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AN EXPLORATION OF UNIVERSITY STUDENTS' UNDERSTANDING OF POPULATION GENETICS

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Abstract: This research examined university students's understanding about various concepts of population genetics and how they integrate those knowledge to explain the theorie of Evolution. A mixed study method was used to explore the students' understanding of differents factors that affect evolution. Data were collected by questionnaire and interview and were analyzed qualitatively.

The results indicate that the majority of students know how can natural selection and mutation affect allele frequency in a population but they have difficulties to understand how act Genetic drift on the evolution of allele frequencies. They had also misconceptions of some concepts related to evolution like speciation.The majority of students don't believe to Human evolution but they accept the theory of evolution for the other species.

Keywords: Genetic population, misconceptions, evolution, natural selection, genetic drift.

Introduction

The scientific and technological developments in genetics have had a considerable impact on different areas of everyday life (agriculture, medicine,...). A scientifically literate public is essential if citizens are to engage effectively with policymakers on issues of scientific importance (Dougherty 2009) .Genetics is also one of important biology basic courses, it is very important to many other subjects. Genetics is one of the most difficult subjects in the biology curricula at university levels (Agorram, 2010, 2015; Kindfield, 1994). Studies in other countries have shown that understanding of genetics and its various aspects is poor among students of various levels (Lewis and Wood-Robinson, 2000).

The population genetics field develops more quickly. However, many Students find numerous difficulties in assimilating this course because it is a specialized course with abstract and difficult knowledge (Agorram 2015). Population genetics is a field of biology that studies the genetic composition of biological populations, and the changes in genetic composition that result from the operation of various factors, including natural selection. Population geneticists pursue their goals by developing abstract mathematical models of gene frequency dynamics, trying to extract conclusions from those models about the likely patterns of genetic variation in actual populations, and testing the conclusions against empirical data (Okasha 2015). Population genetics is concerned

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with the genetic basis of evolution. It differs from much of biology in that its important insights are theoretical rather than observational or experimental. It could hardly be otherwise.

To the best of my knowledge, almost no reports in Morocco have examined students' knowledge and understanding of biology topics related to population genetics. Hence the importance of this research , which aims to analyze Moroccan university students' understanding of population genetics and to identify their most common misconceptions.

Methods

This study is mainly qualitative, our methodology was mixed. We used a questionnaire and interview. this qualitative analytical methods were supplemented with statistical analysis to identify students' misunderstanding in population genetics.

Students sample. All students surveyed in the study were enrolled in a graduate science program at the University, The sample is composed of 86 Graduate Students (baccalaureate plus 3 years of study) and 20 Master' students (baccalaureate plus 4 or 5 years). The mean age of students was 24 years (range: 22 to 37 years). Females comprised 46 percent of the sample.

The questionnaire. We composed an questionnaire to acquire information on several key issues: (a) the students' understanding of population concept, Hardy-weinberg law, genetic structure, (b) the students' understanding of the mechanisms by which evolutionary change occurs, and (c), the level of acceptance of evolution among science graduate students.

Some of the questions were inspired by previous studies (Shtulman 2006, Kampourakis and Zogza 2009) ; however, we developed many new questions appropriate for students at the graduate level.
In this article, we only analyze the students' responses in respect of two evolutionary factors: natural selection and genetic drift.

The interview. Interview was conducted on eight voluntary participants. The interviews lasted approximately 30 minutes. Thematic interview questions are used to explore in greater detail the most commonly held misconceptions identified by the questionnaire analysis. The Interview was recorded and a coding rubric was used to score student responses.

Results

Genetic variation and Hardy-Weinberg law (equilibrium law)

Genetic variation describes naturally occurring genetic differences among individuals of the same species. This variation permits flexibility and survival of a population in the face of changing environmental circumstances. Consequently, genetic variation is often considered as an advantage for populations (Klug and al 2012) .

Nearly half of students think that existing variation among individuals are rare and unimportant for evolution. The existing genetic variation within and between populations is an important factor for evolution, without variation, there isn't evolution. For these students, the fact of belonging to a species is opposed to the existence of genetic variation between individuals of this species.

Students are familiar with the statement of the Hardy-weinberg law (H-W) and the conditions of its application but a student out of four believes that this law is only valid in the case of diploids organisms (table 1). In interviews, we asked the students to show and explain this central law of population genetics. Over a third of students are unable to link this law to reproduction and they are unable to use the chessboard of gametes (Punnet square) to find the genetic structure of the offspring. Other students do not understand why they use gametic frequencies different of the Mendelian ones (1/2; 1/2).

