

Natural selection among Kinnaura of the Himalayan highland: A comparative analysis with other Indian and Himalayan populations

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The present investigation on fertility and mortality differential among Kinnaura of the Himalayan highland is based on data collected from 160 post-menopausal women belonging to the middle and high altitude region of Kinnaur district of Himachal Pradesh (Indian Himalayas). Selection potential based on differential fertility and mortality was computed for middle- and high-altitude women. Irrespective of the methodology, the total index of selection was found to be highest among middle-altitude women (0.386) as compared with high-altitude (0.370) women, whereas for the total population it is estimated to be 0.384. It was found that the Kinnaura of the Himalayan highland showing moderate index of total selection and relative contribution of the mortality component (Im) to the index of total selection is higher than the corresponding fertility component (If). The analysis of embryonic and post-natal mortality components shows that the post-natal mortality components are higher in comparison with the embryonic mortality components among highlanders and needs special intervention and health care. The present findings are compared with other Indian tribes as well as non-tribes of the Himalayan region and other parts of the country. It reveals that this index among Kinnaura is moderate than the other population groups; among the Himalayan population, the highest was reported for Galong (It = 1.07) of Arunachal, whereas the lowest was reported from Ahom (It = 0.218) of Manipur. The correlation and regression analysis between total index of selection (It) and fertility (If) and mortality (Im) components for pooled data of populations of the Indian Himalayan states show that If and Im account for 21.6 and 29.1% variability, respectively. In Crow's total index of selection (It) along with strong association, which is significant at the 1% level, this indicates that mortality plays a greater role in natural selection in comparison with fertility among populations of the Indian Himalayas.

Key words: Ecology, Himalayas, Indian population, Polyandrous-Kinnaura, selection potential

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Introduction

Natural selection is the process of preservation of genotypes among organisms, which increase chances of survival, procreation and multiplication from generation to generation at the expense of less-advantageous ones. Evolution often occurs as a consequence of this process. Natural selection may arise from differences in survival, fertility, rate of development, mating success or any other aspect of the life cycle. All such differences result in natural selection to the extent that they affect the number of progeny an organism leaves. It was difficult to measure the intensity of natural selection directly in human populations (*Homo sapiens sapiens*). The problem of measuring the selection intensity is solved by Crow.^[1] He devised an index called the "index of opportunity for natural selection." This index enables the change in fitness to be measured from specific birth and death rates. Thus, "natural selection" is the relative probability of survival and reproduction of the genotype. Only when a certain variability of this fitness is present in a population does natural selection occur. In human populations, the relative reproductive success of the different genotypes depends on the total number of offspring that each couple leaves to the next generation.^[2] However, natural selection does not operate only through differential fertility; the existence of differential survival of descendents up to reproductive age also determines the biological fitness.^[3,4] Crow's index of opportunity

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for natural selection merely sets an upper limit on the amount of selective opportunity that can exist in any particular population. It measures actual selection only if the heritability of fitness were complete and if birth and death rates were totally determined by genetic factors.^[5] Despite this limitation, Crow's index has been widely used in human populations because it allows indirect quantitative estimation of the selection inherent in the evolutionary process simply on the basis of demographic statistics for birth and death rates.^[6-10]

Fertility and mortality can cause a major disruption of gene frequencies from those predicted by the Hardy–Weinberg theorem. Therefore, the quantum of change of differential genetic transmission becomes a significant indicator of the amount of potential evolutionary change within a group, which is actually the production of reproductive viability expressed in the form of differential fertility and mortality.

Studies from all over the world have brought forth evidence in support of the contention that the socioeconomic and sociocultural milieus of a population have a tremendous impact on the fertility and mortality components of that population and, subsequently, on selection.^[1,5,11-14] In India, a few studies have demonstrated the role of natural selection in imposing characteristic fertility and mortality differentials among the different populations.^[3,7,15-23] All these studies reveal a relationship between socioeconomic conditions and the index of total selection. Himalayan populations are widely studied by Kapoor *et al.*,^[7] wherein they computed the index of total selection for 24 Himalayan populations, revealing that the contribution of fertility component (I_f) in determining total index of selection (I_t) is stronger than the mortality component (I_m). Simultaneously, they observed that both I_f and I_m are strongly associated with I_t , accounting for 76 and 67% variability in I_t , respectively. But, in their study, highlanders are small in number. Therefore, an attempt was made in the present study to generate data on the highland population.

Area and People

The present study was conducted in District Kinnaur, which is among one of the 12 districts of Himachal Pradesh of the Indian Republic. The area lies between 31°-05'-

55'' and 32°-05'-20'' north latitude and between 77°-45'-0' and 79°-0'-50'' east longitude, being demarcated as District Kinnaur. The word Kinnaur is derived from the word *Kinnar*. *Kinnars* are often referred to in Hindu religious books. According to mythologies, they are neither God nor human, but are in between these two. In 1960, the northeastern region of Himachal Pradesh was administratively recognized to form the present-day district of Kinnaur. It is spread over 80 km in length and about 64 km in breadth.^[24] The total area of the district is 6401 sq km, which is 11.5% of the total area of the state. The district headquarter is located at Reckong Peo. The district is a land of scenic beauty and, at the same time, comprises a cold desert zone too. Sangla, Kalpa and Nichar valleys are enchanting valleys, with lush green forests and apple orchards, whereas the Yangthang, Pooh and Ropa etc. valleys experience cold desert, with no natural flora. National highway no. 22 is constructed in place of the old Hindustan–Tibet road, which goes along the river Sutlej, the river itself passing through narrow fissures of extremely vertical mountains. The vertical valleys are blasted toward the river to construct the present national highway. In many places, the road looks like a tunnel, the mountain hanging over the road, with the deep furious river flowing underneath. Many hanging bridges are constructed over the river to make transportation easy and convenient. But, in spite of all these efforts, the road communication network is not very efficient. It is believed that the district derived its name from its inhabitants who are known as Kinner, or Kinnaura. According to an Indian traveler — Sanskritayan, the original name of the district was Kimpurus Desh, i.e. land of Kimpurusa.^[25]

In the absence of an authentic historical record, the early history of Kinnaur region is obscure and the reference of the Kinnaura or Kannaura and their land is by and large confined to legends and mythological accounts.

