

### **Ophthalmological Traits in Three Populations of Kalimpong Sub-division, Darjeeling District, West Bengal, India : Effects of Ethnic, Sexual and Physical Environmental Factors**

HENRIK FORSIUS, BARUN MUKHOPADHYAY, AMITABHA BASU, RANJAN GUPTA,  
SANAT K. BHATTACHARYA AND VIVEK MAJUMDER  
*University of Oulu, Oulu, Finland (H. F.); Indian Statistical Institute, Calcutta, India (B.M., A.B., R.G., S.K.B.); and Indian Association of Occupational Health, Calcutta, India (V.M.)*

**Abstract :** A biomedical study programme, entitled Human Adaptability Programme, was undertaken on the Sherpas and some other populations of eastern Himalaya, following the basic design of the IBP/HA Panel and the UNESCO/MAB programme. The results of the ophthalmological survey are presented here. The data show that (i) there is virtually no detectable effects of ethnic factors on the ophthalmological characteristics, (ii) the physiological factors related to sex may have appreciable effects on them, and (iii) the variations observed in our data are within normal human ranges found among diverse other populations.

Ophthalmological investigations were carried out in the autumn of 1981 on the Sherpa, Lepcha and "mixed Nepali-speaking" populations of Kalimpong subdivision, Darjeeling district, West Bengal, India as part of a broader, multi-disciplinary, biomedical study programme, entitled Human Adaptability Programme. The general objectives of the programme, initiated in early 1976 following the recommendations of the IBP/Human Adaptability Section and UNESCO/Man and Biosphere programme, were to identify and measure (i) the impacts of three sets of factors, i.e., physical environmental, sociocultural and genetic/ethnic, on health, and (ii) the impacts of health and activity patterns on environment. Health was defined rather narrowly in terms of physical well-being and lack of disease and infirmity, for operational convenience, although we were aware of the WHO's (1971) more comprehensive definition in terms of complete physical, mental and social well-being.

The specific objectives of the ophthalmological study reported here were (i) to compare the eye characteristics of three ethnically distinct populations inhabiting the same environment in the neighbourhood of Kalimpong town to detect possible effects of ethnic factors on these characteristics, (ii) to compare the males and females of the some ethnic group to detect the effects of physiological factors related to sex, and (iii) to compare the Kalimpong samples with those from other populations inhabiting different physical environmental zones.

### Materials and Methods

234 Lepcha, 104 Sherpa and 143 "mixed Nepali-speaking" subjects, both males and females, were examined in seven villages located at altitudes of 1000-2000m in the neighbourhood of Kalimpong town. The ophthalmological examinations were carried out by an ophthalmologist (HF) following standard methods. An investigation centre was set up in each village where the necessary facilities, including the possibility of semi-darkness, were available. The centres were set up in Lepcha and Sherpa houses which were already surveyed for demographic and other traits, and subjects were chosen from among these households in case of these two populations, and in a room attached to the hospital of a government-owned medicinal plantation, but the "mixed Nepali" sample comprised those who volunteered for examination at these centres. No statistical sampling procedure could be followed for obvious difficulties in the field.

The Sherpas are an indigenous high altitude population which migrated from the Tibetan plateau to northeastern Nepal about 450 years ago and thence to Kalimpong about 200 years ago (Gupta 1980). The Lepchas are indigenous to the medium altitudes of Kalimpong, or probably a much wider region (Das 1978). Both are mainly agriculturists. The Nepalis are a linguistically and culturally different group which migrated from Nepal to vast areas in northeastern India 200 to 150 years ago. The present "mixed Nepali" sample includes several ethnic groups, i.e., castes or tribes, of the Nepali-speakers. All three populations live in close proximity in the Kalimpong region as well as much wider neighbouring regions of Darjeeling district in West Bengal, Sikkim, etc.

In the Kalimpong region, the climate is not as hot as in the plains. The rainy season extends from May to September/October; the rest of the year is somewhat drier. The maximum temperature varies from 15.5°C in January to 19.3°C in July, relative humidity from 69% in March to 92% in August, rainfall from 4.9 mm in December to 635.0 mm in July and wind speed from 7.4 kmph in July to 10.0 kmph in April (Government of India 1960). The region is neither windy nor dusty and trees provided shadows more than in the plains.

