PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES

Haemoglobin Studies of Yemenite and Kurdish Jews in Israel

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X. Haemoglobin studies of Yemenite and Kurdish Jews in Israel

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Haemolysates from Yemenite and Kurdish Jews now living in Israel were analysed qualitatively and quantitatively by starch gel electrophoresis.

No electrophoretically separable haemoglobin variants were detected in any of the haemolysates. The Hb-A_2 levels were elevated above the upper normal limit (3.5% of total haemoglobin) in 9.2% of the Yemenite Jews and 24.5% of the Kurdish Jews. These findings suggest that the approximate frequencies of the gene for β-thalassaemia may be of the order of 0.05 and 0.1 respectively in these previously expatriate Jewish communities.

The high incidence of the β-thalassaemia trait in the Kurdish Jewish subjects is in agreement with previous studies on Jewish communities of Kurdish origin. No previous reports of β-thalassaemia in Yemenite Jews appear to have been recorded.

Experimental methods

The haemolysates used in this work were prepared from the blood samples in Dr Mourant's laboratory for the study of red cell enzyme polymorphisms. Samples of each haemolysate were made available for haemoglobin studies. These were diluted slightly to an approximate concentration of *ca.* 10%, one drop of neutralized 0.1 M potassium cyanide (pH 7) added to convert any methaemoglobin into the cyanmethaemoglobin form (which has the same charge and hence electrophoretic mobility at pH 8.6 as oxyhaemoglobin) and recentrifuged before electrophoretic analysis in starch gel using the tris-EDTA-borate buffer system (pH 8.6) which has been widely employed for the analysis of haemolysates. One slice of each gel was stained in the usual way with naphthalene black protein stain in water–methanol–acetic acid (50:50:10, v/v) and differentiated in the same solvent system. A second slice was stained and differentiated with the same dye in a glycerol-based solvent mixture, namely water–glycerol–acetic acid (50:50:10, v/v). The resulting transparent gels were examined by transmission densitometry as previously described and the densitometer records evaluated by planimetry to determine the proportions of the various components of the haemolysates. The records are linear in absorbance (optical density) units, so that the area of any zone, relative to the total area of all the haemoglobin zones is a measure of its proportion (in terms of bound dye). Since the gels are stained with a dye which binds to proteins generally, the main non-haem protein of the red cell (n.h.p.) which is the major carbonic anhydrase B isozyme, also stains and can be estimated and its concentration expressed relative to the total haemoglobin (and in terms of bound dye). In a normal human haemolysate this is the only n.h.p. of the red cell which is invariably seen, though the weaker band of the carbonic anhydrase C isozyme can sometimes be detected on the cathodic side of the starting position of the tris-EDTA-borate (pH 8.6) gel system.

Results

No electrophoretically separable haemoglobin variants were detected in any of the haemolysates from the Yemenite Jewish and Kurdish Jewish subjects. All the starch patterns were inspected to detect any haemolysates in which the normal minor component Hb-A_2 might be elevated above the normal level. The starch gel patterns for these haemolysates were evaluated quantitatively by densitometry, as described above, together with several apparently normal patterns on the same gel. The visual estimates and quantitative Hb-A_2 levels of all the subjects examined are listed in table 1, together with the corresponding haemoglobin values. The main