The people inhabiting the district of Kinnaur in Himachal Pradesh are known as Kinnaura. They are indigenous occupants of the area. According to the Census of India,^[26] their total population in Himachal Pradesh is 45,154. A majority of them identify themselves as Rajputs, the suffix "Negi" being a common title after their names. Some of the authors^[27] Chandra,^[28]

had associated the term Kinnaura with Indian religious mythology. These authors tried to describe the term Kinner, as mentioned in the Vedas, Puranas, Epics and other religious books, which means half-God or Godly-people or angle-like people. Ethnically, genetically and religiously, Kinnaura are a heterogeneous group of people. Earlier researchers and travelers had reported five different ethnic groups, viz. Kanet, Koli, Badhi, Lohar and Nangloo in the district of Kinnaur. But, today, Kanet is an obsolete term. Raha and Mahato^[25] opined that it was a derogatory term, indicating to *kunit* and *Kanya-het*. *Kunit* means one who does not perform his duties as per norms — a violator, whereas *Kanya-het* means a father who has a lot affection for his daughter. *Kanya* is a Hindi word, a synonym for daughter, and *het* meaning liking or affection or love. According to hearsay, in the ancient period, there was a custom of female feticide or female infanticide among the Rajput, the occupants of the region. But, some of these Rajputs had violated the norms of killing the newly born daughter; hence, they were called Kanet (the term “Kanet” was possibly derived from hindi words, either *Kunit* or *Kanya-het* or both) by the “daughter killer group of Rajputs” of the area.

It is observed that there are two clear-cut divisions in terms of habitations too. These may be designated as middle- and high-altitude region. The high altitude can be associated with an area above an altitude of 3,000 m and the middle altitude can be associated with an altitude ranging between 2,000 and 3,000 m. The Kalpa, Nichar and Sangla valleys fall in the middle-altitude zone and their habitant are migrants, largely from Shimla and Rampur districts. Whereas Kinnaurs of the high altitude are always struggling for subsistence due to the harsh environment and tough challenging ecological conditions, hardly having large land holdings. Hence, they were rendered economically and politically weak.

Methodology

For the present investigation, the Kinnaura tribe of Kinnaur district of Himachal Pradesh is taken into consideration. As Kinnaura are occupants of two different geoclimatic set-ups, i.e., middle and high altitudes, the study sample for the present investigation comprises a

subsample of a total of 160 post-menopausal mothers belonging to the Kinnaura of the Himalayan highlands. Village-wise distributions of mothers are presented in Table 1. A total of 820 households were covered. Of these 820 households, 160 mothers were found in the post-menopausal stage.

The information was collected using anthropological techniques, viz. case studies, focus group discussion, in-depth interview, participants' methods, genealogy and semi-structured schedule. Post-menopausal women are interviewed for different aspects, like age at menarche, menopause, children born, children surviving, child death, etc. and the information given by them is cross-checked through different methods by other members of the family. Case study or life histories of selected women were taken for achieving the goal. Many doubts were cleared from the focus group discussion. In all the cases, genealogy was found helpful in determining the

Table 1: Village and population-wise distribution of the sample

Village	Altitude	Household covered	Number of mothers	%
Middle altitude				
Kilba	2,000	35	4	2.5
Kashmir	2,100	31	3	1.9
Kothi	2,290	29	9	5.6
Khwangi	2,100	32	3	1.9
Sudharang	2,120	32	6	3.8
Yuwarangi	2,300	30	6	3.8
Pangi	2,350	32	6	3.8
Khwanta	2,350	21	6	3.8
Duni	2,300	18	7	4.4
Kalpa	2,400	38	4	2.5
Saryo	2,320	31	9	5.6
Telingi	2,250	33	4	2.5
Brilingi	2,300	32	8	5.0
Average altitude	2244	394	75	
High altitude				
Nako	3,662	41	6	3.8
Thangi	2,900	20	6	3.8
Maling	3,660	30	3	1.9
Giabong	3,500	18	2	1.3
Leo	3,550	36	4	2.5
Pooh	3,420	64	18	11.3
Dubling	3,420	27	5	3.1
Akpa	2,950	16	3	1.9
Morang	2,800	35	9	5.6
Sumra	3,900	37	11	6.9
Shalkher	3,860	65	18	11.3
Kanam	2,890	7	-	-
Hango	3,690	7	-	-
Chango	3,700	23	-	-
Total		426	85	100
Average altitude	3,421			
Average altitude of total villages	2,854			
Grand total (middle + high altitude)	820	820	160	

age of the women.

Data regarding other Himalayan and Indian populations were collected from 33 different published studies conducted on 70 various endogamous populations of eight Himalayan and four non-Himalayan (plain) states.

The data collected from primary and secondary sources were given essential statistical treatment using MS-Excel and SPSS softwares. Among the chief statistical treatments are regression analysis, error bar diagram and scattered plot diagram.

The following formulas are used for computing different indices and indicators:

Crow's index of natural selection

The index of opportunity for natural selection (I_t) is calculated using Crow's index,^[1] as cited below:

$$I_t = I_m + \left(\frac{1}{P_{s1}} \right) I_f$$

$$\text{where } I_m = \frac{P_d}{P_{s1}} \quad \text{and} \quad I_f = \frac{V_f}{(\bar{x})^2}$$

Here, I_m = index of opportunity for natural selection due to pre-reproductive mortality (mortality from birth to reproductive age – below 15 years)

I_f = index of opportunity for natural selection due to fertility

x = average number of live births per women aged 45 years and above who has completed her reproductive life span

V_f = variance (average deviation from mean) of number of live births

P_d = proportion of pre-reproductive deaths

P_{s1} = proportion of survivors from birth to reproductive ages

Proportion of pre-reproductive deaths (P_d) is calculated from children ever born from mothers of age 45 years and above (who have completed their fertility) and pre-reproductive deaths, as cited below:

Proportion of pre-reproductive deaths (P_d)

$$= \frac{\text{Children ever born from mothers of age of 45 years and above (with completed fertility)}}{\text{Children died before attaining reproductive age (under 15 years) born from these mothers}}$$

Proportions of survivors were calculated by subtracting P_d from 1, as given below:

$$P_{s1} = 1 - P_d$$

Johnston and Kensinger's index of natural selection

The index of opportunity for natural selection (I_2) following Johnston and Kensinger's index^[9] has been calculated as follows:

$$I_2 = I_{me} + \left(\frac{1}{P_b} \right) I_{mc} + \left(\frac{1}{P_b P_{s1}} \right) I_f$$

$$\text{where } I_{me} = 1 - \frac{P_d}{P_b}, I_{mc} = \frac{P_d}{P_s}, I_f = \frac{V_f}{(\bar{x})^2} \quad \text{and} \quad P_b = 1 - P_d$$

$$P_d = \frac{\text{Total prenatal deaths experienced by the mothers of age of 45 years and above (with completed fertility)}}{\text{Number of pregnancies experienced by the same mothers of age of 45 years and above (with completed fertility)}}$$