Table 1 : Students' understanding of variation and h-w law (In %)

«	Statement	1	2	3	4	5	6
Q 6	Variation among individuals within a species is important for evolution.	12	33	12	8	22	13
Q 27	Existing variation among individuals are rare and unimportant for evolution.	19	29	2	35	12	3
Q 32	The Hardy-Weinberg law can not be applied in the case of natural populations	22	45	9	14	8	2
Q 33	In the Hardy-Weinberg law, $p^2 + 2pq + q^2$ are the genotypic frequencies	28	54	7	4	7	0
Q 36	HW Law is valid only in diploids	5	37	13	17	23	5

1 I Strongly agree 2 I agree 3 Neutral 4 I disagree 5 I Strongly disagree 6 Non answer

Acceptance and Understanding of Evolution Among Students

About 84 % of the students who completed the questionnaire doesn't identified evolution as an established scientific fact supported by overwhelming evidence and think that there is lots of evidence against evolution. More than 92% of students surveyed assert that Apes and man have not a common ancestry and that the theory of evolution doesn't explain the development of life (about 86% of students surveyed).

Nevertheless, they accept the statement that Humanity came to be through evolution, which was controlled by God (37%) (Fig 1).

This attitude toward the theory of evolution is explained by the fact that all these students are Muslims and that the majority of them are believers. Many researches have found similar results (*BouJaoude S. & col 2009 ; Clément & Quessada 2008 ; Miller & col 2006).*

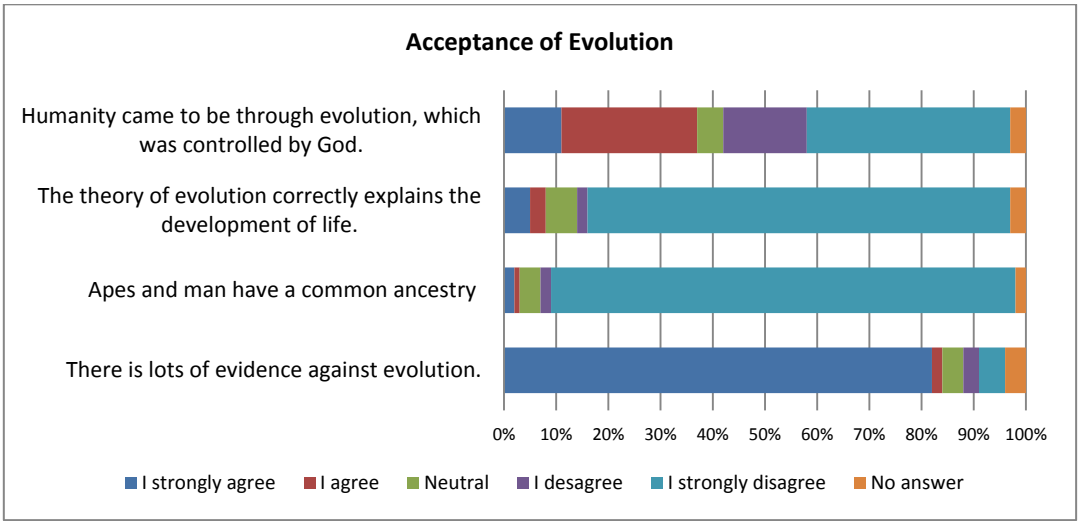

Fig 1 : Students' attitude toward evolution theory

Evolution : Lamarckism versus Darwinism

Table 2 : Students' understanding of how evolution occurs (In %)

	Statement	1	2	3	4	5	6
Q 5	If two light-skinned people moved to a sunny location and got very tan , their children would be more tan than they (the parents) were originally.	3	16	11%	7	59	4
Q 8	A species evolves because individuals want to.	2	14	8	12	58	5
Q 24	Evolution is always an improvement.	20	32	8	18	10	12
Q 10	A species evolves because individuals need to.	20	34	8	5	25	8
Q 18	All individuals in a population of ducks living on a pond have webbed feet. The pond completely dries up. Over	14	33	11	12	23	7

	time, the descendants of the ducks will evolve so that they do not have webbed feet						
Q 30	"Survival of the fittest" means basically that "only the strong survive".	11	39	6	11	26	7
Q 13	New traits within a population appear at random.	8	25	10	43	9	5
Q 14	The environment determines which new traits will appear in a population.	11	41	11	12	18	7
Q 22	Evolution cannot work because one mutation cannot cause a complex structure (e.g., the eye).	17	31	10	22	12	8

1 I Strongly agree 2 I agree 3 Neutral 4 I disagree 5 I Strongly disagree 6 Non answer

One student out of five imply that acquired traits can be inherited (19 % for question Q5), and more than the half of students (54%) think that a species evolves because individuals need to. About one student out of two imply that a trait is developed as a result of loss through disuse of the trait (Q 18). The ideas of ''use and disuse'' and of ''the inheritance of acquired traits'' are associated with Lamarck. ''Lamarck asserts that the need of organisms to adapt to environmental demands and their innate drive towards better, more complex, organizations drive the evolution of new species'' (Samarapungavan & Wiers, 1997). Numerous elements charachterizes lamarckian conceptions : individual organisms are changing in response to "need" ; change through conscious efforts toward improvement, and enhancement or loss of features as a result of use or disuse ; inheritance of acquired characters (Gregory, 2009 ; Kampourakis and Zogza 2009).

