F. García Novo, F. Díaz Pineda y A. Gómez Sal, coords.

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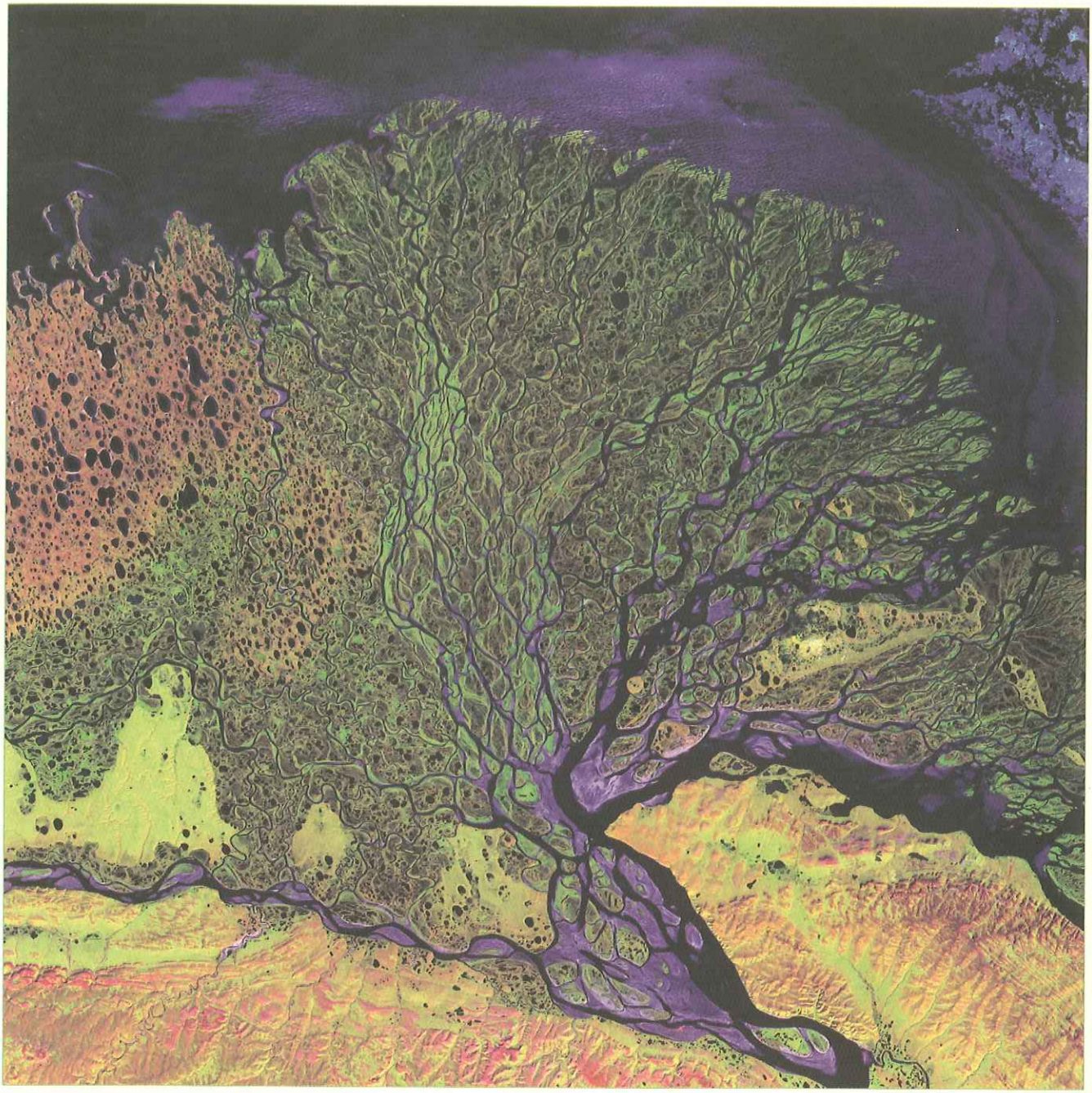

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# *Drosophila* chromosomal diversity and climate-warming

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## Introduction

Greenhouse-induced increase in world temperature has been inferred to be exceedingly rapid compared with prehistoric changes of similar magnitude. In such scenario, biological systems that are currently at equilibrium with their environment will have to deal with ecological circumstances that no longer fit to those in which they evolved. As a result, it is expected that, unless populations can track the environment to which are preadapted by shifting their geographic distributions, adaptive evolution may be the only route to long-term species survival. In spite of this, microevolution has been neglected from research devoted to unveil the biological consequences of global-warming (5). Here, we present results of a 16-yr study of the chromosomal diversity of *Drosophila subobscura* in a southern-Palearctic locality (NW Spain) experiencing a sustained climate-warming since ~1976 (Fig. 1).

