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Special Issue: **Need for food! Conciliating sustainable protein economy and ethical treatment of animals: A science-based social imperative**

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Editorial

Necessidade de alimentos! Conciliação entre a economia da produção de proteína sustentável e o tratamento ético dos animais: Um imperativo social de base científica.

Enquanto médico veterinário de formação tive oportunidade de trabalhar em diferentes áreas da profissão, e vão quase quarenta anos. De entre elas, a inspeção sanitária de produtos de origem animal, a medicina da produção e a medicina da conservação serão aquelas em que o papel destes profissionais será mais importante numa sociedade exigente e em marcada evolução. No meu caso, o exercício prático, o ensino e a investigação foram pontuando uma parte relevante da atividade profissional. Não obstante a apaixonante clínica de animais de companhia e a investigação em imunoalergologia, nunca perderia a perceção sobre o principal papel do médico veterinário na sociedade humanizada, o de promover a produção de alimentos de origem animal seguros, em quantidade suficiente e a custo acessível, num contexto mais lato, composto por quatro pilares fundamentais da responsabilidade dos Estados: alimentação, saúde, educação e justiça.

No século XX, excetuando alguns períodos de grande conturbação política e social, até à década de 1960 o modelo de progresso então em curso parecia solidamente imparável. Porém, a evolução a todos os níveis exponencial, observada no planeta, encaminhava-se para uma preocupante insustentabilidade, comprometedora da própria sobrevivência de inúmeras espécies. Ainda na segunda metade do século XX, tal situação começava já a virar progressivamente o foco da consciência social no sentido da necessidade de travar as gravosas e previsivelmente trágicas modificações climáticas associadas. O modelo de desenvolvimento tecnológico em curso não cabia já na nossa Terra. Havia-se chegado à lua, mas, apesar do turismo espacial ser já uma realidade, mesmo que exclusivista, uma possível colonização em massa do espaço afigura-se mais complicada. Certo é que teremos já ultrapassado o ponto de viragem, em termos de impacto ambiental, do modelo de progresso saído da revolução industrial. É como se o planeta começasse a suar mais do que a água que consegue beber, desidratando-se perigosamente. Começa a ser evidente a necessidade cada vez mais urgente de inverter o rumo, perante uma natureza em asfixia. Especialistas mundiais vêm-se reunindo para discutir este cada vez mais assustador problema. A opinião pública começa a reparar nele, preocupando-se, ainda que a sociedade, rendida à volúpia consumista, não permita, para já, o necessário grau de cidadania aderente. Em todo o caso, e felizmente, as questões ambientais começam a chamar a atenção real de líderes políticos um pouco por todo o mundo e os resultados, não sendo tão rápidos quanto desejável para garantir já o salvamento do planeta doente, vêm, pelo menos, colocando aquelas questões na agenda política internacional, de forma incontornável, vincando a preocupação dos cidadãos. Com as sucessivas Conferências das Nações Unidas sobre Alterações Climáticas (COP) lá vamos seguindo de COP em COP e, mesmo com as fraturantes ausências de importantes poluidores, o caminho vai-se fazendo. Diz-se que água mole em pedra dura, tanto bate até que fura – temos, ainda, uma nesga de esperança neste mundo global, entre pandemias supra-bíblicas e a biologia molecular mais *state of the art*. Como resumia Frans Timmermans, vice-presidente da Comissão Europeia e representante europeu nas negociações da COP26, relativamente aos resultados alcançados: “O perfeito é inimigo do bom”. Que o tempo gasto não tenha sido tempo perdido, como onomatopeicamente expressava a ativista sueca Greta Thunberg: “Blá, blá, blá”. É o que todos nós cidadãos, esperamos.

Para poder ultrapassar os exigentes desafios que temos pela frente precisamos focar o extraordinário potencial científico, que não para de crescer, no desenvolvimento de um modelo tecnológico de produção alimentar seguro, acessível e de distribuição justa. O conhecimento científico e tecnológico deve permitir à população mundial um equilíbrio incontornavelmente democrático, respeitando também os nossos parceiros na natureza, de forma a mantê-la sã e sustentável para as gerações vindouras. Só assim garantiremos a nossa própria sobrevivência, como parte integrante do ecossistema terrestre. Não nos considerarmos pares dos outros seres vivos, posicionando-nos arrogantemente como superiores, resulta no que está à vista de todos. Neste contexto, afigura-se especialmente importante que a humanidade comece, de forma inequívoca, por respeitar todos os que, de forma senciente, são capazes de sentir e de sofrer, física e emocionalmente. Também neste aspeto a ciência deve ser ouvida, sendo consideravelmente preocupante observar que, após a extraordinária evolução do conhecimento científico, grandes massas populacionais continuem a fazer opções à sua margem, promovendo lideranças políticas flutuantes entre a ignorância e o cinismo, com graves consequências para todos os habitantes de um planeta que, do espaço, de onde o conjunto que somos se pode observar, não apresenta fronteiras.