Only a student out of three state that new traits within a population appear at random (33% for Q13).

These results show the existence of two antagonistic conceptions:
individual organisms are changing in response to "need" ; change through conscious efforts toward improvement, and enhancement or loss of features as a result of use or disuse. These changes are passing on to the offspring (more than 50% of surveyed students) : "Lamarckian" conceptions (Gregory, 2009 ; Kampourakis and Zogza 2009).

Species evolve by mechanisms, which are based on over production, chance mutation, and nonrandom survival and reproduction as influenced by the heritable traits of organisms. Only random processes produce new traits or a chang in existing traits.The following environmentally directed influences do not cause a change in genetic traits (Darwinian conceptions).

Mechanisms of Evolution

Natural selection

Four students out of ten say that the two most important factors that determine the direction of evolution are survival and reproduction (Q12) wich are the cause of the various fitness (66% for Q38).
But, the majority of surveyed students do not understand the differents models of selection and their actions on genetic variation (Q35). They confound these different types of selection (Directional, Disruptive, Stabilizing). They also say that dominant alleles are always selectively advantageous (63% for Q31), "Survival of the fittest" means basically that "only the strong survive" (50% for Q30), they also say that Natural selection can not act when genetic drift occurs (37% for Q23) (Table 3).
Survival in the struggle for existence is not random, but depends in part on the hereditary constitution of the surviving individuals. Those individuals whose surviving characteristics fit them best to their environment are likely to leave more offspring than less fit individuals. The unequal ability of individuals to survive and reproduce will lead to gradual change in a population, with the proportion of individuals with favorable characteristics accumulating over the generations.

Table 3 : Students' understanding of natural selection

	Statement	**1**	**2**	**3**	**4**	**5**	**6**
Q 24	Evolution is always an improvement.	20%	32%	8%	18%	10%	12%
Q 11	I have a clear understanding of the term "fitness" when it is used in a biological sense.	2%	25%	5%	43%	8%	16%
Q 12	Two of the most important factors that determine the direction of evolution are survival and reproduction.	16%	24%	10%	27%	11%	11%
Q 15	Directional selection occurs when natural selection favors both the homozygous genotypes	16%	27%	23%	7%	11%	16%

Q 16	Disruptive selection can lead to two new species.	14%	29%	14%	17%	11%	14%
Q 21	Stabilizing selection occurs when natural selection favors the intermediate states of continuous variation.	34%	10%	6%	23%	16%	11%
Q 23	Natural selection can not act when genetic drift occurs	10%	27%	11%	20%	13%	18%
Q 25	If webbed feet are being selected for, all individuals in the next generation will have more webbing on their feet than individuals in their parents' generation.	14%	26%	12%	16%	24%	8%
Q 28	Disruptive selection occurs when natural selection favors both extremes of continuous variation.	9%	27%	10%	14%	23%	16%
Q 30	"Survival of the fittest" means basically that "only the strong survive".	11%	39%	6%	11%	26%	7%
Q 31	Dominant alleles are always selectively advantageous	24%	39%	2%	10%	17%	8%
Q 34	The mutation is an effective evolutionary strength	35%	22%	7%	21%	13%	2%
Q 35	Natural selection always decreases genetic variation	24%	41%	7%	7%	21%	0%
Q 37	individuals have different fitness because of their different phenotypes	19%	28%	21%	10%	15%	7%
Q 38	survival rate and fertility are the cause of the various fitness	23%	39%	6%	12%	11%	9%

