

«On the Origin of Species»: Didactic transposition to the curriculum and Portuguese science textbooks (1859-1959)

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Abstract: This research aimed to contribute to the history of the teaching of Darwinism in the Portuguese curriculum from 1859 to 1959. To this end, it was analysed the didactic transposition of the book *On the Origin of Species* for the standards and textbooks of Natural Sciences of secondary education. This study showed that some standards did not address Darwinism (Standards of 1856, 1872, 1880, 1886, 1926 and 1929), while others only prescribed the study of some subjects of Darwinism (Standards of 1889 and 1905). The standards of 1895 were the ones that addressed more Darwinists ideas in the 19th century. In the 20th century, the overall approach to Darwinism was related to the study of transformist ideas (Standards of 1919) or evolution (Standards of 1936 and 1954). However, even when the respective standards did not make that prescription, the major part of textbooks addressed the mechanisms of Darwinian evolution: adaptation, variability, growth correlations, heredity, natural selection, vital competition, geographic isolation and sexual selection.

Keywords: curriculum; Darwin; mechanisms of evolution; science textbooks.

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1. Introduction

Evolutionism should not be confused with Darwinism. However, there is no doubt that the book *On the Origin of Species by Means of Natural Selection, or The Preservation of Favoured Races in the Struggle for Life* (Darwin, 1859) brought a coherent explanatory framework for evolutionism. In this book, Darwin (1859) advocated that the species are the result of evolution, by branches, from a common ancestor, and the natural selection is one of the proposed mechanisms for this transformation of species.

According to Almaça (1999), who studied the impact of Darwinism in Portuguese Universities, Darwin became known in the Portuguese academic world of the 19th century due to French translations of his work, which arrived in the country since 1862. Almaça (1999) argues that the Portuguese academy of the 19th century advocated evolutionism, even at a time when the same doctrine had great difficulties of implantation in countries such France, Great-Britain, Germany, Italy and Spain. However, the translation of Darwin's work to Portuguese took about half a century since its initial publication, having only appeared for sale in Oporto in the Chardron bookshop in 1913 (Pereira, 2001). Thus, the statements of Almaça (1999) suggest that in the 19th century, the Portuguese textbooks authors had access to French translations of Darwin's book, while the study of Pereira (2001) suggests access to the Portuguese version since 1913.

This research was influenced by the Young (2010) notion of curriculum, which Pacheco (2013) summarized as a corpus of knowledge and values, socially and culturally recognized as valid. The present study aims to complement the way the origin of species has been expressed in the Portuguese Natural Sciences curriculum, through the analyses of didactic transposition of evolutionary ideas presented by Darwin in the book *On the Origin of Species* to school standards and textbooks published between 1859 and 1959.

2. A historical approach to the origin of species theories in textbooks

Goodson (2001), in his studies about social construction of the curriculum, advocates that it is necessary to examine the relation between the content and the subject and to analyse deeply the issues about the practice and the school processes. Textbooks can give a good help to the enlightenment of those processes. Textbooks are halfway between the curriculum prescribed institutionally and the curriculum that is actually taught in the classroom by teachers. Thus, the study of those books may allow access to the teaching of the origin of species theories, contributing to the understanding of the process of historical construction that Cuesta Fernández (1997) named as «disciplinary code», in this case, Biology. The study of textbooks is also according to Chervel (1991), who stated that «the study of the curriculum effectively taught is the main task of the historian of the subjects» (p. 77). For Chervel (1991), the content analysis of the school discourse, in specially of the textbooks, allows the revelation of the ideology that impregnates an educative system. Adding this idea to the fact that 90% of science teachers use the science textbook during 95% of the class and the curriculum is usually taught through only one textbook (Harms & Yager, 1981), we can assume that the content of the textbooks is one of the main responsible ones for the ideology transmitted and the curriculum effectively taught in classrooms. Skoog (1979) also endorsed those ideas by stating that a way of assessing whether evolution was taught or neglected in the past is through the analysis of science textbooks.

Previous studies (Cavadas, 2009, 2010, 2011) showed that the teaching of the origin of species in Portuguese textbooks was only addressed in secondary school curriculum and expressed through different perspectives or theories in

textbooks published between 1859 and 1959: Creationism, Darwinism, Lamarckism, Mutationism, Neo-Lamarckism, Orthogenesis and Theistic evolutionism. None of those ideas reached the status of Kuhnian paradigm (Kuhn, 1996) in textbooks because their analysis showed that there was not the replacing process of one theory by another one. The different perspectives coexisted at the same time, though with different degrees of scientific validation. That conclusion shows that, as the development of science is inextricably intertwined with various social parameters (Gavroglu, 2007), its expression in textbooks also reflects the interaction between science and society, being another evidence of the Goodson's (2001) ideas of the social construction of curriculum.

However, the approach to the origin of species theories in Portuguese textbooks (Cavadas, 2009, 2010, 2011) shows that several authors were strongly evolutionists. An evidence of this statement is their preference to present, in great depth, this explanation of the origin of species. In contrast, they lightly addressed the creationist approaches. Creationism was explored briefly in textbooks of Amado and Leite (1887) and Lemos (1890), but in the early 20th century it was suppressed in textbooks of Aires (1907, 1920). It was addressed again from 1930s to 1950s in the textbooks of Aires (1931), Primo (1937) and Pires de Lima and Soeiro (1955), though only within a framework of History of Science of the origin of species and as an introit to the evolutionary theories. Later, the same creationist perspective evolved to a new attempt to explain the origin of species, the Theist evolutionism, which appeared for the first time in textbooks published at the end of 1930s, remaining until the 1950s. However, despite the fact that standards imply the presence of Theistic evolutionism in textbooks of Zoology, Primo (1937) and Pires de Lima and Soeiro (1955) did not present empirical arguments to support it, but merely described its meaning. Similarly, in textbooks of the United Kingdom, although some works published between 1950s and 1960s mixed religious beliefs with the teaching of evolution, the scientific facts predominated and the references to the influence of divine entities disappeared progressively (Williams, 2008). In the Portuguese case, an explanation for the introduction of this creationist upgrade in textbooks may have been the influence, on the curriculum, of the dictatorial regime at the time, which was very close to the Catholic Church. A similar phenomenon occurred in Spain, as Puellez Benítez and Hernández Laille (2009) concluded that the transmission of science in textbooks suffered ideological and religious influences.

