

ASSESSMENT OF FERTILITY AND INFERTILITY IN BORON-EXPOSED TURKISH SUBPOPULATIONS 6: RELEVANT DATA FROM ALL CENTERS

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SUMMARY

In this last article, part of a large-scale work to reveal health effects of boron exposure, findings of fertility-infertility states of subjects exposed to borates environmentally and/or occupationally in a country with the world's largest deposits are described. The study covered all centers of borate production, namely, Bigadiç county of Balıkesir; Kestelek village of Mustafa Kemal Paşa county, Bursa; Emet and Hisarcık counties of Kütahya, and Kırka town, Seyidgazi of Eskişehir, an area nearly 350 km long and 150 km wide. Drinking water piped out from springs and wells has boron concentrations 0.2 to 29 ppm (mgB/kg or mgB/l). Dust amount at work-sites was below permissible level of 10 mg/m³. The work, questionnaire-based, was realized in field as an observational one. Residents were visited at home and coffee houses in villages and public buildings in towns, and workers at facilities and ore pits without any selection. The inquiry was mainly concerned with marital state and childbearing properties of probands, and of other members in the kindred.

Infertility of the primary type among 2529 probands (participants), as a convenient sample, was 3.1%, changing from 0.0 to 6.5% regarding subpopulations from 12 centers, differences being statistically insignificant. No differences with respect to birth place and professional state as well were revealed either. Pedigree data showed the rate was 3.2% covering 14,320 marriages over 3 generations. No appreciable concentration of infertiles either in subgroups or in so-called 'borate families' in borate towns was observed. Approached as an independent test, marriages of male and female sibs of proband and his (her) spouse ranged from 2.4 to 4.2%. None of these was so far higher than found in different sets of controls and of general population over 50,000 families. Childlessness was found 1.7% among workers versus 4.3% among employees from all facilities, the difference attributable to socio-cultural grounds.

It was then once more concluded that continuous boron exposure at the present level does not affect human reproductive performance adversely primarily and secondarily over 3 generations for at least 60-70 years.

Key Words: Boron Exposure, Borates, Fertility, Infertility, 'Borate Families'.

ÖZET

Türkiye'de Bor ve Bileşiklerine Maruz Toplum Kesimlerinde Fertilite ve Infertilite Araştırması: 6. Tüm Bulgular

Dünyanın bilinen en geniş bor yataklarına sahip Türkiye'de bor ve bileşiklerine maruziyetin insan sağlığına etkisini belirlemeğe yönelik uzun vadeli bir çalışmaya ilişkin yayınların bu sonuncusunda bor mineralleriyle çevresel ve/veya mesleksel teması bulunan kişilerin fertilite-infertilite durumları anlatılmaktadır. Araştırma bütün bor üretim merkezlerini içine almıştır. Buraları hem geniş maden yataklarının hem üretim tesislerinin yer aldıkları Balıkesir'in Bigadiç ilçesi, Bursa'nın Mustafa Kemal Paşa ilçesinin Kestelek köyü, Kütahya'nın Emet ve Hisarcık ilçeleriyle Eskişehir'in Seyidgazi ilçesine bağlı Kırka beldesi ve civarlarıdır ki aşağı yukarı 350 km uzunluğu, 150 km genişliği olan bir yurt kesimini içlerine alırlar. Ayrıca Balıkesir'in Bandırma ilçesindeki Boraks ve Asit Fabrikaları çalışanlarıyla Susurluk ilçesinin Sultançayırı, Aziziye ve Yıldız köylerinden bir grup eski madenci eklenmiştir. Bölgelerin kaynak ve kuyulardan getirilen içme ve kullanma suları bor içerikleri 0.2-29 ppm (mgB/kg veya mgB/l) arasında değişmekte olup sonuncu rakam yerleşim birimleri arasında bilinenlerin en yükseğidir. Ocak ve fabrikaların toz yoğunluğu ise yasayla çizilen 10 mg/m³ yoğunluk sınırını aşmamaktadır. Anketeye dayalı bu gözlemsel çalışma sahada gerçekleştirilmiştir. Katılımcılarla ev ziyaretleri, kahvehane, ofis, dükkan sağlık ocaklarında, işçilerle maden ocağı ve fabrikalarda yüzyüze görüşülmüştür. Cinsel etkinliğe ağırlık veren sorular yanısıra ailenin öteki bireylerinin evlilikleri de irdelenmiştir.