Table 1. Hb-A_2 levels and Hb values for individual subjects

reference number	sex	name	family relations	Hb g %	Hb-A_2 %	Hb-A_2 class
Yemenite (Bitha)						
1	f	Guri, Mazel	.	12.7	2.5	−
2	m	Mori, Rafael	.	16.5	3.3	−
3	m	Aron, Zecharia	.	15.5	.	(−)
4	m	Yosef, Gabi	b 52; b 53; c 55	15.5	2.7	−
5	f	Yosef, Myryam	.	12.0	.	(−)
6	m	Aron, Chaim	.	14.2	.	(−)
7	f	Aron, Cochava	.	12.6	1.9	−
8	f	.	.	14.0	.	.
9	f	Nissim, Cochava	s 35; 43	.	1.7	−
10	m	Aroni, Shlomo	b 12; 13; s 44	12.8	.	(−)
11	f	Aroni, Lea	s 21	12.4	1.9	−
12	m	Aroni, Yermiya	b 10; 13; 44	13.7	4.0	+
13	m	Aroni, Efraim	b 10; 12; 44	14.4	.	(−)
14	f	.	.	12.0	3.2	−
15	m	Cohen, Yafet Chaim	.	12.8	3.2	−
16	f	Cohen, Hana, Yafet	.	12.6	3.8	+
17	m	Sharabi, Roni	.	13.0	2.8	−
18	f	Sharabi, Il Myryam	.	12.0	.	(−)
19	m	.	.	15.7	.	−
20	f	Cohen, Rachel	.	11.0*	.	(−)
21	m	Yosef, Menahem Salem	b 11	14.6	4.1	+
22	m	Efraim Said, Shmuel	.	15.7	3.7	+
23	f	Efraim Said, Yona	.	12.0	2.6	−
24	m	Yehuda, Yehuda	b 34	15.2	3.5	±
25	f	Yehuda, Cochava	.	11.2*	.	(−)
26	m	.	.	13.4	.	−
27	f	Tsur, Zvia David	s 45; c 56	12.4*	.	(−)
28	m	Aron, Yafet	40	.	.	(−)
29	f	Aron, Malka	41	13.8*	2.2	−
30	m	Yosef, Yafet	hb(m) 46; 2c 55	14.6	2.7	−
31	m	.	.	13.2	.	.
32	f	Tsur, Shoshana Said	s 56; c 33; 27	11.9	2.5	−
33	m	Tsur, Said David	b 49; c 32	13.0	3.4	−
34	m	Yehuda, Soleman	b 24	14.8	.	(−)
35	f	Yehuda, Myryam	s 9; 43	12.5	.	(−)
36	f	.	.	12.2	.	(−)
37	f	Sharabi, Salama	.	11.8	3.0	−
38	f	.	.	12.6	.	(−)
39	m	Sharabi, Said	.	13.8	.	(−)
40	f	Sharabi, I Miryam	s 28	12.0	.	(−)

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TABLE 1 (*cont.*)