Here, I_{me} = index of opportunity for natural selection due to embryonic mortality

I_{mc} = index of opportunity for natural selection due to pre-reproductive mortality (mortality from birth to reproductive age – below 15 years)

I_f = index of opportunity for natural selection due to fertility

x = average number of live births per women aged 45 years and above who have completed their reproductive life span

V_f = variance (average deviation from mean) of number of live births

P_b = proportion of survivors to birth

P_d = proportion of pre-reproductive deaths

P_s = proportion of survivors from birth to reproductive ages

Result

Among the Kinnaura, a total of 813 mothers were interviewed, of whom 160 had already completed their fertility (above 45 years of age) and constituted the sample size for analysis of natural selection. Village-

wise distribution of mothers with completed fertility is presented in Table 1. These 160 mothers had conceived a total of 809 pregnancies, which resulted in 793 live births. Of these 793 live births, 664 survived up to their reproductive ages. The mean number of live birth per mother has been found to be 4.89, with a variance of 3.79 [Table 2]. For further elucidation of facts, box pot and error bar diagrams are constructed [Figures 1 and 2]. It is evident from the error bar diagram that there is a significant difference in the numbers of pregnancy experienced by the mother, children ever born and children surviving. The number of children surviving is significantly less than those born and conceived. This indicates that fetal loss and child mortality is significant among Kinnaura of middle and high altitude.

The indices of total selection, based on differential fertility and mortality data, have been computed using the methodologies of Crow^[1] and Johnston and Kensinger,^[13] presented in Tables 3 and 4. The mean number of live births is slightly higher among middle-altitude Kinnaura (5.14) as compared with high-altitude Kinnaura (4.49). The index of total selection intensity (I_t) calculated

according to Crow is always lower than that of the Johnston and Kensinger index (I_2), perhaps because of inclusion of embryonic deaths in the latter. It is also evident that differential mortality contributes more than differential fertility to the total selection intensity.

The proportions of survivors from birth to reproductive age were found to be slightly higher for high-altitude Kinnaura (0.842), as compared with middle-altitude Kinnaura (0.832). Contrary to this, the proportions of pre-reproductive deaths were found to be higher among middle-altitude Kinnaura (0.168) as compared with high-altitude Kinnaura (0.158). On the whole, the proportion of survivors from birth to reproductive age was found to be 0.837 and the proportion of pre-reproductive deaths was 0.163. However, the proportion of embryonic (pre-natal) deaths varied from 0.007 to 0.033 [Table 4]. It has been noticed that the total index of selection is higher among middle-altitude Kinnaura as compared with high-altitude Kinnaura, irrespective of the methodology used. However, all the estimates (as per Crow's formulation) were below 1.18, as reported by Sphuler^[6] for various populations.

Table 2: Demographic variables utilized in calculating the index of total selection for middle- and high-altitude Kinnaura

Eco-zones	Fertility performance of the mother with completed fertility (aged 45+)					
	Number of mothers with completed fertility (age 45+)	Total number of pregnancies	Number of children ever born (live births)	Number of children surviving	Mean live births (from mothers aged 45+)	Variance of live births
Middle altitude	74	394	381	317	5.14	4.049
High altitude	86	415	412	347	4.79	3.533
Kinnaur (pooled)	160	809	793	664	4.89	3.794

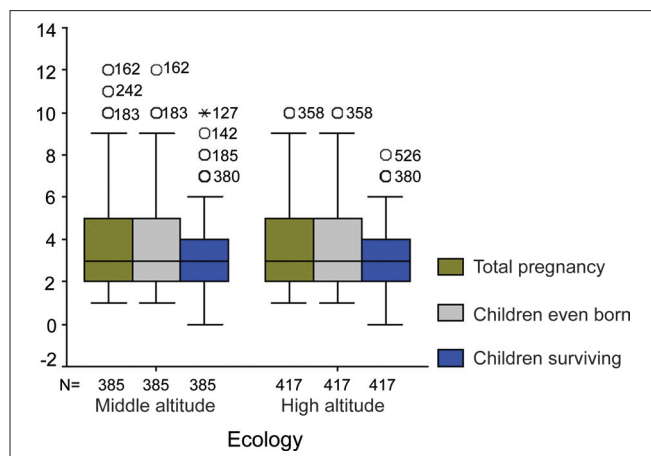


Figure 1: Clustered box plot diagram showing comparative details of median, quartile and extreme values of number of pregnancies, total live birth and surviving children among the Kinnaura of middle- and high-altitude zones

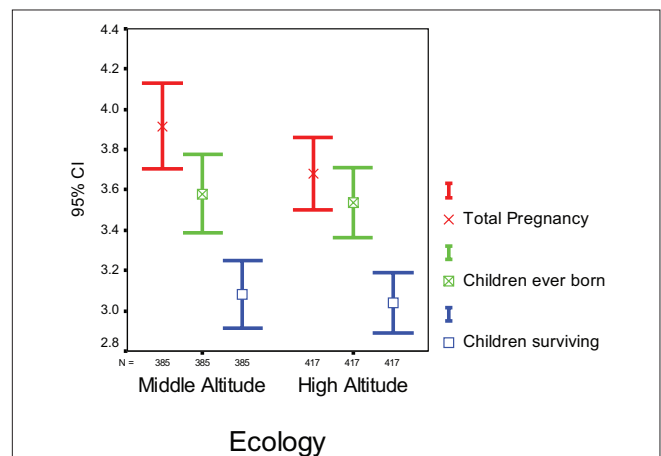


Figure 2: Error bar diagramme showing comparative details of median, quartile and extreme values of number of pregnancies, total live birth and surviving children among Kinnaura of Middle and High altitude zones

Table 3: Selection intensities (based on live births and pre-reproductive mortalities)^[1] among the Kinnaura of middle and high altitudes