Primer infertilite 2529 probanda göre %3.1 çıkmış, 12 çalışma bölgesinde değişiklik %0.0-6.5 arasında bulunmuştur (farklar anlamlı değil). Katılımcıların doğum yerleriyle meslekleri açısından herhangi fark gözlenemezken pedigr analiziyle üç kuşak boyunca 14,320 evliliğe göre primer çocuksuzlar %3.2, sekonderler % 0.4 düzeyinde kalmışlardır. Gerek bunlar gerekse bor kentlerinin 'bor aileleri' içersinde infertilite yığılımı ortaya konamamış; bağımsız bir test olarak uygulanan proband ve eşinin erkek ve kız kardeşlerinin evliliklerindeyse %2.3-4.0 gibi benzer infertilite rakamları saptanmıştır. Hiçbiri kontrol ve genel toplum rakamlarından daha yüksek değildir. Tesislerdeki memurlar arasında saptanan % 4.3'lük infertiliteye karşın işçilerin %1.7'lik oranı sosyo-kültürel farklılara bağlanmıştır.

Sonuç olarak kuşaklar boyunca en az 60-70 yıl süreyle bor bileşiklerinin ağır ve sürekli baskısı altındaki toplum kesimlerinde çocuk edinme ve evlilik durumları bakımından cinsel performansın primer ve sekonder olarak olumsuz etkilendiği savı desteksiz kalmıştır.

Anahtar Kelimeler: Bor Maruziyeti, Boratlar, Fertilite, Infertilite, 'Bor Aileleri'.

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Boron, ubiquitous in the human environment, is an essential micronutrient for normal plant growth and optimal crop as proved by Warington in 1923; although it is herbicide at high doses (1). In animal kingdom it does not show an adverse effect at low concentration but at higher amounts signs of acute toxication appear (2,3). In chronic exposure it exerts deleterious effects, the target organ being testis. At doses as high as 3000-9000 ppm (mg/kg or mg/l) boric acid, a boron compound naturally occurring in environment, and corresponding to 26-68 mgB/kgbw, testes are atrophied and eventually degenerated by as yet not an understood mechanism (2,3). The rats are the most sensitive animal but it is also true for mice, rabbits and even dogs (4,5).

Meanwhile two Russian writers reported that workers exposed to borate dusts and cadmium exhibited reduced sperm count and impaired sexual activity (6,7). However such observations have not been supported. And despite much work on several animal species little is known relating to human exposure. Whorton and his colleagues in the U.S.A. and I myself as well as our team here in Türkiye have published reports providing evidence that boron does not associate with an adverse effect so far as the marital status and childbearing properties of subjects exposed to borates environmentally and/or occupationally are concerned (8-10). We found the rate of childless participants was 3.17 %, and 3.0 % over three-generations. Independently, it ranged from 2.3 to 4.0 % among male and female sibs of probands and their spouses (11); none being higher than the rate revealed for the general population. Similar results have also been obtained in 'borate families' in 'borate towns' (11). More recently it has been shown that the frequency of infertility concerning borate workers only was not higher either (12).

Since the study started in 1995 has recently finished, we here give all relevant data from all borate regions of the Country, lending support that continuous exposure to the element does not interfere with human reproduction primarily and secondarily.