The expression of Evolutionism in 19th century Spanish and English textbooks of secondary school was deeply studied by Hernández Laille (2010). This researcher classified the textbooks in different categories, according to the defence of creationism or Darwinism. Hernández Laille (2010) concluded that the creationist textbooks were the most common in Spain between 1875 and 1881, due to a big ideological control over school policy. This is another strong evidence of the Goodson (2001) ideas about the social construction of curriculum. However, from the Albareda law of 1881 and especially from 1890s, period in which Spain felt the effects of Restoration, predominated the Darwinist textbooks, a phenomenon that finds parallels in Portuguese textbooks of that period (Cavadas, 2009). Among the authors who defended Darwinism in textbooks, Hernández Laille (2010)

concluded that some of them cited Darwin explicitly, others defended their ideas without naming Darwin and others add at the evolutionist explanations conciliatory proposals between religion and science. Despite this consolidation of Darwinism in Spanish textbooks, in the 19th century it was also published some textbooks which did not refer to Darwin openly, as well as some anti-Darwinist textbooks (Hernández Laille, 2010).

Swarts, Anderson and Swetz (1994) in a comparative study of textbooks of USA, Republic of China and URSS published between 1886 and 1990, concluded that the country where the evolutionism teaching prevailed was USSR, followed by USA and the Republic of China. Despite this prevalence, it is in USA that the creationist/ evolutionist controversy has generated the sharpest debate (Scott, 2009) and has been the motor of some studies about evolutionism in Biology textbooks. The approach to evolutionism in zoology, botany and geology textbooks published post-*Origin of Species* until 1920 was analysed by Larson (1987). This researcher found that in the first two decades Post-*Origin of Species*, the textbooks, especially those who addressed zoology and geology, consisted essentially of reviews of pre-Darwinian books. The explanation of Larson (1987) to the late introduction of evolutionism in the USA textbooks is due to the academic origin of their authors: "These textbooks, typically written by science educators rather than research scientists, lagged far behind those of the masters in recognizing scientific advances" (p. 98). However, after that phase, the evolutionist ideas impregnated the textbooks gradually, a process that was completed before the turn of the 19th century to the 20th century (Larson, 1987). Skoog (1979) complemented this study by analysing the textbooks published between 1900 and 1977. This researcher found that the teaching of evolutionism was peripheral and not controversial in textbooks prior to the Biological Sciences Curriculum Study (BSCS) published in the 1960s. Skoog (1979) concluded that the textbooks published between 1900 and 1919 eclipsed the evolutionism and that only three of the eight analysed textbooks had chapters in which this subject was handled. In the 1920s, despite an increase in the coverage of evolution in textbooks, it has not been treated as an integrative concept in Biology. In the 1960s, curricular reconstruction promoted by BSCS stopped the suppression of evolutionism, which happened to have a meaningful expression in textbooks (Skoog, 1979).

3. Methodology

Taking into account the problem, objectives and the theoretical approach that support this work, it was carried out under a qualitative study through content analysis (Amado, Costa & Crusoé, 2013; Bardin, 1979; Bogdan & Biklen, 1994). This analysis was influenced by the didactic transposition theory (Chevallard, 1991) and included the following steps:

The first step, heuristic, involved the selection, recovery or localization of the standards and textbooks published between 1859, the year *On the Origin of Species* publication, and 1959, the year of its first centenary. Taking into account the representative standards of that period (Cavadas, 2008) (Table 1), it was analysed the first edition of the most relevant textbooks written accordingly those standards (Table 2).

In the second step, were created «coding categories» (Bogdan & Biklen, 1994). The coding categories were restricted to items associated with mechanisms of evolution, defined as the conditions or processes that promote evolution. Firstly, the categories emerged from a free content analysis of standards and textbooks. Later, they were applied to some textbooks in order to delimit them. The final categories were: adaptation, variability, growth correlations, hereditability, natural selection and vital competition, geographic isolation¹ and sexual selection (Table 2).

The third step, hermeneutics, was based on the content analysis of the standards in order to identify the transposition of Darwinism. Then, it was evaluated the presence or the absence of each mechanism in the science textbooks, followed by their content analysis to assess the didactic transposition of mechanisms of evolution. The scientific work of reference was the first edition of *On the Origin of Species* (Darwin, 1859).

The result of that analysis was compared with similar studies and crossed with other researches that addressed Darwinism, in a history of science perspective (Avelar, 2007; Avelar, Matos & Rego, 2004; Bowler, 1992, 2003; Browne, 2008).

4. The didactic transposition of Darwinism to school standards

The following table presents the year of publication, name, legislation and class year of the Natural Sciences standards analysed. The Darwinist concepts addressed in those standards were also presented.

Table 1. Darwinist concepts in Portuguese standards of Natural Sciences (1859-1959)

Year	Name	Legislation	Year/ Class	Darwinist concepts
1856	Principles of Physics, Chemistry and Introduction to Natural History of Three Kingdoms ²	Edict (s. d.). Diário do Governo number 122, 26 May 1856, p. 702.	n. i.	Absent.
1872	Standards of Principles of Physics and Chemistry and of Introduction to Natural History	Ordinance of 5 October 1872. Diário do Governo number 231, 12 October 1872, p. 1550.	n. i.	Absent.
1880	Standards of Elements of Physics and Chemistry and Natural History	Ordinance (s.d.). Diário do Governo number 241, 21 October 1880, p. 2754.	n. i.	Absent.
1886	Standards of Introduction to Natural History	Ordinance of 19 November 1886. Diário do Governo number 267, 23 November 1886, pp. 3392-3393.	n. i.	Absent.

¹ The geographic isolation, which was also taken in consideration by Skoog (1979) as a mechanism of evolution, should not be considered objectively as a mechanism that promotes evolution, but only as a circumstantial element of the environment which favours the other mechanisms of evolution. However, it will be present in this category due to their indirect contribute to the action of those mechanisms. Some authors also addressed the mutations as an agent of evolution. However, it was not considered the analysis of this mechanism due to the discovery of its influence on evolution only after the work of Darwin.