Kinnaura	Proportion of pre-reproductive deaths	Proportion of survivors from birth to reproductive age	Index of selection due to mortality	Index of selection due to fertility	Total index of selection	Percentage of	
	P_d	P_s^a	I_m	I_f	I_t	Fertility component	Mortality component
Middle altitude	0.168	0.842	0.202	0.153	0.386	47.67	52.33
High altitude	0.158	0.842	0.187	0.154	0.370	49.46	50.54
Kinnaura (Pooled)	0.163	0.837	0.194	0.159	0.384	49.48	50.52

Table 4: Selection intensities (based on live births and pre-reproductive mortalities)^[10] among the Kinnaura of middle and high altitudes

Kinnaura	Proportion of pre-reproductive deaths	Proportion of survivors from birth to reproductive age	Proportion of embryonic (prenatal) deaths	Proportion of survivors to birth	Index of selection due to embryonic mortality	Index of selection due to post-natal mortality	Index of selection due to fertility	Total index of selection	Percentage of		
	P_d	P_s^a	P_{ed}	P_b^a	I_{me}^a	I_{mc}^a	I_f^a	I_2	Fertility component	Post natal mortality component	Embryonic mortality component
Middle altitude	0.168	0.832	0.033	0.967	0.034	0.202	0.153	0.433	45.54	46.58	7.87
High altitude	0.158	0.842	0.007	0.993	0.007	0.187	0.154	0.380	48.81	49.28	1.92
Pooled	0.163	0.837	0.020	0.980	0.020	0.194	0.159	0.412	47.91	47.19	4.90

Table 5: Indices of natural selection among different population groups (tribes and non-tribes) of the Himalayan region and other parts of India

Region Population	Crow's Index (1958)			Johnston & Kensinger' Index (1971)				Reference
	I_m	I_f	I_t	I_{me}	$I_{mc/Pb}$	$I_{f/pbPs1}$	I_2	
	Himalayan Region							
Eastern Himalayas								
Arunachal Pradesh								
Muklom	0.107	0.188	0.315	0.021	0.107	0.188	0.342	Sarkar (1997)
Apatani Guchi	0.435	0.190	0.710	-	-	-	-	Padmanabham (1982)
Apatani Guth	0.440	0.312	0.889	-	-	-	-	"
Singapos	0.437	0.406	1.020	-	-	-	-	Padmanabham (1981)
Galong	0.750	0.180	1.070	-	-	-	-	Chakraborty & Ahmed (1989)
Min	0.107	0.180	0.315					
Max	0.750	0.406	1.070					
Mean	0.433	0.255	0.800					
Assam								
Semsa	0.471	0.098	0.616	0.038	-	0.098	0.677	Ghosh & Limbu (2002)
Khamti	0.179	0.113	0.312	0.005	0.179	0.113	0.319	Sarkar <i>et al.</i> (1994)
Sonawal Kachari	0.192	0.141	0.360	-	-	-	-	Deka (1978)
Bengali Muslim	0.430	0.310	0.860	-	-	-	-	Chakraborty (1989)
Oraon	0.990	0.131	0.243	0.102	0.099	0.131	0.370	Sengupta & Phukan (1997)
Ahom	0.083	0.119	0.218	0.074	0.083	0.119	0.308	Sengupta & Chakraborty (1998)
Min	0.083	0.098	0.218	0.005	0.083	0.098	0.308	
Max	0.990	0.310	0.860	0.102	0.179	0.131	0.677	
Mean	0.391	0.152	0.435	0.055	0.120	0.115	0.419	
Meghalaya								
Hajongs	0.443	0.131	0.631	0.032	0.443	0.131	0.684	Barua (1983)
Jaintias	0.456	0.125	0.638	0.107	0.456	0.125	0.814	Deka (1989)
Phar	0.236	0.134	0.401	0.202	0.236	0.134	0.681	Khongsdier (1990)
War Khasi (Christian)	0.147	0.185	0.359	0.093	0.147	0.185	0.486	Khongsdier (1994)
War Khasi (Non-Christian)	0.180	0.225	0.446	0.084	0.180	0.225	0.568	Khongsdier (1994)
Dalu	0.499	0.231	0.847	0.032	0.499	0.231	0.897	Patra and Kapoor (1997)
Min	0.125	0.359	0.359	0.320	0.147	0.125	0.486	
Max	0.231	0.847	0.847	0.202	0.499	0.231	0.897	
Mean	0.171	0.553	0.553	0.091	0.326	0.171	0.688	
Manipur								

(contd...)