Materials and Methods

Study Areas

Türkiye is a country with the world's largest borate deposits ever discovered. It is also a remarkable producer and exporter of boron products. Two underground ore pits around Sultançayır, Aziziye and Yıldız villages of Susurluk county, Balıkesir, have been the earliest sites of borate mining. Pandermite, hence the name of Bandırma, a sodium borate species, has been exploited in 1861 and exported to Europe from 1867 till 1960. Etibank, recently Eti Holding A.Ş., established in 1935 by Atatürk, has taken borate industry over in 1978 by all means. Much work has been done with respect to geological and technical as well as trading issues of borate minerals in this country. Helvacı together with Alonso, one of the main researchers on the subject, lastly compared Turkish borates with those in Argentina (13). It has been stated that our borate salts are of superior quality.

This study covers all four regions, that is, all areas with large borate deposits, open-field and -once- underground pits, and processing facilities (Table 1).

1. Bigadiç area: From Bigadiç district where borate ore was discovered in 1950 İskele town and Osmanca and Yeniköy villages were included. There are 4 open-field pits and 3 underground ones first owned and managed by private companies. These latter all was abandoned by 1998. The 3 settlements have already been referred to as Region I. As Prof. B. D. Culver has aptly pointed it out İskele is "a natural human boron laboratory" together with surrounding villages. An open pit called Acep still lies side-by-side with the walls of some dwellings in İskele. The town has a population little over 2000.

Separated by the River Bigadiç (Simav River) are Bademli, Değirmenli and Kadıköy villages far way from borate deposits and the facility, even though they too lie within the same geological zone -collectively referred to as Region II as a control of some sort in early days of the study. Many among other villages of Bigadiç and the province Balıkesir have been covered by so-called 'Bigadiç Controls'; this designation

however bears now no much value as before. In several of these villages there are inactive -left out- underground pits.

2. Kestelek area: Kestelek village is situated 22 km southeast Mustafa Kemal Paşa county, Bursa, with a borate area known since 1954. Near this small village there is an open pit and a processing plant.

3. Emet and Hisarcık areas: The two counties of Kütahya are 11 km apart each other with colemanite deposits discovered in 1956. Here Kocaçay (Emet River) runs across the valley with thermal resources aside. Underground mining has been abandoned in Kestelek and Emet-Hisarcık belt in 1990's.

4. Kırka region: The last center of borate industry active since 1968 is Kırka town of Seyidgazi county, Eskişehir. Kırka-Sarıkaya line of borates extending west is the world's largest deposit ever discovered. Likewise there are several inactive underground pits. In all these areas colemanite and ulexite are dominating major borate species -minor ones and other details can be found elsewhere (13).

Triangle formed by Sultançayırı, Aziziye and Yıldız villages have been the first quarters of production as already mentioned, and were included to evaluate late effects of boron exposure. Additionally, Bandırma Borax and Acid Plants built in 1976, were covered. Here borax, boric acid, borax decahydrate, borax pentahydrate, sodium perborate tetrahydrate and sodium perborate monohydrate are processed as refined products. These and concentrated mineral brought out here from other centers are also shipped worldwide. It has been stated that boron content of soils in Türkiye ranges from 0.75 to 4.55 ppm (mg/kg; 14).

Boron Exposure

Second parameter was boron amount of drinking and utility waters piped out through springs and wells. For convenience study areas were divided into three: a) Those places up to 2 ppm (mgB/l); b) those up to 10 ppmB, and c) those with higher levels. The highest concentration was consistently found in İskele-

Osmanca belt. It is 6.7-9.7 ppmB in one street fountain, and 18.5-29.0 in the other which both still are in use. There are reports showing that the amount has been measured as high as 60-90 ppmB in a well in the heart of the town – not in use any longer. In recent years fresh water from a remote spring with as little as 1.7 ppmB is pumped out to houses. Boron amounts range from 0.1 to 2.8 ppmB/l in other places, none is due to contamination. Higher levels up to 9.05 ppmB are reported in Emet-Hisarcık belt. In Kırka the concentration is 0.30-2.35 ppmB.

Another parameter was dust amount; although it turned out to be not possible to discriminate boron dusts alone. The management has routine measures in different points across a pit and facility, and these also cover dust on clothes of workers at these places. As mixed dust it never exceeds the permissible level 10 mg/m³. Yet one would expect higher concentrations, thus heavy exposure, on some occasions.

