	9579.7*	494.41	9838.38	377.56	9807.46	678.97
11	10203.48	508.11	10927.88	897.06	10982.7*	1594.3	10838.84	821.79	10759.3	901.56
12	11167.84	880.55	11421.36	990.50	11002.3*	730.57	10999.49	858.03	11197.6	904.00
13	10998.53	596.61	11926.08	732.13	12039.11	558.16	11746.51	1132.1	11804.6	859.44

TABLE 65 Body surface area/weight (cm^2/gr) in South Sinai Bedouin boys, by tribe and age.

TRIBE	Gebeliya		Muzeina		Hamada &Aleigat		Others**		TOTAL	
AGE	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
5	0.445*	0.02	0.421	0.01	0.430*	0.01	0.436	0.01	0.427	0.01
6	0.436	0.01	0.415	0.01	0.409	0.02	0.423	0.01	0.418	0.02
7	0.412	0.02	0.403	0.01	0.410	0.01	0.410	0.02	0.406	0.01
8	0.403	0.02	0.398	0.01	0.383	0.00	0.402	0.01	0.399	0.01
9	0.404	0.03	0.384	0.01	0.401*	0.02	0.399	0.01	0.392	0.02
10	0.397	0.02	0.384	0.02	0.392*	0.01	0.387	0.01	0.387	0.01
11	0.389	0.01	0.368	0.01	0.365*	0.02	0.367	0.01	0.372	0.01
12	0.373	0.02	0.359	0.02	0.369*	0.00	0.366	0.01	0.365	0.01
13	0.375	0.02	0.352	0.01	0.346	0.01	0.358	0.02	0.355	0.01

* less than 5 cases

** Gerarsha, Awlad Said, Sawalcha, Haweitat

Basal Metabolism

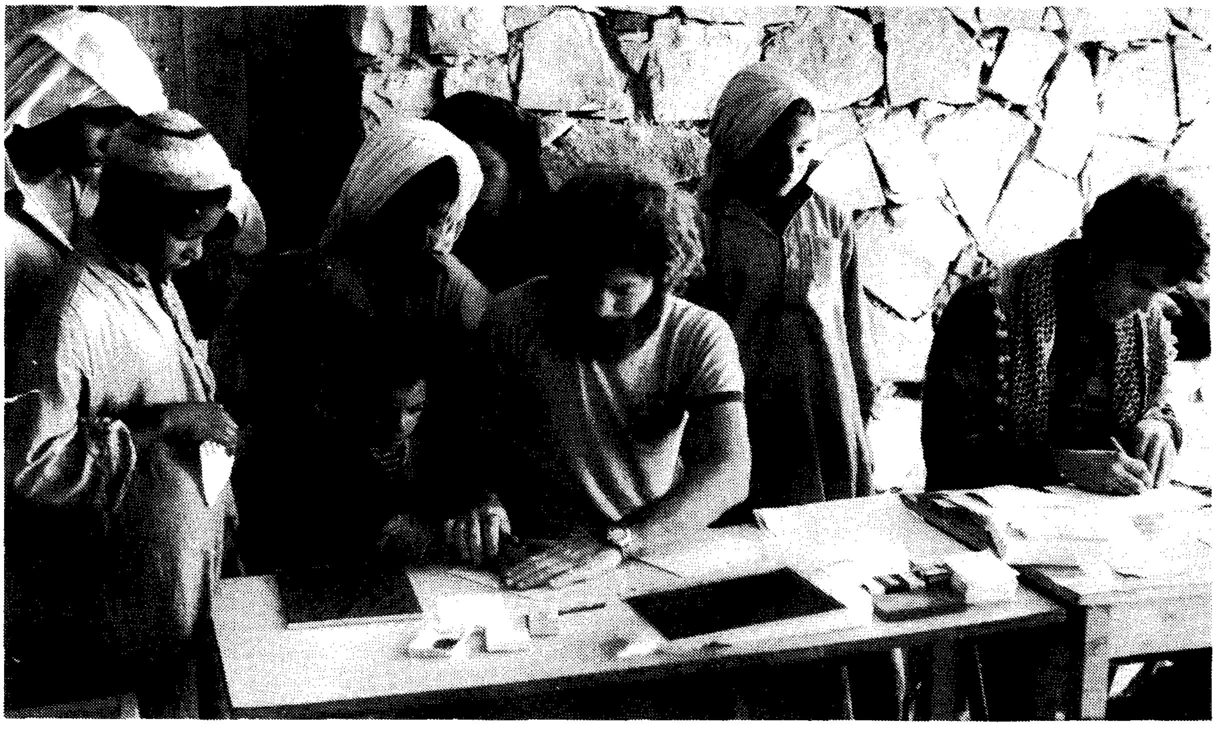
The Muzeina and Gebeliya boys differ significantly with respect to energy expenditure required to perform an identical task (KJ), as indicated below (Table 66).

TABLE 66 Energy expenditure required to perform identical tasks (Kj/min) in South Sinai Bedouin boys, by tribe and age.

TRIBE	Gebeliya		Muzeina		Hamada &Aleigat		Others**		TOTAL	
AGE	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
5	7.46*	0.45	7.77	0.33	7.63*	0.19	7.42	0.38	7.65	0.36
6	7.81	0.46	8.08	0.39	8.26	0.56	7.80	0.23	8.01	0.44
7	8.31	0.40	8.59	0.45	8.38	0.49	8.34	0.56	8.49	0.47
8	8.73	0.71	8.82	0.54	9.34	0.40	8.63	0.42	8.78	0.55
9	8.79	0.84	9.31	0.56	8.91*	0.41	8.87	0.49	9.10	0.61
10	9.13	0.51	9.37	0.68	9.11*	0.44	9.29	0.30	9.28	0.54
11	9.45	0.42	10.15	0.73	10.26*	1.30	10.11	0.67	10.01	0.75
12	10.20	0.76	10.60	0.96	10.16*	0.54	10.22	0.67	10.36	0.81
13	10.07	0.56	10.97	0.67	11.13	0.52	10.79	1.02	10.86	0.79

* less than 5 cases

** Gararsha, Awlad Said, Sawalcha, Haweitat



Dr. Hershkovitz (middle) taking fingerprints from Bedouin children.

TABLE 67: Comparison of morphological similarity and disparity between Muzeina and Gebeliya tribes by means of two-way analysis of variance, 41 traits; boys, 5-13 years.

TRAIT	Head length		Head breadth		Cephalic index		Bizygomatic breadth		Bigonial breadth		Morphological facial ht.	
Source of variation	F	Sig.	F	Sig.	F	Sig.	F	Sig.	F	Sig.	F	Sig.
Main effects	5.92	.001	3.62	.001	1.14	.337	19.11	.001	4.24	.001	29.80	.001
Age	6.57	.001	3.88	.001	1.05	.401	21.39	.001	2.67	.008	33.41	.001
Ethnic	0.05	.829	4.02	.046	1.38	.242	1.19	.277	10.14	.002	13.45	.001
2-way interaction												
Age-Ethnic	0.51	.841	1.36	.216	0.95	.479	1.146	333	1.719	.095	2.05	.041
Explained	3.37	.001	2.56	.001	1.05	.408	10.65	.001	3.055	.001	16.74	.001

TRAIT	Sitting height (1)		Biacromial breadth		Biiliac breadth		Chest circumference		Sitting height(2)		Trunk length	
Source of variation	F	Sig.	F	Sig.	F	Sig.	F	Sig.	F	Sig.	F	Sig.
Main effects	66.73	.001	49.54	.001	21.23	.001	39.81	.001	44.51	.001	27.15	.001
Age	4.90	.001	55.74	.001	22.97	.001	44.75	.001	49.79	.001	30.51	.001
Ethnic	8.89	.003	10.47	.001	22.36	.001	12.23	.001	2.51	.114	3.85	.051
2-way interaction												
Age-Ethnic	1.41	.194	0.98	.452	0.36	.939	0.21	.989	1.11	.357	0.84	.570
Explained	35.98	.001	26.69	.001	11.41	.001	21.18	.001	24.09	.001	14.77	.001

TRAIT	Sitting ht. stature		Biacromial breadthx100/ stature		Biiliac br.x 100/stature		Chest circumference x100/stature		Total arm length		Upper arm length	
Source of variation	F	Sig.	F	Sig.	F	Sig.	F	Sig.	F	Sig.	F	Sig.
Main effects	21.25	.001	2.93	.003	11.11	.001	9.55	.001	70.34	.001	40.65	.001
Age	21.42	.001	1.85	.069	8.11	.001	7.98	.001	77.91	.001	44.76	001
Ethnic	5.39	.021	7.88	.005	20.09	.001	10.38	.001	1.41	.236	0.42	.515
2-way interaction												
Age-Ethnic	2.16	.031	0.48	.871	1.49	.161	1.07	.384	1.18	.314	0.87	.539
Explained	12.27	.001	1.77	.032	6.58	.001	5.56	.001	37.79	.001	21.93	.001

Note: Sitting height (1) differs from Sitting height (2) - see tests and/or explanations chapter.

Cont. next page

Table 67: Cont.

TRAIT	Lower arm length		Hand length		Total arm length/stature		Iliospinal ant. ht.		Tibial height		Upper leg length	
Source of variation	F	Sig.	F	Sig.	F	Sig.	F	Sig.	F	Sig.	F	Sig.
Main effects	38.33	.001	23.03	.001	1.36	.206	95.77	.001	90.46	.001	85.21	.001
Age	42.36	.001	25.84	.001	1.50	.157	106.35	.001	100.42	.001	94.31	.001
Ethnic	0.25	.616	2.64	.106	0.75	.388	1.70	.194	1.50	.221	0.71	.399
2-way interaction												
Age-Ethnic	0.42	.910	0.91	.509	0.74	.660	0.69	.703	1.04	.403	0.79	.612
Explained	20.49	.001	12.62	.001	1.07	.386	51.02	.001	48.38	.001	45.48	.001

TRAIT	Leg length/ stature		Foot length		Foot breadth		Foot br. x100/foot l.		Upper arm skinfold		Subscapular skinfold	
Source of variation	F	Sig.	F	Sig.	F	Sig.	F	Sig.	F	Sig.	F	Sig.
Main effects	16.93	.001	62.59	.001	39.99	.001	3.95	.001	1.94	.047	5.68	.001
Age	18.49	.001	69.30	.001	44.80	.001	1.52	.150	1.76	.087	4.62	.001
Ethnic	0.18	.667	0.72	.396	18.17	.001	17.74	.001	4.73	.031	20.94	.001
2-way interaction												
Age-Ethnic	1.24	.276	0.47	.876	0.66	.728	1.13	.343	0.91	.510	0.77	.631
Explained	9.55	.001	33.36	.001	21.48	.001	2.62	.001	1.45	.113	3.37	.001

TRAIT	Hand strength (L)		Hand strength (R)		Stature		Upper body segment ht.		Acromial height		Body weight	
Source of variation	F	Sig.	F	Sig.	F	Sig.	F	Sig.	F	Sig.	F	Sig.
Main effects	34.55	.001	35.39	.001	138.7 4	.001	24.37	.001	95.77	.001	92.03	.001
Age	37.65	.001	39.07	.001	154.5 1	.001	27.08	.001	105.5 1	.001	103.4 9	.001
Ethnic	0.01	.940	0.51	.474	1.82	.178	0.79	.372	0.37	.545	23.58	.001
2-way interaction												
Age-Ethnic	0.38	.929	0.94	.486	0.92	.502	0.57	.798	0.76	.641	0.98	.449
Explained	18.47	.001	19.18	.001	73.88	.001	13.17	.001	51.06	.001	49.18	.001

Cont. next page

Table 67: Cont.

TRAIT	Weight x100/ stature		Body surface area		Body surface area/weight		Weight x100/stature^3		Kj	
Source of variation	F	Sig.	F	Sig.	F	Sig.	F	Sig.	F	Sig.
Main effects	60.85	.001	120.64	.001	47.53	.001	18.22	.001	92.03	.001
Age	67.77	.001	135.57	.001	52.24	.001	14.58	.001	103.49	.001
Ethnic	32.65	.001	14.67	.001	37.10	.001	26.82	.001	23.58	.001
2-way interaction										
Age-Ethnic	0.90	.513	0.84	.564	0.76	.637	1.41	.192	0.98	.449
Explained	32.64	.001	64.26	.001	25.52	.001	10.31	.001	49.18	.001

Detection of Morphologic Differences Between South Sinai Bedouin Boys of Different Tribes by ANOVA Standard Scores

Method

In the second stage of our comparison between the Muzeina and Gebeliya tribes, we converted all the numerical values, i.e. "raw scores", to standard scores and combined the different age groups. We did this in order to overcome the difficulty of obtaining valid statistical answers because of the small samples available to us, some of the age-tribal groups comprising less than 10 individuals. This statistical procedure was made available because the interaction: Age X ethnic origin, for most anthropometric measures was not significant.