## Material and Methods

The study site was located at 260 m altitude on the south slope of El Pedroso mountain, 3 km from Santiago de Compostela. Samples were collected by net sweeping over conventional mashed banana baits. Methods for chromosomal isolation and staining were described in Rodríguez-Trelles *et al.* (4). Dates of collection were chosen to coincide with four significant seasons in the yearly active period in natural populations of *D. subobscura* at this latitude, spring, early summer, late summer, and autumn. The sampling spanned 16 years, from 1976 to 1980 and from 1988 to 1991. Up to 15 different O inversions were found. Chromosomal diversity was computed as 1-IFR, where IFR is the Index of Free Recombination (1). This coefficient has the advantage of having in account not only the number of inversions and their frequency, but also their length. The index quantifies the amount of euchromatin that is heterozygous for gene arrangements and it is basically a measure of heterozygosity weighed by the length of the inversions.

$$1 - IFR = \sum_{i,j=1\ i\neq j}^{k} \cdot p_i \cdot p_j \cdot (1 - l_{ij})$$

where $p_i$ is the relative frequency of the O arrangement i, $p_j$ is the relative frequency of the O arrangement j, $l_{ij}$ is the proportion of O euchromatin that freely recombines between arrangements i and j, and k is the number of different O arrangements in the sample. Because we did not record individual genotypes but only inversion frequencies, we assumed Hardy-Weinberg heterozygote proportions. Temperature data were obtained at Labacolla Airport Meteorological Station, ~7 km from the study site.

## Results and Discussion

Annual mean temperature has significantly increased in the study area between 1976 and 1991 ($\Delta = 0.45$ °C; $y = -46.2$

+ 0.03x, r = 0.46, P < 0.01, N = 31); i. e. the year this study begun (Fig. 1). During the sampling period (1976-1991), there was a significant loss of *O* chromosomal diversity (18.3 %) (Fig. 2). This appeared strongly associated with increasing temperatures; in particular, with average minimum temperature. Regression models were y = 6.59 - 0.003x, for year ($r^2 = 0.30$; P = 0.010); and y = 0.35 - 0.007x, for average minimum temperature ($r^2 = 0.44$; P = 0.001).

The data show that chromosomal diversity has rapidly decayed over the study period, and point to that this occurred in response to climate-warming. In light of this, findings from another populations throughout the distribution range of the species (2, 3, 6), suggest that *O* chromosomal diversity is responding to the climate-warming affecting the Northern hemisphere since the mid-1970s. This study vindicates a more prominent role for evolutionary ecology in research on biological consequences of global-warming.

**References**


(1) Carson, H. L., 1955. Variation in genetic recombination in natural populations. J. Cell. Comp. Physiol., 45 (suppl. 2): 221 - 236.

(2) Gosteli, M., 1990. Chromosomal polymorphism in natural populations of *Drosophila subobscura* near Zürich, Switzerland: a contribution to long-term comparisons. Genetica, 81: 199-204.

(3) Orengo, D. J. & Prevosti, A., 1996. Temporal changes in chromosomal polymorphism of *Drosophila subobscura* related to climatic changes. Evolution, 50: 1346-1350.

(4) Rodríguez-Trelles, F., Álvarez, G. & Zapata, C., 1996. Time-series analysis of seasonal changes of the *O* inversion polymorphism of *Drosophila subobscura*. Genetics, 142: 179 - 187.

(5) Rodríguez-Trelles, F., Rodríguez, M. Á. & Scheiner S. M., 1998. Tracking the genetic effects of global warming: *Drosophila* and other model systems. Conservation Ecology [online] 2(2): 2. Publicado en Internet, [URL: www.consecol.org/vol2/iss2/art2]

(6) Zivanovic, G., Milanovic, M. & Andjelkovic, M., 1995. Chromosomal inversion polymorphism of *Drosophila subobscura* populations from Jastrebac Mountain shows temporal and habitat-related changes. Journal of Zoological Systematics and Evolutionary Research, 2: 81-83.