Study Population

Anyone participated to the work was called proband, and the only criterion to be included was the presence of a marriage, no matter one spouse was a widow or divorced. For reasons explained below, study population was treated in two phases. In the first phase 2529 probands, and hence families, were ascertained (Table 1). Of these 2015 (79.6 %) were males and 514 (20.3 %) females, the excess of males being due to the nature of work. Concerning work 1459 (57.7 %) had a boron-related and the remaining 1070 (42.3%) boron-unrelated job. These corresponded to about 65 % of families in Region I, and about 45 % in Region II. There were 448 persons as 'Bigadiç Controls' composed of individuals both from Bigadiç area and far away. From Susurluk 65, from Bandırma 191, from Kestelek 166, from Emet-Hisarcık 732 and from Kırka 378 subjects were covered. Of males with a boron-related occupation 184 (7.2 % of total) and of females (at least) 53 (2.1 % of total) were retirees. Men and women worked only just a few months or years were not encountered as borate workers.

Table 1: Study areas and number of probands (proband families)

Province	County	Town/Village	No. probands	Total	
Balıkesir	Bigadiç	Region I*	İskele	266	359
			Osmanca	56	
			Yeniköy	37	
		Region II*	Bademli	55	190
			Değirmenli	53	
			Kadıköy	82	
Balıkesir	Bigadiç Controls'*			448	
Balıkesir	Susurluk			65	
Balıkesir	Bandırma			191	
Bursa	Mustafa Kemal Paşa	Kestelek		166	
Kütahya	Emet & Hisarcık			732	
Eskişehir	Seyidgazi	Kırka		378	
Totals				2529	

* Not credited in later work and publications.

At the beginning İskele, Osmanca and Yeniköy villages have been referred to as Region I, against Region II, formed by Bademli, Değirmenli and Kadıköy villages, relatively far away from the deposits and the facility, as controls of some sort, together with 'Bigadiç Controls'—this division was not maintained any further (see Table 1).

Methods

A questionnaire-based interview with the proband in field was the method of choice at the first phase. Details were not related only to participant himself (herself) but also to the spouse and offspring. Emphasis was mainly put onto the reproductive story; then to diseases, habits and drugs. No physical examination and laboratory tests were attempted to carry out in field but blood and urine samples were taken for different purposes (not to be given here). Pedigree data was obtained through the proband and analyzed to reveal if there was a clustering of childless families over generations, either vertical or horizontal. For statistical evaluation chi-square test was applied using SPSS for Windows 11.5 software package.

Findings

Demographic Data

Age distribution of male interviewers ranged from 19 to 92 years and that of females from 20 to 79, averaging 47.7 and 46.4 years, respectively. The means for individual areas were 37.5-56.8 for the former and 34.5-52.7 for the latter subgroup, implying that a relatively young population was under discussion.

General character of it was suburban so that approximately 75% of probands were natives of settlements surrounding borate centers. Of the remaining about 20% were from a nearby county and only 5 % from bigger places, namely, cities. The same was also applied for spouses; for nearly 70% of whom were born in the same place as the proband, and 20 % in a close quarter. About 10 % of participants were from a remote place. Needless to say, all were living all around at the time of inquiry, mostly in their home towns and villages with transportation offered by the management for those who work at a borate pit/facility. Couples were relatives between 17.1-22.7% percent of the cases, excepting such urban places as Bandırma and Susurluk. Educational state was likewise rural. While many elderly has no formal education at all, a considerable number of miners had preliminary school

training, again excepting metropolitan subpopulations. Some 20 % were high-school and about 5 % university graduates. These latter were engineers and administrative people in general.

Any marriage without offspring until about the end of the second year of wedding was considered primary type of infertility, provided couples applied no birth control devices. The two-year allowance was because of military duty of males, staying away from home. And any family childless at the time of inquiry despite previous conceptions and/or births was accepted secondary infertile.