A standard score (Z_i), it may be recalled, is the distance of individual X_i with respect to a particular trait from the mean distribution $\overline{X}$ for the particular trait within the population, given in units of standard deviation (S.D.). Thus $Z_i=(X_i-\overline{X})/S.D.$ We combined the boys of all tribes in each age group (5-13 years) and regarded them as a single sample. We then computed for this "sample" the mean and standard deviation, and calculated the standard score for each child in the expanded "sample". Subsequently we reassigned the children according to their tribal affiliation, and, based on their standard scores, computed the mean and standard deviation of each trait's distribution.

We then carried out a one-way analysis of variance where the independent variable was the tribe and the dependent variable was the mean distribution of each trait, in standard deviation units.

In addition, we examined the degree of relatedness between the Muzeina and Gebeliya tribes to the remaining tribes, utilizing the Scheffe Method for a one-way analysis of variance. This test divides the tribes into homogeneous groups by likenesses and differences of traits.

Results

Results of the analysis of variance, following standardization of the raw scores, are given in Table 68. The number of traits differing significantly between Muzeina and Gebeliya boys is 23 out of 41, identical to that obtained by a two-way analysis of variance of the "true" scores. The ranking of the trait means, and the discrimination between them performed by Scheffe's Method for the 4 Bedouin groups considered in Table 68, shows that for the 23 out of 41 traits that were found significantly different in the four groups, the Gebeliya group belongs to a subset which is different from that of the Muzeina subset. Furthermore, most of the trait means in the Gebeliya tribe are ranked lower than that of the Muzeina tribe. The morphologic uniqueness of the Gebeliya tribe is further emphasized by the fact that regarding 10 traits the Gebeliya children belong in a separate subset, i.e. their traits do not resemble those of any other group of children. In this respect, none of the other groups (Muzeina, Hamada + Aleigat, others) was found to belong to a separate subset, this for all 41 traits examined, i.e. no single morphological trait was unique to any of these groups.

The anthropological team of Tel-Aviv University with Bedouin children: left Prof. Arensburg, sitting Prof. Ben-David (Kobyliansky) and Rachel Nefesh (the nurse).

TABLE 68: Comparison of morphological likenesses and differences between the Gebeliya, Muzeina and four Bedouin tribes separately, by means of one-way analysis of variance based on 42 traits.

TRIBES	Muzeina-Gebeliya		Four tribal groups*		
TRAITS	F	Sig.	F	Sig.	Scheffe procedure subsets
Stature	2.45	.117	5.33	.001	I=4,1;II=1,2,3
Iliospinal ant. height	2.66	.103	5.38	.001	I=4,1;II=1,2,3
Tibial height	2.07	.150	7.99	.000	I=4,1;II=1,2,3
Acromial height	0.79	.372	3.36	.018	I=4,1,2,3
Sitting height (1)	9.75	.002	5.43	.001	I=1,4,3;II=3,2
Foot breadth	17.54	.000	8.98	.000	I=1;II=4,2,3
Foot length	1.00	.316	3.19	.023	I=4,1,2;II=1,2,3
Head length	0.04	.836	1.11	.342	I=1,4,2,3
Head breadth	3.86	.050	1.75	.155	I=1,4,3,2
Bizygomatic breadth	0.72	.395	1.31	.267	I=4,3,1,2
Bigonial breadth	8.28	.004	6.11	.000	I=3,2;II=2,4;III=4,1
Morphological facial ht.	10.92	.001	4.46	.004	I=1,4,3;II=4,3,2
Upper arm skinfold	3.88	.049	2.95	.032	I=1,4,2,3
Subscapular skinfold	18.36	.000	19.68	.000	I=4,1,3;II=3,2
Biacromial breadth	11.18	.001	7.79	.000	I=1;II=2,4,3
Biiliac breadth	27.42	.000	13.12	.000	I=1,4;II=2,3
Chest circumference	14.01	.000	9.18	.000	I=1;II=2,4,3
Body weight	22.87	.000	12.46	.000	I=1,4;II=2,3
Hand strength (L)	0.00	.982	0.36	.778	I=4,1,2,3
Hand strength (R)	0.47	.491	0.51	.672	I=1,4,2,3
Total arm length	1.97	.160	4.40	.004	I=4,1,2;II=1,2,3
Upper body segment length	0.87	.351	2.76	.041	I=1,2,4,3
Upper leg length	0.80	.370	2.86	.036	I=4,1,2,3
Upper arm length	0.45	.501	1.00	.389	I=4,1,3,2
Lower arm length	0.50	.478	3.93	.008	I=4,1,2;II=1,2,3
Hand length	1.84	.176	1.68	.169	I=1,4,2,3
Trunk length	4.18	.041	3.17	.024	I=1,4,3,2
Sitting height (2)	2.62	.106	2.50	.058	I=1,4,2,3
Weight x 100/Stature^3	28.26	.001	9.87	.000	I=1;II=4,2,3
Total arm length/Stature	1.21	.272	0.75	.520	I=1,2,4,3

Cont. next page

Table 68: cont.

Sitting height/Stature	4.93	.027	4.22	.005	I=3,1,4;II=1,4,3
Leg length/Stature	0.21	.643	2.87	.036	I=4,3,2,1
Foot breadth x 100/Foot length	21.09	.000	7.88	.000	I=1;II=3,4,2
Head breadth x 100/Head length	1.65	.200	1.69	.166	I=3,1,4,2
Biacromial breadth x 100/Stature	10.39	.001	14.31	.000	I=1;II=2,3;III=3,4
Biiliac breadth x 100/Stature	21.93	.001	8.53	.000	I=1;II=4,2,3
Chest circumf. x 100/Stature	11.79	.001	15.87	.000	I=1;II=2,3;III=3,4
Weight x 100/Stature	32.68	.000	14.21	.000	I=1,4;II=4,2,3
Body surface area	14.39	.000	9.41	.000	I=1,4;II=2,3
Body surface area/Weight	38.79	.000	15.73	.000	I=3,2,4;II=1
Kj	22.70	.000	12.41	.000	I=1,4;II=2,3

*1 = Gebeliya; 2 = Muzeina; 3 = Hamada and Aleigat; 4 = Beni-Wassal, Haweitat, Gararsha, Awlad Said, Sawalcha

Sitting height (1) differs from Sitting height (2) - see tests and/or explanations chapter.

Weight x 100/ Stature^2-was omitted from two way ANOVA

A Bedouin with his camels.

Morphological Differences Between Boys Of Sub-Tribes Within The Gebeliya And Muzeina Tribes

The morphological differences between boys in the sub-tribes were evaluated in two tribes. One of these tribes is the Gebeliya, for which there is clear-cut evidence that one of its sub-tribes (Awlad Gindi) is different from all the others in origin. The Awlad Gindi sub-tribe, as previously noted, came from Egypt whereas all the other sub-tribes (Wehebat, Hamaida and Awlad Salim - see Fig. 4) probably originated in the Arabian Peninsula. Hence one reason for differences in morphology of children within a tribe could be the fact that they belong to sub-tribes which initially came from different geographical regions. However, morphologic differences among children of the Muzeina tribe, which is a relatively homogeneous social unit compared to the Gebeliya tribe, could also stem from the nature of marital patterns in the group, namely a clear preference (about 75%) for marriages within the sub-tribe level, thus creating isolated social units within the broader tribal framework.

Morphological Differences Among Boys of Sub-tribes in the Gebeliya Tribe

The number of boys in the Gebeliya sub-tribes is very small, as indicated below:

Group No.	Sub-tribe	No. of Individuals	Common Ancestor
1	Awlad Gindi	19	Gindi (?)
2	Wehebat Hamaida Awlad Salim	36	Bachit

In order to detect morphological differences between boys of the Gebeliya sub-tribes, we had to overcome the problem of sampling limitations, stemming from the very small numbers in each age group within each sub-tribe. We therefore used the following statistical procedure:

a)"Standardization" process: For each trait, per each boy in the tribe, we calculated the relative standing with respect to the mean in that particular age group (standard score).

b) The sample: We divided the boys according to their sub-tribal affiliation.

c) Distribution of traits: For each sub-tribe, and each trait, we constructed a new distribution based on the standard scores of its children, regardless of age.

d) Measures of central tendencies and variability were calculated by means of condescriptive statistics (SPSS, 1975).

e) Significant differences between the means (Awlad Gindi vs. all other sub-tribes) were computed by a one-way analysis of variance (ANOVA).

Results

Of the 41 traits examined by the one-way analysis of variance following standardization of measurements, 16 were found to vary significantly between the Awlad Gindi boys and boys of the other subtribes (Table 69). The Awlad Gindi children were found to be broader in girth, heavier, and longer limbed, as well as having a broader head and a longer face. In trunk height, however, the Awlad Gindi boys resembled those of the other subtribes. Also the indices of the various bodily measures were similar in these two child groups (Awlad Gindi vs. other Gebeliya sub-tribes). Yet the body surface area and the caloric expenditure required to perform a defined task were greater in the Awlad Gindi boys.

The statistical non-significance of many of the differences in measurements among the sub-tribes is no doubt due, at least in part, to the small samples.

TABLE 69: Comparison of morphological likenesses and differences between the Gebeliya sub-tribes by means of one-way analysis of variance based on 41 traits.

	Awlad Gindi	
GEBELIYA SUB-TRIBES	Hamaida, Wehebat, Awlad Slim	
TRAITS	F	Sig.
Stature	6.88	.011
Iliospinal ant. height	7.14	.011
Tibial height	10.58	.002
Acromial height	7.98	.006
Sitting height (1)	3.30	.074
Foot breadth	1.18	.282
Foot length	4.88	.031
Head length	1.08	.301
Head breadth	4.49	.038
Bizygomatic breadth	2.42	.125
Bigonial breadth	0.12	.727
Morphological facial ht.	6.67	.012
Upper arm skinfold	0.84	.363

Cont. next page

TABLE 69: cont.

GEBELIYA SUB-TRIBES	Awlad Gindi Hamaida, Wehebat, Awlad Slim	
Subscapular skinfold	0.27	.603
Biacromial breadth	8.44	.005
Biiliac breadth	6.98	.010
Chest circumference	3.85	.055
Body weight	4.08	.048
Hand strength (L)	1.16	.285
Hand strength (R)	2.49	.120
Total arm length	4.59	.036
Upper body segment length	2.47	.121
Upper leg length	3.09	.084
Upper arm length	4.77	.033
Lower arm length	5.65	.021
Hand length	0.01	.925
Trunk length	0.99	.323
Sitting height (2)	1.24	.269
Weight x 100/Stature^3	1.57	.214
Total arm length/Stature	1.10	.298
Sitting height/Stature	2.05	.157
Leg length/Stature	0.67	.415
Foot breadth x 100/Foot length	1.27	.265
Head breadth x 100/Head length	0.14	.703
Biacromial breadth x100 /Stature	0.88	.352
Biiliac breadth x 100/Stature	0.11	.739
Chest circumf. x 100/Stature	0.00	.960
Weight x 100/Stature	2.37	.129
Body surface area	6.03	.017
Body surface area/Weight	1.38	.244
Kj	4.02	.050

Note: Sitting height (1) differs from Sitting height (2); see tests and/or explanations chapter.

The fact that for more than a third of the traits here considered there were significant differences between different groups of the same tribe points to the great importance of social structure when one carries out a biological investigation of any sort, probably even more so in studies of endogamic tribal societies.

Morphological Differences Among Muzeina Boys

A. Boys divided according to common ancestor

In order to detect morphological differences within the Muzeina tribe itself, we first divided the boys into three groups:

Group No.	Sub-tribe	No. of individuals	Common ancestor
1	Shadadine Smehat	37	Alwan
2	Mehaysina Gsenat Dararme	142	Farag-Ali
3	Gawanme	30	Farag-G'hanem

We then followed the same statistical procedure as in the Gebeliya boys, additionally applying the Scheffe method to rank all six sub-tribes according to mean values for each trait.