² Probably only adopted at the Lyceum of Coimbra (Beato, 2011).

1889	Standards of Introduction to Natural History	10 October 1889. Diário do Governo number 245, 29 October 1889, pp. 2471-2472.	5th year	Brief news on organization, differentiation and selection of living beings. (p. 2472)
1895	Standards of Physical Sciences and Natural Sciences	Decree of 14 September 1895. Diário do Governo number 208, 16 September 1895, pp. 2518-2520.	7th class	Variability. (...) Heredity, its forms and laws. Relations of animals with the environment. Vital competition. (...) struggle for existence; natural and artificial selection. (p. 2519)
1905	Standards for the Teaching of Physics, Chemistry and Natural History	Decree number 3, 3 November 1905. Diário do Governo number 250, 4 November 1905, p. 3871.	7th class	Adaptation and heredity (p. 3871)
1919	Standards of Natural Sciences	Decree number 6.132, 26 September 1919. Diário do Governo, I Series, number 196, 26 September 1919, pp. 2056-2057.	7th class	Notions on adaptation; heredity; Mendelism; Transformism. (p. 2572)
1926	Standards of Natural Sciences	Decree number 12.594, 02 November 1926. Diário do Governo, I Series, number 245, 02 November 1926, pp. 1174-1788.	n. i.	Absent.
1929	Standards of Natural Sciences	Decree number 16.362, 14 January 1929. Diário do Governo, I Series, number 11th, 14 January 1929, pp. 91-107.	n. i.	Absent.
1936	Standards of Sciences	Decree number 27.085, 14 October 1936. Diário do Governo, I Series, number 241, 14 October 1936, pp. 1249-1252; 1270-1271 e 1278.	7th year	Evolution of organisms. Theories of evolution: Lamarckism, Darwinism, Mutationism and Theist Transformism. (p.1278)
1954	Standards of Biological Sciences	Decree number 39.807, 07 September 1954. Diário do Governo, I Series, number 198, 07 September 1954, pp. 1016-1025; 1037-1043.	7th year	Fixism and Transformism. Theories of evolution of organisms. (p. 1039)

n. i: Not indicated.

The standards of 1856 did not refer to explanations about the origin of species, at a time that preceded the publication of *On the Origin of Species* (Darwin, 1859). Despite the huge debate around this book, its influence in Portuguese curriculum was delayed. The standards of 1872 did not directly prescribe the study of evolutionism. Eight years later, the standards of 1880 in the second part of Zoology, prescribed the study of «Successive improvement of the pre-historic man to modern man» (p. 2754). This statement may indicate some evolutionary influence. However, it was not possible to identify textbooks that were written according to the standards of 1880, as well as with the standards of 1872, which prevented the analysis of didactic transposition of the mechanisms of evolution.

The standards of 1886 that were published a few years later seemed to regress. These standards do not address evolutionism or other subject regarding evolutionism. However, this situation was reversed three years after. The standards of 1889, although they still do not directly prescribe the study of the origin of species, indicate that the concept of selection must be addressed: «Brief news about organization, differentiation and selection of living beings» (p. 2472). This statement may reveal knowledge, by the legislator, of the Darwinian mechanism of natural selection. However, the standards never explicitly mentioned the study of evolutionary theories, such as Darwinism. Nevertheless, the textbooks authors, such as Amado and Leite (1887)³, understood that they should address this subject as an introduction to descriptive Zoology, a theme prescribed in the standards of 1886. Another author, Lemos (1890), also addressed the conceptions about the origin of species, though that subject was not explicit in the standards of 1889.

The most obvious example of didactic transposition of the book *On the Origin of Species* occurred in the standards of 1895 because it prescribed directly the study of «Variability. (...) Vital competition. (...) The fight for existence; natural and artificial selection» (p. 2519). Unfortunately it was not possible to locate textbooks written according to these subjects.

In the early 20th century, the standards of 1905 seemed to take a step back by prescribing only the study of «Adaptation and heredity» in the final section of Zoology standards of the 7th and last secondary school class. Despite this omission, Aires (1907), a representative author of science textbooks of that time, University Professor of Zoology and director of the Zoological Museum of the University of Coimbra, considered that the standards endorsed implicitly the study of Transformism⁴:

Demanding the heredity and the adaptability, the standards refers implicitly to Transformism, which is an immediate consequence of those principles. So here we show some slight notions of this theory (p. 171).

This option of Aires (1907) reflects, in the Portuguese science textbooks, the following statement of Larson (1987): «Turn-of-the-century zoology textbooks gave new prominence to evolutionary concepts by replacing the old animal catalog format with a presentation focusing on zoological concepts, including evolution» (p. 104).

The next standards, published in 1919, present, for the first time, an explicit, but briefly reference to the study of transformism. Note that, in the next decade, the intensity of the creationist/evolutionist debate increased in USA. This debate was intensified during the Scopes trial, in 1925, and the consequent effort of William Jennings Bryan to decrease or remove the teaching of evolution in secondary schools and in Universities (Bleckmann, 2006). Remarkably, in the laconic standards of 1926, succeeded by the standards of 1929, this subject was not prescribed,

³ At the time he wrote his textbooks, Silva Amado was the Headmaster of Central High School of Lisbon and teacher of the medical-surgical school of Lisbon. Pedro Eusébio Leite was a teacher of Physics, Chemistry and Introduction to Natural History in Central High School of Lisbon.

⁴ Transformism was a term used at that epoch instead of evolutionism.

leaving unclear whether this omission will, or will not, have any relation to the events that took place across the Atlantic. Regardless of this absence, it is certain that Aires (1931), as he did during the writing of the textbooks post-standards of 1905 and post-standards of 1919, considered that, in the 7th grade, the approach to the classification of vertebrates implied implicitly the study of Transformism. Thus, he dedicated the last chapter of the textbook published in 1931 to that subject, naming it «Evolution of animals. Basis for their classification» (p. 308).

