intermediate number of bristles. Although the difference between low and stabilizing lines is not significant statistically, the flies from stabilizing selection line produce more progeny and show higher fertility than the low line flies.

It has been found that *D. ananassae* flies possessing high number of sternopleural bristles are more successful in mating than those with low number of bristles[6]. Thus *D. ananassae* flies with high number of sternopleural bristles are more successful in mating and also show greater fertility than the flies with low number of sternopleural bristles. This provides evidence for a positive correlation between sternopleural bristle number, mating propensity and fertility in *D. ananassae*.

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Chronic arsenic toxicity in West Bengal

I have read with interest the paper 'Arsenic in ground water in seven districts of West Bengal, India – The biggest arsenic calamity in the world', by Mandal *et al.* (*Curr. Sci.*, 1996, **70**, 976–986). Without undermining the gravity of arsenic calamity in West Bengal, I believe that many figures presented in the paper are not based on materials and methods used for the scientific presentation. Materials investigated in the study are water samples of the affected villages and hair, nail, skin and urine samples of some of the people residing in those villages. No scientific epidemiological methodology was described in the paper. Under the circumstances, how was the figure of 20% of the people suffering from chronic arsenic toxicity due to drinking arsenic contaminated water arrived at? Similarly the statement that more than 200,000 people have skin lesions is conjectural. The figure may be much less or much more. Unless an epidemiological survey using statistically designed sampling method involving the whole affected region is carried out one cannot be sure regarding the total number of the affected people.

It needs to be emphasized that diagnosis of chronic arsenic toxicity on the basis of the only finding of diffuse melanosis is fraught with over diagnosis of dark complexioned rural population as suffering from the clinical disease. One is therefore not sure whether 60% of children of Madanpur village of Murshidabad are actually suffering from chronic arsenicosis.

It needs to be further stated that muscle biopsy is not done for the confirmation of diagnosis of chronic arsenic toxicity. Though detection of high level of arsenic in body tissues like nail, hair, skin scale in association of characteristic clinical manifestations of chronic arsenic toxicity confirm the diagnosis of arsenicosis, one can have definitive features of the disease in absence of elevation of arsenic level in those tissues.

We have recently completed an epidemiological survey of South 24 Parganas, one of the affected districts with financial assistance from Rajiv Gandhi National Drinking Water Mission.

We have observed typical raindrop pigmentation of the skin and thickening of the palm and soles characteristic of chronic arsenicosis in 8.82% (152) and 3.64% (368) respectively among 4171 persons who were drinking arsenic-contaminated water (0.05–3.2 mg/l). On the other hand, pigmentation was found in 13 cases and thickening of palm and sole in 4 cases out of 3235 persons drinking water having arsenic level between 0.01 and 0.05 mg/l. None of the 277 people drinking water having arsenic level less than 0.01 mg/l had any pigmentation of skin or keratosis.

Since 1983 we have investigated 248 patients suffering from chronic arsenic toxicity due to drinking arsenic-contaminated water and attending our Post Graduate Medical Institute. The common presenting features found in these patients were rain-drop pigmentation (94.35%), thickening of palm and sole (65.3%), dyspepsia (65%), cough with or without expectoration (62.5%) and burning sensation of the eyes (29.8%). Important physical signs were anaemia (43.9%), hepatomegaly (76.6%), splenomegaly (29.4%), rhonchi and crepitations of the lung due to restrictive and/or obstructive lung disease (30.24%) and polyneuropathy (8.04%). Skin cancer was found in 2% of the case.

The clinical manifestations of chronic arsenicosis as observed in West Bengal are varied and more severe than those observed in other parts of the world.

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Mandal et al. reply:

We appreciate Guha Mazumder's comments but some clarifications are necessary.

For the last 2 years the School of Environmental Studies (SOES) is studying in detail *only one block* out of 55 arsenic affected blocks of 7 districts. The study is made on the anticipation that the results of a detailed study in one block may permit extrapolation of the situation of other blocks. Some blocks according to our survey report are known as seriously affected, like Domkal in Murshidabad, Kaliachalk in Malda and some blocks not so much affected as Baruipur and Sonarpur in South 24-Parganas and moderately affected are some blocks as Basirhat I, Deganga of North 24-Parganas. We have chosen Deganga block for a detailed study. Table 1 summarizes a detailed survey report of Deganga block for a two-year period.