Results

Morphological comparisons: The comparisons of morphologic traits between Groups 1 and 2 (Table 70) show that boys of Group 1 differ from those of Group 2 in three traits (upper leg length, foot length and foot breadth) at a significance level of $p<0.05$ and in five traits at a significance level of $0.1>p>0.05$ (biiliac breadth, sitting height (1), iliospinal height, tibial height and hand length). Most of the statistically significant results pertain to measures of the limbs and trunk dimensions. These differences suggest that the boys of the Shadadine and Smehat (Group 1) differ in important respects from those of the Mehaysina, Gsenat and Dararme sub-tribes of Group 2.

Arrangement of Groups 1 and 2 according to mean values of traits shows that the boys of Group 2 (Farag-Ali descendants) manifest consistently higher values than the boys of Group 1 (Alwan descendants).

A comparison of children of Group 2 with those of Group 3 shows a significant difference ($p<.05$) in chest circumference, cephalic index, foot breadth, head length, trunk length and chest circumference/stature, and at the significance level of $0.1>p>0.05$ in body surface area/weight, foot breadth/foot length, sitting height (1)/stature, ponderal index and bizygomatic breadth. The differences between Groups 2 and 3 seem to center mainly in the trunk and head. Thus the boys of the Mehaysina, Gsenat and Dararme sub-tribes, compared with boys of the Gawanme have on the average a broader head in absolute terms, a broader head relative to head length, and a broader face, as well as a shorter trunk and a larger chest circumference relative to stature, and finally, more weight per unit of body surface area.

The comparison between Groups 1 and 3 shows that in chest circumference/stature, sitting height (1), hand length and upper leg length, averages differ between the groups at the significance level of $p<0.05$, and for leg length/stature, ponderal index and subscapular skinfold, at the significance level of $0.1>p>0.05$. Thus the differences between the boys of the Shadadine and the Smehat and those of the Gawanme are mainly in the trunk and lower limbs, with higher mean values in the former. The boys of Group 1 have a larger mean chest circumference relative to stature than those in Group 3.

TABLE 70:Comparison of morphological likeness and differences between the Muzeina sub-tribes by means of one-way analysis of variance.

MUZEINA SUB-TRIBES	Group 1*vs.Group 2		Group 3 vs. Group 2		Group 1 vs. Group 3	
TRAITS	F	Sig.	F	Sig.	F	Sig.
Stature	2.15	.143	0.01	.940	1.05	.308
Iliospinal ant. height	3.35	.069	0.03	.856	2.06	.156
Tibial height	2.99	.085	0.01	.892	0.21	.647
Acromial height	0.64	.424	0.92	.337	0.50	.479
Sitting height (1)	3.44	.065	0.87	.351	4.99	.029^
Foot breadth	4.54	.034^	4.96	.027^	0.06	.807
Foot length	4.59	.033^	0.96	.327	0.60	.440
Head length	0.10	.744	4.90	.028^	2.04	.157
Head breadth	0.22	.636	1.49	.223	0.32	.571
Bizygomatic breadth	2.29	.131	3.66	.057^	0.20	.651
Bigonial breadth	0.21	.642	0.01	.947	0.05	.810
Morphological facial ht.	0.23	.629	0.03	.844	0.04	.839
Upper arm skinfold	0.02	.871	0.08	.768	0.01	.893
Subscapular skinfold	0.66	.415	2.32	.129	3.26	.075
Biacromial breadth	0.54	.463	0.91	.340	1.74	.192
Biiliac breadth	3.86	.051^	0.43	.512	1.04	.309

Cont. next page

Table 70: cont.

Chest circumference	0.55	.458	5.80	.017^	1.93	.169
Body weight	2.32	.129	1.43	.233	0.01	.906
Hand strength (L)	1.58	.210	0.01	.987	0.75	.387
Hand strength (R)	1.31	.253	0.02	.876	0.53	.469
Total arm length	1.96	.162	0.01	.980	1.18	.280
Upper body segment length	0.62	.432	0.12	.722	0.55	.459
Upper leg length	5.05	.026^	0.31	.577	4.04	.048^
Upper arm length	0.03	.851	0.59	.442	0.27	.599
Lower arm length	0.29	.589	0.16	.684	0.57	.450
Hand length	2.92	.089	1.65	.200	7.32	.008^
Trunk length	0.18	.669	4.04	.046^	2.16	.146
Sitting height (2)	0.82	.366	2.06	.650	0.09	.754
Weight x 100/Stature^3	0.39	.531	2.98	.085	3.95	.051^
Weight x 100/ Stature^2	0.00	.965	1.46	.228	0.93	.337
Total arm length/Stature	0.00	.966	0.16	.682	0.13	.712
Sitting height/Stature	0.44	.508	2.92	.089	0.71	.402
Leg length/Stature	1.79	.181	1.05	.305	3.52	.065
Foot breadth x 100/Foot length	0.00	.967	2.93	.089	2.63	.109
Head breadth x 100/Head length	0.72	.397	5.32	.022	1.58	.213
Biacromial breadth x 100/Stature	0.87	.352	2.21	.139	0.23	.630
Biiliac breadth x 100/Stature	0.10	.744	0.00	.938	0.10	.753
Chest circumf. x 100/Stature	0.40	.523	8.23	.004^	8.35	.005^
Weight x 100/Stature	1.25	.264	2.69	.102	0.23	.626
Body surface area	2.50	.115	0.62	.431	0.22	.636
Body surface area/Weight	0.93	.335	3.07	.081	0.48	.488
Kj	2.29	.131	1.40	.237	0.01	.905

Sitting height (1) differs from Sitting height (2)- see tests and/or explanations chapter. Group 1: Shadadine, Smehat sub-tribes; Group 2: Mehaysina, Gsenat, Dararme sub-tribes; Group 3: Gawanme sub-tribe. ^ signification level $p<0.05$

These results suggest that the greater the genealogical distance between two sub-tribes, the more distinct and consistent are the metric differences between them. Thus we find that between the two groups farthest apart genealogically, Alwan vs. Farag-Ali descendants, the consistency of the results is most marked, whereas between the more related groups, Farag-Ali and Farag-G'hanem descendants, consistency is least in trait differences. Judging by these consistent trends, we are convinced that the few significant results obtained are not fortuitous, but rather imply general morphologic discrimination between sub-tribes.

A tendency towards morphological differences between the Gawanme children and those of the Mehaysina, Gsenat and Dararme may be noted. Here it is apparent that the Gawanme are descended from the ancestor Ali who is the brother of Ghanem, both of whom are the sons of Farag, a later genealogical split than the afore-mentioned (Alwan-Farag) but earlier than that of the Mehaysina, Gsenat and Dararme. By the same token, we can understand why so few traits serve to differentiate between children of the Gsenat, Dararme and Mehaysina, tribal groups descended from a common ancestor (Ghseyn) who live in territorial proximity and tend to exchange brides at a higher rate than in the other sub-tribes. The relatedness of the Smehat and the Shadadine is also understandable in the same context. The Smehat, in fact, was once an extended family within the Shadadine that moved out of the tribal centers and formed a separate sub-tribe.

That many of the mean differences in traits among the groups within the Muzeina are not statistically significant is probably due to the fact that the described social process that leads to sub-tribe formation does not necessarily create at the same time independent biological units. Nevertheless, the possibility also exists that inability to reveal morphological differences among the sub-tribes may be attributed to the small size of the samples and/or to the limited time interval elapsed since each sub-tribe began to act as an independent social and biological unit. Although the differences were generally not "significant", as noted, the directions of our results suggest that such processes (i.e., biological differentiation between the sub-tribes) probably do take place in the Bedouin society even within tribes that are considered homogeneous populations (e.g. the Muzeina tribe).

Definition of Tribal Morphologic Identity

There is scarcely any Bedouin of a tribe who will not brag that he can identify members of other tribes without undue difficulty.

While it is true that there are fine differences in behavior, apparel and language which can be of help in such identification, these apparently are not the only criteria upon which the Bedouin relies. His criteria, as reported by the Bedouins themselves, are rather "morphological" characteristics.

In the present chapter, the question of morphological identity attributed to the tribes will be examined.

We have attempted to differentiate the boys by tribe, by means of "discriminant analysis" of most of the studied anthropometric traits.

The Sample

At first we studied the morphological differences between the boys of the Gebeliya and Muzeina tribes. Subseqeuntly we included the boys of the Hamada-Aleigat and the "other tribes", i.e. the combined Gararsha, Awlad Said, Sawalcha and Haweitat. For each test we made two runs - one for F=1 and the other for F=4. As is known, a variable is a candidate for selection only if its partial F-ratio is greater than an arbitrary value assigned by the investigator. When F=1, the function will include all such variables whose contribution towards distinguishing between the Bedouin groups is above and beyond the separation created by prior variables in the function at a significance level defined as F>1.0. It follows that when the F value is low (F=1), more variables will enter the discriminant function than when the F value is high (F=4). In this manner we were able to manipulate the number of variables included in the functions and ascertain a low number of variables sufficient to yield a good discrimination between the various tribes.

In anthropology, discriminant functions are usually generated and used without reference to the level of chance classification - random results are assigned the value of 50% correct classification (in the case of two groups), and any results greater than 50% are usually considered to be due to the information contained within the descriptors (measurements). However, for a given number of individuals, the probability of fortuitously obtaining 100% correct classification increases as the number of features (d) increases from 1 to the number of individuals in the study (N) (Stouch and Jurs, 1985a,b). These classifications, while correct, are due only to artifacts of mathematics governing the process of generating linear discriminant functions (LDF). They are not due to any relationship between the individuals, and the resulting LDF will have no predictive ability beyond random guessing (Stouch and Jurs, 1985a,b).

Until recently, it was accepted that if the number of descriptors is kept below one-third the number of individuals used, the probability of complete separation due to chance could be kept low. The ratio of $N/d \geq 3$ was accepted as a minimum requirement (Stuper and Jurs, 1976; Varmuza, 1980). More recent studies (Stouch and Jurs, 1985a,b), however, have shown that at that ratio random classification results ranged around 90%. Even one descriptor for every ten individuals would yield random correct classification of about 75%. It was also found that unequal group sizes serves to increase correct random classification and that for any one value of the ratio N/d, the percentage correctly classified is the same regardless of the number of individuals used in the study.

a. Differences between children of Muzeina and Gebeliya tribes

Table 71 gives a summary of the stepwise procedure pertaining to differences between children of the Muzeina and Gebeliya tribes. Because of the small sample size, discrimination at the subtribe level was not applicable.

TABLE 71 Discriminant analysis stepwise procedure based on morphological traits: Muzeina vs. Gebeliya, F=1,4, boys 5-13 years.

Step	Entered	F to enter
1	Body weight/Stature^2	34.39*
2	Bigonial breadth	13.75*
3	Biiliac breadth	10.29*
4	Foot breadth/Foot length	11.70*
5	Sitting height/Stature	3.43
6	Foot breadth	1.71
7	Acromial height	2.36
8	Stature	2.2
9	Lower arm length	1.21

* Traits included within the discrimination function for F=4.

Bedouin children in Nuweiba

Although there is a clear tendency for discrimination between the Muzeina and Gebeliya, the overlap between them is considerable. The effect of this overlap becomes clear when we look at Table 72. It may be seen here that our classification procedure was able to correctly identify 77.7%-78% of these cases as members of the tribes to which they actually belonged.

TABLE 72: Percent of individuals correctly identified by tribal membership, for F=1 and F=4.

Group	No. of cases		Predicted group membership in:			
			Gebeliya		Muzeina	
	F=1	F=4	F=1	F=4	F=1	F=4
Gebeliya	60	62	(46)	(46)	(14)	(16)
			76.7	74.2	23.3	25.8
Muzeina	164	174	(36)	(36)	(128)	(128)
			22.0	20.7	78.0	79.3

Note: figures in parentheses are number of cases

Mean percent of grouped cases correctly classified: 77.7 for F=1 and 78.0 for F=4

b. Differences between the children of four tribal groups

Here, too, we carried out two separate runs, one for F=1 and the other for F=4. Table 73 summarizes the stepwise procedure for the 4 groups for F=1 and F=4.

It will be recalled that the discriminant functions are derived in such a fashion that the first provides maximal discrimination between the groups, the second separates them maximally in a 90 degree direction to the first, and so on. The net result is that the groups are separated as far as possible on the basis of data obtained from the original discriminant variables. The discriminant functions can be regarded as defining axes in a geometric configuration in which each case and each group center are points. The spatial orientation of these axes is basically random, except for the fact that they are arranged in a descending order of maximal discrimination. The axes may be rotated while we hold constant the relative positions of the individuals and the group.