### Results and Discussion

#### *Colour of the iris*

Differences between Lepchas and Sherpas were insignificant with respect to iris colour in both males and females (there were very few subjects from the "mixed Nepali"); females in both groups have darker eyes significantly more frequently than males (Table 1). Compared to Caucasoids, all three populations studied in Kalimpong had very dark iris (they belonged to the four darkest colours of the Bunak colour chart used, which has 12 colours). In addition to the  $\chi^2$  values shown in Table 1 we compared the two darkest colour groups



with the next two lighter colour groups in the Sherpas and Lepchas, and found the Sherpas to have darker eyes significantly more frequently ( $\chi^2$  10.44,  $P < 0.01$ ).

#### Colour blindness

Colour blindness was investigated with American Optics H-R-R pseudoisochromatic charts. As in the case of iris colour, the difference between Lepchas and Sherpas was insignificant and the "mixed Nepali" sample was too small for comparison (Table 2). Of the 165 individuals examined, nine showed defective colour visions, eight of the deutan type and one protan type.

Table 2. Colour blindness

Population	Normal	Deuteranomalialia	Deuteranopia	Protanomalialia	Protanopia	Total
Lepcha	86	0	1	0	1	88
Sherpa	58	0	5	0	0	61
Mixed Nepali	14	2	0	0	0	16
	<i>L&amp;S</i>	<i>L&amp;MN</i>	<i>S&amp;MN</i>			
Chi <sup>2</sup>	2.72	3.80	0.23			
		<i>L, S&amp;MN</i>				
Chi <sup>2</sup>		4.08				

Note: The number of colour blind individuals were too small for computing percentages. For computation of  $\chi^2$  values all colour blind individuals were pooled into one category because of smallness of samples.

#### Lens opacities

We divided the subjects into two categories: (i) those with opacities (in at least one eye) which impaired the visual acuity so much that the subject needed cataract operation, or was already operated upon, and (ii) those with clear lenses, or with only slight opacities, still permitting normal work. Cataractous eyes were rare before the age of 60 years (0.01%), but common thereafter (14.97%). This confirms the results from other Indian studies that cataracts are common in India, much more common than in European countries. The differences among the three ethnic groups were insignificant in both eyes (Tables 3a and 3b).

#### Arcus senilis

Arcus senilis was studied with biomicroscope and with binocular loupe and divided into four categories (No arcus, 1; only biomicroscopically visible arcus, 2; weak arcus also seen with binocular loupe, 3; marked arcus where the fatty ring is either seen complete round the corneal border or at one place stretching through all corneal layers, 4). The inter-ethnic group comparison

Table 3a. *Lens opacities (male and female, right eye)*

Population	Age group (yrs)	Degree of opacity						Total
		1	2	3	4	5	6	
Lepcha	0-19	36	0	0	0	0	0	36
	20-29	38	0	0	0	0	0	38
	30-39	63	1	0	0	1	0	55
	40-49	40	1	1	0	0	0	42
	50-59	31	1	1	0	0	0	33
	60-69	13	0	3	0	3	1	20
	70+	5	0	1	2	0	1	9
	Total	218	3	8	2	4	2	233
Sherpa	0-19	7	0	0	0	0	0	7
	20-29	18	0	0	0	0	0	18
	30-39	32	0	0	1	0	1	34
	40-49	13	0	0	0	0	1	14
	50-59	22	0	0	0	0	0	22
	60-69	7	0	0	1	0	0	8
	70+	1	0	0	0	0	0	1
	Total	100	0	0	2	0	2	104
Mixed	0-19	16	0	0	0	0	0	16
	20-29	31	0	0	0	0	0	31
Nepali	30-39	17	0	0	0	0	0	17
	40-49	25	0	0	0	0	0	25
	50-59	17	0	0	0	1	0	18
	60-69	17	0	1	1	1	0	20
	70+	8	0	0	2	1	3	14
	Total	130	0	1	3	3	3	140
		<i>L&amp;S</i>	<i>L&amp;MN</i>	<i>S&amp;MN</i>				
Chi <sup>2</sup>	2.20	0.96	0.95					
	<i>L, S&amp;MN</i>							
Chi <sup>2</sup>	2.54							

Note : Chi<sup>2</sup> based on two classes : 1 (clear), 2-6 (opaque) (subjects aged 20+ yrs only).

did not reveal any clear trend : the "no arcus" category was most frequent in the Sherpas in both males and females considering all age groups (totals), but while none of the inter-ethnic group differences were significant in females, the Lepcha-Sherpa difference was significant in males (Tables 4a and 4b). The sexual difference is significant only in case of Lepchas. Compared with many populations, e.g., the Finns, the prevalence of arcus senilis is low in the Kalimpong populations. Arcus senilis is caused by accumulation of fat in the corneal parenchyma layer. In age groups less than 40 years its severity is correlated with the fat level in the blood but in old age it is probably a marker of senile changes in the cornea (Forsius 1954), and the relatively low prevalence in the Kalimpong population may be due to their possibly lower blood lipid levels and/or lesser senile changes.

