Frequencies of chromosomal aberrations in rodents of the Rimac Valley - Perú

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The present study analyzes the frequency of chromosomal aberrations found in rodents living in a polluted area near the Rimac river (Casapalca, minery zone) at 120 Km of Lima, compared to that observed in a non-polluted area in the Department of Lima, Perú. The species analyzed were: ***Phyllotis andium, P. darwini*** *and* ***Akodon boliviensis.*** *The rodents were captured alive and bone marrow was processed the same day of capture to obtain metaphases. The results showed significant differences ($p < 0.05$) in the frequency of chromosomal aberrations in the rodents of the exposed area (2.46% of cells) vs those of the control area (0.82% of cells). These results are consistent with the hypothesis that heavy metals and pesticides present in the Rimac river may increment the frequency of chromosomal aberrations in rodents living near that river.*

INTRODUCTION

Toxicological genetics deals with the identification and analysis of toxic agents that modify the genetic material of living species (Garcia-Sagredo, 1991). Chromosomal aberrations may be considered as macroinjuries of the desoxyribonucleic acid (DNA) (Swierenga *et al.*, 1991). They are classified as numerical (lost or gain of one chromosome or a set of chromosomes) or structural (gaps, breaks, fragments, deletions, rearrangements, etc.) aberrations (Savage, 1976).

The Rimac river is used as the main source of water for the population established in the river bank, the city of Lima included. The river carries pollutants resulting from contamination by pesticides used in the agriculture and chemicals derived from the mining processes. Quantifications of metals present in the Rimac river, like iron, zinc, lead, mercury, copper and selenium, show quantities exceeding the permissible levels for human use of water (ONERN,1986). Contamination with pesticides used in the area near the river has not been monitored nor regulated.

Heavy metals represent a serious form of pollution in aquatic systems, since they do not degrade as most organic compounds do. Instead, heavy metals accumulate in aquatic micro- and macro-phytes, thus entering the food chain.

There is abundant information about the genotoxicity of metals and pesticides on some organisms (Apostolli *et al.*, 1989; Bauchinger *et al.*, 1977; Carson *et al.*, 1987; Dean, 1972; Deknudt and Deminatti, 1978; Deknudt and Leonard, 1975; Deknudt *et al.*, 1973; Dubins and La Velle, 1986; Ficsor and Lo Piccolo, 1972; Gabliks *et al.*, 1967; Hanna and Dyer, 1975; Nicholas and Van Den Berghe, 1982; Yoder *et al.*, 1973).

The high concentrations of heavy metals observed in the Rimac river waters (ONERN, 1986), and the massive use of pesticides in the nearby area, are expected to result in an increased frequency of chromosomal aberrations in rodents living near the river. Thus, the present study compares the chromosomal aberrations observed in rodents residing near the Rimac river (Casapalca, minery zone) to those dwelling in the Marcahuasi's plateau of the Department of Lima, Perú, an still unpolluted area.

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MATERIALS AND METHODS

The study was carried out in the Rimac Valley, at the minery camp of Casapalca (4,154 m altitude), located 120 Km west of the city of Lima. Sherman traps were put in the Rimac river bank (Fig 1), at distances of no more than 15 m, in parallel to the river bed, selecting areas that meet some characteristics of possible habitat for the rodents (availability of food, refuge, footprint, etc).

The control area was localized in the Marcahuasi plateau (Fig 1), Community of San Pedro de Castas, in the zone commonly known as "Fortaleza" (4,100 m altitude). Its ecological characteristics are similar to those of Casapalca. This area is populated by the same rodents. However, this place is not inhabited by humans and should be free of contamination from mining or agricultural work.

Both Casapalca and San Pedro de Casta are between 11°-12° latitude south and 76°-77° longitude west (Fig 1).