TABLE 73 Discriminant analysis stepwise procedure based on morphological traits of South Sinai Bedouin boys, 5-13 years, by tribe; F=1: Gebeliya (1), Muzeina (2), Aleigat and Hamada (3), and all other tribes (4).

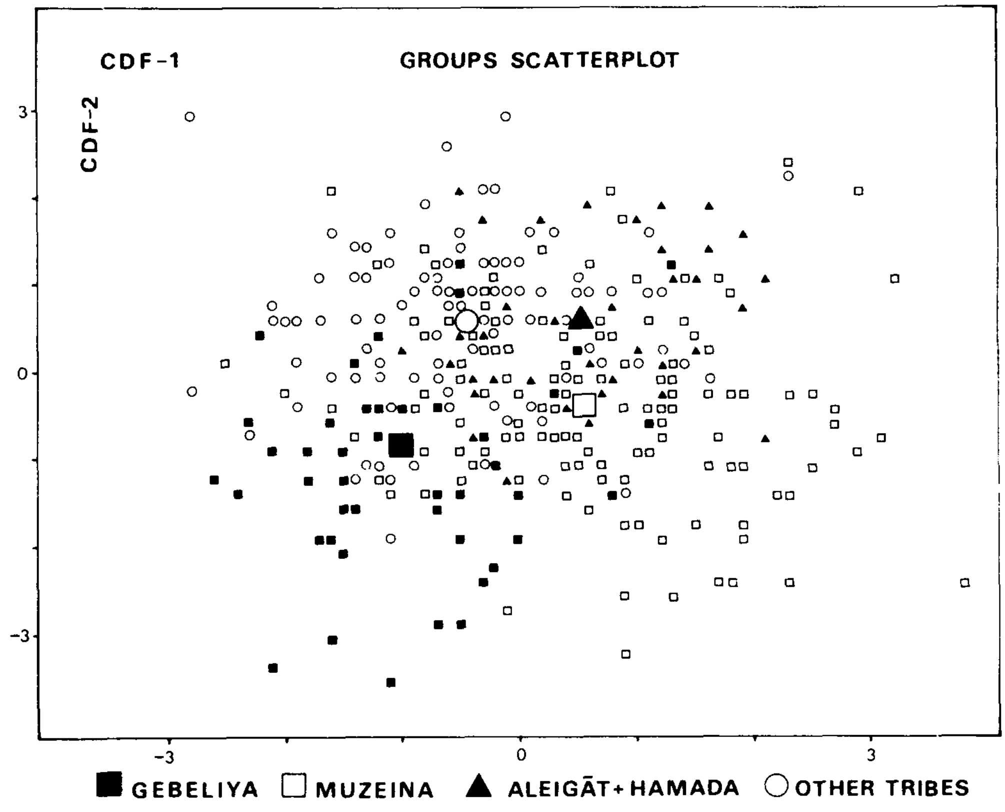
Step	Variable entered	F to enter
1	Chest circumference/Stature	12.44*
2	Subscapular skinfold	11.23*
3	Bizygomatic breadth	2.25
4	Sitting height/Stature	2.88
5	Biacromial breadth/Stature	5.92
6	Biiliac breadth	3.80
7	Leg length/Stature	1.18
8	Foot breadth/Foot length	3.53*
9	Bigonial breadth	7.16*
10	Trunk length	1.70
11	Foot breadth	1.55
12	Upper arm length	1.42
13	Body weight/Stature	2.62
14	Upper arm skinfold	1.02
15	Iliospinal height	1.37
16	Body surface area	1.06*
17	Acromial height	3.38
18	Biiliac breadth/Stature	1.04
19	Hand length	1.01
20	Total arm length	1.36
21	Kj	1.16*
22	Body weight/Stature^3	1.57

* Traits included in discriminate function for F=4.

Further information on the intergroup differences may be derived from the discriminant scores of the individuals after plotting them and the group centroids on a graph defined by the first two discriminant functions (Fig. 29). The centroids summarize also the group locations in the space defined by the discriminant functions, as seen in figure 29, where they are designated by large geometric forms. The spatial scatter of the scores provide insight into the separations achieved by the functions. Thus, on the horizontal axis (function No. 1) the discrimination is pronounced between Group 1 (Gebeliya) and Group 2

(Muzeina), whereas the separation on the vertical axis (function No. 2) is mainly between Group 1 (Gebeliya) and Groups 3 (Aleigat-Hamada) and 4 (all other tribes). We can now discern different meaning for the morphological differences between the groups, thus where the differences between Group 1 (Gebeliya) and Group 2 (Muzeina) refer mainly to shape while those between Group 1 and Group 3 (Aleigat-Hamada) are mainly ones of body size. It is also evident (Fig. 29) that there is no small measure of congruence between the groups, that is, one cannot discriminate clearly between the groups.

<u>FIGURE 29</u>: Plot of Discriminant Scores for Four Bedouin Tribes



The adverse influence of this congruence becomes clearer the more we observe the data given in Table 74. This table exemplifies the ability of the function to assort the individuals in the sample into one of the possible groups. In other words, the table indicates the probability that a certain individual will fit into the tribal category to which he belongs.

TABLE 74 : Percent of individuals correctly identified, by tribe, and F=1 and F=4, respectively.

			Predicted Group Membership							
Group	No. of cases		Gebeliya		Muzeina		Aleigat&Hamada		Other tribes	
	F=1	F=4	F=1	F=4	F=1	F=4	F=1	F=4	F=1	F=4
Gebeliya	56	62	(37) 66.1	(39) 62.9	(7) 12.5	(9) 14.5	(5) 8.9	(7) 11.3	(7) 12.5	(7) 11.3
Muzeina	141	159	(17) 12.1	(26) 16.4	(71) 50.4	(69) 43.4	(31) 22.0	(38) 23.9	(22) 15.6	(26) 16.4
Aleigat&Hamada	48	49	(6) 12.5	(5) 10.2	(5) 10.4	(11) 22.4	(30) 62.5	(23) 46.9	(7) 14.6	(10) 20.4
Other tribes	108	116	(17) 15.7	(22) 19.0	(14) 13.0	(10) 8.6	(15) 13.9	(19) 16.4	(62) 57.4	(65) 56.0

Note: Figures in parentheses are number of cases.

Mean percent of grouped cases correctly classified for F=1; 56.66 and for F=4; 50.76%.

Bedouin rock art

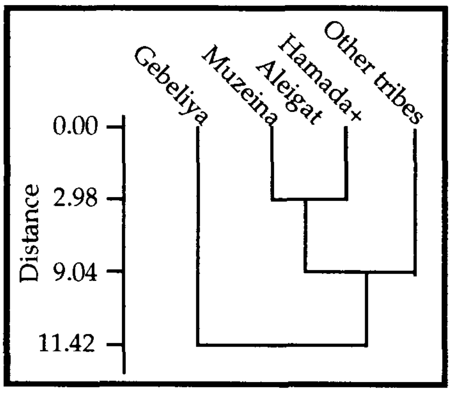
Evaluation of intertribal morphological distances by cluster analysis

We performed a cluster analysis to measure intertribal morphological distances, according to the BMDP-PIM program (1983, pp.621-622). This program creates clusters of variables based on the measurement of a connection or similarity between variables, such as the coefficient of correlation, or of the distance between variables such as the Mahalanobis distance, which we preferred. Morphological traits included to compute the Mahalanobis distances on the intertribal level are the same as those used in construction of discriminant functions (see Table 73). The Mahalanobis distance matrices were carried out by discriminant analysis of morphological traits on intratribal level under conditions of F=4. On the basis of these matrices, morphological similarities between the Gebeliya and Muzeina tribes, and between the four studied tribes, were estimated by cluster analysis. In the present study, we relied on the mean (Average linkage) amalgamations rule to construct the group cluster (BMDP, 1983).

Biological distances between Bedouin tribes (Fig. 30)

As expected, the Gebeliya tribe, whose true origin is shrouded in uncertainty, possesses a separate morphologic identity and it does not link with one of the other tribes (Fig. 30).

FIGURE 30: Morphologic Similarity Between Bedouin Tribes*: Cluster Analysis (F=4, Average linkage).



The Gebeliya presents a distance from the other tribes which is larger that between the Muzeina, Hamada and Aleigat tribes. The fact that the Muzeina and Hamada+Aleigat, join into a single cluster affirms the existence of a biologic link between these tribes and their common historic and ethnic backgrounds (see also chapter on history of tribes).

Primary Components in Bedouin Morphology

In the course of our survey and evaluation of growth processes and morphological features of children (boys) in Bedouin tribes, we have used different traits and measures in classifying body structure. Clearly many of them are inter-correlated and hence their numbers could be considerably decreased. We may lose some information in the process but in turn we probably would benefit by a marked simplification of procedures and greater ease of translating and interpreting the results of the measurements. We opted to simplify matters by the method of Principle Component Analysis, which is in fact a mathematical procedure for reducing complex correlation systems to a few measures only. The use of such a tool for studying growth patterns linked with age has been adopted by several investigators (e.g. Waliszko and Welon, 1975; Welon et al., 1976; Relethford et al., 1978). Our own study however differs from those cited in that it was made on standardized data, owing to the small samples available to us in each age group. The PCA method employed by us is basically a transformation of the original variables into a series of linear combinations, or components, which are derived in such a way as to be orthogonal to one another. A further important feature of the latter method is that the components are derived continuously so that at each step the residual variance is computed as much as possible (Harman, 1967). Most of the total variance will be explained by a small number of components with no connection between them (i.e. uncorrelated components), which hopefully are interpretable as different measures of the variance.

The PCA in this study was carried out by computer program BMDP (Dixon and Brown, 1979). The program was run twice, once for the Muzeina sample, to identify the principle components defining an intratribal structure, and once for the overall sample in order to define the principle components for the total South Sinai Bedouin group. The decision as to the number of components (the program was run for 10 components in each sample) was made subjectively, albeit one could use for this purpose statistical criteria.

Studies from various biological areas have shown that the first component includes positive loadings only (Jolicoeur and Mosimann, 1960; Reyment, 1969; Relethford et al., 1978). This finding has been mathematically justified (Rao, 1964). Many, if not most, investigators of the subject regard the first component as a size component and the subsequent ones as shape components (Castle, 1913, 1929; Wright, 1918, 1932; Jolicoeur and Mosimann, 1960; Altmann, 1966; Reyment, 1969; Blackith and Reyment, 1971; Devor et al., 1986). According to this viewpoint, size is regarded as an unidirectional increase, while shape is in fact a measure of the relationship between different body parts (Lestrel, 1974). Recently, Devor and coworkers (1986) showed that body length and body width measures as well as measures of the head and face represent different body "fields" which are possibly under differing degrees of genetic control and environmental influence.

Finding the components for total South Sinai Bedouin group

Table 75 presents the loadings (squared multiple correlations) of each trait in one of the 10 components.

Only loadings whose values are greater than 0.40 appear in tables, where they are arranged in descending order in each column. The loading is interpreted as a correlation between the variables and the factors. The Vp values are the sums of the squared loadings per column and represent the variance explained by the factor. The results indicate that 80.5% of the total variance of the 41 original variables are accounted for in 10 components. We shall now examine the proportion of variance accounted for solely by each factor, and the variables which are correlated with them.

First component. The first component accounts for over 34.9% of the overall variance and is linked, as evident from the tables, mainly to bodily length measurements. This finding is supported in other studies (Welon et al., 1976; Relethford et al., 1978; Devor et al., 1986). The fact that most of the variables in this component have a high loading testifies to a high correlation between them. Therefore, in intertribal and intratribal morphologic comparisons of Bedouin populations, there is actually no need to use many variables describing length of different parts of the body; we could rely only on few out of the 24 represented in the first component with hardly any loss of information. In addition, table 75 enable us to choose the most suitable variables for representing the particular component since these are the ones with the highest loading. The fact that some of the variables have significant, i.e., relatively high, loadings in two components (e.g. Chest Circumference) indicates that there are at least two factors that affect the morphologic expression of this variable, e.g. in the present instance, both the growth of bone tissue as well as growth of adipose and muscle tissue. According to Devor et al. (1986) the first factor is a body length factor.

TABLE 75 Results of principal component analysis. First ten loading factors; All South Sinai Bedouin tribes combined; boys 5-13 years^.

