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SEX RATIOS IN NATURAL POPULATIONS OF *Drosophila pseudoobscura* FROM MEXICO

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Most species show an equal proportion of individuals of both sexes. In diploid species sex ratio is determined by a genic balance between sex chromosomes. In *Drosophila* sex is determined by the ratio of X-chromosomes versus autosomes and in some species of the genus it is related to the presence of an inversion in the sex chromosome. The present work analyses the sex ratio in 27 natural populations of *Drosophila pseudoobscura* that inhabit Mexico. Female flies captured in nature were counted and their sex ratio calculated and been called generation P, then cultured individualy, allowed to leave adult offspring which was quantified in order to get its sex ratio and designated generation F1. sex ratio was calculated using the expression: number of males times 100 divided by the

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number of females proposed by Darwin (1871). The sex ratio of each population was taken using the average of all the individual counts from each sample. The values found varied among different generations and populations, so for generation P their values varieded 37.4 to 190.4 and in generation F1 from 31.3 up to 96.4 males for each 100 females. According to their geographical distribution four North to South transects were arranged and in them means varied from 60.8 to 81.7 males for each 100 females. All this means that in Mexican population are more females than males, exceptionally more males than females.

Key words: Drosophila pseudoobscura, population, sex

INTRODUCTION

DARWIN (1859), mentions that natural selection tends to equalize the numerical proportion among sexes and when this tendency produces an equal number of individuals of each sex this is advantageous for the species, this condition leads to the concept of Fisher´s equilibrium (1930) given certain adaptation value to this parameter. Later on, DARWIN (1871) in "The descent of man...", dedicated a good amount of a chapter to the problem of numerical proportion among sexes and pointed out the importance and implications that represents the preponderance of either sex, among other observations he mentioned that the preponderance of one sex allows polygamy in the other sex and even more, points out how important is this numerical proportion in relation to natural selection with respect to sex and of course the advantage for the species.

Sex ratio in the species is related to a not jet complete explained mechanism of sex determination. Most species independent of the sex determination mechanism they present should show an equal proportion of individuals of each sex, so when sex is determinated by a sex chromosome then the numerical proportion of them is controlled by means of chromosomal segregation during meiosis, usually in males. In diploid species sex ratio is mainly determined by a genic balance of sex chromosomes in different combinations.

In *Drosophila* sex is determined by the proportion of sex chromosomes versus autosomes, (STURTEVANT 1949), even do, mechanisms by which numerical proportions among sexes are alterated are well known, in this context several species of the genus such are the cases of *D. pseudoobscura, D. persimilis* and *D. subobscura* among others, sex ratio is also related to the presence of a pericentric inversion in the sex chromosome (X) that tends to reduce the number of males, inclusive their complete absence, in the progeny of females carriers of that inversion, phenomenon first detected by MORGAN *et al.* (1925), this aspect is broadly studied in natural populations of *D. pseudoobscura, D. persimilis* and *D. subobscura* and other species, as examples we have reports such are the ones of Sturtevant and DOBZHANSKY (1936), DOBZHANSKY and EPLING (1944), BRYANT *et al.* (1982) and SALCEDA (2009) in natural populations of *D. pseudoobscura* and *D. persimilis* from the United States and Mexico; similar studies were done with *D. subobscura* by KRIMBAS (1992), TERZIC *et al.* (1997) and PASCUAL *et al.* (2004) in Europe.

Other mechanism that disturbs numerical proportion if sexes in *Drosophila* is meiotic drive first reported by NOVITSKI (1947) in *D. affinis,* this phenomenon is continuously studied in this and other species of the genus, a recent report is that of CAVASINI *et al.* (2008), which includes a short list of authors, and HANNA *et al* 2010 in two natural populations of *D. melanogaster.*

A third type of studies related to distortions of the numerical proportion of sexes in *Drosophila* and specialy in *D. melanogaster* is that initiated by KERR and KERR (1952) and continued by DRESCHER (1964) called sex limited effect. These three disturbing mechanisms of sex ratio or numerical proportion of sexes are of genetic importance.

Numerical proportion of sexes or sex ratio (from now on NP) could be represented in two ways: number of females per 100 males used by L´HERITIER (1936) with value of 106.8 females per 100 males found in *D. melanogaster* ; and PASCUAL *et al.* (2004) whom reported for *D. subobscura* more males than females in natural populations and more females than males in experimental ones; HANNA *et al* (2010) in *D. melanogaster* and *Zaprionus indianus,* from urban and rural location found more males than females, these authors gave values in percentage. The other representation for NP is that employed by DARWIN (1871) and given by the number of males for each 100 females, this latter option we consider more appropriate due to be the first one used for this purpose.