In the 1930s other few standards were published. However, this analysis was circumscribed to be published in 1936 because, unlike the previous ones, they explicitly prescribed the study of evolution through the analysis of different perspectives, all classified as theories of evolution: «Evolution of organisms. Theories of evolution: Lamarckism, Darwinism, Mutationism and Theistic evolution» (p. 1278). The legislator presented, inclusively, some instructions about the suitable method to teach Biology. Among other recommendations, it indicated that teachers should only give very elementary notions of those subjects, and students should acquire their knowledge through the study and memorization of the textbook for later evaluation in class. Those legislative prescriptions led the authors of textbooks, like Primo (1937), to address the origin of species theories briefly.

The standards of 1936 were used almost until the end of the 1940s, and were replaced by the standards of Biological Sciences published in 1948⁵. These last standards were slightly changed by the standards of Biological Sciences published in 1954, the ones with greater longevity during the 20th century. These standards went through the 1960s and influenced the teaching of sciences in the first years of the 1970s. For this reason, it was preferred the analysis of the 1954's standards instead of the 1948's. The 1954 standards prescribed the study of the origin of species theories at the end of secondary education and based the study of those theories on these subjects: «Fixism and Transformism. Theories of evolution of organisms» (p. 1041), which the legislator named «biological philosophy» (p. 1041). These standards also presented explicit instructions for the approach to the study of origin of species. That indicates an attempt to control this subject at governmental level because the legislator advised the teachers to address it «very carefully and without exaggeration», because, although he considered those issues as very important ones, «there is no unanimity on some of them» (p. 1041). The legislator warned that the teacher should be limited to the neutral arguments of competing versions, excusing himself to utter individual assessments.

5. Didactic transposition of mechanisms of evolution

One of the first Zoology textbooks, named *Lessons of Elementary Zoology* and organized in two parts, was written by Júnior (1859, 1860)⁶. The edition of

⁵ Decree 37.112, 22 October 1948. *Diário do Governo*, I Series, number 247, 22 October 1948, pp. 1119-1133; 1142-1149.

⁶ It is unknown if Júnior (1859, 1860), teacher in the High School of Santarém, has taken into account the standards of 1856 when he was writing his textbook because, according to Beato (2011), these standards did not have national coverage, and were only used in the High School of Coimbra.

the first part of the textbook (Júnior, 1859) is contemporary with the first edition of the book *On the Origin of Species*, therefore, the author probably would not have knowledge of it. Nevertheless, in the scientific world other origin of species theories were known, like the one presented in the book *Philosophie Zoologique* published by Lamarck fifty years before. However, the content of the first textbook of Júnior (1859) shows clear creationist influences (Cavadas, 2009), which indicates that this author was not aware of, or at least rejected, the evolutionist ideas. Hernández Laille (2010) also identified creationist textbooks in Spain from the same epoch of Junior's textbooks. Inclusively, in that study, the researcher found the existence of creationist textbooks of natural sciences used in secondary schools in the post-1874 period, associated with the Restauration of Antonio Cánovas del Castillo.

However, Junior's creationist works were the beginning of a series of textbooks where evolutionism became the dominant conception of the origin of species (Cavadas, 2009, 2010, 2011). This section presents the content analysis of the didactic transposition of mechanisms of evolution presented in the book *On the Origin of Species* for the textbooks analysed (Table 2).

Table 2. Mechanisms of evolution in Portuguese textbooks of Natural Sciences (1859-1959)

Mechanism	Textbooks							
	Júnior (1859) (1860)	Amado and Leite (1887)	Lemos (1890)	Aires (1907)	Aires (1920)	Aires (1931)	Primo (1937) ⁷	Pires de Lima and Soeiro (1955) ⁸
Adaptation		√		√	√	√	√	
Variability		√	√	√	√	√	√	√
Growth correlations			√	√	√			
Heredity		√	√	√	√	√	√	√
Natural selection & vital competition		√	√	√	√	√	√	√
Geographic isolation				√	√	√		
Sexual selection			√	√	√	√	√	√

⁷ Seomara da Costa Primo was a teacher in the High School of Maria Amália Vaz de Carvalho, activity which she accumulated with University teaching in the Faculty of Sciences of the University of Lisbon (Primo, 1943).

⁸ Pires de Lima was a teacher of Botany in the University of Porto. Augusto Soeiro was a teacher in D. Manuel II High School (Nóvoa, 2003).

5.1. Adaptation

Currently, the adaptation is not understood as a mechanism of evolution itself, but as a result of the action of other mechanisms like natural selection or sexual selection. However, in ancient textbooks, the authors seem to have understood the adaptation as a promotor and not as a result of those mechanisms. In this line of thinking, the adaptation to the environment was referred by Amado and Leite (1887), in the textbook *Elements of Zoology*, in strict relation to heredity, as an enhancer of the process of natural selection because the less adapted individuals would be defeated in the struggle for existence. This transposition of the adaptation process, associated with natural selection, expressed correctly the ideas of Darwin (1859):

The slightest advantage in one being, at any age or during any season, over those with which it comes into competition, or better adaptation in however slight a degree to the surrounding physical conditions, will turn the balance (...) The most vigorous individuals, or those which have most successfully struggled with their conditions of life, will generally leave most progeny (...) and the slightest advantage will lead to victory (p. 468).

The adaptation process was also present in Aires (1907, 1920) textbooks entitled *Lessons of Zoology*. The author dedicated an entire chapter explaining it, arguing that adaptation means the «adjustment (...) of the organism to their functions explains their conformations and structures» (1907, p. 161; 1920, pp. 114-115). However, he did not connect it properly to natural selection, preferring to advocate, in a Lamarckian perspective, that the living matter was plastic and seemed to have a property, which he called «adaptability», related to the ability of an organism to shape to the natural environment. As a result of this property, the characters of living beings were generally appropriated to the vital conditions and could exercise their functions with minimal effort «as if they were designed to live in the environment where they normally are» (1907, p. 161; 1920, p. 114). Primo (1937), in the textbook *Compendium of Biology*, interpreted the mechanism of adaptation in the same way, also approaching Lamarckism when stating that the variations result from the evolutionary process of adaptation to the environment. This influence was evident in the thought of Aires, when he stated that «the animals have the property to modify under the influence of variations of the environment or the exercise of their organs» (1907, p. 169; 1920, p. 125). This author extended this relationship claiming that due to the correlation of organs each change is reflected in the other parts of the organism.