Table 3b. *Lens opacities (male and female, left eye)*

Population	Age group (yrs)	Degree of opacity						Total
		1	2	3	4	5	6	
Lepcha	0-19	38	0	0	0	0	0	38
	20-29	37	0	0	0	0	1	38
	30-39	54	1	0	0	0	0	55
	40-49	40	1	1	0	0	0	42
	50-59	31	1	1	0	0	0	33
	60-69	13	0	3	1	3	1	21
	70+	5	0	1	2	0	1	9
	Total	216	3	6	3	3	3	234
Sherpa	0-19	7	0	0	0	0	0	7
	20-29	18	0	0	0	0	0	18
	30-39	32	0	1	0	0	1	34
	40-49	13	0	0	0	0	1	14
	50-59	21	0	0	1	0	1	23
	60-69	7	0	0	1	0	0	8
	70+	1	0	0	0	0	0	1
	Total	99	0	1	2	0	3	105
Mixed	0-19	15	0	0	0	0	0	15
	20-29	31	0	0	0	0	0	31
Nepali	30-39	17	0	0	0	0	0	17
	40-49	24	0	0	0	0	1	25
	50-59	18	0	0	0	1	0	19
	60-69	18	0	0	0	2	0	20
	70+	9	0	0	1	2	2	14
	Total	132	0	0	1	5	3	141
	Chi <sub>1</sub> <sup>2</sup>	LAS 2.80	L&MN 2.89	S&MN 0.45				
Chi <sub>2</sub> <sup>2</sup>	L, S&MN 4.45							

Note : Chi<sup>2</sup> based on two classes : 1 (clear), 2-6 (opaque) (subjects aged 60+ yrs only).

#### *Anterior chamber depth*

Anterior chamber depth was measured in pooled male and female samples in 214 Lepchas, 92 Sherpas and 50 "mixed Nepalis" of both sexes. Among the three ethnic groups Lepchas have highest mean value (Lepcha 2.88, Sherpa 2.78, "mixed Nepali" 2.77); Lepcha-Sherpa difference is significant ( $t$  2.50,  $P < 0.05$ ), so is Lepcha-mixed Nepali ( $t$  2.75,  $P < 0.05$ ), but not Sherpa-mixed Nepali ( $t$  0.20,  $P > 0.5$ ). Males have deeper anterior chambers than females, as expected, in all three ethnic groups. An anterior chamber depth of less than 2 mm is crucial for developing acute glaucoma. The values for the three ethnic groups under study, however, were comparable with European values and suggested that glaucoma probably was not a major problem in these populations as it was in, for instance, Eskimos and probably Peruvian Amerindians.

Table 4a. *Arcus senilis (male)*

Population	Age group (yrs)	None		Biomicroscopically visible		Can be noted using loupe		Marked		Total	
		No.	%	No.	%	No.	%	No.	%	No.	%
Lepcha	20-39	21	65.62	7	21.88	4	12.50	0	0.00	32	100.00
	40-59	4	10.00	10	25.00	16	40.00	10	25.00	40	100.00
	60+	1	5.56	2	11.11	6	33.33	9	50.00	18	100.00
	Total	26	28.89	19	21.11	26	28.89	19	21.11	90	100.00
Sherpa	20-39	24	82.76	4	13.79	1	3.45	0	0.00	29	100.00
	40-59	8	28.57	7	25.00	8	28.57	5	17.86	28	100.00
	60+	0	0.00	1	16.67	1	16.67	9	66.67	6	100.00
	Total	32	80.79	12	19.05	10	15.87	9	14.29	63	100.00
Mixed Nepali	20-39	12	80.00	3	20.00	0	0.00	0	0.00	15	100.00
	40-59	5	33.33	5	33.33	2	13.33	3	20.00	15	99.99
	60+	0	0.00	1	9.09	5	45.45	5	45.45	11	99.99
	Total	17	41.46	9	21.95	7	17.07	8	19.51	41	99.99
	L&S		L&M/N		S&M/N						
	Chi <sup>2</sup>	7.52*	1.97		0.86						
	L <sub>r</sub>	7.62*									
	Chi <sup>2</sup>		7.62*								

\* Significant at 5% level.