The species analized in the present work were: *Phyllotis andium* (2n = 64) (Pearson, 1972), *P. darwini* (2n = 38) (Pearson, 1972) and *Akodon boliviensis* (2n = 40) (Myers *et al.*, 1990). The processing of the samples was done the same day of the capture, followed by the taxidermic preparations of

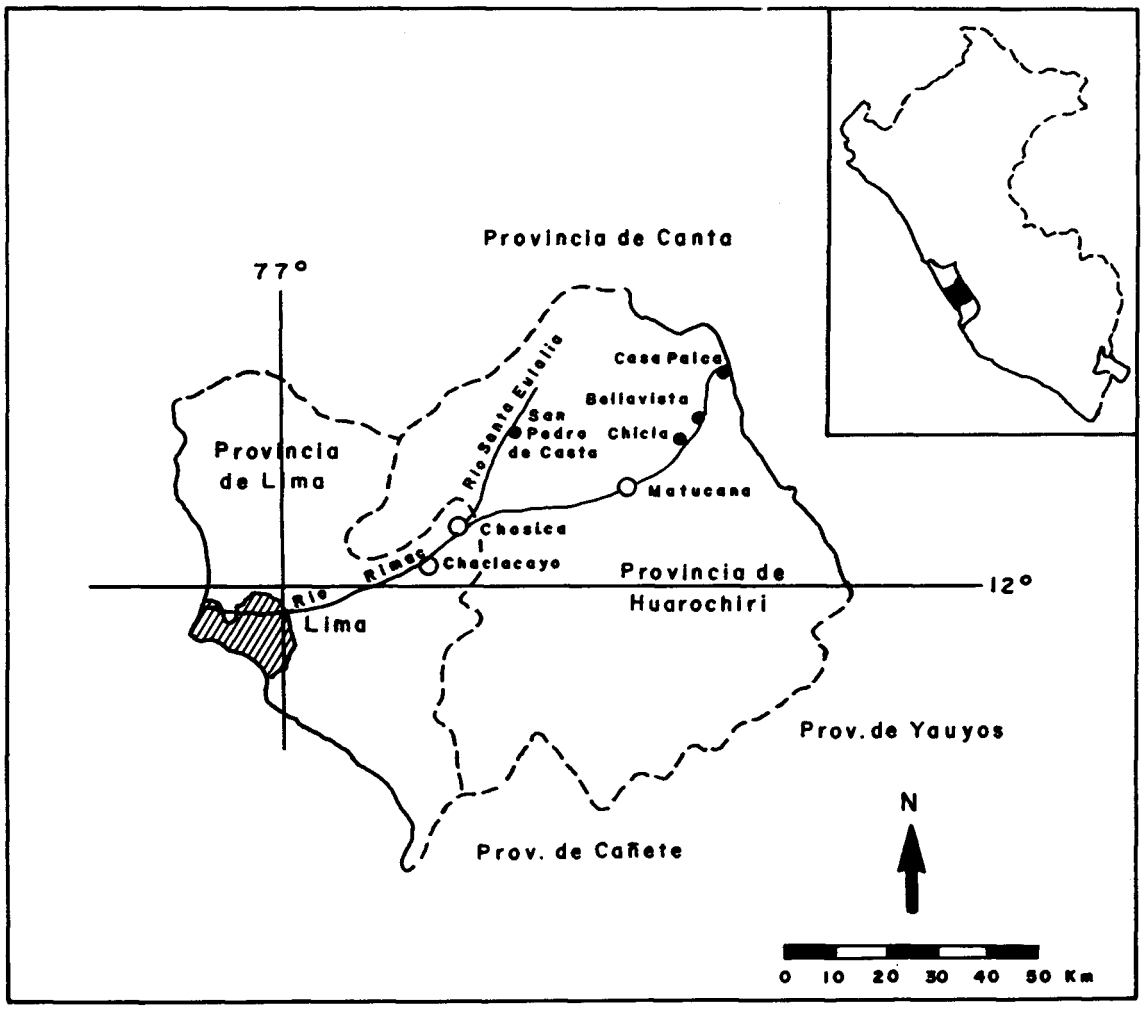

Fig 1: Location of collecting sites for capture of rodents included in this study. Names of places in Spanish, as originally named.

skin and cranium of the animals, which were identified and deposited in the Museo de Historia Natural, UNMSM, Lima.

Chromosomal preparations were obtained from the bone marrow of the femora using the methods described by Ford and Hamerton (1956), with modifications such as the substitution of the sodium citrate solution by KCl 0.075 M and the staining with 2% Giemsa for 15 min. One hundred metaphase plates were analysed for each animal (Preston *et al.*, 1987). Cells were selected for scoring on the basis of a good spread of metaphase chromosomes, good differential staining and normal chromosome number for each species.