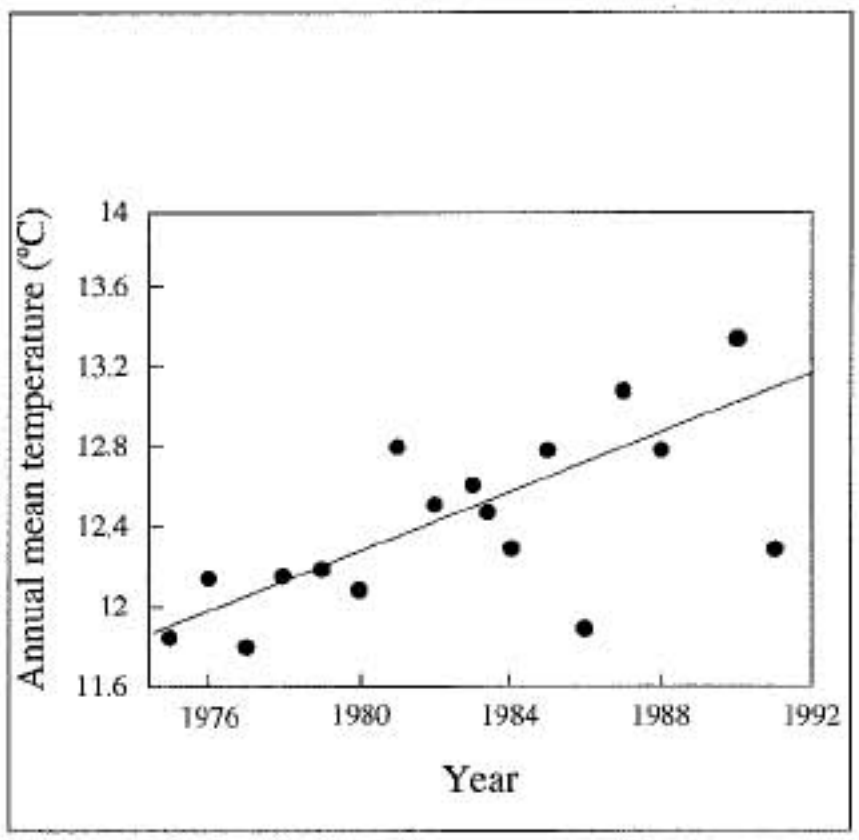


**Fig. 1.** Variation of annual mean temperature in the area during the study period.

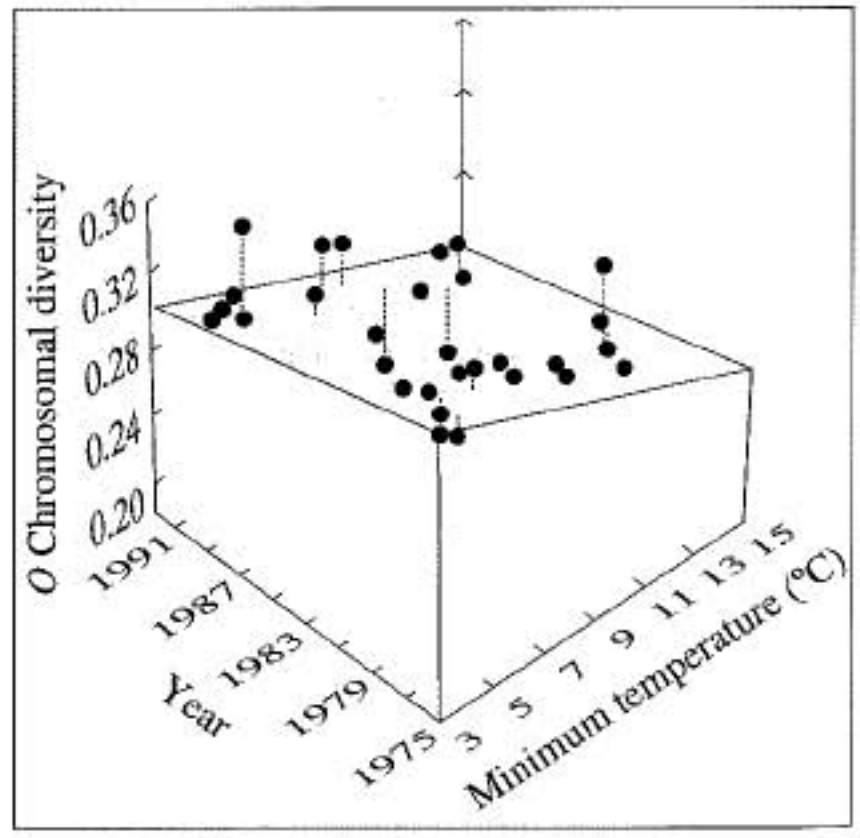


**Fig 2.** Relationships of *O* chromosomal diversity with time and average minimum temperature.

Imagen de portada: Delta del río Lena en el Mar Ártico de laptev, Siberia. El delta, de unos 45,000 $Km^2$, forma parte de la Reserva de vida silvestre Delta de Lena, de 61,000 $Km^2$. Imagen en falso color combinando bandas del Landsat 7, tomadas el 27-7-2000. Cedida por USGS Natural Center for EROS and NASA, Lansat Projet Science Office.



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