Table 4b. *Arcus senilis* ( female )

Population	Age group (yrs)	None		Biomicroscopically visible		Can be noted using loupe		Marked		Total	
		No.	%	No.	%	No.	%	No.	%	No.	%
Lepcha	20-39	51	94.44	3	5.56	0	0.00	0	0.00	54	100.00
	40-59	8	23.53	14	41.18	2	5.88	10	29.41	34	100.00
	60+	0	0.00	1	9.09	3	27.27	7	63.64	11	100.00
Sherpa	Total	59	59.60	18	18.18	5	5.05	17	17.17	99	100.00
	20-39	18	85.71	1	4.76	2	9.52	0	0.00	21	99.99
	40-59	3	33.33	3	33.33	3	33.33	0	0.00	9	99.99
Mixed Nepali	60+	0	0.00	1	33.33	1	33.33	1	33.33	3	99.99
	Total	21	63.64	5	15.15	6	18.18	1	3.03	33	100.00
	20-39	22	91.67	1	4.17	1	4.17	0	0.00	24	100.01
Total	40-59	6	50.00	2	16.67	2	16.67	2	16.67	12	100.01
	60+	0	0.00	2	11.11	4	22.22	12	66.67	18	100.00
	Total	28	51.85	5	9.26	7	12.96	14	25.93	54	100.00
		L&S	L&M/N	S&M/N							
		0.17	0.85	1.14							
Chi <sup>2</sup>		M&F(L)	M&F(S)	M&F(M/N)							
		18.02*	1.47	0.99							
Chi <sup>2</sup>		L, S&M/N									
		1.38									

\* Significant at 5% level.



*Corneal thickness*

Corneal thickness was measured in 155 Lepchas, 74 Sberpas and 45 "mixed Nepalis" of both sexes. The mean thicknesses in the three groups were of similar magnitudes, i.e., between 0.5225 mm and 0.5300 mm (Table 5). A thin cornea can theoretically be of value in the arctic, because it is warmed up by

**Table 5.** *Corneal thickness (in mm)*

Population	Age group (yrs)	Male		Female	
		n	mean	n	mean
Lepcha	0-19	13	0.5377	15	0.5300
	20-29	5	0.5420	23	0.5391
	30-39	20	0.5225	18	0.5139
	40-49	19	0.5418	7	0.5300
	50-59	9	0.5200	14	0.5271
	60-69	5	0.5200	1	0.5600
	70+	4	0.5075	2	0.5050
	Total	76	0.5300	80	0.5282
Sherpa	0-19	2	0.5150	2	0.5400
	20-29	12	0.5283	3	0.5433
	30-39	13	0.5292	11	0.5282
	40-49	8	0.5183	3	0.5333
	50-59	14	0.5271	2	0.5150
	60-69	4	0.5300	2	0.5100
	70+	0	0.0000	0	0.0000
	Total	51	0.5267	23	0.5291
Mixed Nepali	0-19	4	0.5200	5	0.5500
	20-29	7	0.5257	2	0.5400
Nepali	30-39	2	0.5650	4	0.5300
	40-49	8	0.5250	3	0.4933
	50-59	3	0.5033	4	0.5225
	60-69	1	0.5100	1	0.5000
	70+	1	0.5000	2	0.6350
	Total	24	0.5225	21	0.5281

the water in the anterior chamber; the thinner the cornea is, the easier it is for the cornea to be kept warm. In Eskimos and in Skolt Lapps Forsius and Eriksson (1980) did actually find a thin cornea which corroborates this theory, but obviously, in Kalimpong no such advantage of a thin cornea is likely to exist.