Variables	I	II	III	IV	V	VI	VII	VIII	IX	X
Stature	.95									
Body surface area	.93*									
Acromial height	.92									
Iliospinal height	.89									
Kj	.85*									
Body weight	.85*									
Tibial height	.84									
Sitting height (1)	.82*		.42							
Foot length	.77									
Total arm length	.75			.61						
Upper leg length	.74									
Body weight/ Stature	.69*	.60								
Hand strength (R)	.65									
Lower arm length	.61									
Biacromial breadth	.61*									
Hand strength (L)	.60									
Chest circumference	.60*	.57								
Upper arm length	.59									
Trunk length	.56*		.50							
Body weight/ Stature^3		.86*								
Body weight/ Stature^2		.83*								
Chest circumference / Stature		.81*								
Body weight/Body surface area	.61	.66*								
Leg length/Stature			-.78							
Sitting height 1/Stature			.72*							
Head breadth				.74*						
Bizygomatic breadth				.72						
Bigonial breadth				.68*						
Total arm length/ Stature					.92					
Hand length					.69					
Biiliac breadth/ Stature						.92*				
Biiliac breadth	47					.82*				

Cont. next page

Table 75: Cont.

Variables	I	II	III	IV	V	VI	VII	VIII	IX	X
Subscapular skinfold							.76*			
Upper arm skinfold							.68*			
Head length								.85*		
Head breadth/ Head length				.45				-.84		
Foot breadth/ Foot length									.91*	
Foot breadth	.55								.69*	
Biacromial breadth/ Stature		.44								.60*
Upper body segment	.43									47
Morphological facial height	.45									
Vp value	13.1	4.39	2.30	2.25	2.11	1.94	1.91	1.90	1.67	1.40
% total variance	34.9	13.2	6.51	5.41	4.53	4.02	3.49	3.14	2.78	2.69
Cumulative % total variance	34.9	48.1	54.6	60.1	64.3	68.3	71.8	75.0	77.7	80.4

^ Only loadings >0.4 are shown

* traits significantly different between South Sinai Bedouin tribes, based on ANOVA, see table 67

Sitting height (2) was excluded from PCA

Second component. As noted in table 75, the second component accounts for about 13.2% of the overall variance. The loaded variables of this component are mainly the ones associated with weight/stature ratios, that is, to body mass, and indicate the connection between osseous tissue to muscle and adipose tissue. It is not surprising, therefore, that a variable like chest circumference is also represented in this component. Yet, while this latter component represents shape as commonly regarded, it probably represents more specifically shape of the trunk, and hence could possibly be considered a measure of trunk robustness. According to Devor et al. (1986) the second factor is a body bulk factor heavily loaded with the soft tissue measures and weight.

Third component. The third component accounts for some 6.5% of the overall variance and represents mainly variables associated with the trunk and its relation to body height; as such, the third component may possibly be regarded a measure of the trunk.

Fourth component. The fourth component accounts for about 5.4% of the overall variance and contains variables that represent breadth measurements of the head and face. Relethford et al. (1978) propose this component as a measure of brain size because, in their opinion, the high loading of all the three breadth measures concerned are indicative of expansion in the parietal region of the skull, and are not merely a general measure of breadth as some have proposed (see also Howells, 1951). In the study of Devor et al. (1986) there is a cranial factor with high loadings on head circumference and breadth.

Fifth component. The fifth component accounts for some 4.5% of the overall variance and is represented by variables that describe the upper limbs and their link with stature and, consequently, we may view it as an upper limb index.

Sixth component. The sixth component accounts for 4.0% of the overall variance. It represents the waist (biiliac diameter) and its link with body height. Hence, it may be defined as a "loin index".

Seventh component. This component accounts for about 3.5% of the overall variance. It is a direct representative of bodily adipose tissue.

Eighth component. The 8th component accounts for about 3.1% of the overall variance and in fact represents only head measurements. This component is noted in previous studies (e.g. Howells, 1951; Lombardi, 1976), where it was regarded as a general component of skull length. Relethford et al. (1978) rejected this view on the grounds that the component is poorly correlated with the skull length and skull breadth variables, and considered the eighth component merely as a measure of the head diameter. Our own findings (PCA) support this latter conclusion.

Ninth component. This component accounts for about 2.8% of the overall variance. It represents foot size. Most morphometric studies do not include variables associated with foot dimensions because these are apparently not contributing much beyond what is obtainable from other measures of bodily length and breadth dimensions. However, in the case of the Bedouins and their environment, this component is considered important.

Tenth component. The tenth and last component accounts for about 2.7% of the overall variance. This component represents the upper part of the body and its relation to stature. We elected to regard the component as a measure of the shoulder index (biacromial breadth/stature).

We shall briefly try to clarify why the results of the PCA for all the tribes (Table 75) were not identical with those obtained for the Muzeina tribe alone (Table 76), i.e., 1st, 2nd, 4th and 9th factors are almost identical in their traits' composition; 7th and 8th change positions and the other factors are loaded with different traits. We believe that the main reason is the differences in genetic constitution of the different Bedouin tribes. We have already seen that the level of the inbreeding coefficient in the Muzeina tribe is F=0.09802. Such a high level can in various forms result in abrogation of the correlations between morphologic traits, and consequently tend to the creation of different components. We may therefore expect that in each of the South Sinai tribes the PCA results would be somewhat different. The PCA results for all the tribes combined thus reflect no more than an aggregate of the different PCA's which must be taken into account when working with components rather than with the variables themselves.

The PCA results (Tables 75 and 76) inform us that when we compare the morphologic makeup of children from different Bedouin tribes it is desirable to choose the most highly correlated variables for each factor: Stature; Body weight/ stature3; Sitting height/ stature; Head breadth; Total arm length/ stature; Biiliac breadth/ stature; Subscapular skinfold; Head length; Foot breadth/ foot length; Biacromial breadth/ stature.

A local Bedouin "Doctor" treating a patient: notice that a nail and a match box are used to perform cauterization

TABLE 76 Results of principal component analysis. First ten loading factors for 41 morphological traits; Muzeina tribe only; boys, 5-13 years^ .

Variables	I	II	II	IV	V	VI	VII	VIII	IX	X
Body surface area	.94[1]									
Stature	.94[1]									
Acromial height	.92[1]									
Iliospinal height	.91[1]									
Body weight	.89[1]									
Kj	.89[1]									
Tibial height	.85[1]									
Sitting height (1)	.79[3]									.52
Upper leg length	.76[2]									
Body weight/ Stature	.75	.54								
Total arm length	.73[1]		.53							
Foot length	.73[1]									
Hand strength (R)	.68[1]									
Body weight/ Body surface area	.67[1]	.61								
Biacromial breadth	.61[1]		.61							
Hand strength (L)	.61									
Foot breadth	.61[2,3]								.50	
Lower arm length	.58[1]									
Upper arm length	.58[1]		.49							
Biiliac breadth	.53[1,3]				.50					
Chest circumference/ Stature		.84[2,3]								
Body weight/ $Stature^2$		.78								
Body weight/ $Stature^3$		.78[3]								
Chest circumference	.61	.63[1,3]								
Total arm length/ Stature			.84							
Biacromial breadth/ Stature			.75[2]							
Head breadth				.79[1]						
Bizygomatic breadth				.71[3]						
Bigonial breadth				.51						

Cont. next page

Table 76: Cont.

Variables	I	II	II	IV	V	VI	VII	VIII	IX	X
Biiliac breadth/ Stature					.68[1,3]					
Upper body segment					-.674					
Leg length/ Stature	.487					.737[2]				
Trunk length	.503					-.67[2,3]				
Head length							.854[3]			
head breadth/ Head length				.448			-.833[3]			
Subscapular skinfold								.771[2]		
Upper arm skinfold								.678		
Foot breadth/ Foot length									.937[2]	
Sitting height/ Stature										806[2]
Vp value	13.35	3.96	2.72	2.44	2.03	2.01	1.94	1.85	1.64	1.50
% total variance	35.73	11.89	7.40	4.90	4.76	4.35	3.80	3.06	2.93	2.79
Cumulative % total variance	35.7	47.6	55.02	59.9	64.6	69.0	72.8	75.8	78.8	81.6

^ Only loadings >0.40 are shown

1 traits significantly different between Gebeliya sub-tribes, based on ANOVA,

2 traits significantly different between 6 Muzeina sub-tribes, based on ANOVA,

3 traits significantly different for all other comparisons of Muzeina sub-tribes, based on ANOVA.

Evaluation of inter- and intratribal morphological differences in light of PCA results

The PCA method enabled us to reveal varied aspects of Bedouin morphology and to examine these morphological components in regard to inter- and intratribal morphological comparisons estimated by ANOVA. Morphological differences between the Gebeliya and Muzeina children will be examined in light of both the ANOVA and PCA methods. The variables are examined according to different regions of the body.*

---

* In ANOVA comparisons between Gebeliya and Muzeina Bedouins, (+) will denote statistical significance ($p<0.05$) and (-) non-significanc ($p>0.05$).

Head and face

Variables associated with the head and face are represented in three different components. Three of the variables [bizygomatic breadth(-), head breadth(+), and bigonial breadth(+)] belong to the fourth component, one variable [cephalic index(-)] belongs to the eighth component, and another one [morphological facial height(+)] to the first component. In this manner, new elements which were not previously recognized are now added to the intertribal morphologic differences. For instance, two out of the three variables occurring in the fourth component indicate significant intertribal differences.

The trunk

The variables appearing under this heading fall into four different components. Four variables [biacromial breadth(+), trunk length(+), chest circumference(+), and sitting height(+)] belong to the first component, one variable [chest circumference/stature(+)] to the second component, another variable [ratio of sitting height (1) to stature(+)] to the third component, two variables [biiliac breadth(+), biiliac breadth/stature(+)] are in the sixth component; and one [biacromial breadth/stature(+)] belongs to the tenth component. We found that all the variables selected to represent one region of the body actually belong to five different components of the morphologic variance.

Upper limb

The variables appearing under this heading belong to two different components. Three of them [lower arm length(-), upper arm length(-), and total arm length(-)] belong to the first component, and two others [total arm length/stature(-) and hand length(-)] belong to the fifth component. Of the first component, none of the variables shows a significant intertribal difference, despite the fact that part of the variables representing the first component in other areas of the body (trunk and head) do show significant intertribal differences. Therefore if one chooses a small number of variables for the first component, to which most of the variables belong, the results differ from those derived from a one-way analysis of variance of all the studied variables (ANOVA).

Lower limb

The variables here occur in two different components, with three of them [upper leg length(-), tibial height(-), and iliospinal height(-)] represented in the first component and another one [leg length/stature(-)] in the third component.

No differences among the Muzeina and Gebeliya tribes were noted in regard to the morphology of the leg.

Foot

The variables here are represented in two different components, one [foot length(-)] belonging to the first component, and two others [foot breadth/foot length(+) and foot breadth(+)] to the ninth component.

Subcutaneous adipose tissue

The variables here, namely, subscapular skinfold (+) and upper arm skinfold (+), belong to the seventh component. Skinfold measures are, in fact, the only morphologic trait in which there is full accord of the variables between it and its component.

Hand strength

The two variables included here [hand strength R(-) and hand strength L(-)] belong to the first component. Inasmuch as they also have a high loading, it seems their contribution to the intertribal morphologic differences is very negligible.

Heights and weight

All the variables in this category [stature(-), iliospinal height(-), acromial height(-) and body weight(+), body weight/stature(+)] have a high loading in the first component. Some of these variables, especially those associated with weight, show significant intertribal differences while the remainder (associated with longitudinal measurements) do not show significant differences.

Body size and shape

One of the variables here [body surface area(+)] is linked with high loading to the first component while the remaining four [body weight/ $stature^2$(+); body weight/$stature^3$(+); chest circumference/stature(+) and body weight/body surface area(+)] are the core of the second component.

Basal metabolism

Here, the single representative variable [KJ(+)] appears in high loading in the first component.

Intertribal differences, the link between the PCA and ANOVA.

The connection between the PCA and ANOVA results in regard to the morphological differences between the tribes in general and between the Muzeina sub-tribes in particular, is elucidated in Tables 75 and 76 respectively. The variables displaying significant differences in the ANOVA for inter- and intratribal comparisons are marked by asterisk within the tables of the PCA.

From Table 75 it is clear that the morphological differences between the Gebeliya and the Muzeina boys is not restricted to a specific component of the overall variance. In the first component one can separate between variables linked directly to osseous tissue growth, mainly in the limbs which possess a large genetic element (Osborne and DeGeorge, 1959), and variables linked to muscle or adipose tissue of the trunk, in which the genetic determinant is relatively smaller.

Now let us assume that, for the purpose of analyzing intertribal morphologic differences, we would have used ten representative variables (the first ones in each component), and that we would have applied them in the ANOVA system.