reference number	sex	name	family relations	Hb g %	Hb-A_2 %	Hb-A_2 class
Yemenite (Bitha)						
41	m	Shlomo, Hadar	b 29	.	3.0	–
42	f	.	.	12.6	.	.
43	m	Yehuda, Israel	b 9; s 35	14.0	3.3	–
44	f	Yehuda, Rivka	s 10; 12; 13	12.2	.	(–)
45	f	Yehuda, Tamar	s 27; c 56	11.2	2.3	–
46	f	Shoker, Simcha Yaacov	hs(m) 30	12.6	.	(–)
47	m	Yehuda, David Soleman	.	14.1	.	(–)
48	f	Yehuda, Bracha Soleman	.	11.4	.	(–)
49	m	Tzur, Pinhas	b 33; c 32; 56	15.8	.	(–)
50	m	Shlomo, Yehuda	.	14.6	.	(–)
51	f	Shlomo, Myryam	.	12.4	.	(–)
52	.	Yosef, Ruti	s 53; 4; c 55	13.6	2.3	–
53	f	Yosef, Miriam	s 4; 52; c 55	14.8	.	(–)
54	f	Shoker, Symcha Cohen	.	12.4	.	.
55	m	Yosef, Yosef	c 53; 2c 30	12.1	.	(–)
56	m	Tsur, Tovin	b 32; c 27; 33	12.1	2.1	–
57	f	.	.	12.9	.	(–)
58	m	David, Reuben	.	16.5	.	.
59	f	Calaf, Cocheva	.	16.6	2.3	–
60	f	Hassan, Hamam	.	12.7	3.0	.
Yemenite (Peduim)						
61	f	.	.	12.8	.	(–)
62	f	.	.	13.3	.	.
63	f	.	.	11.9	.	.
64	.	.	.	14.7	.	.
65	m	.	.	14.8	.	(–)
66	f	.	.	11.6*	.	.
67	m	Saadia, Ben David	c 69	14.0	3.7	+
68	m	Sharifa, Chaim	.	12.6	3.3	–
69	f	Mansur, Aiala	c 67	12.4	3.2	–
70	f	.	.	12.0*	.	.
71	m	Saadia, Mualem	b 73	16.0	2.6	–
72	m	Hassan, Shmuel	b 80; 81	13.8	3.0	.
73	f	Hassan, Shulamit	s 71	13.4	2.7	–
74	f	Omasi, Chana	s 80; 81	12.9	3.3	.
75	m	Yosef, Arraham	hb 80; 81	14.2	2.3	–
76	f	Yosef, Siona	s 86; c 88; 84	.	2.1	–
77	f	Levi, Rina	.	.	1.7	–
78	m	Levi, Shmuel	b 85; 79; 90	.	.	(–)
79	m	Levi, Zecharia	b 90; 85; 78	.	.	(–)
80	f	Levi, Mazel	s 81	.	3.4	–
81	f	Hassan, Myryam	s 80; 74; 72; hs (75)	.	3.8	+
82	f	Hatuka, Sara	.	.	.	(–)
83	f	Mahfud, Mazel	.	.	3.4	–
84	m	Dahari, Shalom	c 86; 88	.	.	(–)
85	m	Levi, Ovadia	b 90; 78; 79	.	3.6	+

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TABLE 1 (*cont.*)

reference number	sex	name	family relations	Hb g %	Hb-A_2 %	Hb-A_2 class
Yemenite (Peduim)						
86	f	Dahari, Svia	s 76; c 88; 84	.	.	(−)
87	f	Madmon, Ester	.	.	.	(−)
88	f	Dahari, Mazel	c 86; 84	.	.	(−)
89	f	Levi, Tsipora	.	.	3.3	−
90	m	Levi, Haim	b 85; 79; 78	.	.	(−)
91	m	Madmon, Nissii	.	.	3.4	−
92	.	.	.	.	.	.
93	.	.	.	.	.	.
94	.	.	.	.	.	.
Kurds (Pattish)						
95	m	Davidian, Moshe	c 101	.	.	(−)
96	f	Shaked, Chana	.	.	2.8	−
97	m	Hanuka, Ishak	b 128	.	.	(−)
98	m	Yaari, Baruch	b 99	.	3.5	±
99	m	Yairi, Yehuda	b 98	.	.	(−)
100	m	Mizrachi, Yona	.	14.4	2.9	−
101	m	Davidian, Arraham	hb 107 (f); c 95	14.2	4.2	+
102	m	Nissani, Nisan	.	14.5	.	(−)
103	m	Kalimi, Bynyamin	.	14.3	.	(−)
104	f	Kalimi, Chana	.	14.0	2.1	−
105	m	Cohen, Michael	.	12.4	2.6	−
106	f	Cohen, Prina	hs 114; (f)	12.1	.	(−)
107	m	Davidan, Shlomo	hb 101 (f)	13.4	.	(−)
108	f	Davidan, Myryam	.	13.1	3.1	−
109	m	Magribi, Moredechai	c 116; 130	11.1	.	(−)
110	f	Magribi, Rivka	.	11.1	2.8	−
111	m	Habibyan, Reuven	.	13.5	4.6	+
112	f	Habibyan, Sara	s 141; 123	12.4	.	(−)
113	m	.	.	13.9	.	(−)
114	f	Gavriel, Simcha	hs 106 (f)	12.2	3.8	+
115	m	.	.	13.2	3.1	−
116	m	Saati, Yaacov	c 109; 130	14.0	.	(−)
117	f	Saati, Nazi	s 118; 120	12.2	3.6	+
118	m	Baruchi, Baruch	b 117; 120	12.7	.	(−)
119	f	Baruchi, Sara	.	12.7	.	(−)
120	f	Baruchi, Yochebet	s 117; 118	14.5	.	(−)
121	m	Musavi, Rahamii	.	13.0	4.0	+
122	f	Musavi, Malka	.	10.8*	3.4	−
123	m	Levi, Sason	b 112; 141	13.4	.	(−)
124	m	Ishaki, Baruch	.	15.0	4.1	+
125	m	Cohen, Efraim	c 133	12.8	.	(−)
126	f	Amba, Naima	.	11.4	.	(−)
127	m	Amba, David	.	14.1	3.8	+
128	m	Hanuka, Yaacov	b 97	13.0	4.2	+
129	m	.	.	13.9	.	(−)
130	m	Mualem, Nechanya	c 109; 116	14.3	.	(−)
131	f	Chosvachti, Simcha	s 140	11.8	4.7	+
132	f	Zafrian, Atara	.	10.8*	2.9	−
133	m	Cohen, Yoel	c 125	15.2	.	(−)
134	m	Zafoni, David	.	11.8	5.4	+
135	m	Sabagi, Renven	b 142; 145	13.0	3.2	−