*Corneal refraction*

Corneal refraction was measured with the Javal-Schiotz device. A corneal radius of 7.5 mm gives a refraction power of 45 diopters. The normal range of corneal power is 41-47 diopters according to Forsius and Eriksson (1980), with the males having lower values than females. Data presented in Tables 6

and 7 show that all inter-ethnic group differences in corneal power, horizontal and vertical, are insignificant in both males and females, but the sexual difference is significant only in Lepchas, in both horizontal and vertical powers, and in Sherpas, in the vertical power. The value for the vertical power is generally slightly higher than that for the horizontal one in young people (i.e.,

Table 6. Corneal refraction

	Male			Female		
	n	mean	sd	n	mean	sd
Horizontal						
Lepcha	103	42.88	4.50	119	44.42	4.39
Sherpa	59	43.33	1.20	29	43.23	5.70
Mixed	23	43.72	1.18	20	44.39	1.53
Nepali						
Vertical						
Lepcha	103	43.22	4.56	119	44.52	1.66
Sherpa	59	43.67	1.37	29	44.86	1.82
Mixed	23	44.11	1.54	20	44.84	1.50
Nepali						

Table 7. *t* values (corneal refraction)

Horizontal	Male			Female		
	L&S	L&MN	S&MN	L&S	L&MN	S&MN
t	0.98	0.89	1.34	1.24	0.03	0.81
df.	160	124	80	146	137	47
	M&F(L)		M&F(S)	M&F(MN)		
t	2.58*		0.13	1.02		
df.	220		86	41		
Vertical						
	Male			Female		
	L&S	L&MN	S&MN	L&S	L&MN	S&MN
t	0.93	0.92	1.26	0.98	0.81	0.04
df.	160	124	80	146	137	47
	M&F(L)		M&F(S)	M&F(MN)		
t	2.74*		3.12*	1.13		
df.	220		88	21		

\*Significant at 5% level.

the "astigmatism with the rule"), but the difference decreases with age or changes to a negative value (i.e., the "astigmatism against the rule") in aged people (Forsius et al. 1964). A decrease in the amount of "astigmatism with the rule" was also found to occur in the Kalimpong populations.

*Total refraction*

The right eye was used for estimation of the prevalence of myopia. Figures given in Table 8 refer to mean refraction, i.e., (horizontal+vertical)/2. No subject (male or female) had more myopia than -6D. In males all inter-ethnic group differences were insignificant in the Lepcha-Sherpa and Lepcha-"mixed

Table 8. *Total refraction (right eye)*

Population	Age group (yrs)	Male			Female		
		n	mean	sd	n	mean	sd
Lepcha	0-29	21	3.81	0.51	47	3.74	0.44
	30-59	63	3.84	0.37	62	3.73	0.48
	60+	16	3.75	0.46	8	3.00	1.31
	Total	100	3.82	0.41	117	3.68	0.58
Sherpa	0-29	15	3.80	0.41	8	4.00	0.00
	30-59	43	3.91	0.29	22	3.91	0.29
	60+	6	3.80	0.46	3	3.67	0.68
	Total	63	3.87	0.34	33	3.91	0.29
Mixed	0-29	18	3.94	0.24	17	4.00	0.00
	30-59	29	3.79	0.41	30	3.87	0.36
Nepali	60+	13	3.85	0.38	15	3.60	0.63
	Total	60	3.85	0.36	62	3.84	0.41
		<i>Male</i>			<i>Female</i>		
		<i>L&amp;S</i>	<i>L&amp;MN</i>	<i>S&amp;MN</i>	<i>L&amp;S</i>	<i>L&amp;MN</i>	<i>S&amp;MN</i>
t		0.79	0.48	0.32	3.65*	2.08*	1.11
df.		161	168	121	148	177	93
		<i>M&amp;F (L)</i>		<i>M&amp;F (S)</i>		<i>M&amp;F (MN)</i>	
t		1.97*		0.73		0.14	
df.		215		94		120	

\*Significant at 5% level.

Nepali" comparisons. The sexual difference was marginally significant in males. In the pooled sample (Table 9), myopia prevalence increases from 12.96% through 14.81% to 20.00% in males, and from 16.22% through 19.13% to 38.46% in females, among 15-29, 30-59 and 60+ years age groups. This is an interesting finding because in most populations studied so far myopia prevalence is higher, or is increasing, in the young people. The cause of increasing myopia prevalence with increasing age, a pattern very different from most other populations studied, could not be definitively ascertained but might be related to high prevalence of cataract in the aged people. The first sign of cataract is often a change to myopic refraction caused by swelling of the lens.