MATERIALS AND METHODS

This presentation does not concern directly with either mechanism of sex determination but rather with observed deviations in numerical proportions of sexes in several natural populations of *D. pseudoobscura* inhabiting Mexico, aspect in where less information is available.

Samples of *D. pseudoobscura* were taken in 27 locations along Mexico, they were arranged in four North-South transects to allow a possible gradients that could permit comparisons. Flies were captured by using 20-25 plastic buckets containing fermenting banana as attractant, when flies started to visit them and helping us with an entomological net they were caught, this operation was done in rounds of 15-20 minutes until achieving a considerable amount of flies, later flies were sorted by species and sex; *D. pseudoobscura* females in groups of 30-40 were kept into vials with fresh food and carried to the laboratory to perform this and other studies.

Once in the laboratory each female was cultured individually in a regular 1/4 pint flask with fresh medium an incubated for a week allowing them to lay eggs and their further development of larvae until hatching of adults. When adults emerged they were counted, sex ratio of the progeny for each culture was calculated and average sex ratio of each locality also calculated, this allowed us to build up a table with our results. Cultures were feed with a mixture of flour-sugar-yeast added with bactericide and fungicide of regular use in the laboratory and kept at 25± 1 ºC and 65% humidity.

RESULTS

A grand total of 1442 *D. pseudoobscura* females captured in 27 localities were analyzed in order to obtain their individual numerical proportion of sexes derived from their progenies an it represented by the expression: number of males for a 100 females as reported by DARWIN (1871). Those locations were arranged in four North-South transects to facilitate their analysis and looking for a possible presence of clines.

The mean sex ratio for the whole sample gave a value for the parental population of 85.9 males for each 100 females and for their offspring, generation F1 a mean value of 72.8 males for a 100 females, individually averages for each location or population varied from 31.3 up to 96.4 males for each 100 females.

Transect "A", the northern one, showed a mean proportion of sexes or sex ratio for P generation of 122.2, since we observed two very high values (those of populations Alcalá an Presa) we eliminated them and found a mean of 104.7 with variation from 89.8 to 190.4 ; in generation F1 its mean value was 60.8 with a variation from 32.9 to 84.7, these values correspond to six localities and represented by the offspring of 141 females.

Table 1. Sex ratio in natural populations of Drosophila pseudoobscura from Mexico. Transect "A"

POPULATION	Sex Ratio **P**	Sex Ratio **F1**	# Females
TORREON	111.9	78.8	21
LOS LIRIOS	89.8	54.4	76
D. de ALCALA	190.4*	34.5	11
PRESA	123.9*	79.8	7
PRESIDIO	107.1	84.7	10
MATEHUALA	110.0	32.9	6
MEAN	122.2 (104.7)	60.8	

Next in order, transect "B", had an average sex ratio in generation P of 57.7 with a range from37.4 up to 86.6 and in F1 generation of a 81.7 with values ranging from 63.3 to 95.1 and represented by the descendents of 547 females belonging to seven populations.

The third transect "C" in where ten localities were analyzed their mean parental value was 93.9 here also one population showed a high value of 161.8 and we eliminated it, so the new value is 79.5 with variations from 51.7 to 161.8; from their descendents with 623 sampled females we found a mean sex ratio of 68.0 and this varied from 31.3 up to 91.3 males for each group of 100 females.

Table 2. Sex ratio in natural populations of Drosophila pseudoobscura from Mexico. Transect "B"

POPULATION	Sex Ratio **P**	Sex Ratio **F1**	# Females
VALPARAISO	55.5	63.3	78
LA CONGOJA	86.6	75.1	166
RIO VERDE	46.4	74.6	147
LOS REYES	55.5	92.1	4
T. NUEVA	73.3	95.1	7
EL LOBO	50.0	88.1	30
P. de AMOLES	37.4	83.5	115
MEAN	57.7	81.7	

Table 3.Sex ratio in natural populations of Drosophila pseudoobscura from Mexico. Transect "C".

POPULATION	Sex Ratio **P**	Sex Ratio **F1**	# Females
VICTORIA	77.3	31.3	14
HUIMILPAN	114.3	91.3	12
TULANCINGO	51.7	86.4	128
CD. GUZMAN	116.7	85.7	4
ZIRAHUEN	161.8*	59.2	22
C. NUCLEAR	117.2	76.2	22
AMECAMECA	66.5	62.8	65
LA MALINCHE	97.6	65.5	39
EL SECO	61.7	81.7	250
LA PERLA	74.5	63.5	67
MEAN	93.9 (79.5)	70.4	

Table 4. *Sex ratio in natural populations of Drosophila pseudoobscura from Mexico. Transect "D".*

POPULATION	Sex Ratio **P**	Sex Ratio **F1**	# Females
F. de CABALLO	52.5	80.6	33
OAXACA	38.9	70.7	38
OCOSINGO	82.3	96.4	27
S.C. las CASAS	69.7	77.9	33
MEAN	60.8	81.4	

Lastly, transect "D" the southern one, represented by only four populations and 131 females analyzed showed a variation for this parameter with values from 70.7 up to 96.4 with a mean of 81.4 males for each 100 females in the F1 generation been that of their parents 60.8 ranging from 38.9 to 82.3.