Table 2 shows figures related to the marital state of probands from all 12 borate centers. In 2261 out of 2349 fertiles the marriage was continuing whereas 77 persons were widows, and 11 separated; the rates being 89.4, 3.0 and 0.4%, respectively. From the remaining 180 childless families, 81 represented recent marriages, 79 primary - and 20 secondary-infertility with rates 3.2, 3.1 and 0.8%, respectively. Couples without children changed

Table 2: Fertile and infertile probands

Marital state	n	%
With children		
Marriage continuing	2261	89.4
Widowed	77	3.0
Separated	11	0.4
Without children		
Recent marriage	81	3.2
Primary	79	3.1
Secondary	20	0.8
Total	2529	100.0

from 0 % in Osmanca to 6.5 % in Kestelek, differences between communities being insignificant ($\chi^2=15.65$, $p=0.15$). It seemed of note that very few subjects indeed were divorced.

In order to get a closer insight for fertility-infertility state probands were first treated with their birth place and then with occupation. Although open to critics, interviewers were divided into 3 subcategories with respect to their birth place. It was cumbersome however, for no one could separate properly boron-rich soils from -poor ones. Yet they were classified for practical purposes as boron-rich, boron-poor and -necessarily- as intermediate soils (Table 3).

It was found that 969 subjects born in a high-boron community had at least one living child at the time of investigation versus 32 who had no offspring at all, the rates being 96.8 and 3.2%, respectively. Similar findings were revealed for those from a boron-poor territory and an intermediary locality as well, proving that to be born on/near borate deposits is by no means a predisposition to infertility ($\chi^2=0.30$, $p=0.86$).

One of the important issues with this work is the fact that individuals from high-boron regions with elevated levels of boron in fresh water has a job at a nearby pit and/or a facility, thus exposing to the element both environmentally and occupationally. The time spent at this industry changed from 2 to 34 years, averaging 12 years for an active and 20.7 for a retired miner. In some cases both spouses have involved. Because of the occurrence of probands describing few months of work, only those with a 2-year job and longer were encountered for. As it can be seen in Table 4 primary infertility stood at 2.8 % relating

Table - 3: Birth place of fertile probands and infertility

Birth place (of both sexes)	Marital state				Total	
	Fertile		Primary infertile			
	n	%	n	%	n	%
Boron-rich territory	969	96.8	32	3.2	1001	41.1
Intermediary	1133	96.4	42	3.6	1175	48.3
Boron-poor territory	250	96.9	8	3.1	258	10.6
Total	2352	96.6	82	3.4	2434	100.0

Table 4: Boron-related occupation and infertility

Occupation (active&retired)	Marital state				Total	
	Fertile		Primary infertile			
	n	%	n	%	n	%
Boron-related	1356	97.2	39	2.8	1395	57.3
Boron-unrelated	996	95.9	43	4.1	1039	42.7
Total	2352	96.6	82	3.4	2434	100.0

to 1356 miners against 4.1 % covering 996 subjects having a boron-unrelated occupation ($\chi^2=3.3$, $p=0.07$). It then appears clear that to have a boron-related occupation does not associate with an increased frequency of primary childlessness.

To reveal if there is a concentration of infertility, one would expect more individuals would be affected, if an agent is in operation in a given kindred or a region or a professional class of people, pedigree analysis were carried out by means of individual files. In the first generation, involving fathers' and mothers' sibs of both proband and his (her) spouse primary infertiles were found 3.5 % among 3331 couples. In the second, covering sibs and cousins of probands and their spouses, probands themselves included, there were 9105 families of which 292 had no children primarily, making 3.2 %. This was 2.7 % concerning third generation, composed of offspring of probands and of their sibs. Briefly, this unique approach, a 3-generation analysis, revealed that primary infertility among 14,320 families was 3.2 %, quite similar to that of probands themselves, indicating no a common adverse attack to marital and childbearing properties of subjects under consideration is operational for at least 60 years if one puts a 20-years span per generation. This result has also been the case through the stories of miners among Susurluk contacteds. Besides it showed that no aggregation of childless families over generations have occurred remarkably. Secondary failures standing at 0.4 % indicate that reproductive performance is also not affected secondarily.