*Vision in better eye*

While studying the data for visual acuity, where acuity is classified into five categories, it appeared that all inter-ethnic and sexual differences were insignificant (Table 10). The age-wise breakdown of the data showed that if,

Table 9. Myopia (right eye)

Age (yrs)	More than -6		-6 to -3.01		-3 to -0.01		0 to +2.99		Total	
	M	F	M	F	M	F	M	F	M	F
15-29	0	0	1	0	6	12	47	62	54	74
30-59	0	0	0	1	20	21	116	93	135	115
60+	0	2	0	1	7	7	28	16	35	26
Total	0	2	1	2	33	40	190	171	224	215
Chi <sup>2</sup>	2.09									

Note: Total refraction measured in dioptres.

Table 10. Vision in better eye

Population	Age group (yrs)	Vision in better eye															
		Male					Female										
		1	2	3	4	5	1	2	3	4	5						
Lepcha	0-19	No.	0	0	0	0	0	0	0	0	0	0	0	0	0	20	100.00
		%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
	20-29	No.	1	0	0	0	0	0	0	0	0	1	2	2	24	24	100.00
		%	11.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.45	6.90	6.90	89.66	100.00	100.00
	30-39	No.	0	0	0	1	23	24	0	0	0	1	3	3	26	30	100.00
		%	0.00	0.00	0.00	4.17	95.83	100.00	0.00	0.00	0.00	3.33	10.00	10.00	86.67	100.00	100.00
	40-49	No.	0	0	1	1	24	26	1	0	2	1	2	1	12	16	100.00
		%	0.00	0.00	3.85	3.85	92.31	100.00	6.25	0.00	12.50	6.25	6.25	75.00	100.00	100.00	100.00
	50-59	No.	0	0	0	3	12	15	2	0	1	4	1	4	11	18	100.00
		%	0.00	0.00	0.00	20.00	80.00	100.00	11.11	0.00	5.56	22.22	6.11	11.11	61.11	100.00	100.00
60-69	No.	1	0	0	4	6	11	2	0	2	1	2	1	2	7	100.00	
	%	9.09	0.00	0.00	36.36	54.55	100.00	28.57	0.00	28.57	14.29	28.57	14.29	28.57	100.00	100.00	
70+	No.	0	0	0	1	5	6	1	0	0	0	2	0	0	3	100.00	
	%	0.00	0.00	0.00	16.67	83.33	100.00	33.33	0.00	0.00	66.67	0.00	0.00	66.67	100.00	100.00	
Total	No.	2	0	1	10	93	106	6	0	7	13	97	123	123	100.00	100.00	
	%	1.89	0.00	0.94	9.43	87.74	100.00	4.88	0.00	5.69	10.57	78.86	100.00	100.00	100.00	100.00	
Sherpa	0-19	No.	0	0	0	1	3	4	0	0	0	0	0	0	3	3	100.00
		%	0.00	0.00	0.00	25.00	75.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00	100.00	100.00
	20-19	No.	0	0	0	0	13	13	0	0	0	0	0	0	5	5	100.00
		%	0.00	0.00	0.00	0.00	100.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00	100.00	100.00
	30-39	No.	0	0	0	0	16	16	1	0	0	0	0	0	15	16	100.00
		%	0.00	0.00	0.00	0.00	100.00	100.00	6.25	0.00	0.00	0.00	0.00	0.00	93.75	100.00	100.00
	40-49	No.	0	1	0	0	7	8	1	0	0	0	0	0	5	6	100.00
		%	0.00	12.50	0.00	0.00	87.50	100.00	16.67	0.00	0.00	0.00	0.00	0.00	83.33	100.00	100.00
	50-59	No.	0	0	0	1	19	20	0	0	0	0	0	0	2	2	100.00
		%	0.00	0.00	0.00	5.00	95.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00	100.00	100.00
60-69	No.	0	0	1	2	2	5	1	0	0	0	0	0	2	3	100.00	
	%	0.00	0.00	20.00	40.00	40.00	100.00	33.33	0.00	0.00	0.00	0.00	0.00	66.67	100.00	100.00	



corrected with glasses, the vision is normal upto the end of the sixth decade in males and to that of the fifth in females ; then the acuity decreases rapidly.