A prossecução de objetivos tão necessariamente ambiciosos, relacionados com a nossa própria sobrevivência planetária, requer uma estabilidade decisória que permita um desenvolvimento económico equilibrado e sustentável, associado a uma redistribuição da riqueza. É isso a que chamamos progresso, paz social e democracia. Trata-se, verdadeiramente, de uma responsabilidade dos Estados, mas nem todos a demonstram, levando, perante a falta de acesso a uma vida digna, tantas vezes sem a elementar expectativa de sobrevivência, a que "os pobres assaltem a casa dos ricos". É o triste espetáculo que entra diariamente pelas nossas casas dentro, quando a ausência de paz social, e mesmo de recursos alimentares, promove ondas migratórias vindas de sul, rumando em direção à Europa e à América do Norte. Este espetáculo desumano, e que conta também com muros e arame farpado como atores, não é compatível com os princípios democráticos, exigindo consensos internacionalmente alargados. Esse objetivo deve também manter-se na agenda política internacional, devendo mesmo ser um dos temas fulcrais das políticas públicas transnacionais. Curiosamente, do espaço não se vê o arame farpado!

Neste número especial do Jornal Português de Políticas Públicas, dedicado à produção alimentar sustentável, às alterações climáticas e ao tratamento ético dos nossos maiores fornecedores de proteína, os animais, é com apreciável satisfação que pudemos contar com vários nomes de reconhecido prestígio naqueles domínios. **Carlos Fiolhais**, professor universitário, físico, ensaísta e um extraordinário divulgador de ciência, expõe-nos com uma lucidez clarificadora aspetos essenciais associados às alterações climáticas e à produção de alimentos. Afinal, a agricultura industrializada não é a mãe de todos os males, mas, no global, aqueles tendem claramente a agravar-se se mudanças cientificamente baseadas não se fizerem. Os factos científicos aqui desmontados e explicados com extraordinária clareza permitem-nos compreender melhor a dimensão inerente a estes temas. **Manuel Chaveiro Soares**, professor universitário, agrónomo, administrador e empresário de sucesso é alguém que muito admiro, pela extraordinária visão científica que mantem da sociedade, a qual lhe permite manter na crista do sucesso empresarial as atividades que empreende. Apresenta-nos factos incontornáveis do desenvolvimento biotecnológico, que, com a sua repercussão a nível farmacêutico e da produção alimentar, sem contornar a questão do impacto ambiental, nos mostra como foi possível sermos hoje mais saudáveis, sentirmo-nos mais seguros e, talvez mesmo, mais felizes. **Fernando Bernardo**, professor universitário, médico veterinário e ex-Diretor Geral de Alimentação e Veterinária foi, desde que o conheci como meu professor, alguém cuja elevação me captou a atenção e marcou positivamente. Como poucos, recorrendo aos seus conhecimentos científicos e do terreno, apresenta-nos o panorama atual da produção alimentar em Portugal, em termos de sustentabilidade e, de forma integrada, em termos sociais, económicos, culturais e sanitários. Trata-se, pois, de uma perspetiva a levar muito em conta, em termos de política agroalimentar. **Christiane Souza**, **Flávio Vieites**, **Antônio Castro**, **Luís Martins** e **Cristina Ribeiro de Lima** são também todos académicos, com estreita ligação ao terreno e um denominador comum, a experiência diferenciada no domínio da produção avícola de elevada eficiência. Experiências diferentes, mas complementares, permitiram a presente visão da produção avícola, nas suas diferentes vocações, em termos da extraordinária evolução tecnológica, do impacto socioeconómico e da dinâmica territorial, recorrendo ao exemplo de uma grande potência como o Brasil. Demonstram, acima de tudo, como a produção de proteína alimentar de alto valor biológico é possível, de forma muito eficiente, ou seja, com contido impacto ambiental. **José Afonso de Almeida**, professor universitário, médico veterinário, cedo demonstrou uma capacidade singular de gestão académica, cuja competência o levaria a ocupar diferentes lugares cimeiros da organização universitária. Sem nunca perder o gosto por ensinar, tornou-se para muitos de nós uma referência de pensamento. O seu contributo para este número não podia ser mais relevante e inquietante. De facto, a arena moral em que colocamos os outros animais, sejam eles de companhia, trabalho, desporto, lazer ou mesmo de comer e vestir, é algo que colide frequentemente com os valores modernos que consideramos humanistas e cívicos. Mas é preciso conhecer bem o histórico e a natureza animal, nas suas várias facetas, para melhor enquadrar a dimensão da questão. É isso que, de forma brilhante, aqui nos oferece.