Region Population	Crow's Index (1958)			Johnston & Kensinger' Index (1971)				Reference
	I_m	I_f	I_t	I_{me}	$I_{mc/Pb}$	$I_{f/pbPs1}$	I_2	
Hmar	0.072	0.250	0.340	0.028	0.072	0.250	0.379	Varte (1998)
West Bengal								
Sherpa	0.206	0.173	0.415	-	-	-	-	Reddy & Chopra (1990) cf. Gharami <i>et al.</i> (2003)
Western Himalayas								
Himachal Pradesh								
Bodh	0.105	0.143	0.263	-	-	-	-	Chaudhury (1982)
Shipi	0.227	0.207	0.482	-	-	-	-	"
Swanga	0.157	0.157	0.339	-	-	-	-	"
Min	0.105	0.143	0.263	-	-	-	-	
Max	0.227	0.207	0.482	-	-	-	-	
Mean	0.163	0.169	0.361	-	-	-	-	
Jammu and Kashmir								
Ladakh Region ^{HA}								
Bodhs	0.387	0.387	0.340	0.103	0.387	0.340	1.049	Bhasin & Nag (2002)
Baltis	0.201	0.327	0.594	0.076	0.201	0.327	0.714	"
Brokpas	0.624	0.243	1.020	0.127	0.624	0.243	1.277	"
Arghuns	0.506	0.168	0.759	0.057	0.506	0.168	0.860	"
Kashmir Region								
Kashmiri Pandit	0.265	0.455	0.828	0.120	0.265	0.455	1.048	
Kashmiri Muslim	0.059	0.214	0.286	0.000	0.059	0.214	0.286	"
Jammu Region								
Dogra Rajput	0.154	0.556	0.795	0.000	0.154	0.556	0.795	"
Min	0.074	0.223	0.313	0.017	0.074	-	0.223	"
Max	0.059	0.168	0.286	0.000	0.059	0.000	0.223	
Mean	0.624	0.556	1.020	0.127	0.624	0.556	1.227	
Central Himalayas								
Uttaranchal (erstwhile UP)								
Bhoksa	0.282	0.058	0.356	-	-	-	-	Garg <i>et al.</i> (1980)
Bhotia (Migratory)	0.277	0.158	0.479	0.091	0.277	0.158	0.606	Kapoor and Patra (1998)
Bhotia (Settled)	0.167	0.142	0.330	0.095	0.167	0.142	0.456	"
Raji	0.585	0.174	0.862	0.0625	0.585	0.174	0.979	Patra (2001)
HPA ^b								
Barbatiya	0.243	0.443	0.794	0.076	0.261	0.593	0.930	Kapoor <i>et al.</i> (2004)
Tibetan	0.142	0.324	0.512	0.060	0.151	0.392	0.603	"
Khampa	0.207	0.369	0.653	0.131	0.235	0.505	0.871	"
Harkotiya	0.114	0.244	0.386	0.081	0.123	0.294	0.498	"
Bodh	0.148	0.226	0.407	0.098	0.163	0.285	0.546	"
Kuthalia Bora	0.223	0.330	0.627	0.076	0.240	0.435	0.751	"
Brahman group								
Brahman	0.059	0.312	0.389	0.039	0.062	0.343	0.444	
Brahman	0.178	0.278	0.505	0.098	0.195	0.359	0.652	"
Brahman	0.111	0.249	0.388	0.058	0.118	0.292	0.468	"
Brahman	0.065	0.283	0.366	0.045	0.067	0.316	0.428	"
Brahman	0.125	0.239	0.395	0.041	0.131	0.280	0.452	"
Rajput group								
Rajput	0.148	0.263	0.450	0.065	0.157	0.322	0.544	
Rajput	0.155	0.219	0.408	0.085	0.168	0.274	0.528	"
Rajput	0.083	0.262	0.367	0.056	0.088	0.300	0.444	"
Rajput	0.096	0.297	0.422	0.088	0.104	0.354	0.546	"
Rajput	0.140	0.180	0.345	0.061	0.149	0.218	0.428	"
Rajput	0.163	0.246	0.449	0.049	0.171	0.301	0.521	"
SC (Shilpkar group)								
Shilpkar	0.193	0.326	0.582	0.062	0.205	0.413	0.680	"
Shilpkar	0.089	0.263	0.376	0.082	0.097	0.310	0.489	"
Shilpkar	0.103	0.251	0.380	0.055	0.109	0.291	0.455	"
Shilpkar	0.145	0.631	0.446	0.022	0.148	0.308	0.478	"
Shilpkar	0.114	0.208	0.346	0.047	0.119	0.243	0.410	"
Shilpkar	0.130	0.255	0.418	0.067	0.139	0.307	0.513	"
SC of Himachal Pradesh								
Min	0.108	0.244	0.379	0.073	0.116	0.290	0.479	"
Max	0.059	0.180	0.345	0.022	0.062	0.218	0.410	"
Mean	0.243	0.631	0.794	0.131	0.261	0.593	0.930	"
Indian plain								
Madhya Pradesh								
Kol	0.504	0.122	0.688	0.036	0.504	0.122	0.749	Gharami <i>et al.</i> (2003)
Ladiya ^{sc}	0.396	0.089	0.521	-	-	-	-	Gharami and Mandal (2001)

(contd...)

Region Population	Crow's Index (1958)			Johnston & Kensinger' Index (1971)				Reference
	I_m	I_t	I_s	I_{me}	$I_{mc/Pb}$	$I_{I/pbPs1}$	I_2	
Muria	0.217	0.173	0.492	0.014	0.272	0.173	0.514	Basu <i>et al.</i> (1988)
Madia	0.310	0.191	0.558	-	0.308	0.191	0.558	Basu <i>et al.</i> (1988)
Bhattra	0.277	0.281	0.633	0.002	0.275	0.281	0.637	"
Halba	0.200	0.148	0.388	0.016	0.209	0.148	0.410	"
Min	0.200	0.089	0.388					
Max	0.504	0.281	0.688					
Mean	0.317	0.167	0.546					
Karnataka								
Koranga	0.008	0.280	0.340	-	-	-	-	Chandrasekar <i>et al.</i> (1998)
Andhra Pradesh								
Manne Kolam	0.544	0.306	1.012	-	-	-	-	Murthy and Ramesh (1978)
Chenchu	0.500	0.200	0.810	-	-	-	-	Sirajuddin and Basu (1984)
Hill Kolam	0.344	0.284	0.728	-	-	-	-	Murthy and Ramesh (1978)
Kolam	0.444	0.295	0.870	-	-	-	-	"
Sugalis	0.375	0.162	0.606	-	-	-	-	Reddy and Reddy (1985)
Yanadi	0.113	0.408	0.566	-	-	-	-	Vasulu (1987)
Min	0.113	0.162	0.566					
Max	0.544	0.408	1.012					
Mean	0.386	0.275	0.765					
Tamil Nadu								
Kota	0.445	0.638	1.367	-	-	-	-	Reddy & Chopra (1990) cf. Gharami <i>et al.</i> (2003)
Present Study								
Kinnaura (Pooled)	0.194	0.159	0.384	0.020	0.194	0.159	0.412	Present Study (2006)
Kinnaura ^{MA}	0.202	0.153	0.386	0.034	0.202	0.153	0.433	"
Kinnaura ^{HA}	0.187	0.154	0.370	0.007	0.187	0.154	0.380	"

HPA = Himalyan population with Asian affinities; HA = High altitude; MA = Middle altitude; SC = Scheduled altitude; UP = Uttar Pradesh

Discussion and Conclusion

The present findings are compared with other Indian tribes as well as non-tribes of the Himalayan region and other parts of the country [Table 5]. It reveals that this index^[1] among the Kinnaura is moderate as compared with the other population groups. Among the Himalayan population, the highest was reported for Galong ($I_t = 1.07$) of Arunachal, whereas the lowest was reported from Ahom ($I_t = 0.218$) of Manipur. In the western Himalayas, the index was found to be highest for Baltis ($I_t = 1.02$) of Jammu and Kashmir and lowest for the Bodhs ($I_t = 0.263$) of Himachal Pradesh, whereas for all of Kinnaura, the index is computed to be $I_t = 0.384$, which varies from $I_t = 0.370$ (high altitude) to $I_t = 0.386$ (middle altitude). Thus, Kinnaura show similarities with Muklom ($I_t = 0.315$) of Arunachal Pradesh, Khamti ($I_t = 0.312$) and Sonawal Kachari ($I_t = 0.360$) of Assam, Swangal ($I_t = 0.339$) of Himachal Pradesh, Ladakhi ($I_t = 0.34$) as a whole, Dogra Rajput ($I_t = 0.313$) of Jammu and Kashmir and Halba ($I_t = 0.388$) of Madhya Pradesh. The overall Indian scenario shows that the Kota ($I_t = 1.367$) have the highest selection intensity while Ahom ($I_t = 0.218$) have the lowest index of total selection [Table 5]. The correlation and regression