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TABLE 1 (*cont.*)

reference number	sex	name	family relations	Hb g%	Hb-A_2 %	Hb-A_2 class
Kurds (Pattish)						
136	m	.	.	14.8	.	.
137	f	.	.	13.0	.	.
138	m	.	.	16.3	.	(−)
139	.	.	.	12.6	.	−
140	f	Zafoni, Malka	s 131	11.2*	.	(−)
141	f	Levi, Simcha	s 112; 123	11.9	.	(−)
142	m	Sabagi, Avraham	b 135; 145	14.6	.	(−)
143	m	Zefryan, Yesheskel	.	17.0	3.1	−
144	f	Levi, Sara	.	11.6	.	(−)
145	f	Levi, Kali	s 135; 142	13.0	2.7	−
146	m	Reuven, Yehuda	.	11.9	2.9	−
147	f	Zafrian, Yael	.	14.5	3.3	−
148	.	.	.	11.6	.	−
149	.	.	.	13.8	.	−
150	.	.	.	15.9	.	−
151	m	.	.	15.7	.	.
152	.	.	.	13.2	.	.
153	m	.	.	14.6	.	.
154	f	.	.	13.5	.	.
Kurds (Eshbol)						
155	f	Jona, Malka	s 165; 197	13.5	.	(−)
156	m	Jona, Nuri	b 163; 170; 180; 198	14.0	6.0	+
157	f	Jona, Sara	.	.	.	(−)
158	f	Shlomi, Sahar	.	13.5	4.8	+
159	m	Jona, Yehuda	b 171; 181	16.8	.	(−)
160	f	Jona, Hana	c 156 *et al.*	13.6	2.6	−
161	f	Hanuka, Batia	.	14.0	.	(−)
162	m	Michael, Jacov	.	15.5	2.7	−
163	m	Jona, Shukri	b 156; 170; 180; 198	16.8	.	(−)
164	f	Dino, Miriam	s 174	13.5	3.2	−
165	m	Dino, Jacov	b 155; 197	14.5	2.2	−
166	m	Levy, Gideon	b 184	16.4	.	(−)
167	f	Levy, Esther	n 175	14.0	3.0	−
168	m	.	.	16.5	.	.
169	.	.	.	11.7	.	−
170	m	Jona, Gershan	b 163; 180; 198; 156	17.0	.	(−)
171	m	Jona, Shmuel	b 159; 181	17.1	2.9	−
172	f	Jona, Mazel	.	13.2*	.	(−)
173	.	.	.	11.2	.	−
174	m	Jona, Rahamin	b 164	14.3	.	(−)
175	m	Hevroni, Asher	u 167	15.0	4.0	+
176	f	Hevroni, Rivia	.	13.8	3.9	+
177	f	.	.	14.2	.	(−)
178	f	Hevroni, Ora	s 189	13.2	3.3	±
179	m	Renasi, Benjamin	.	15.9	.	(−)
180	m	Jona, Reuven	b 156; 170; 163; 198	14.7	4.5	+
181	f	Jona, Rachel	s 159; 171	15.5	.	(−)
182	m	Nazet, Nosrati	.	15.0	3.0	−
183	m	.	.	14.3	.	.