The chi-square test was used for statistical analyses, accepting $p < 0.05$ as level of significance (Bragança, 1991).

RESULTS

The only type of chromosomal aberration found in our study corresponds to fragments or pieces of acentric chromosomes. Tables I and II show the frequency of chromosomal fragments (CF) in rodents collected from both the polluted and control zones. The percentage of cells with CF obtained from Casapalca rodents is 2.46%, while the percentage of cells with CF in Marcahuasi rodents is 0.82%.

In Table III we have compared the population of rodents (not considering the species) in the exposed area (Casapalca) with the control one (Marcahuasi). This table shows the number of cells with CF and the number of cells without CF (normal cells). Statistical analysis demonstrates a significant

TABLE I

Frequency of chromosomal fragments (CF) in rodents collected in Casapalca*

Species	Nº of animals	Nº of metaphases	Acentric fragments	Nº Cells with CF	% Cells with CF
P.andium	13	1,300	39	36	2.77
A.boliviensis	7	700	15	14	2.00
P.darwini	6	600	15	14	2.33
Total	26	2,600	69	64	2.46

* 100 metaphases analyzed per animal

TABLE II

Frequency of chromosomal fragments (CF) in rodents collected in Marcahuasi*

Species	Nº of animals	Nº of metaphases	Acentric fragments	Nº Cells with CF	% Cells with CF
P. andium	12	1,200	12	12	1.00
P. darwini	10	1,000	7	6	0.60
Total	22	2,200	19	18	0.82

* 100 metaphases analyzed per animal.
Specimens of *A. boliviensis* not captured in this area.

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difference between both populations. Table IV shows the statistical comparison between exposed and control groups of *Phyllotis andium* and *P. darwini*; in both cases the differences are statistically significant. The same analysis can not be done with *A.boliviensis*, since no samples of this species were obtained in Marcahuasi.

TABLE III

Statistical analysis of the numbers of cells with chromosomal fragments (CF) and without CF, in all rodents in Casapalca and Marcahuasi

Group	Nº Cells with CF	Nº Cells without CF	Size of sample	X^2
Exposed	64 (a)	2,536	2,600	19.62
Controls	18 (b)	2,182	2,200	
Total	82	4,718	4,800	

a, b: Significant differences ($p < 0.05$).
X^2: Chi-square.

TABLE IV

Statistical analysis of numbers of cells with chromosomal fragments (CF) for species of rodents in Casapalca *vs.* Marcahuasi

Species	Group	Nº Cells with CF	X^2
P. andium	Exposed	36 (a)	10.10
	Controls	12 (b)	
P. darwini	Exposed	14 (a)	7.50
	Controls	6 (b)	

a,b: significant differences ($p < 0.05$)
X^2: Chi-square.

DISCUSSION

The rodents collected in Casapalca show a high frequency of chromosomal fragments compared to those collected in Marcahuasi; these differences can be interpreted as effects of mutagenic contaminants in their environment, since it is known that Rimac river carries pollutants resulting from the use of pesticides in the agriculture and chemicals in mining processes.

The mutations microscopically detectable may point to: (1) mutagenic agents provoking such alterations, (2) inefficient repair mechanisms, (3) affected cells not being eliminated, and (4) increasing genetic load for the population. Since organisms carrying these alterations are surviving, the damage described in this study might nonetheless be just a fraction of the total damage. Other cells and/or organisms carrying mutations, which died as a consequence, will not be detected (Bueno *et al.*, 1992). Therefore, we assume that the presence of these pollutants may have produced the cytogenetic damage reported in this work. Our results agree with the observations of Bueno *et al.* (1992), who analyzed the frequency of chromosomal aberrations in *Akodon cursor* and *Oryzomys sp.* of the Sangâo river (Forquilhinha, Criciuma - Brasil), which has a high level of pollutants, mainly due to residues of industrial, agricultural and mining activities.

Biomonitoring the environment through cytogenetic techniques applied to wild rodents may serve as an important methodology for the evaluation of the genotoxic effects of environmental pollution. However, we believe that other animal models (marsupials, amphibians, fishes, mollusks, etc) should also be assayed. In this way one could be able to plan proper investigations, using the animal model appropriate for each specific case.

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