The question, however, is not in how many traits the tribes differ morphologically, but rather whether such differences can be revealed by using a small number of metric variables. In our opinion, analyzing the variables within the components with regard to the ANOVA results shows that conclusions drawn from a restricted number of variables may be misleading, that important information can be lost.

The link between the PCA and ANOVA, as far as the intratribal differences are concerned, is shown in Table 76.

To simplify matters we elected to use the results of the run of the ANOVA on the Gebeliya tribe, a run which examined the morphologic differences between boys of the Awlad Gindi sub-tribe and those of the other sub-tribes. It may be recalled that of the 41 examined traits, 16 (39%) were found to show significant difference among the subtribes. In the division of variables by ten components (Table 76), it was found that all the traits, except two, separating the Gebeliya sub-tribes were concentrated in the first component. Hence, it can be argued with considerable justification that the morphological differences between boys of the various sub-tribes of the Gebeliya tribe are concentrated in one major aspect of their morphology.

The fact that most of the variables manifesting significant intratribal differences are contained in one component and are of a relatively high degree of heritability (see Osborne and DeGeorge, 1959; Kobyliansky, 1984), supports the hypothesis that the intratribal difference between the children stems from different genetic background. And if we examine the morphologic differences between various sub-tribes of the Muzeina, for example between Group 2 (Mehaysina, Gsenat and Dararme) and Group 3 (Gawanme), we note that 16.7% of variables (7 of 42 traits) showing significant intratribal differences according to ANOVA are distributed over five components (I, II, IV, VI, and VII). If we employed ANOVA only with the first variables within each component (Table 76), we would have found that 21.4% of the variables showed significant morphological differences between the sub-tribes.

It should be remembered that in summarizing our ANOVA results we claimed that the morphologic differences between boys from the various sub-tribes of the Gebeliya (38% of the traits significantly different) were more prominently significant than those between the boys from the various sub-tribes of the Muzeina (9 of 42 traits, or 21.4%, of traits significant). This condition is reflected also in the results of the PCA, albeit in a different manner.

The morphologic differences between children from various sub-tribes of the Muzeina are scattered over most of the components. On the other hand, the morphologic differences between children from the various sub-tribes of the Gebeliya tribe are concentrated in the first component. This clearly indicates that the source of morphological variation largely differs between tribes.

Geographical Factors In Intertribal And Intratribal Morphologic Variability

South Sinai is essentially a mountainous region with mountain peaks of 2500 meters or more. In this chapter we shall attempt to ascertain whether morphological differences among Bedouin boys are affected by the high altitude of South Sinai. Much attention has been given in the literature to the affects of high altitude on growth and development (e.g. Eveleth and Tanner, 1976). Most of it, however, deals with groups in regions where the elevation exceeds that of South Sinai, heights usually in excess of 3000 meters. Probably any differences between the groups in South Sinai, living at different altitudes, will be more the result of the biome.

Investigators of populations in geographic regions of high altitudes, such as the Quechua in the Andes (Frisancho, 1966, 1969), the Aymaras in the Andes of Bolivia (Rothammer and Spielman, 1972) and the Sherpa in the Himalayas (Pawson, 1974; Basu et al., 1980; Majumder et al., 1986) provide data indicating a slower and longer duration of growth compared to coastal peoples, also lower average body weight and stature, a higher ratio of weight to stature, shorter legs compared to trunk length and a larger chest circumference. A recent study by Majumder et al. (1986) on two ethnic groups, the Sherpa and Lepcha from the eastern Himalayan region, showed clear differences in morphological traits between population groups living at low (1000-2000 m) and high (>3500 m) altitudes. Of the 16 variables examined, the most important discriminant was sitting height, and the least important was head breadth.

Yet other published data on high altitude groups indicate opposite findings. For example, the study on the Kuzul-Djar populations in high altitudes of the USSR (Miklashevskaya et al., 1973) shows average smaller dimensions in chest circumference, in chest depth and in chest breadth, than in groups living at low altitudes. Another example of conflicting results occurs in the highlands of Ethiopia (Simien Mountain), where populations are larger-bodied than those of the lowlands, also taller and heavier, but they did not possess a greater chest circumference than lowlanders (Harrison et al., 1969). Although anthropometric differences have been observed between high and low altitude populations (Baker and Little, 1976; Baker, 1978), these differences have been attributed to different factors: environmental stresses such as hypoxia, cold, etc. (Hurtado, 1974), or to sociocultural factors (Weitz, 1984). The findings of the most recent study (Majumder et al., 1986) on the effect on adult body dimensions of altitude, geographical distance, ethnicity-religion and occupation showed that 1)altitude has a significant effect; 2)ethnicity-religion and occupation have no discernible effect; 3)the effect of geographical distance is inconsistent.

We selected the Muzeina tribe as a model for evaluating the effect of high altitude because it is the only tribe in South Sinai whose members are distributed over a wide geographic area, ranging from coastal settlements like Dahab and Nuweiba to mountainous settlements like Tarfat Qiderein (see Fig. 1). The other Bedouin tribes in South Sinai inhabit restricted geographical regions and topographically uniform areas (see Fig. 2). For example, the Gebeliya tribe resides only in the center of the High Mountain area and its sub-tribes, as noted, originate from different "ethnic" groups from at least two different geographic regions, Egypt and southern Europe.

The Muzeina tribe was divided into a "Coastal Group" (Nuweiba, Dahab, Hereize and et-Tur), and a "Mountain Group" (Bir-Saal, Santa Katharina, Tarfat Qiderein and Feiran). The elevations of sites in the latter group ranged from 600-700 meters (Bir-Saal) to 1200-1400 meters in the region surrounding the high peaks of the South Sinai mountains (e.g. Gebel Katharina, 2642 m; Gebel Musa, 2285 m; Gebel Umm Shaumar, 2586 m).

We must take into account that owing to migration routes of some of the sub-tribes, and the cross-sectional nature of our investigation, it is possible that some individuals considered to be the "Coastal" group may have belonged to the "Mountain" group, their presence in a particular settlement during the study being fortuitous and temporary. It is worth noting that there exists at least partial correlation between the territorial assignation of individuals to coastal or mountainous settlements and their social affiliation (sub-tribe), which may have some effect on our results.

In order to control the effect of "blood relationship" while evaluating the effect of topography, we performed the following. First, we compared mountain and coastal boys of the Shadadine and Smehat sub-tribes with Alwan as their ancestor, with mountain and coastal boys of the Dararme, Gsenat and Mehaysina sub-tribes with Ali, the son of Farag, as their ancestor. Second, we compared mountain and coastal boys of the Gawanme, with Ghanem as their ancestor, with mountain and coastal boys of the Shadadine and Smehat sub-tribes, with Alwan as their ancestor. The third comparison referred to the six separate sub-tribes, namely, the Shadadine, Smehat, Dararme, Mehaysina, Gawanme, and Gsenat.

The rationale behind these various divisions was the structure of the genealogical tree of the tribe and its use to assess the extent of influence of the "blood relationship" factor on the morphological and developmental differences between the groups.

In order to evaluate in Bedouin children the effect of "altitude" on general morphology while controlling "blood relationship", we performed three separate runs of the two-way analysis of variance on the standard scores so that in each run the components of "blood relationship" were changed (see below).

<u>The sample</u>

The samples for each of the three runs are given in Table 77.

<u>TABLE 77</u>: Number of Muzeina boys aged 5-13 years, according to "blood relationship" (descendents) and place of residence (altitude).

	Descendant			Subtribes*						
Residence	Alwan	Farag Ali	Farag G'hanem	1	2	3	4	5	6	Total
Mountains	23	23	21	11	1	12	21	10	12	67
Coast	11	88	7	11	30	3	7	55	0	106
Total boys	34	111	28	22	31	15	28	65	12	173

* Numbers refer to sub-tribe as follows:

1 - Smehat+Shadadine 2 - Dararme 3 - Mehaysina-A (Saradike clan)

4 - Mehaysina-B (all other clans) 5 - Gawanme 6 - Gsenat

Results

The summarized results of the two-way analysis of variance are given in Table 78.

In each run 42 morphometric variables were examined. The number of physical traits manifesting significant differences between coastal and mountain children was small, the maximum being in the third run, 4 out of 42 traits, namely, tibial height, bizygomatic breadth, upper arm skinfold and leg length/stature. None of these four had any significant interaction with the second independent variable of "blood relationship". Hence, although it might be that differences in place of residence are responsible for the observed morphologic differences in these traits between Muzeina boys, it is more logical to assume that a chance factor is involved. Also in the third run, the "blood relationship" factor was found to be responsible for morphological differences between Muzeina boys in 9 out of 42 traits examined: iliospinal anterior height, bizygomatic breadth, subscapular skinfold, biiliac breadth, upper leg length, trunk length, sitting height/stature, leg length/stature, chest circumference/stature.

TABLE 78: Number of traits for which a significant/non-significant difference was found between ethno-territorial Muzeina Bedouin groups by means of MANOVA, based on 42 traits.

	Independent variables					
	Altitude		Blood Relationship		Interaction	
Runs according to ethnic origin	Sign.*	Non-Sign.	Sign.	Non-Sign.	Sign.	Non-Sign.
First run	3	39	2	40	1	41
Second run	0	42	4	38	2	40
Third run	4	38	9	33	1	41

*Significant when $P<0.05$

1 The first run: Distribution of the independent variables: altitude and genealogical origin (degree of blood relationship).
The first independent variable: mountain residents vs. coastal residents.
The second independent variable: Alwan descendents vs. Farag Ali descendents.

2 The second run: Distribution of the independent variables: altitude and genealogical origin.
The first independent variable: mountain residents vs. coastal residents.
The second independent variable: Farag G'hanem descendents vs. Alwan

descendents.

3 The third run: Distribution of the independent variables: altitude and genealogical origin.
The first independent variable: mountain residents vs. coastal residents.
The second independent variable: Shadadine, Smehat (1); Dararme (2), Mehaysina-A (3), Mehaysina-B (4), Gawanme (5), Gsenat (6).

The combination of the two independent variables (the interaction effect) in the third run showed significance only in one variable, subscapular skinfold.

In sum the results indicate:

a) There was little morphologic difference between mountain and coastal groups in the Muzeina tribe. The few significantly different traits obtained are not correlated and are not ones we would expect to obtain under the altitude variable, those associated with the respiratory system, for example.
b) Morphologic differences between groups in the Muzeina tribe can be detected when its members are categorized according to their genealogical ties. These morphological differences are more pronounced than the differences obtained by site of residence only. The more precise the genealogical classification, i.e., the more restricted the social grouping, the more pronounced the trend towards morphologic variability among the groups.
c) Combination of the two independent variables (interaction) does not contribute more to an understanding of the morphologic differences between the sub-tribes than does each independent variable alone.

Nutrition In Bedouins: Inter- And Intratribal Morphological Differences

Apart from a few romantic references on the subject, the nutritional status in Bedouin society has never been studied in detail. Burckhardt (1822) noted that the Bedouins of South Sinai were the poorest among the Bedouin tribes. He wrote:

> *The Towara are some of the poorest of the Bedouin tribes, which is to be attributed principally to the scarcity of rain and the consequent want of pasturage. Their herds are scanty, and they have few camels... Their means of subsistence are derived from their pastures, the transport trade between Suez and Cairo, the sale at the latter place of the charcoal which they burn in their mountains, of the gum arabic which they collect & of their dates &*

other fruits. The outcome of this trade at Cairo culminates in purchasing clothing and provisions, particularly corn, for the supply of their families; and if anything remains in hand, they buy with it a few sheep and goats at Tor or at Sherm, to which latter place they are brought by the Bedouins of the opposite coast of Arabia (p.561).

Burckhardt also estimated their annual per capita income and mentioned that their food list is meager, thus:

They live, of course, according to their means; the small sum of fifteen or twenty dollars pays the yearly expenses of many, perhaps of most of their families, and the daily and almost unvarying food of the greater part of them is bread, with a little butter or milk for which salt alone is substituted when the dry season is set in, and their cattle no longer yield milk (p.562).

Twenty years after Burckhardt, Sinai was visited by another famous traveller and investigator, namely, Robinson (1841), and he, too, noted the low nutrition level of the Bedouins, particularly among children and the elderly. He wrote:

The young and middle-aged men looked well and hardy; but there were old men and sick persons and children, who came around the convent, the very pictures of famine and despair. These miserable objects, nearly naked, or only half-covered with tatters, were said to live very much upon grass and herbs; and even this food now failing from the drought, they were reduced to mere skeletons (p.201).