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TABLE 1 (*cont.*)

reference number	sex	name	family relations	Hb g%	Hb-A %	Hb-A_2 class
Kurds (Eshbol)						
184	f	Hevroni, Jafa	s 166	13.0	3.2	–
185	m	Michael, Sara	.	14.4	.	.
186	m	David, Simha	.	14.6	2.9	–
187	f	Ishakhai, Salimi	.	15.1	.	.
188	m	Ishakhai, Daniel	.	15.4	3.7	+
189	f	Harendish, Lea	s 178	15.8	2.7	–
190	m	Jona, Ezra	.	12.3	3.4	–
191	f	.	.	.	.	.
192	m	.	.	15.4	.	.
193	f	.	.	14.6	.	.
194	f	Jona, Sara	c 155; 149; 165	13.2	.	.
195	m	Jacov, Rahamin	.	13.8	1.9	–
196	m	Hanuka, Kalima	.	13.3	.	.
197	m	Jona, Zaki	b 155; 165	.	3.9	+
198	m	Jona, Yoshua	s 156; 163; 170; 180	16.0	3.9	+
199	f	Sabacan, Marcel	.	14.1	.	.
200	m	Sabacan, Galil	.	15.6	2.9	–
201	m	.	.	14.5	.	.
202	m	.	.	15.8	.	.
203	m	.	.	15.8	.	(–)
204	m	.	.	17.6	.	.
Kurds (Paamez Tashaz)						
205	m	Afsai, Josef	b 220	15.2	.	(–)
206	f	David, Esther	s 224; 226	12.7	6.3	+
207	m	Sharabi, Haviv	.	16.5	3.8	+
208	m	Gavbrieli, David	.	15.8	3.1	–
209	m	Govez, Menashe	2c 223	14.2	.	(–)
210	m	Josefi, Daniel	b 216	14.8	.	(–)
211	f	Magadi, Rachel	s 219	14.6	2.7	–
212	f	Gavrieli, Aviva	.	13.0	.	(–)
213	f	Aaroni, Sara	.	12.7	2.9	–
214	f	Michael, Malka	.	13.4	.	(–)
215	f	Sharbi, Carmela	.	11.4	2.9	–
216	m	Josefi, Ovadia	b 210	14.8	.	(–)
217	f	Johanan, Lili	.	13.6	2.5	–
218	f	Nagadi, Batia	s 228; c 223; 233	12.4	3.0	–
219	m	Nagadi, Israel	b 211; c 201	13.2	2.8	–
220	m	Afsai, Efraim	b 205	.	2.5	–
221	m	Sarizada, Yosef	.	.	.	(–)
222	m	Borcani, Eliezer	.	.	2.3	–
223	m	Nagadi, Moshe	b 233; c 211, 218; 219; 228	.	3.3	–
224	m	David, Nehemia	b 220; 206	.	3.6	+
225	m	Johanan, Efraim	.	.	4.7	+
226	m	David, Yohai	b 206; 224	.	.	.
227	f	Calvazada, Sonia	.	.	3.9	+
228	f	Calvazada, Mazel	s 218; c 201	.	4.4	+
229	f	Amrani, Miriam	.	.	.	.
230	f	Hevroni, Malka	.	.	3.8	+
231	f	Smuel, Chana	.	.	4.0	+
232	m	Michael, Zion	.	.	.	.