Table 6: Regression and correlation of the fertility (I_t) and mortality (I_m) components with the index of total selection (I_t) among populations of the different Himalayan states (dependent variable, I_t)

States	Independent variable I_t							
	R	R ²	df	F	P value	β_1	SE	t
Arunachal Pradesh	0.460	0.211	4	0.804	0.436	1.396	1.557	0.897
Assam	0.744	0.553	4	3.711	0.150	2.206	1.145	1.926
Himachal Pradesh	0.872	0.761	5	12.733	0.023	2.745	0.769	3.568
Jammu and Kashmir	0.243	0.059	7	0.376	0.562	0.497	0.812	0.613
Meghalaya	0.172	0.030	5	0.122	0.745	0.656	1.881	0.349
Uttaranchal	0.619	0.384	3	1.246	0.381	2.944	2.638	1.116
Pooled	0.464	0.216	33	8.793	0.006	1.084	0.366	2.965
States	Independent variable I_m							
	R	R ²	df	F	P value	β_1	SE	t
Arunachal Pradesh	0.883	0.779	4	10.583	0.047	1.185	0.364	3.253
Assam	0.167	0.028	4	0.086	0.788	-0.130	0.443	-0.294
Himachal Pradesh	0.958	0.918	5	44.984	0.003	1.603	0.239	6.707
Jammu and Kashmir	0.636	0.404	7	4.075	0.090	0.860	0.426	2.019
Meghalaya	0.933	0.870	5	26.741	0.007	1.107	0.214	5.171
Uttaranchal	0.969	0.938	3	30.298	0.031	1.325	0.241	5.504
Pooled	0.540	0.291	33	13.142	0.001	0.655	0.181	3.625

analysis [Table 6] between total index of selection (I_t) and fertility (I_t) and mortality (I_m) components for pooled data of populations of Indian Himalayan states [Figures 3 and 4], showing that I_t and I_m account for 21.6 and 29.1% variability, respectively, in the Crow's total index

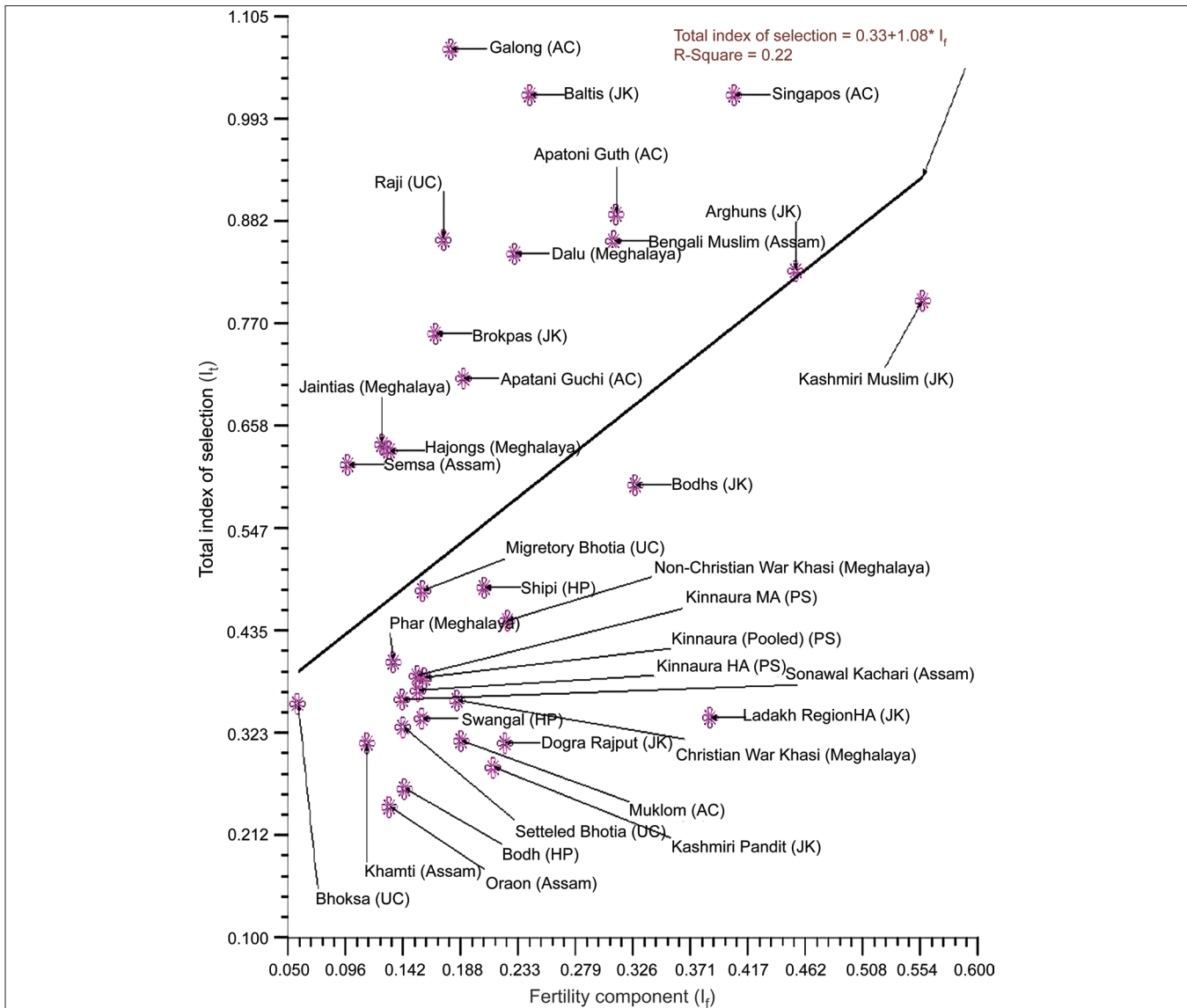


Figure 3: Bivariate scattered plot diagram showing regression and correlation between the fertility component and total index of selection among Himalayan populations