Robinson (1841) further claimed that the Towara tribes were among the poorest of the Middle Eastern Bedouin tribes (pp.203-204).

Almost identical accounts on the means of subsistence of Bedouins are provided by a later traveller, Palmer (1871). Palmer also noted the dire state of Bedouin children in the Sinai, most of whom lacked clothing, were undernourished and exposed to diverse diseases. Among the numerous folklore tales gathered by Levi (1980) in South Sinai are many that describe periods of famine and plague.

These tales reinforce the impression gained from reading the journals of travellers and investigators in the 19th century and lead to the conclusion that poverty was, then as now, rife among the Bedouins of South Sinai. Similar impressions occur in the report by Marx (1974, p.29) on the life of Bedouins in the Israeli Negev. He comments:

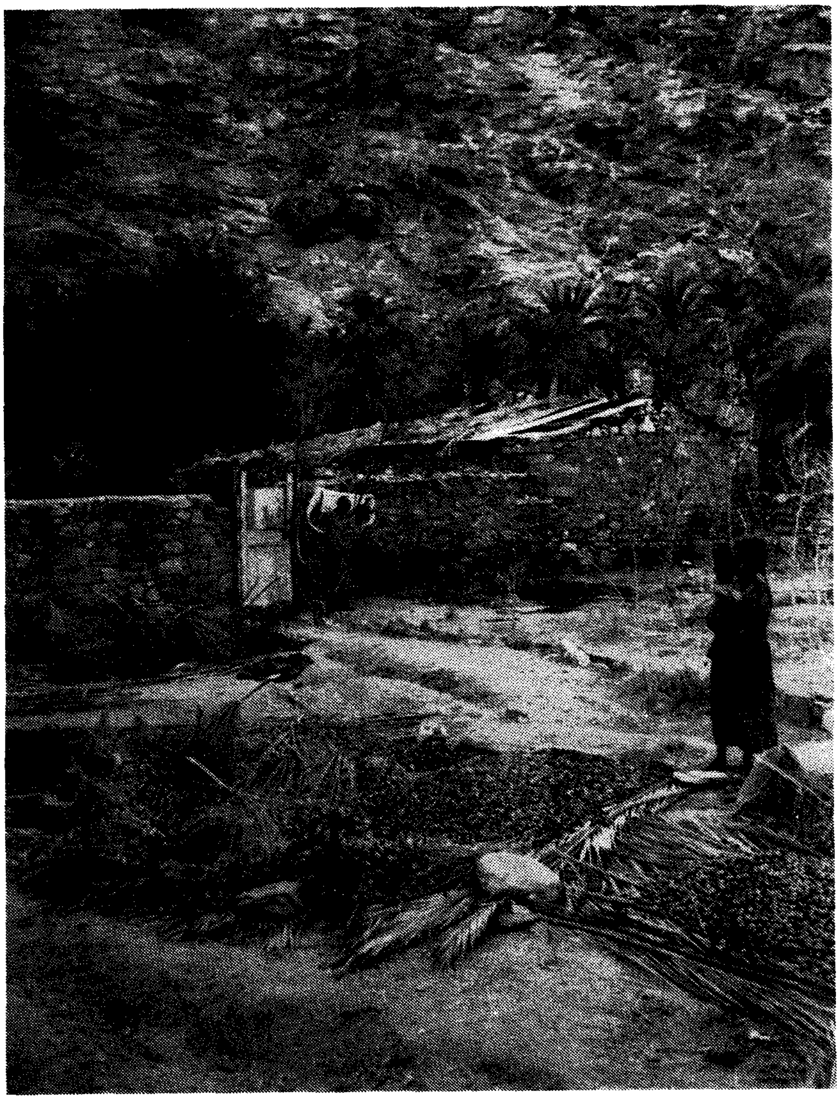
In the course of a regular working day the Bedouin is accustomed to eating a single meal only, mostly comprised of "Pat" (Pate') - a dish of flour boiled in water and oil which serves as a main course (Idda) and is served any time between 8 AM and 5 PM, as the master of the house so wishes on the *particular day. On getting up in the morning, the Bedouin is mostly accustomed to drink a cup of coffee or tea together with a slice of dried bread from the previous day. Meat is eaten only on festive occasions and the main staples are cereals which the Bedouin has learned to store for prolonged periods... In the spring, the diet is enriched with milk and wild vegetables such as Khubeisa [Malva plant] and Kima [truffle]. In other parts of the year the diet does not include vegetables or fruits... many Bedouins, even the wealthy among them, suffer from undernourishment, general malaise and even tuberculosis, to which the Bedouins are more susceptible than any other society (p.129).*

A first attempt to tackle nutritional status in terms of the energy contribution of traditional Bedouin economy was made by Perevolotzky and Perevolotzky (1979). They calculated the energy value of the product of an orchard in the Gebeliya tribe as tantamount to 2,237,760 calories which they believed comprised 55.8% of the yearly energy consumption of a Bedouin family. To this we should add the energy value obtained from the flock, namely, milk - 15.4%, and meat - 6.0%, which also represent the energy value referable to the family consumption per year. According to these calculations, the basic economics of the Gebeliya tribe provide about 77% of the energy expenditure of a Bedouin family. But these figures refer to conditions in about 1965, before relative modernization in the region. The socioeconomic changes that occurred in the wake of the takeover by Israel in 1967 led to a significant diminution in the relative energy value (per yearly family expenditure) provided by the aforementioned economies. Thus Perevolotzky and Perevolotzky wrote:

The Israeli rule has brought about numerous transformations in Bedouin life. The employment situation, for one, has changed, with practically unlimited and well-paying job opportunities opening up (owing to settlement of East Sinai, tourism, etc.). Thus, even though there was shut-down of the markets for the sale of the fruits of the orchard and herds, and despite the rise in the cost of living (mainly because of rampant inflation in recent years), the standard of living increased. Along with this, there was change also in the patterns of migration, the Bedouins coming to settle closer to vehicular routes and forming permanent settlements. These latter have had a drastic effect on the development of natural resources. The clear outcome was the abandonment of many orchards concomitant with the inauguration of job opportunities in Israel (1968-1970) and also the pronounced diminution of the flocks (p.53).

Israeli rule plainly brought about substantial changes in the Bedouin economy, generally for the better, including a rise in the nutritional level. Most of the children surveyed in the present study were born after 1967 and therefore grew up under nutritional conditions immeasurably better than those of their parents. In Table 79 are given data on the monthly expenditure of a Bedouin family in the 1960's compared with that in the 1970's, according to Perevolotzky and Perevolotzky (1979). Part of the observed rise in the level of consumption may be due to an increase in size of the family.

The amounts of food products the South Sinai Bedouins received gratis from various welfare agencies appear in Tables 80 and 81. All Bedouins were eligible to receive economical support, although the amount of support depended largely on the individual's specific welfare situation.



Harvesting the dates at the Feiran Oasis

TABLE 79: Average monthly consumption by Bedouin families in South Sinai in the 60's and 70's (data from Perevolotzky and Perevolotzky, 1979).

Product	**1960**	**1975**
Rice	14 kg.	15 kg.
Sugar	8 kg.	15 kg.
Oil	5 kg.	7 kg.
Flour	18 kg.	40 kg.
Lentils	4 kg.	7 kg.
Vegetables	-	50 kg.
Canned meat	-	5 cans
Canned sardines	-	30 cans
Canned vegetables	-	10 cans
Poultry	-	3 units

TABLE 80: Support per month per capita received by South Sinai Bedouin from different welfare agencies including the Israeli government (kg)[1].

Food product	Full Support	Partial Support	Temporary Support
Flour	6.50	6.50	3.25
Soy beans	2.00	2.00	1.00
Rice	2.50	2.50	1.25
Lentils	0.50	0.50	0.25
Milk powder*	0.50	0.25	none
Canned butter*	0.50	0.50	none
Oil	0.50	0.50	0.25
Sugar	5.00	none	none
Tea	0.60	none	none
Additional money	equivalent to value of products	up to 50% of value of products	none

[1] Official information received from the Israeli Ministry of work and Welfare for 1978.

* received from the Red Cross occasionally

Full welfare support - to those with no other income

Partial welfare support - to those with partial income

Temporary suport-to those with permanent income, every three months

TABLE 81: Number of South Sinai Bedouins receiving food support (full or partial) in 1979, according to data supplied by the Israeli Ministry of Work and Welfare.

	Full support	Partial support	Temporary support	TOTAL
Place*	No. of indiv.	No. of indiv.	No. of indiv.	No. of indiv.
Santa Katharina	80	21	1344	1445
El-sahab Tarfat Qiderein	92	43	913	1048
Feiran A Wadi Sulaf	49	18	302	369
Feiran B Wadi Tar	64	10	531	605
Um-Gsur Ilianes, Nasrin	99	29	664	792
Wadi Raraged Wadi Sidri	144	34	639	817
Abu Ga'ada Tar	79	16	856	951
Wadi Baba	25	5	203	233
El-ramla	86	9	545	640
Bir Nasib	78	14	451	543
Et-Tur	125	19	890	1034
Hereize	35	7	598	640
Dahab	127	51	769	947
Nuweiba	96	11	680	787
Waset	39	18	327	384
Khasham Altarif	52	11	339	402
TOTAL	1270	316	10051	11537

*see Fig. 1

Note:Different sources present different numbers for the South Sinai populations between 1970-1980. In the present case there is some infiltration of elements which are not formally included in the Towara framework (e.g. Tarabin).

Full welfare was given to those with no source of income, and included food products, and a sum of money equal to the value of the food products given. Partial support was given to those who had some source of income, and consisted of the same amounts of most of food products as given for full support, but half the amount of money. Temporary support was given to all other Bedouins, and included about half the amounts of food products as above, with no financial support. The level of financial support was determined according to the average salary per month of the Bedouins in the region. Food was usually received from three main sources: the CARE Organization (USA), the International Red Cross, and the Military Governor of South Sinai.

In addition to our anthropometric study on the Bedouins, we gathered information on the kinds of food consumed by Bedouin children in the Sinai. We prepared a special form written in Arabic listing 79 different kinds of food (including wild herbs that Bedouins are accustomed to eating). These forms were distributed in ten different schools in South Sinai, and the teacher cooperating would every morning write down for each pupil the items consumed the previous night (without stating amounts). This procedure continued for one week, in some cases 2 weeks, and was repeated every 6 months over a period of 3 years. Thus we could evaluate the changes in types of food habits over both brief and extended periods, as well as the influence of seasonal changes on food consumption. Other fluctuations in the kind of food consumption as a consequence of economic instability to which a Bedouin family is exposed were also recorded as well as the effects of cultural and social happenings, such as holidays, religious ceremonies, marriage, circumcision, etc.

a. The geographical factor

We chose four geographic regions in South Sinai, each with its own typical Bedouin economy. First was the coastal region (Dahab, Nuweiba) in order to assess the piscatory component in the Bedouin `food basket'; second, the large, water-rich oasis (Feiran), to check the agricultural component; third, the dune regions, serving as grazing land (G'hamlat-Hemaier, Bir Beida), to assess the contribution of sheep to the diet; and fourth, the mountain region (Nasrin) as a neutral region with no apparent economic or nutritional "advantages" of any kind.

The results are indicated in Table 82 and may be summarized as follows. With the exception of the coastal region, where an average 30% of the children eat fish daily, there are no significant differences between the regions in the array of food items made available to the children. Territorial location of a tribe apparently is no major factor in the available food items afforded its children with the possible exception of the coastal Bedouins.

b. The seasonal factor

On seasonal differences in the food staple one can learn from a comparison of the data for Dahab area which were collected in the end of the winter and beginning of spring, with those which were collected at the end of the summer and beginning of winter (Table 82). It should be pointed out that for the majority of food products, there was no difference in the consumption rate, the primary differences being in the consumption of milk and milk products, and mutton. In the winter, when pasture is abundant, the sheep produce more milk and some of the numerous lambs are sacrificed (mainly the male animals). Concurrently, there is a drop in the consumption of fish, primarily because of the strong winds blowing in the bay which cause high waves and prevent fishing near the coral reefs. In the summer, the situation reverses, mutton becoming rare, and fish consumption increases considerably; vegetables and fruits also become more prevalent.

A Bedouin child might taste meat only at a special festive occasion. Indeed, a month could pass between one meat "meal" and the next.

The main staples in the children's diet are various flour products, primarily "phatir"; the latter is a bread variety favored by Bedouins, comprised of flour and water only. Other common food items are rice and lentils.