Despite several advantages this approach has an inevitable pitfall so as to lead to duplications, that is, to encounter some individuals repeatedly particularly in a small community with prevailing blood-related weddings. To prevent this, and to rule out any possible critics so far, marriages of brothers and sisters of both proband and his (her) spouse were taken into account only. Primary type of infertility was found 2.4, 2.5, 4.2 and 3.3 %, respectively, and 3.1 % concerning 6464 families in total. The differences being insignificant and findings quite similar to those mentioned above, this last independent study leaves no room for any other alternative.

Familial occurrence of childlessness was of further attack. Boron industry has created in time the so-called 'borate families' in 'borate towns'. There are such kindreds with father, mother, son, brother... being active or former borate workers. If boron exposure interferes with human fertility, one should meet with such kindreds in which two or more members sharing the same milieu would have the condition. Data from 12 borate centers showed that there was another active or retired miner in addition to proband in 171 (52.9 %) cases; two in 68 (21 %) cases; three in 27 (8.3 %) cases; four in 29 (8.9 %) cases, five in 7 (2.1 %) cases; six in 3 (0.3 %) cases; seven in 5 (1.5 %) cases; eight in 3 (0.9 %) cases and nine in 1 (0.3 %) case - about 13 % of total. Fifteen families only out of 323 kindreds were primary infertiles, making an incidence 4.6 % that was not higher than those observed across the work. This figure was 6.9 % with 4 examples relating to 58 kindreds where proband himself was not borate worker. This and the fact that among 2529 probands as well as some 15,000 within-proband

families only 75-80 couples described 1-4 members with infertility that could not be regarded significant.

To end up the presentation two more issues are to be addressed. One is pertaining to the second phase of the study. Since the conclusion drawn here might be criticized by the assumption that anyone reluctant to be questioned before the public or because of another reason or an appointment might not be covered, thus lowering the rate of infertility unduly. Although much care has been paid not to introduce a bias or make a selection, to ensure data be cleared of any suspicion all borate centers were once more visited, and computerized files of both workers and employers asked. Table 5 shows data offered by personal departments. They included marital state and related things; however no information was available on the number of abortions or dead offspring. Similarly no mention was there whether childlessness is primary or secondary.

By May 2003 there were 2375 workers and 534 employers in all facilities, and infertiles were found 1.7 % with only 40 persons among workers, and 4.3 % with 23 subjects among employers (Table 5). The difference between two subpopulations was significant and not unexpected both on technical and socio-cultural grounds ($\chi^2=14.16$, $p<0.001$).

Table 5: Fertile and infertile marriages between workers and employers in all facilities

Marital state	With children		Without children		Total
	n	%	n	%	
Worker	2335	98.3	40	1.7	2375
Employer	511	95.7	23	4.3	534
Total	2846	97.8	63	2.2	2909

These figures clearly indicate that childlessness is not a matter for both workers and employers giving services at close buildings; though borate exposure for the latter might not be comparable. As stated before this last approach

provides firm evidence that borate exposure, how heavy and continuous it is, at present levels do not affect reproduction primarily and secondarily.

Controls

Because of the lack of reliable information concerning infertility prevalence across the country, controls were of our own, and derived from several sources as well as from seemingly boron-poor regions. Almost all have been collected at random throughout.

There were 88 families from Balya, Balıkesir, one of the earliest sites of mining in Türkiye; 81 families from Altınova, Ayvalık, Balıkesir, a sea-and-sun town, and 74 families from Çamlıdere, Ankara. Primary type of infertility was found 2.3, 4.9 and 4.0 %, respectively. Not tested statistically, an overall rate 3.8 % among 243 appeared quite comparable with those reported for borate areas. Pedigree data were also remarkable: 3.9 % childless with respect to 2215 marriages over 3 generations. Lastly we will refer to a general-population survey (15, 16): prevalence of the primary infertiles relating to over 50,000 couples gathered from almost all parts of the country hardly exceeds 4 %.