The Lamarckian concept that the members of a species adapted physically and intentionally to changes in the environment, differs from the competitive perspective of Darwin, as well as other authors, who saw in these phenomena a clear example of action of natural selection (Bowler, 1992). Actually, Darwin, in the opinion of Bowler (2003), concluded that an approach to changes that happen in organisms centred in Lamarckism was inadequate because «although the environment might well be the stimulus, the majority of the changes it produced were not purposeful (...) they were essentially random» (p. 159). Lamarckism assumed that the changes that happened

in the organisms had a direction, while natural selection assigned randomness to these changes. Those different perspectives are a clear example that the same phenomena can be interpreted differently according to the theoretical framework that is being considered.

In fact, a better understanding of the phenomenon of heredity that Mendelism brought, lead Aires, in the textbook published in 1931, to consider that «beings do not adapt to the environment neither the environment adapts them to it» (p. 331). Now he states that the adaptation of living beings to the environment is simply «the effect of variations randomly favourable or randomly in accordance with the environment» (p. 331). When these changes are unfavourable, he argues that organisms come into conflict with the environment and may succumb. These considerations show some delay in relation to the considerations that E. Caustier, Spanish author of textbooks, presented in the book *Ciencias Naturales*, published in 1917, considering that even then «by the combined action of variation, adaptation, selection and mutation, it is explained how new species can appear» (1917, cited in Hernández Laille, 2010, p. 246).

In the previous considerations it is possible to observe some ideas that would lead later to the synthetic theory of evolution. In fact, they show the understanding of some phenomena that govern the laws of heredity and how natural selection acts to favour characters. The rupture with adaptation as a fundamental evolutionary mechanism was followed by Pires de Lima and Soeiro (1955), in the textbook *Compendium of Biology*, because they did not address this phenomenon in their work.

5.2. Variability

Almost all authors presented the existence of variability as a fact and dedicated a lot of text to clarify the concept of variations (Amado & Leite, 1887; Lemos, 1890; Aires, 1907, 1920, 1931; Primo, 1937; Pires de Lima & Soeiro, 1955). They agreed that the changes in the shape of animals give origin to the varieties that naturally occurred in the nature, transposing correctly the considerations of Darwin (1859): «organic beings have varied under nature (...) in the same way as they generally have varied under the changed conditions of domestication» (p. 468). In this regard, Amado and Leite (1887) stated that, for Darwin, «variety is a species in process of formation» (p. 6), in accordance with the following statements of this naturalist: «varieties are species in the process of formation, or are, as I have called them, incipient species» (p. 111).

As variability is a fact, the authors centred the discussion in the hypothesis that explains its origin. They referred that, for Darwin, the cause of variability is the natural selection, although, according to Bowler (2003), Darwin had suggested that the influence of the environment on the reproductive system was the source of variability: «Darwin believed that there was a source of new variations as a result of the disturbing influence of a changed environment upon the reproductive system» (p. 160). Darwin (1859) suspected that the variability in offspring was due to changes that occurred in the reproductive system of the progenitors. However, he acknowledged: «but why, because the reproductive system is disturbed, this or that part should vary more or less, we are profoundly ignorant» (p. 132). Therefore, Darwin (1859) could never fully explain the origin of variability, admitting that «our

ignorance of the cause of each particular variation» (p. 131). This was, in fact, the most important gap of Darwinism, marked by most authors of the textbooks analysed: Darwin did not explain the causes of variation between individuals of the same species, a phenomenon in which the theory itself is founded and that would only be clarified later by Mutationism. According to Aires (1907), Darwinism explained that process only saying that «the living matter has as a fundamental property the variability, and, thus, the living beings differ from each other by more or less considerable particularities» (p. 177). Therefore, he only admits the experience of variability and does not elucidate its origin. He highlighted that, although Darwinism was very coherent, that important gap in its explanatory framework committed the fully understanding of natural selection. This mechanism can only act in individuals of the same species because, within a pattern of common characteristics, they have some individual differences, like Darwin (1859) recognized: «These individual differences are highly important for us, as they afford materials for natural selection to accumulate» (p. 45). However, Aires (1907, 1920) warned that, although there is a gap in the explanation of the origin of variability, its existence was a fact, remaining a convinced Darwinist (Cavadas, 2009). The same did not happen with the authors of Spanish textbooks, such as Fidel Faulín Ugarte who stated that «transformism (and with more reason Darwinism), today lacks evidence showing the evolution of all beings» (1898, cited in Hernández Laille, 2010, p. 233).

5.3. *Growth correlations*

Darwin (1859) explained growth correlations indicating that «the whole organization is so tied together during its growth and development, that when slight variations in any part occur, and are accumulated through natural selection, other parts become modified» (p. 143). This mechanism has been transposed similarly by Lemos (1890) arguing that «introducing any change in an organ, and piling up by selection, other organs are necessarily modified» (p. 273). For Lemos (1890), the successive changes that occur in specific species give gradually origin to other species, and do not abrupt changes that only occur in a character. This finding met the gradualism that highlights the importance of very small changes for evolution, as Darwin (1859) stated: «As natural selection acts solely by accumulating slight, successive, favourable variations, it can produce no great or sudden modification; it can act only by very short and slow steps» (p. 471) Aires (1907), unlike Lemos (1890), did not just explain the meaning of growth correlations, but he enhanced that argumentation associating them to the process of adaptation:

Animals have the property to modify themselves under the influence of the environmental changes (...) due to the correlations of organs; each change is reflected more or less deeply in the rest of the organism and often produces unexpected effects (p. 169).

Aires (1907) also highlighted that the processes of adaptation and growth correlations were not only identified in animals, but also in plants, meeting the examples of Darwin (1859) about this subject. In the textbook of 1920 he repeated

that argumentation. However, that work delimits a missing period of this mechanism of evolution, because neither Aires (1931) nor the following authors approached it again.