Table 1. Survey report of Deganga block under North 24-Parganas*

Parameters studied	
Total area of Deganga	: 201.05 sq. km
Total population of Deganga	: 234142
Total no. of Gram Panchate (G.P.) in Deganga	: 14
Total no. of G.P. where arsenic in water above 0.05 mg/l	: 14
No. of G.P. where arsenic patients were detected	: 10
Total no. of Mouzas	: 108
Total no. of Mouzas where arsenic in tubewell water more than 0.05 mg/l	: 93
Total no. of tubewells in Deganga (almost)	: 15000
Total no. of tubewells analysed for arsenic	: 8500
% of the tubewells having arsenic within 0.01–0.049 mg/l	: 18%
% of the tubewells having arsenic above 0.05 mg/l	: 40%
Total shallow tubewells in use for agriculture (recently started this work)	: 110
% of the shallow tubewells having arsenic above 0.05 mg/l	: 43%
Total no. of school tubewells analysed for arsenic	: 84
% of the school tubewells having arsenic above 0.05 mg/l	: 50%
Total no. urine samples analysed	: 4867
% of urine samples having arsenic above permissible limit (40 µg/1.5 l/day)	: 86%
Total no. of nail samples analysed	: 1450
% of nail samples having arsenic above permissible limit (1.08 mg/kg)	: 78%
Total no. of hair samples analysed	: 1360
% of hair samples having arsenic above permissible limit (1 mg/kg)	: 48%

* For the last 2 years seven persons are engaged six days a week for survey work in Deganga.

Table 2. Analytical report of water, hair, nails and urine of South 24-Parganas district*

Sample	Total no. of samples analysed	Total no. of samples having arsenic above maximum permissible limit	Percentage of samples having arsenic content above maximum permissible limit	Range from above maximum permissible limit
Water	458	249 (above 0.05 mg/l)	54.37	0.05–2.22 mg/l
Urine	467	232 (above 40 µg/1.5 l/day)	49.68	40.00–9375 µg/1.5 l/day
Hair	509	274 (above 1 mg/kg)	53.83	1.00–7.43 mg/kg
Nail	464	246 (above 1.08 mg/kg)	53.02	1.08–57.4 mg/kg

Maximum permissible limit of arsenic in drinking water : 0.05 mg/l.
Normal range of arsenic in hair : 0.08–0.25 mg/kg.
Normal range of arsenic in nail : 0.43–1.08 mg/kg.
Normal range of arsenic in urine : 5–40 µg/1.5 l/day.
* These are the results of a joint project of School of Environmental Studies with D. N. Guha Mazumder in epidemiological study of South 24-Parganas.

It is clear that 234,142 people were consuming tubewell water from 15,000 tubewells (our survey reveals that most of the people drink tubewell water). On an average, 40% of the total tubewells we have surveyed (8500) contain arsenic above 0.05 mg/l, leading to the estimate of 93,600 people in Deganga block alone drinking arsenic-contaminated water. Assuming conservatively only 50% of the value we have calculated is correct, then even 2.55 million people were drinking arsenic contaminated water above 0.05 mg/l in 55 blocks.

Chakraborti and Saha[1] studied the incidence of arsenical dermatosis in 14 villages of West Bengal in 1987. Dermatosis was characterized by diffuse and palmoplanter melanosis and keratosis. According to their study the lowest arsenic concentration in water producing dermatosis was found to be 0.2 mg/l. In our study at Deganga block, about 7.3% tubewells have arsenic concentration above 0.2 mg/l. So, at Deganga block about 17,000 people are drinking arsenic-contaminated water and according to the study of Chakraborti and Saha these people, i.e. about 18% of the people drinking arsenic-contaminated water may have dermatological symptoms. We mentioned at the very beginning that Deganga is a moderately-affected block in seven districts. So our observation of about 20% of the people showing arsenical skin lesions out of the total people drinking arsenic-contaminated water in West Bengal may not be ruled out.