All these data is shown in Tables I-IV. These tables give information such are: locality, their corresponding numerical proportion of sexes, number of females analyzed by locality, total number of descendents from which sex ratio was calculated and the corresponding average values for each transect.

DISCUSSION

As Darwin (1859, 1871) pointed out, numerical proportion of sexes has important implications in relation to natural selection, here without refering to such aspects but only to see how proportion of sexes is manifested, we gathered information concerning this parameter in 27 natural populations of *Drosophila pseudoobscura* inhabiting Mexico. We should mention two things: first which is the SR in nature, it means among the captured flies or parental generation and second how it is in their offspring or F1 generation, one with this explanation we are able to see how our data manifested this parameter in both situations.

Our data showed that in about one third of the sampled populations males prevailed over females but only in nature, it means in the parental generation, in all other cases in both generation females were more abundant, even do average values allways manifested a numerical superiority of females. In nature, generation P, this value ranged from 37.4 to 190.4 males for each 100 females; in F1 generation those values ranged from 32.9 up to 96.4.

Since we arranged our populations in four geographical north-south transects, it is possible to observe trends as follow: in northern most transect going south, from A to B in nature, generation P, it clearly showed a cline favoring females going from value of 85.9 to 57.7 but the contrary in generation F1 going from 60.8 to 81.7, then passing to transect C in generation P it raised to a value of 83.6 but generation F1 decreased to 70.4 and from this point to transect D new changes occurred so for generation P its value went down to 60.8 and in generation F1 it elevated to 81.4, in general it looks that alternate increases with decreases from generation to generation; these changes we assume are due to some climatic, geographic or even biotic (vegetation) factors such presence of a volcanic axe that produce higher elevation and changes in vegetation from xeric to arboreal.

As for comparisons with similar studies done with other species of the genus that are few , we could mention those that we consider relevant for our purposes, in this sense it is the one of l´Heritier (1936) who found in *D. melanogaster* more females than males in the ratio of 106.8 females per 100 males; in *D subobscura* Pascual *et al.* (2004) got more males than females in natural populations but the contrary in experimental ones; Cavasini *et al.* (2008) analyzing natural populations of *D. mediopunctata* also found more females than males and finally Hanna *et al.* (2010) observing *D. melanogaster* and *Zaprionus indians* from urban and rural populations in both cases found more males than females. Concluding we could say that the study if this parameter, numerical proportion of sexes , is quite variable both in nature and laboratory depending of several factors such are: kind of species, experimental or natural populations, geographic origin as well as climatic or biotic aspects like surrounding vegetation in where populations live. No doubt that this phenomena needs more studies of this kind as well those oriented to a better understanding of the way this parameter works in nature and how it responds to selection pressures.

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ODNOS POLOVA U PRIRODNIM POPULACIJAMA *Drosophila pseudoobscura* U MEKSIKU

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Većina populacija pokazuje iste odnose jedinki oba pola. Kod diploidnih vrsta odnos polova je determinisan genetičkim balansom polnih hromozoma. Kod *Drosophila* vrsta pol je determinisan odnosom X – hromozoma prema autozomima a kod nekih vrsta gena zavisi od prisustva inverzija u polnim hromozomima. U radu su predstavljeni rezultati odnosa polova u 27 prirodnih populacija *Drosophila pseudoobscura* koje žive u Meksiku. Utvrđen je broj ženki sakupljenih u prirodnim uslovima, odnos polova je izračunat i nazvan generacija P, gajene su individualno i ostavljene da daju potomstvo koje je kvantifikovano u nameri da se dobije njihov odnos polova označen kao F1 generacija. Odnos polova je izračunat korišćenjem jednačine: broj muških individual pomnožen sa 100 što je podeljeno sa brojem ženki kako je predložio Darvin (1871). Odnos polova svake populacije je uzet kao prosek svih individua izbrojanih u svakom uzorku. Utvrđene vrednosti su varirale između različitih generacija i populacija: za generaciju P vrednosti su varirale od 37.4 do 190,4 a u generaciji F1 do 96,4 mužjaka na svakih 100 ženki. Prema njihovoj geografskoj distribuciji formirane su četiri Sever-Jug preseka i u njima su proseci varirali od 60,8 do 81,7 mužjaka na svakih 100 ženki. Dobijeni podaci ukazuju da u populacijama Meksika ima više ženki nego mužjaka sa izuzecima više mužjaka nego ženki.

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