5.4. Heredity

Darwin (1859) understood heredity as a supporting process of natural selection, as it is shown in his words: «the nature of the affinities of all organic beings may be explained (...) through inheritance and the complex action of natural selection» (pp. 128-129). The hereditary process defended by Darwin (1859) for domestic animals, and transposed to the natural environment, approached the Lamarckian ideas, as it can be checked through this statements: «there can be little doubt that use in our domestic animals strengthens and enlarges certain parts, and disuse diminishes them; and that such modifications are inherited» (p. 134)⁹. Similarly, the way inheritance acts has been interpreted by Lemos (1890) in a Lamarckian framework of the transmission of characters to the offspring, as reflected in its considerations:

First if the individual was not modified by special causes that acted during their development or after birth, they tend to reproduce in offspring their almost exact image; second if the individual suffered any change, they tend to reproduce that character in the next generation (p. 270).

The Lamarckian hereditary process was also referred by Aires (1907, 1920) when he stated that the adaptations acquired by individuals are transmitted and accumulated in their offspring through the heredity of those characters.

Darwin tried to find an explanation for the mechanism of heredity, but he never had success on that task (Avelar, 2007). At the time, Mendel's work was not globally known and understood in its usefulness, so the naturalists used the best available and known explanation, the law of inheritance of acquired characters. As natural selection, according to the ideas of that time, seemed to have serious limitations, the inheritance of the acquired characters remained as the only adjustment mechanism and it was inevitable that the naturalists recovered it (Bowler, 1992). This combination led to the origin of Neo-Lamarckism, explanation that, although acknowledging the process of natural selection as one of the causes of species transformation, attributed a higher importance to the inheritance of acquired characters.

⁹ In certain passages of the book *On the Origin of Species*, Darwin (1859) mixed the process of use and disuse with natural selection: «On the whole, I think we may conclude that habit, use, and disuse, have, in some cases, played a considerable part in the modification of the constitution, and of the structure of various organs; but that the effects of use and disuse have often been largely combined with, and sometimes overmastered by, the natural selection of innate differences» (pp. 142-143). However, Bowler (2003) warned that, for Darwin, an explanation of the changes in an organism using only Lamarckism was not enough: «although the environment might well be the stimulus, the majority of the changes it produced were not purposeful (...) they were essentially random» (p. 159). Lamarckism presupposed that the changes that occurred in organisms had a direction while the natural selection would give randomness to those changes.

In accordance, the authors of the 19th century, like Lemos (1890), although they described the consequences of the inheritance process, had difficulty explaining how it worked. However, this author referred that there are certain causes that print a particular direction to inheritance, like the vital competition¹⁰. The natural selection was also identified by Lemos (1890) as having a strong influence on heredity. Amado and Leite (1887) indicated that heredity is, thus, the promoter of the process of natural selection, because the most adapted organisms prevail in the struggle for existence, transmitting its mechanisms to offspring.

In the early 20th century, Aires (1907, 1920) added more ideas to the heredity process, explaining that it acts in two types of characters, the innate ones, inherited from the parents, and the acquired ones, that result from the influence of the environment, exercise or the inaction of the organs. Regarding the innate characters, he referred that heredity plays a conservative role because «it tends to keep the innate characters and transmit them to their offspring» (Aires, 1907, p. 170) and «it tends to keep the similarity of the individual with their ancestors» (Aires, 1920, p. 125). As for the second ones, he warned that «currently there is no hard evidence about the inheritance of acquired characters» (1907, p. 172; 1920, p. 131). However, he asserted that «the hypothesis of that heredity explains satisfactorily the remarkable effects of adaptation» (1907, p. 172; 1920, p. 132). He also considered that the inheritance of acquired characters explains the origin of the vestigial organs, crossing this with the ideas of Darwin (1859) who attributed its origin to a heredity process of disuse: «I believe that disuse has been the main agency; that it has led in successive generations to the gradual reduction of various organs, until they have become rudimentary» (p. 454). Although Aires assigns the inheritance of acquired characters, associated with the adaptation mechanism, a great explanatory power of evolutionism, he also reinforced his doubts about this process when he stated that «Heredity offers a considerable resistance to the invasion of acquired characters, keeping, on the contrary, the innate ones with a certain persistence» (1907, p. 171; 1920, p. 131). Despite previous evidence, the textbooks of Aires (1907, 1920) revealed an approach to inheritance of acquired characters, highlighting the influence of neo-Lamarckism and providing a good example of the slowly process of the didactic transposition of new scientific information for the science textbooks. This delay may have been caused by the strong bond of the Portuguese naturalists to French literature, as shown in the list of authors of the books used in the area of Natural History in Portuguese secondary schools since 1854, elaborated by Beato (2011). In that list there are abundant references to Langlebert, French author of Natural History books. French naturalists were linked to Lamarckism longer than their Anglophone peers and, with few exceptions, there were not Darwinists in France in the first half of the 20th century (Lepeltier, 2009; Avelar, Matos & Rego, 2004). So, due to the

¹⁰ Lemos (1890) considered that natural selection and the struggle for existence imprinted a direction to heredity. However, what these evolutionary mechanisms actually do is changing the frequency of the characters of organisms, when they are favourable or unfavourable, and not guiding heredity.

probable access of Aires to francophone zoological information, it is natural that he has approached these perspectives.

The acceptance of the Lamarckian thesis of the inheritance of acquired characters was a phenomenon that Skoog (1979) also identified in the USA textbooks published between 1920 and 1930. The removal of this mechanism, in the Portuguese case, occurred in the textbooks of Primo (1937) and Pires de Lima and Soeiro (1955) who explained the transmission of characters through the laws of Mendelian heredity of the uniformity, disjunction and independence. In contrast, Aires (1907) did not present any explanation of how the transmission of characters works, justifying himself with the existing delay in scientific knowledge of the time on this subject. This claim may indicate that he did not know Mendel's works. However, Aires (1907) summarized the rules of heredity in two laws that seemed to suggest some approach to Mendelism:

1st A common character to both parents ordinarily appears in the offspring and in a more pronounced way;

2nd If individuals with common characters intersect with a certain number of successive generations, those characters end up appearing regularly in the offspring (p. 170).