Energy sources and calorie consumption in South Sinai Bedouins compared with various populations

All estimates were based on data obtained from welfare agencies as well as on our questionnaire data and our personal knowledge of Bedouin economy. We estimated the caloric intake of a Bedouin child (aged 8-9 years) between 1500-1800 calories per day. Since our calculation takes into account only the main energy sources (flour, rice, oil and lentils) the mean caloric intake (1667 kC) might actually be somewhat higher. This number is very similar to that obtained by Pervolotzky and Pervolotzky for the Gebeliya tribe (1979).

TABLE 82: Food consumption by Bedouin children in South Sinai: Percentage of children who obtain one of the enumerated food items per day .

Region	Coastal Plain					Mountains		Dunes		Oasis*
Tribe	Muzeina					Gararsha		Aleigat		All tribes
Place	Dahab				Nuweibba	Nasrin		Bir Beida		Feiran
Product/Dates	Feb.	Mar.	Apr.	May	Feb.	May	June	May	June	Apr.
Staples										
Sugar	84.9	-	85.1	79.0	-	-	-	-	-	85.7
Milk	95.2	64.0	43.4	49.5	96.0	68.2	79.8	73.2	76.9	37.9
Eggs	15.7	6.8	10.0	10.3	2.2	1.5	0.8	7.1	4.3	36.6
Rice	54.5	48.8	57.1	48.0	58.2	58.7	48.7	46.4	48.3	57.1
Meat (1)	9.8	7.1	6.3	4.5	8.2	1.5	6.7	3.5	7.6	5.0
Fish (2)	38.4	32.0	32.2	27.3	36.0	5.0	0.0	6.2	2.1	4.8
Bread (3)	82.7	80.5	79.0	71.4	84.5	77.7	78.9	66.9	70.3	73.4
Sweets (4)	10.9	3.4	24.9	19.4	29.7	26.1	22.6	17.8	-	29.7
Vegetables A (5)	16.2	17.1	10.0	8.8	22.2	19.0	21.0	23.2	16.4	11.9
Leguminous plants (green) (6)	1.0	0.0	5.1	2.7	2.8	1.5	0.8	1.3	0.0	2.0
Leguminous plants (dried)(7)	37.3	26.8	29.7	26.4	26.2	29.3	-	24.1	28.5	20.6
Vegetables B (8)	11.3	1.7	11.5	14.8	15.4	11.1	-	16.0	9.8	18.3
Local cooking plants (9)	4.3	0.0	3.0	4.2	2.8	0.0	-	5.3	12.0	1.6
Condimemts (10)	4.0	2.4	2.4	0.0	2.3	0.0	0.0	0.0	0.0	1.0
Citrus fruits(11)	13.5	0.0	10.3	7.9	14.2	10.3	-	5.3	0.0	6.5
Deciduous fruits (12)	0.0	-	4.5	3.3	2.8	1.5	-	1.7	0.0	2.5
Local fruits (13)	8.4	-	3.6	1.2	0.5	0.0	-	0.0	0.0	0.0
Other fruits (14)	0.0	-	3.3	8.5	0.0	0.0	-	0.0	0.0	0.0
Preserve	2.9	-	0.9	1.8	1.7	0.7	-	0.0	0.0	0.0

*The Feiran oasis is inhabited by people from all Bedouin tribes of Sinai

-No information

Note: Many fruits (e.g. figs. pears) and vegetables (e.g. beets, lettuce) were excluded from the table since they are rarely included in the Bedouin food basket.

[1] Including chicken, mutton and canned meat; [2] Including dried, fresh and canned fish (tuna, sardines, etc.); [3] Israeli bread, local bread (patir, pita), biscuits, bagels, macaroni, etc.; [4] Chocolate , candy, waffles, chewing gum, etc.; [5] Potatoes, carrots, radishes.; [6] Horsebeans, beans, peas, other pulses.; [7] Lentils, beans, peas, pulses, etc.; [8] Corn green peppers, cucumbers, onions, tomatoes, cabbage, etc.; [9] Meluchia, gergir, rijla, etc.; [10] Pickles, canned tomatoes, olives, etc. ; [11] Oranges, mandarins, etc.; [12] Apples, apricots, peaches, etc.; [13] Dates, rapes, almonds.; [14] Watermelon, etc.

In Table 83 we show the average caloric consumption in several populations of contrasting economies. As noted, the caloric consumption of the Bedouin child population of South Sinai is low, and their dietary combinations differ widely, compared with other groups. Not only do the proportions of their energy-yielding foods differ greatly, but also the sources by which they are obtained. The intake of energy from protein is low among South Bedouins, comprising only up to 7% of the total caloric intake, compared to 13-14% for other comparable groups. Worth noting is that protein needs (grams per day), according to European standards of 30-50 gr at age 5, 50-80 gr at age 12, 50-90 gr for adult males, and 40-70 gr for adult females (Weiner, 1977), are far beyond the amount available to South Sinai Bedouins. This protein inadequacy is one of the great dietary hazzards of these Bedouins. Fat comprises 23% of the total caloric intake, which is similar to that in Israeli and British groups, much lower than that of Eskimos, and higher than that of the Kikuyu (Kenya). The main staple in Bedouin society is carbohydrates, about 70% of the total caloric intake, which appears to be true also for many African populations, whereas in Israeli and British child populations, this dietary component provides only 50-58% of the total caloric intake.

TABLE 83: Average daily caloric consumption and daily intake per person of protein, fat, and carbohydrates in five contrasting economies[1].

Calorie sources							
Region	Calories	Protein		Fat		Carbohydrates	
		g/day	%	g/day	%	g/day	%
South Sinai (Bedouin)	1667	28	6.7	43	23.3	290	70.0
Israel*	2920	130	21.8	71	26.9	305	51.3
Britain**	3000	100	13.4	110	33.1	400	53.5
Kenya (Kikuyu)**	2153	100	18.5	22	9.2	390	72.3
Alaska (Eskimos)**	3100	377	47.1	162	45.5	59	7.4

[1] % = percent of total caloric consumption

* from Baily (1972)** from Weiner (1977)

In sum, the Bedouins can be categorized in nutritional terms as a "low protein,high-carbohydrate" dietary group (Weiner, 1977, p.410), in spite of being a pastoral society with large herds of sheep and camels, and having to import carbohydrate sources (mainly cereal grains) due to poor cultivation conditions. Consequently, the Bedouin children suffer a chronic lack of protein.

Correlation between body structure, climate and caloric consumption

The customary formula for estimating the body weight factor in energy consumption, according to Gugenheim (1964) is: $E = 152 \times W^{0.73}$, or $E = 815 + (36.6 \times W)$, E representing the needed energy in calories, W designating body weight in kg. Thus, a male weighing 45 kg should consume 2450 calories per day and a man weighing 80 kg requires 3730 calories. The Bedouins have a comparatively slight body structure. An average Bedouin adult male weighs 57 kg and is 169 cm tall, and accordingly his energy consumption would be, according to the formula, 2908 calories. In contrast, the average Israeli adult male weighs 71 kg and is 174.5 cm tall (Kobyliansky et al., 1979-1980), requiring an energy expenditure of 3413 calories. The average Bedouin adult woman, weighing 49 kg and 156 cm tall, would require about 2000 calories per day, compared to an Israeli adult woman who weighs an average of 56 kg, and is 160 cm in height, requiring some 2375 calories. The sex factor is also important in that a woman consumes fewer calories than would a man of the same height and weight.

Another factor affecting energy consumption is the climate. According to various computations, an increase of 5 degrees C in the mean annual temperature results in a reduction of 2.5% in the caloric intake, while a 5 degree C drop in the annual temperature leads to a 1.5% increase in the caloric intake (Gugenheim, 1964). Consequently, in South Sinai, which is a relatively warm region compared to most areas on the European continent, the caloric intake per day of the Bedouin is lower by approximately 7.5-10% than that of the European of comparable age.

In sum, owing to differences in body size and climatic conditions, adult Bedouins generally require on the average almost 900 calories less than do Israelis and Europeans. The above calculations are not totally applicable for children since the developmental process demands additional caloric expenditure.

Influence of age and physical activity on the caloric intake

The caloric expenditure is dependent also on age and physical activity. Between the ages of 20 and 30 years, a man is at the height of his physical activity and thereafter his physical activity and basal metabolism are on the decline (Gugenheim, 1964). It has been noted that after 30 years of age for each decade up to age 50, the caloric intake diminishes by 3%, each decade from 50 to 70, by 2.5% and each decade from 70 on, by 10% (Gugenheim, 1964). A growing boy requires a relatively large amount of energy and the faster the rate of growth the greater the caloric requirement. Taking into account the mentioned conditions (e.g. body build, climate), the question arises as to the needed caloric intake for proper development of a Bedouin boy. According to American standards, children aged 4-6, whose mean weight is 18 kg and mean height is 109 cm, require 1700 calories per day; those aged 7-9 with a mean weight of 27 kg and height 129 cm, require 2100 calories; those 10-12 years of age with a mean weight of 36 kg and a height of 144 cm require 2500 calories; and finally, children aged 13-15 with a mean weight of 49 kg and a mean height of 162 cm need 3100 calories for proper development. If we take into account that Bedouin children live in warmer regions, show different patterns of growth, and probably are less physically active than American children, we may estimate that Bedouin children of comparable ages would need 300-500 fewer calories for proper development, e.g., for age 6, 1500 calories; for age 8, 1800 calories; and for age 12, 2100 calories. Yet, and despite corrections made for temperature, body build and physical activity, the number of calories available to the Bedouin children is less than the above "norm".

The influence of nutrition on growth

It is well established that an insufficient supply of food hampers the growth of children (Tanner, 1962). Most of the studies supporting this assumption belong to one of two categories. The first comprises studies made on human societies that had undergone a nutritional crisis and then reverted to their normal level, as in the case of wartime populations (e.g. Ellis, 1945; Howe and Schiller, 1952; Kimura et al., 1959). The main conclusion drawn from such studies was that following the nutritional crises which hamper development, at a later "normal" stage the children regain their full biological development. Studies of the second type are more controlled and are performed mainly on animals. Such studies show that only the most deficient nutrition can harm the growth process to an irreparable extent. In most instances, improved nutrition will "restore" the animals to their normal level (Schultze, 1955; Widdowson and McCance, 1960).

From the 1960's on, the majority of investigations on growth and development have been focusing on the correlation between social status (with its nutritional implications) and development of children (e.g. Douglas and Simpson, 1964; Barry and Robert, 1978; Rona et al., 1978; Schutte, 1980; Little et al., 1986). The main conclusions from these studies are: a)children of low social status present comparatively lower values of weight and height; b)the morphologic differences between children of different social strata are already evident at very early ages, usually pre-school; c)the smaller dimensions of children of lower social status stem from retarded development and late sexual maturation; d)children of low status may `catch up' with children of higher status at a later age, provided their diet is improved.

The question of adequate nutrition for proper development among Bedouin children has two unique aspects: First, there is almost no socioeconomical stratum among South Sinai Bedouin families, and therefore all Bedouin children can be studied as a single group; and second, the Bedouin children of today are the products of a long-time adaptation to nomadic life in the desert, and of a special diet. Selection was in favor of those who could properly develop under the harsh desert conditions, i.e., those who manifested physiological and morphological characteristics, such as small body size, low rate of basal metabolism, etc., which were advantageous under conditions of inadequate nutrition. Their "advantage" lies in their reduced demand for energy.

There is also some evidence suggesting that reduced body size may be an adaptive response to poor nutrition (Frisancho et al., 1973; Stini, 1975), although the latter has been found to be associated with higher morbidity and mortality (Martorell et al., 1981), reduced physical working capacity (Shephard, 1985), and reduced muscular strength and motor performance (Malina and Buschang, 1985). To be sure, the Bedouins have "weeded out" behavioral habits in which energy costs were too high. Thus, the low rate of physical activity is not the result of laziness, as ascribed in so many travellers' reports (e.g. Burckhardt, 1822; Robinson, 1841). Rather, by a combination of physical traits and daily activity, present-day Bedouin children succeed in growing and developing fairly adequately despite the small quantity, poor quality and lack of variety of their food.

A respectable study carried out on the diet in an African tribe is relevant in this connection. Thus Fox (1953) showed how the balance between calories expended and calories available is reached in an African tribe during one year, and how the group was content with a low level of activity, working no harder than necessary, and their body weight kept low. Yet, when intake of energy increased, the opposite was observed.

Studies undertaken recently, contrary to many published works, indicate that poor nutrition does not necessarily hamper the intellectual capacity, nor even physical activities, but only causes change in the behavioral pattern (Robin et al., 1983).