The definition of blindness varies among different countries. In some countries, e.g., the US, the upper limit of visual acuity is 0.1 (20/200). A vision less than 0.1, corrected with lenses, occurred in 3.31% in the pooled male, and 7.02% of the pooled female, Kalimpong samples. More often, however, the ability to count fingers from a distance of 1 m in the better eye is taken as the borderline for blindness. Using this definition of blindness, it appears that in the pooled Kalimpong samples no one out of the 241 males, and only one out of the 228 females, was blind before the age of 40 years. Of the total of 469 individuals examined, 23 had a visual acuity of no more than finger count at 1 m which showed that of the total population as high as 4.90% was blind. The most common cause of blindness was cataract.

To sum up the findings presented above,

(i) of the seven traits studied (no statistical tests were done in case of corneal thickness), differences are significant between Lepchas and Sherpas in only two (arcus senilis, male ; total refraction, female, right) out of 45, between Lepchas and "mixed Nepalis" in one (total refraction, female, right) out of 43 and between Sherpas and "mixed Nepalis" in none out of 43, suggesting that ethnic factors hardly make any effects on these traits ;

(ii) significant differences occurred between males and females in five (arcus senilis, Lepcha ; corneal refraction, horizontal, Lepcha, and vertical, Lepcha and Sherpa ; total refraction, right eye, Lepcha) out of 16, suggesting that physiological factors related to sex may have greater effects on these traits than microcultural and/or genetic factors associated with ethnic ancestry ; and

(iii) all values of the ophthalmological traits studied lied within the normal ranges compared to most other populations examined by the same ophthalmologist (HF).

The Kalimpong area is well suited for study of the possible environmentally-induced changes in eye characteristics at middle altitudes, as there live in close proximity, for a couple of hundred years or more, three ethnically/genetically different populations (i.e., Lepchas, Sherpas and several Nepali-speaking ones) with large sections of each having similar occupation (agricultural), economic condition, living condition, health and other facilities, etc.

Overall, the eye examinations in Kalimpong did not reveal any remarkable features ; all the values obtained were within the normal ranges compared to most other populations studied, and there were no striking inter-ethnic group variations, as has already been mentioned. However, a few changes which were possibly directly caused by climatic factors were noted : e.g., pterygium corneae were very common and pingecula was markedly large (but climatic keratopathy was rare). Detailed analyses of the possible climatological inter-

relations of eye characteristics will be published elsewhere (Forsius et al. 1984). An interesting finding is that myopia-endemicity found in many populations does not seem to occur in the Kalimpong populations studied, but no interpretation is offered at this stage. Comparisons of the Kalimpong populations with ethnically similar ones living in the plains and/or high altitudes (above 3,500 m), as well as with other tropical, sub-arctic and arctic ones, which should yield valuable results, have been undertaken and would be reported in future.

*Acknowledgements*: The authors are indebted to the peoples of the study area for their unhesitating help and cooperation; to Mr. Paritosh Adhikary for secretarial assistance; and to the authorities of the Indian Statistical Institute, Calcutta and the University of Oulu for financial and logistic support.

#### References

- DAS, A.K. 1979. *The Lepchas of West Bengal*. Calcutta: Editions Indian.
- ERIKSSON, A.W., FELLMAN, J.O. AND FORSIUS, H. 1980. Some genetic and clinical aspects of the Aland Islanders. In A.W. Eriksson (ed): *Population structure and genetic disorders*. London: Academic press.
- FORSIUS, H. 1954. Arcus senilis corneae, its clinical development and relationship to serum lipids, proteins and lipoproteins. *Acta Ophthal.* 42: 78.
- , ERIKSSON, A.W. AND FELLMAN J.O. 1964. Corneal refraction according to the age, sex in an isolated population and the heredity of the trait. *Acta Ophthal.* 42: 224-235.
- , AND ERIKSSON, A.W. 1980. *Investigations of ophthalmology and population genetics in Iceland*. Nordic Council Arc. Med. Res. Rep. 26: 40-47.
- , BASU, A., GUPTA, R., MAJUMDER, V., MUKHOPADHYAY, B. AND BHATTACHARYA, S.K. 1984. Climate changes to the eye in medium altitude populations in India: A comparison between tropical and arctic populations. in prep.
- GOVERNMENT OF INDIA 1960. *Climatological tables of observatories in India (1931-1960)*. Nasik: Meteorological Department, Government of India Press.
- GUPTA, R. 1980. Altitude and demography among the Sherpas. *J. Biosoc. Sci.* 12: 103-114.
- WORLD HEALTH ORGANIZATION 1971. Family Planning in Health Services. *WHO Technical Report Series*, No. 476. Geneva: WHO.