1 I Strongly agree 2 I agree 3 Neutral 4 I disagree 5 I Strongly disagree 6 Non answer

Genetic Drift

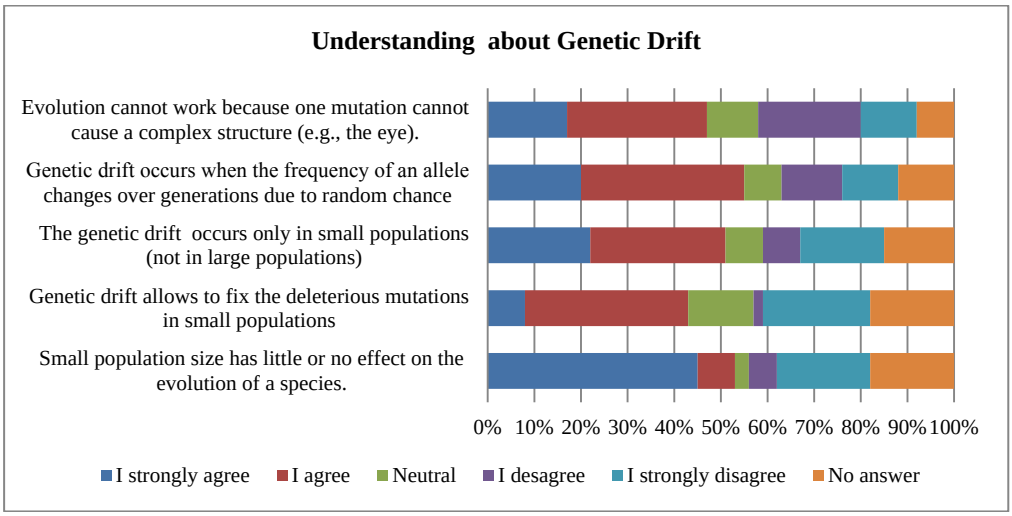

Fig 2 : Students' understanding about genetic drift

More than half of surveyed students say that the genetic drift has no effect in small populations (53%) and that the drift does not occur in large populations (51%) (Table 3). This is strange because more than half of the students correctly identify genetic drift as a random phenomenon which causes a change of allele frequencies over generations.

The effects of genetic drift are all the more important as the population is small, because the observed differences of allele frequencies from one generation to the other are all the more noticeable. Genetic drift concerns mainly neutral alleles that confer no selective advantage or disadvantage. Genetic drift is a major mechanism of evolution.

Discussion

The results show that the majority of surveyed students reject the theory of evolution, this can be explained by the fact that these students are Muslims.These results accord well with recent polls regarding the acceptance of evolution in numerous countries despite the differences in cultural and religious contexts between these countries (Angus Reid GlobalMonitor 2007 ; Miller et al. 2006, Gallup 2009).

Among the factors contributing to students' low score in accepting Evolution are poor understanding of genetics, the politicization of science and the literal interpretation of the sacred books of each religion.(Miller, et al. 2006).

The results show also that the majority of surveyed students have difficulties in understanding the basic concepts of population genetics. Analysis of the questionnaire results and interviews allow to identify some misconceptions. Thus the most common students' misconceptions relate to the fact that if an organism changes during life in order to adapt to its environment, those changes are passed on to its offspring, these changes are made by what the organisms want or need. evolution happens according to a predetermined plan and that the results have already been decided. Such views have often been labeled "Lamarckian".

But, this was commonly mixed with a semi-Darwinian notion of "advantage," implying at least a basic appreciation of variation among individuals and competition for resources. Numerous students says that organisms, even of the same species, are all different and that those which happen to have variations that help them to survive in their environments survive and have more offspring. The offspring are born with their parents' helpful traits, and as they reproduce, individuals with that trait make up more of the population. Such misconceptions have been identified in students by other researchs (Gregory 2009 ; Gregory et Ellis 2009).

Most students had a basic understanding of the process of evolution by natural selection. Their ideas about how and why evolution occurred differed from those accepted by biologists.

Biologists recognize that two distinct processes, fundamentally different in cause and effect, influence traits exhibited by populations over time.New traits appears by random charges in genetic material (random mutation or sexual recombination) then theses traits survive or disappear due to selection by environmental factors (natural selection). The results of this study show that many students fail to recognize the existence of two processes and they fail to maks a distinction between the appearance of traits in a population and their survival over time.

The results show also the existence of many misconceptions about Genetic Drift. Misconceptions about random processes" emerged as factors contributing to student difficulties in learning evolutionary and molecular biology (Garvin-Doxas and Klymkowsky, 2008). This is not surprising, because probability and randomness perplex students of all ages (Lecoutre et al., 2006). Students are challenged by both the terminology associated with random evolutionary processes and the conceptual complexities of these processes (Mead and Scott, 2010).

Despite these obstacles, understanding random processes such as genetic drift is essential for a deep understanding of the theory of evolution. In contrast to natural selection, genetic drift is nonselective and therefore results in nonadaptive changes in populations. Genetic drift occurs in any finite population and therefore occurs in every population all the time (Staub 2002).

Conclusion

The population genetic is a challenging topic for students to learn. These students have complex and strongly held scientific misconceptions wich are an obstacle to understanding Evolution. Genetic drift and Natural selection are the most topics which present learning difficulties for students.

The results suggest that most presently used methods of teaching about evolution by natural selection are ineffective for this population of students. Even students who had taken more than three years of biology generally showed little understanding of the evolutionary process.

Efforts should be made by instructors to develop strategies to facilitate student learning of population genetic.

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