These findings, i.e., similarity between frequencies among probands, among 3-generation families, among families of probands' sibs, and among control- and general-population families do lend support to the conclusion already reached that boron exposure at the present levels environmentally and/or occupationally does not harm human reproduction primarily and secondarily.

Discussion

The population presented here displays several features of bearing. First of all, nearly 85 % of participants are natives of settlements on or near borate deposits and processing plants. They have been living thereabouts lifetime without much moving, mainly engaged in traditional agriculture and animal husbandry no doubt for centuries. Secondly, the same holds true for

spouses, since over 90 % of them have come from the same milieu. Briefly, the population is rather homogenous, though suburban in general. Inter-marriages, running about 20 %, excepting urban communities, would add weight to this structure. It is so a convenient sample exhibiting similar features over generations and the study is an observational one, being the first of its kind.

This peculiarity finds echo in living styles, hence marital characteristics and in turn in fertility-infertility states. Theoretically, three different sets of population could be defined regarding borate exposure, either environmental or occupational or both environmental and occupational. However it was not so easy to distinguish each in practice. Primary infertility was around 3 % and the secondary 0.5 %. Figures were consistent throughout the work, and were so between different subgroups of probands, between borate regions as well as between generations, and were comparable with figures 3.2-4.6 % of controls. This low rate in subjects having borate job could not be ascribed to some workers have escaped from questioning. Number of infertiles in subpopulations was not high enough to cause any difference of meaning. Besides, clustering of the condition was not significant over generations nor in so called 'borate families' of borate towns (11), thus ruling out the operation of a common environmental agent, boron in this case, is harmful to human reproduction. Individuals from high-boron territories with elevated level of boron in waters and residing on/near deposits thus exposing to borates for years had nothing to do with generative performance. Though considered primary one would expect late fertility in some, slightly reducing the observed rate.

As an independent test of some sort to prevent duplications unavoidable across a community with prevailing consanguineous marriages, infertility-fertility states of male and female sibs of probands and their spouses were treated separately. Again the rates ranged from 2.3 to 4.0 % without concentration of infertiles. No etiology was addressed with this study; nevertheless, because of the fact that many miners have

married before or just after the work, a supposition that exposure to borates causes infertility remains unsupported. It is then clear that the underlying basis would be the trends of marriage and childbearing. The low rate of infertility concerning workers of borate facilities only should not be underestimated.

In a conference delivered to Gynecology and Obstetrics Seminar in 1974 Baran declared the rate of women complaining from sterility was 13.4 % depending out-patients admissions (17, see 21). Later on General Director of Health Ministry spoke in 1985 that the prevalence of infertility was at least 15 %, even though a reliable study has not been available (17, see 21). In a recent publication frequency of "infertile women not under pregnancy risk" was given 6.9 % for the year 1993, and 6.6 % for 1998 (18). Although there was not a mention whether the rate represented primary or secondary failures, these last figures are rather close to those given here. In another work it has been found infertility was 2.2 % in a segment of the population (19).

Inhalation route of borates has extensively been worked out in different species, and it has been claimed that testicular atrophy is associated in rats with aerosol exposure of boric acid (6, 20). Despite systemic uptake due to swallowing particles, the most frequent and appreciable general-population exposures are from ingestion of food and of beverages (2-4). Occurrence of only 34 subjects supposedly under heavy and continuous borate pressure among 1423 miners do not support that respiratory intake is associated with human infertility.

Although not given here in detail one of the findings was the presence of families having 5 or more children in those days where birth controlling (or family planning) have not been so effective (21). Today's couples even in villages do get fewer offspring than their parents. Elderly people have apparently enjoyed having as many children as they liked or could do, implying that reproductive performance has not been affected at boron exposure at present levels for centuries.

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