of selection (I_t) along with a strong association that is significant at the 1% level. This indicates that mortality plays a greater role in natural selection in comparison with fertility among populations of the Indian Himalayas. Furthermore, the individual analysis for states [Figures 5 and 6] exhibit great variation, the least variability of fertility component (I_f) being noticed in Meghalaya (3%), followed by Jammu and Kashmir (5%), whereas the highest was noticed in Himachal Pradesh (76%), followed by Assam (55.3%), Uttaranchal (38.4%) and Arunachal (21.1%). Similarly, the least variability of the mortality component (I_m) on Crow's total index of selection (I_t) was found to be in the state of Assam (2.8%), followed by Jammu

and Kashmir (40.4%), whereas the highest was noticed in Uttaranchal (93.8%), followed by Himachal Pradesh (91.8%), Meghalaya (87%) and Arunachal (77.9%). In light of the above discussion, the findings of the present study indicate that Kinnaura have a moderate value of component of fertility (I_f), mortality (I_m) and mortality playing a greater role in natural selection over fertility, as is true to a majority of the Himalayan populations. The present findings do not show any great variation from the previous one,^[29] but more or less support it, the average (0.361) of total index of selection being present closer to the present findings (0.384).

It can be concluded that determinants of mortality

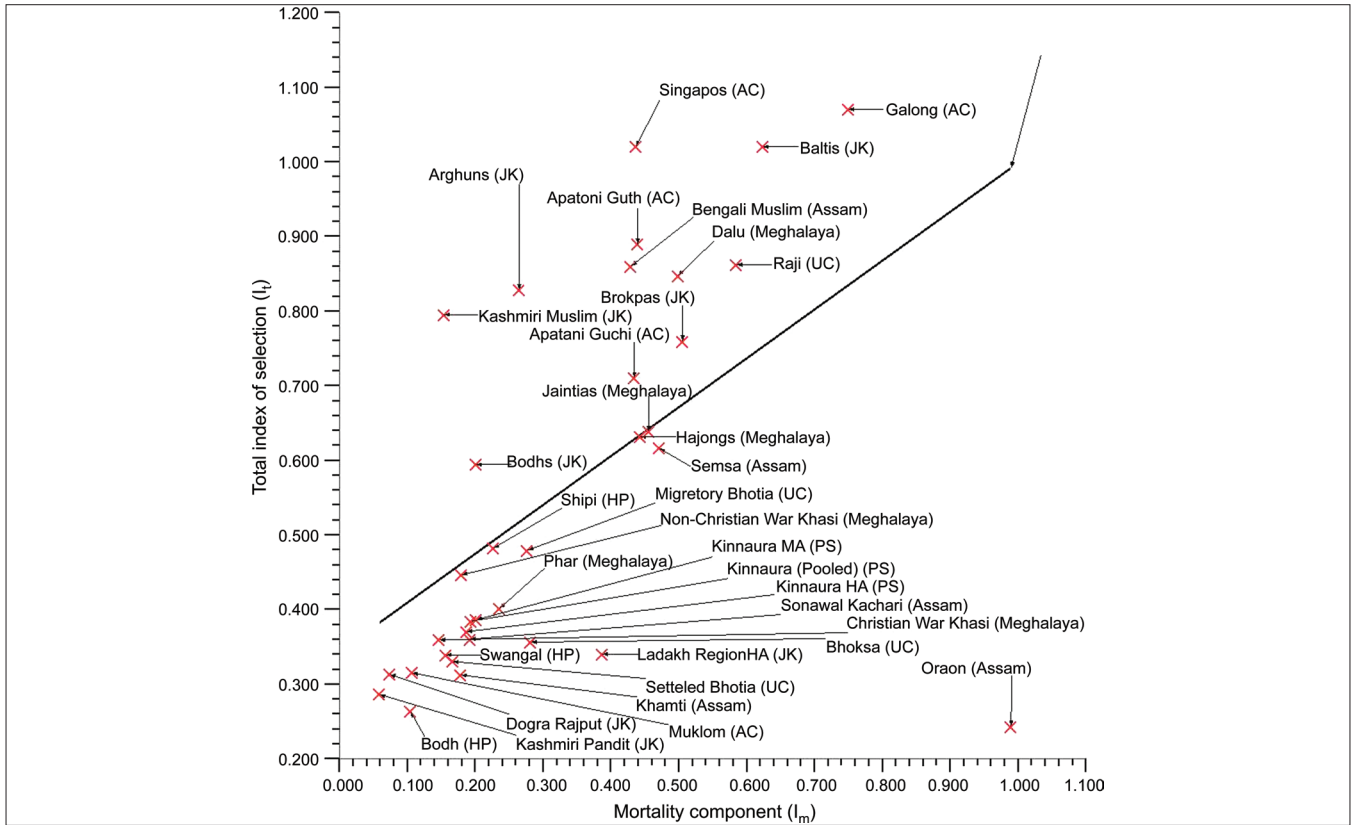


Figure 4: Bivariate scattered plot diagram showing regression and correlation between the mortality component and total index of selection among Himalayan populations