In textbooks of 1920 and 1931, Mendelism was already known by Aires because he dedicated part of the text explaining Mendel's laws of dominance, disjunction and independence of characters. He mentioned that they show the transmission of certain characters obeys to fixed rules, but he warned that the laws are elementary or generalizations of phenomena that occurred in simple conditions and rarely occurred in the natural environment. For its part, Primo (1937), Pires de Lima and Soeiro (1955) transposed with some depth the laws of Mendel, assigning them a great explanatory capacity in the mechanism of transmission of characters. This change reflects the observation of Bowler (1992) that the appearance of the experimental studies of heredity led to the fact that Darwinism inevitably emerged from its eclipse, when it was possible to gradually show that the interpretation of these mechanisms fitted well to natural selection.

5.5. *Natural selection and vital competition*

The method that Darwin used to explain how natural selection works was to clarify firstly how the artificial selection worked. Secondly, Darwin transposed that process to natural environment, advocating that it is responsible for adapting the species to their environment (Bowler, 2003). Similarly, all authors of textbooks allude to phenomena associated with the artificial selection to support the discourse about natural selection. Another idea that Darwin (1859) used to defend his evolutionism point of view was associating the explanation of natural selection with the process of struggle for life, summarizing them as follows:

If variations useful to any organic being do occur, assuredly individuals thus characterised will have the best chance of being preserved in the struggle

for life; and from the strong principle of inheritance they will tend to produce offspring similarly characterised. This principle of preservation, I have called, for the sake of brevity, Natural Selection (p. 127).

All authors did the correct didactic transposition of those ideas, linking the process of natural selection, or of survival of the fittest, to the vital competition¹¹. In this regard, Amado and Leite (1887) and Lemos (1890) summarized, in a similar manner, the process of natural selection, stating that there are individuals with different characteristics in the same species that result from any modification in the original species; from those individuals, the ones with favourable characters «to achieve victory in this *struggle for surviving* would be the chosen ones» (Amado & Leite, 1887, p. 6; italics in the original). Lemos (1890), in the same line of thought, highlighted that «the variety that represents an improvement in any sense, is most likely to resist and develop» (p. 271), adding that the organism which as unfavourable characters will be quickly sacrificed by nature. Therefore, they highlighted one of the main assumptions of Darwinism, the persistence of favourable variations, promoted by natural selection, transposing correctly the line of thought of Darwin (1859): «Only those variations which are in some way profitable will be preserved or naturally selected» (p. 117). They also stated that, over time, those differences are accentuated with the aid of heredity, clearly transposing Darwin's thought: «natural selection, also, leads to divergence of character» (pp. 127-128). Amado and Leite (1887) and Lemos (1890) agreed that, after several generations, the sum of small changes originates varieties, those races, and, finally, new species, rightly extrapolating the cumulative process highlighted by Darwin (1859): «natural selection will then accumulate all profitable variations» (p. 134). They also stated that this process leads to the disappearing of intermediate forms, rightly transposing to the natural environment the ideas of Darwin (1859) on the process of divergence of characters under human influence: «As the differences become greater, the inferior animals with intermediate characters, being neither very swift nor very strong, will have been neglected, and will have tended to disappear» (p. 112).

The textbooks of Aires (1907, 1920, 1931) were those where the mechanism of vital competition was transposed with a greater development, a phenomenon similar to what happened in the EUA: «Turn-of-the-century zoology textbooks gave new prominence to evolutionary concepts» (Larson, 1987, p. 104). Hernández Laille (2010) also stated that the Spanish textbooks of the earlier 20th century explicitly recognized Darwin as the founder of the theory of evolution and included items that explained the concepts of natural selection and struggle for existence, among others. In this regard, Aires considered that the struggle for existence, or vital competition, acts from the embryonic state to adulthood of an organism, meeting Darwin's argumentation (1859): «that every single organic being (...) lives by a struggle at some period of its life» (p. 66). Aires (1907) warned that the struggle of the males for the conquest of the females is an important example of vital competition. Globally, he

¹¹ It should be mentioned that Darwin (1859) focused, essentially, the competition between individuals and not between species: «As the individuals of the same species come in all respects into the closest competition with each other, the struggle will generally be most severe between them» (pp. 467-468).

considered that in the struggle for existence: «In all cases victory will belong to the most favoured ones, from the point of view of the special form that takes the struggle in each particular case, that means, *the fittest* ones» (p. 175; italic in the original). About the expression «surviving of the fittest», Browne (2008) concluded that «in the late 19th century and in the beginning of the 20th century, for instance, when the evolutionist imperatives of competition and of progress were expressed in the social sphere (...) the expression «surviving of the fittest one» was in everybody mouths» (p. 13). Therefore, it is not surprising that it was often used by Aires to explain the process of natural selection.

Aires (1907, 1920, 1931), Primo (1937) and Pires de Lima and Soeiro (1955), doing the didactic transposition of Darwinist ideas, stated that from this competition arises the mechanism of natural selection, which favours the surviving of the fittest individuals, that would transmit their characters to the descendants, like Darwin (1859) detailed:

Owing to this struggle for life, any variation, however slight and from whatever cause proceeding, if it be in any degree profitable to an individual of any species, in its infinitely complex relations to other organic beings and to external nature, will tend to the preservation of that individual, and will generally be inherited by its offspring (p. 61).

Aires (1907, 1920, 1931) made a clear transposition of those ideas when describing that, through natural selection, the winning organisms of the struggle for life, the fittest ones, are more likely to multiply than the others, so, they are more capable of giving offspring than the others, and so on. On the contrary, the number of the less apt will decrease and then disappear. When the variation that served as a support of that special ability, and which has been amplified from generation to generation, reaches a large number of individuals, becomes the basis of a new variety that could continue to evolve, giving rise to new species.