In West Bengal the affected villagers are farmers and they consume a high amount of water (5–6 l per day). Several studies all over the world provide quantitative toxicity data in human following chronic oral exposure to arsenic. Taking together, these studies clearly indicate that chronic intakes of about 10 µg/kg/day or higher may result in dermatological and other signs of arsenical toxicity[2]. The study of Chakraborti and Saha identified a Lowest Observed – Adverse – Effect-Level (LOAEL) of 18 µg As/kg/day of dermal and hepatic effects. This value is strongly supported by several other studies that identified similar LOAEL values; Hindmarsh *et al.*[3] LOAEL = 19 µg/kg/day; Cerbrian *et al.*[4] LOAEL = 14 µg/kg/day; Abernathy *et al.*[5] LOAEL = 14 µg/kg/day.

Table 4 of our published paper in *Current Science* reports that approximately 20% of the population exposed to arsenic-contaminated water in Taiwan, Chile, Argentina, Mexico, Thailand have arsenical skin lesions. This is similar to our prediction that 20% of the total population drinking arsenic-contaminated water above 0.05 mg/l (1.1 million) may have arsenical skin lesions. Also our survey in many villages shows that up to 40% of the people have arsenical skin lesions. In one such village (Shanpukur, Deganga) D. N. Guha Mazumder went with us and we found that 40 people out of 60 we surveyed had arsenical skin manifestation. The dermatological study carried out in Deganga over the last 2 years will be published soon.

Further, D. N. Guha Mazumder reports that recently he has completed an epidemiological survey of South 24-Parganas, one of the affected districts with financial support from Rajiv Gandhi National Drinking Water Mission (RGNDWM). In fact, one of us (DC) is a co-investigator on this project and all water (458), hair (509), nails (464),

Table 3. Arsenic content in hair and nail and dermatological features of a group of children up to age 10 years in Madanpur village, Murshidabad district, Block: Bhagawangola-II

Patient no.	Age (year)	Sex	Arsenic content in nail (mg/kg)	Arsenic content in hair (mg/kg)	P.P. Melanosis		P.P. Keratosis	
					Diffuse	Spotted	Diffuse	Spotted
1	4+	F	8.63	1.26	+	+	–	–
2	5+	F	6.52	1.27	+	+	–	–
3	5+	M	9.32	1.64	+	+	–	–
4	6+	F	17.68	3.68	++	++	–	–
5	6+	M	28.36	3.21	++	+	–	–
6	6+	M	12.35	2.36	+	++	–	–
7	6+	F	6.69	1.52	+	+	–	–
8	6	M	8.64	1.65	+	+	–	–
9	6	M	10.81	2.12	+	+	–	–
10	6+	M	4.43	1.82	+	+	–	–
11	7+	M	8.80	1.74	+	+	–	–
12	7	M	10.65	2.12	+	+	–	–
13	7+	M	25.37	2.96	++	+	–	–
14	8+	F	18.12	3.60	+	++	+	–
15	8	F	13.69	2.88	++	++	+	–
16	8+	M	4.00	1.54	+	+	–	–
17	8	M	7.91	1.88	+	+	–	–
18	9+	M	57.70	2.27	++	++	+	–
19	9+	F	7.13	1.63	+	+	–	–
20	9+	M	6.86	2.86	+	+	–	–
21	10	M	NA	2.01	+	+	+	+
22	10	M	12.88	NA	++	++	+	+

NA – Not available.

Figure 1.

urine (467) were analysed in our laboratory. Table 2 shows the water, hair, nail, urine analysis report of an epidemiological survey in South 24-Parganas. A large population who have no skin manifestation but high arsenic in hair nails, urine may be subclinically affected. The report of Guha Mazumder to RGNDWM states that, he has identified arsenical skin lesions in some people drinking water containing arsenic in the range 0.01 to 0.05 mg/l.

Although the WHO recommended value in drinking water is 0.01 mg/l, many countries including India believe 0.05 mg/l is the safe limit. Thus according to Guha Mazumder even if people get arsenical skin lesions drinking arsenic-contaminated water from 0.01 to 0.05 mg/l then the magnitude may be much higher than we anticipated.