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TABLE 1 (*cont.*)

reference number	sex	name	family relations	Hb g %	Hb-A_2 %	Hb-A_2 class
Kurds (Paamez Tashaz)						
233	f	Nagadi, Esther	s 223; c 211; 218; 219; 228	.	.	.
234	f	Sarizada, Naski	.	.	3.1	−
235	m	Syachi, Ovadia	.	.	4.3	+
236	m	Buyani, Elisha	.	.	3.3	−
237	m	Aharoni, Rafael	.	.	4.5	+
238	m	Eliasian, David	.	.	3.4	−
239	m	Hana, Rachamim	.	.	3.4	−

Note (1): * denotes pregnant subject.
Note (2): Hb-A_2 class: −, less than 3.5%; ±, 3.5%, upper normal limit; +, greater than 3.5%; (−) visual estimate.
Note (3): Related as stated (b, brother; s, sister; c, cousin; etc.) to the other subjects identified by number.

non-haem protein zone (carbonic anhydrase B) was also estimated and shown to be within the normal range (1 to 2%, referred to total haemoglobin) in about 90% of the initial analyses. Haemolysates in which the n.h.p. appeared to be higher than normal were re-analysed, together with many of the samples with elevated Hb-A_2 levels, but with lower gel loadings, in order to eliminate possible errors in densitometry due to overloading. Duplicate blood samples from 16 subjects whose haemolysates showed elevated Hb-A_2 levels were subsequently taken and the haemolysates analysed to confirm the initial findings. The final results are listed individually in table 1, and grouped according to the geographic origins of the subject in table 2.

TABLE 2. COLLECTED RESULTS

subject group	no. tested	no. not tested†	Hb-A_2		% with Hb-A_2	
			⩽ 3.5%	> 3.5%	⩽ 3.5%	> 3.5%
Yemenite Jews						
Bitha	51	9	47	4	92.2	7.8
Peduim	25	10	22	3	88.0	12.0
total	76	19	69	7	90.8	9.2
Kurdish Jews						
Pattish	47	10	37	10	78.7	21.3
Eshbol	37	8	29	8	78.4	21.6
Paamez Tashaz	30	4	20	10	66.7	33.3
total	114	22	86	28	75.5	24.5

† Based on complete lists of subjects.

DISCUSSION

The present results show a total absence of electrophoretically detectable haemoglobin variants in the haemolysates of the 76 Yemenite Jews and the 114 Kurdish Jews examined. This is not unexpected in the light of the available data, summarized by Livingstone (1967), on the absence of even the commonest haemoglobin variant (Hb-S) in Jewish populations living in various regions of the Middle East and adjacent countries, including Kurdish communities, and examined either in these regions or after their return to Israel.

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Of more interest is the incidence of elevated Hb-A_2 in the present two groups of Yemenite and Kurdish Jewish subjects now living in Israel. The results are summarized in table 2, showing the numbers and percentages of subjects with Hb-A_2 levels in excess of 3.5 % of the total haemoglobin, and hence suggesting that they are carriers, i.e. heterozygotes, for the β-thalassaemia gene. For the Yemenite Jews as a whole (Bitha and Peduim considered together) the incidence of elevated Hb-A_2 is 9.2 % (7/76) while for the Kurdish Jews as a whole (Pattish, Eshbol and Paamez Tashaz) it is 24.5 % (28/114). The difference between the two groups is significant at the 2 % level by the χ^2-test ($0.02 > P > 0.01$). In view of the small numbers tested and the extent to which the subjects in the various groups are related, it is not permissible to calculate gene frequencies directly, but the figures in table 2 suggest that for the Yemenite Jews a tentative value of *ca.* 0.05, and for the Kurdish Jews of *ca.* 0.1, may be reasonable estimates.