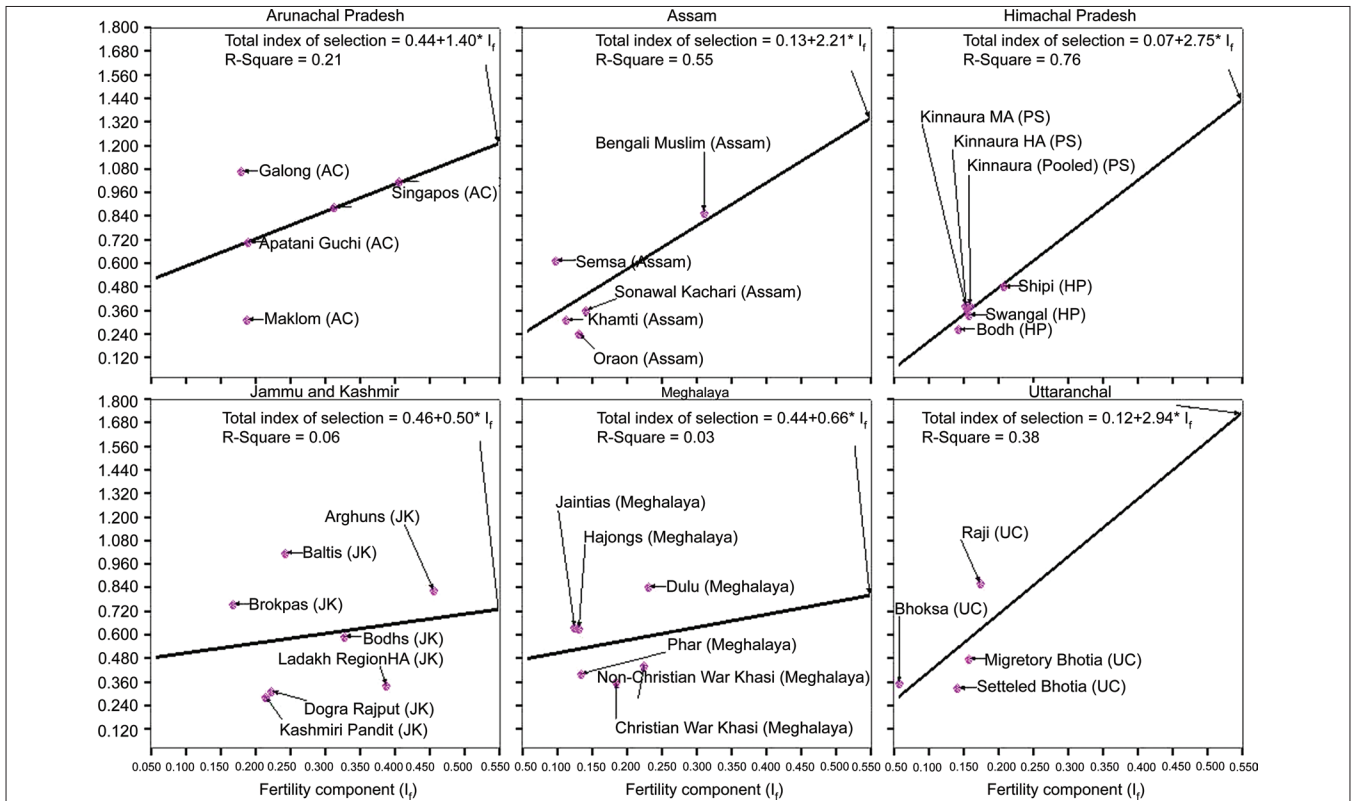


Figure 5: Bivariate scattered plot diagram showing regression and correlation between the fertility component and total index of selection among populations of different Himalayan states

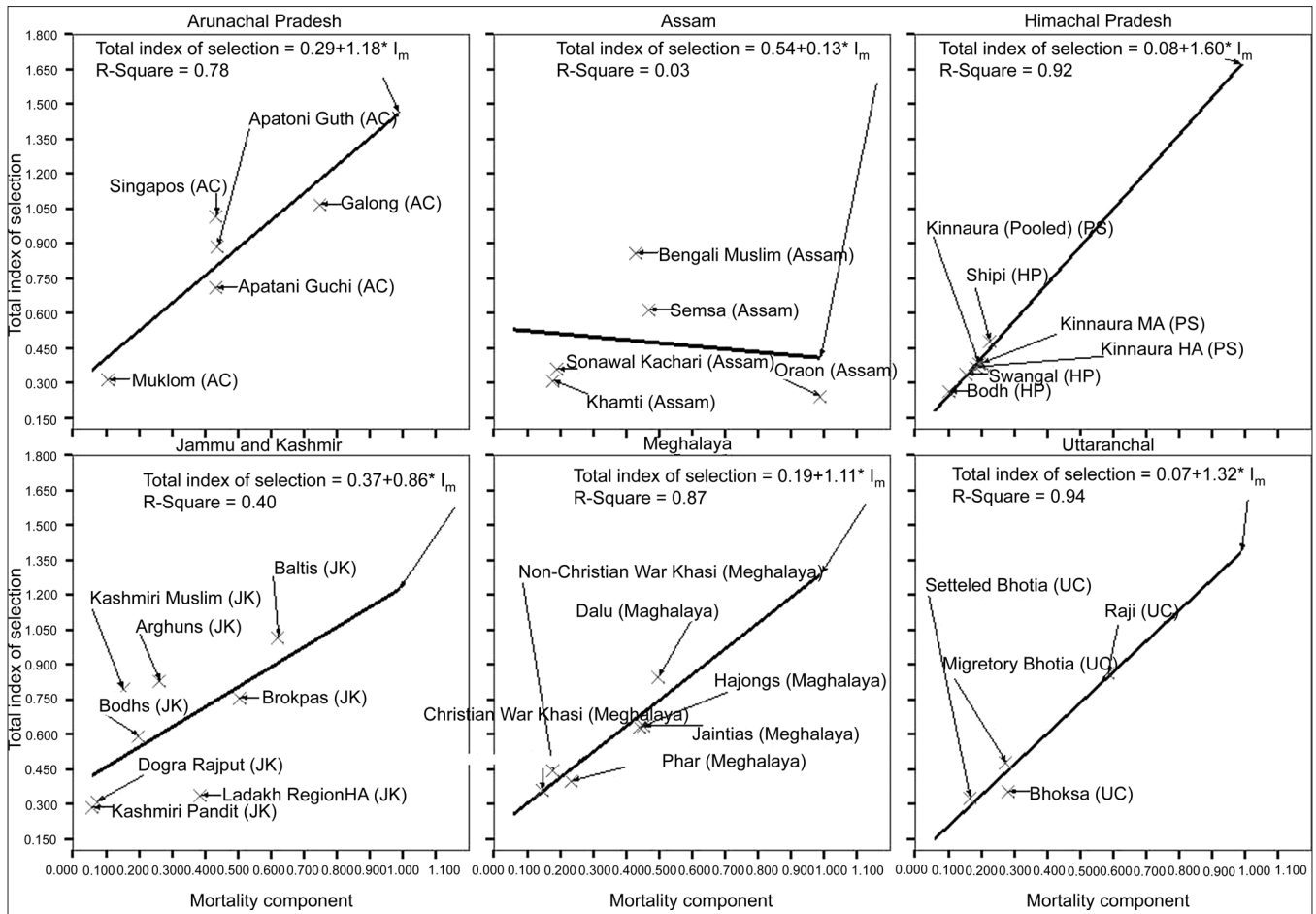


Figure 6: Bivariate scattered plot diagram showing regression and correlation between the mortality component and total index of selection among populations of different Himalayan states

among Kinnaura should be identified and targeted for reduction. The Department of Health and the Integrated Child Development functionaries must pay attention to reduce fetal loss and infant and child mortality. The improvement in health infrastructure and facilities in the remote areas may change the scenario.

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