This strong allusion to natural selection also occurred in US textbooks between 1900 and 1929, as shown in the word count done by Skoog (1979) concerning this subject (2.092 words in textbooks published between 1900-1919 and 2.657 words in the ones published between 1920-1929). However, there is a difference regarding Portuguese textbooks, because this process has not been considered ruthless and bloody, on the contrary of US textbooks. Nevertheless, the set of objections previously pointed to Darwinism, and specifically to natural selection, led Aires (1907) to conclude that it is not a consensual mechanism for the transformation of species. Inclusively, in a footnote he informed that Pfeffer, a German botanist pioneer in the study of plant physiology, defended that «the natural selection, far from leading to the transformation of species, has the effect of keeping the fixed number and characters of their representatives»¹² (p. 177). These words are a strong evidence of the influence of the eclipse of Darwinism (Bowler, 1992) over the evolutionary thought of Aires in that period.

¹² Another critic, Fleeming Jenkin, engineer and Regius Professor of Engineering at the University of Edinburgh, in a review of the Origin of Species, believed that natural selection could not act in a cumulative way. He stated that a new characteristic, though it was advantageous, would be quickly diluted due to the crossing of the carrier individual with individuals without that characteristic (Avelar et al., 2004; Bowler, 1992; Browne, 2008).

5.6. Geographic isolation

The contribution of geographic isolation to the process of natural selection was an important argument of Darwin's thought (Bowler, 2003). However, it was lightly addressed in the analysed textbooks. Those ideas were debated by Darwin (1859) in chapter IV: «isolation, also, is an important element in the process of natural selection» (p. 104). Following Darwin's ideas, Aires (1907, 1920, 1931) transposed the geographic isolation as a process that contributes to the formation of new species. He referred that the origin of species will be facilitated if there is a segregation of new breeds, formed from an original species, caused by geological barriers, such as mountains or rivers that promote a geographic isolation, avoiding its crossing. The geographic isolation, despite its importance for the process of speciation, was not addressed by the other authors, which contrasts with the continuous reference to that evolutionary condition in the US textbooks (Skoog, 1979).

5.7. Sexual selection

Darwin (1859) devoted much attention to sexual selection as an evolutionary mechanism with a parallel action to natural selection. This mechanism was based on the following idea: «This depends, not on a struggle for existence, but on a struggle between the males for possession of the females» (p. 88). Although Darwin (1859) has given some attention to this mechanism, it was vaguely transposed by the Portuguese authors of textbooks. Lemos (1890) only said that sexual selection, as a natural choice of breeders among the winners of the struggle of males for the possession of females, is one of the most important mechanisms of evolution. Forty years later, Aires (1931) added explicitly a text to explore sexual selection, though in the textbooks of 1907 and 1920 he had addressed indirectly that phenomenon when presenting, in a set of examples of advantages in the struggle for life, the attraction of females due to characteristics as colours or more seductive singing, etc. In the textbook of 1931, Aires referred that this mechanism was conceived by Darwin to, among other factors, explain the development and the existence of secondary sexual characters. He repeated the previous example by stating that in the competition of males for possession of females, these ones are conquered by the males who have more effective combat weapons, brighter colours, a more harmonious singing, more accurate sense organs, etc. The result of this competition is that «as females remain extraneous to such a selection, males will differ from females more and more with the development of generations, and so they have developed the secondary sexual characters» (p. 329). Primo (1937), Pires de Lima and Soeiro (1955) have also made the same transposition, when attributing to sexual selection a relevant role in the selection of characters to transmit to the following generations.

6. Conclusion

The transposition of the book *On the Origin of Species* to the Portuguese standards of Natural Sciences can be divided in three clusters: Those who do

not address Darwinism (Standards of 1856, 1872, 1880, 1886, 1926 and 1929), those who address some Darwinian mechanism, like the selection (Standards of 1889) and adaptation (Standards of 1905) and those who prescribe an expanded approach to various Darwinists concepts (Standards of 1895), in the context of studies about transformism (Standards of 1919), or studies about evolution (Standards of 1936 and 1954). The theme of evolution was often addressed in the final year of secondary education, a phenomenon which may indicate an analogy to the Portuguese case of the following conclusion of Skoog (1979): «the study of evolution was a peripheral and neglected part of the biology curriculum prior to the development of the BSCS textbooks in the 1960s» (p. 835). It was also mostly associated with Zoology contents, instead of Botany, a similar phenomenon to what occurred in the US (Larson, 1987).

The authors of Natural Sciences textbooks of Portuguese secondary education probably accessed in the 19th century to French translations of the book *On the Origin of Species*, as it can be concluded from the study of Almaça (1999). The Portuguese translation of this book was only available from 1913, according to Pereira (2001). However, in the present research became evident that the textbooks of Natural Sciences of secondary education published since the late 19th century gradually integrated the Darwinist theoretical body. This phenomenon also happened in US textbooks, between 1900 and 1950, in which Skoog (1979) found a slowly, but progressive increase of the evolutionary theoretical framework. Another point in common with the study of Skoog (1979) is that the human evolution has been ignored in the textbooks analysed.

The evolutionist discussion in Portuguese textbooks focused, unlike what happened in other countries, not in the struggle between creationism and evolutionism, but in the mechanisms that explained evolution, in a framework of strong didactic transposition of the ideas presented by Darwin in the book *On the Origin of Species*. The textbooks addressed unequally the following mechanisms of evolution: adaptation, variability, growth correlations, heredity, natural selection and vital competition, geographic isolation and sexual selection. However, in some cases, those mechanisms of evolution were transposed to the textbooks even when they were not prescribed in standards. The textbooks that developed more deeply those topics were written by Aires (1907, 1920, 1931). In the textbooks published in the next decades (Primo, 1937; Pires de Lima & Soeiro, 1950) the approach to the evolutionary theoretical framework was not increased, unlike what happened in US textbooks published between 1930 and 1949.

Although most textbooks have transposed the mechanisms of evolution, they have also showed some of the Darwinism gaps. This phenomenon reflects a parallelism between the Portuguese textbooks and the European and American movement that led to the genesis of new explanations for evolution, in a period known as eclipse of Darwinism. Although it was not possible to access the scientific sources used by the authors of textbooks, it is raised the hypothesis that a strong influence of French scientific literature in Portugal, at the expense of Anglo-Saxon sources (Almaça, 1999; Beato, 2011), have contributed to the questioning of some Darwinist concepts in that period.

7. References

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