The interpretation of the elevated Hb-A_2 levels as indicative of the presence of the β-thalassaemia gene in these two Jewish population groups must be made with some caution. The haemoglobin values (table 1) show the expected significant differences between the mean values for male and female subjects, but the observed ranges do not indicate an appreciable proportion of anaemic subjects. For the Yemenite Jewish females the mean value was significantly lower than for both the Iraque and Persian Kurdish Jewish females. Since the apparent incidence of the β-thalassaemia trait is clearly much lower in the Yemenite than in the Kurdish Jewish groups (irrespective of the precise gene frequencies), it seems unlikely that the β-thalassaemia gene is an important factor in determining the haemoglobin levels in any of the groups. An attempt was made to confirm the presence of the β-thalassaemia trait in selected subjects with elevated Hb-A_2 levels by looking for evidence of abnormal red cell morphology (target cells, etc.), but the blood films taken for this purpose were inadequately fixed and of no value for diagnostic purposes after staining.

In the absence of any confirmatory evidence, such as red cell morphology or altered osmotic fragility, it seems prudent to regard the Hb-A_2 levels as at least suggestive of the presence of the β-thalassaemia gene in the population groups examined and to note that the apparent gene frequencies are appreciable, especially in the Kurdish Jewish groups.

Some support for these findings can be drawn from previous studies of similar Jewish communities from outside Israel. Matoth, Shamir & Freundlich (1955) reported on the presence of thalassaemia in Jews from Kurdistan and Matoth & Pinhas (1958) estimated the frequency of β-thalassaemia trait as *ca.* 12 %, based on the incidence of the homozygous state in infants. This is a particularly important observation, since the absence of reports of infants with the symptoms of homozygous β-thalassaemia in the Kurdish Jewish communities studied in the present work is the principal reason for accepting the Hb-A_2 levels alone as evidence for a high level of β-thalassaemia trait with some reserve. A similar failure to find homozygous offspring was noted by Cohen *et al.* (1963) in a survey of four Kurdish Jewish villages in Israel. These workers estimated that the incidence of β-thalassaemia trait was at least as high as that predicted by Matoth & Pinhas (1958), but saw no homozygous infants, although expecting to find 1–3 in a total of 400 examined. The same workers studied the association of β-thalassaemia trait and G6PD in Jews from Kurdistan. The incidence of the trait alone was found to be 4.2 %, and of the trait in association with G6PD deficiency 22.1 %, giving a total incidence for the trait of 26.3 % in 190 subjects examined. No significant association between elevated Hb-A_2 and G6PD deficiency was found for either the Kurdish or the Yemenite Jewish subjects of the present study, but the high incidence of the β-thalassaemia trait is noteworthy.

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The most recent and detailed study of Kurdish Jews by Horowitz, Cohen, Goldschmidt & Levene (1966) indicated a β-thalassaemia gene frequency of *ca.* 0.1. This is, in fact, in excellent agreement with the apparent gene frequency of *ca.* 0.1 suggested by the present findings (table 2), and strongly supports the indications, based solely on the Hb-A_2 levels, that the β-thalassaemia gene may be found at appreciable incidence in Kurdish Jewish population groups. Because of the relatively small sizes of these communities, both genetic drift and family relationships are likely to influence very markedly the apparent gene frequencies which are actually observed. As emphasized above, it is also of importance that the evidence from elevated Hb-A_2 levels should be supplemented by studies of red cell morphology and osmotic fragility.

With respect to the present findings on Yemenite Jews, only one previous report by Djaldetti & Klibanski (1961) on thalassaemia minor (trait) in a single individual has been found, and a comment by Ramot, Abrahamov, Frayer & Gafni (1964) that the incidence of thalassaemia is 'relatively low' in Persian, North African and Yemenite Jews.

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