In response to the comment 'Findings of diffuse melanosis is fraught with over-diagnosis of dark complexioned rural population as suffering from the clinical disease', we like to state that due to over length of the paper we could not provide the details of analysis of hair, nail and dermatological symptoms of the Madanpur village children. Table 3 gives the arsenic in hair, nail and dermatological features of some of the children and Figure 1 is the children of Madanpur village having arsenical melanosis (60%).

The following points will further explain the relation of dermatological symptoms and arsenic toxicity.

Pigmentations and arsenical toxicity

In the art of diagnosis of a disease, history is of prime importance followed by clinical examination findings which have to be confirmed by laboratory and other investigations. Findings of one clinical sign without correlation of the other two (history and investigations) never points to the disease. There are

Table 4. Area-wise family distribution of arsenical dermatosis

Village	District	No. of families	Population	No. of the affected family	Percentage	Total members of the affected family	No. of the affected persons	% of affection	
								In village	In family
Gangapur, Barasat	North 24-Parganas	68	243	11	16.18	55	23	9.46	41.82
Ramnagar	South 24-Parganas	24	248	10	41.70	63	58	23.00	92.10
Daulatpur, Habra	North 24-Parganas	21	119	13	61.90	79	40	33.61	50.63
Kachua, Binimoypara, Habra	North 24-Parganas	35	148	22	62.90	116	75	50.70	64.70
Kalobari, Habra	North 24-Parganas	39	168	17	43.59	101	36	21.43	35.64
Madra	Bardhaman	12	763	3	25.00	14	13	17.10	92.86
Charmajdia	Nadia	15	83	3	20.00	35	18	21.69	51.43
Gopalnagar, Karimpur	Nadia	7	51	7	100.00	51	44	86.27	86.27
Katlamari,	Murshidabad	48	335	44	91.67	317	175	52.24	55.20
9	5	270	1471	104	49.63	831	482	35.77	58.00

too many causes of isolated melanosis (diffuse or spotted) as well as isolated keratosis (diffuse or spotted). A clinician should never call racial pigmentation (i.e. Africans), dark coloured persons, solar melanosis, drug-induced melanosis, haemochromatosis, suprarenal deficiency (Addisson's disease), ochronosis, xeroderma pigmentosa and many other hyperpigmentary conditions as arsenical melanosis, because there are distinctive diagnostic criteria of each condition. The differentiating features of arsenical melanosis from all other hyperpigmentary states are taught to the students of dermatology.

When both melanosis and keratosis are present in the same patient, the problem of diagnosis becomes simplified pointing to arsenical dermatosis but these features are not present during birth or before 2 years.

As the keratin layer of palms and soles is thick compared to that of soft skin of body, palms and soles remain non-dark in dark skinned persons which becomes dark in some pathological melanotic states, easily recognized by comparing with the palms of unaffected dark persons.

In Mandapur village arsenical melanosis was pointed to the acquired darkening of palms, not from general pigmentation alone. These were confirmed by high arsenic in nails and hair (Table 3).

Arsenical melanosis is an acquired condition contrary to racial, genetic and other congenital pigmentations.

Clinical expression

From the analysis of arsenical dermatosis in 9 villages in 1985 by K. C. Saha (Table 4) it can be easily seen that all the individuals of the affected family do not have clinical signs of the disease though many of them later on developed the clinical disease if the intake of contaminated water was continued.

Many of these apparent normal subjects show high arsenic in nails, hair and skin scales proving their subclinical arsenical toxicity.

In my grouping of the stages of arsenicosis, the different stages of clinical expression have been clearly mentioned e.g. (i) Chemical or transient phase, (ii) Subclinical or persisting phase, (iii) Clinical melanosis phase, (iv) Clinical melanokeratotic phase, (v) Phase of internal complications (liver, muscles and other organs), (vi) Carcinoma.

Though arsenicosis is a generalized disease, clinical expression in skin appears earlier than the complicating phase of internal toxicity.

Muscle biopsy

For the diagnosis of arsenical toxicity, easy available tissues like skin scales, nails and hair and skin biopsy are recommended rather than routine muscle biopsy, liver or kidney biopsy.

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