Dezembro 2021

Luís Martins

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Editorial

Need for food! Conciliating sustainable protein economy and ethical treatment of animals: A science-based social imperative.

As a veterinarian I had the chance to work in different areas of the profession for almost forty years. Among them, the sanitary inspection of animal-derived products, production medicine and conservation medicine will be those in which the role of these professionals will be more important in a demanding society in marked evolution. In my case, practice, teaching and research composed a relevant part of professional activity. Despite the exciting clinic of companion animals and research in immunoallergology, I would never lose perception regarding the main role of the veterinarian professional in the human society, which is to promote the production of safe food of animal origin, in sufficient amount and affordable, in a broader context, composed by four fundamental pillars of responsibility of States: food, health, education and justice.

In the 20th century, with the exception of a few periods of great political and social disruption, the ongoing model of progress seemed solidly unstoppable until the 60s. However, the exponential evolution at all levels observed on the planet was heading towards a worrying unsustainability, compromising the very survival of countless species. In the second half of the 20th century this situation was already progressively shifting the focus of social awareness towards the need to halt the serious and predictably tragic associated climate changes. The current model of technological development was no longer suitable for our planet. We had traveled to the moon but, despite space tourism being a reality, even if exclusive, a possible mass colonization of space seems more complicated. Probably, we have already passed the turning point of environmental impact, regarding the model of progress that emerged from the industrial revolution. It is like the planet starts sweating more than the water it can drink, dangerously dehydrating itself. The increasingly urgent need to reverse the course, in the face of a stifling nature, becomes evident. World experts are coming together to discuss this increasingly daunting problem. Public opinion is beginning to notice that, worrying, even if society, surrendered to consumer lust, does not allow, for the time being, the necessary level of adhering citizenship. Anyway, fortunately, environmental issues are starting to draw the real attention of political leaders all over the world and the results, not being as fast as desirable to guarantee the immediate saving of the sick planet, are at least placing those issues on the international political agenda in an unavoidable way, accentuating citizens' concern.

With the successive UN Climate Change Conferences (COP) we follow from to COP to COP, and even with the fractious absences of important polluters, the process seems to be on its way. Some say that soft water on hard stone hits until it breaks – we still have a glimmer of hope in this global world, between supra-biblical pandemics and the most state-of-the-art molecular biology. As Frans Timmermans, vice-president of the European Commission and European representative at the COP26 negotiations, summarized in relation to the results achieved: “The perfect is the enemy of the good”. That the time spent was not time wasted, as Swedish activist Greta Thunberg onomatopoeically expressed: “Blah, blah, blah”. That is our hope.

In order to overcome such demanding challenges lying ahead we need to focus the extraordinary scientific potential, which is constantly growing, on the development of a technological model for safe, accessible and fair distribution of food production. Scientific and technological knowledge must allow the world population to achieve an undeniable democratic balance, while also respecting our partners in nature, in order to keep it healthy and sustainable for future generations. Only this way it will be possible to guarantee our own survival, as part of Earth’s ecosystem. Not considering ourselves in a peer-to-peer system with other living beings, placing ourselves above all creatures, results in what it is plain to see. In this context it is especially important that mankind begins, unequivocally, by respecting all those who, as sentient beings, are capable of feeling and suffering. Science must also be listened regarding those issues as it is of considerable concern that, after the extraordinary evolution of scientific knowledge, large population groups continue to make choices on the sidelines, promoting political leaderships floating between ignorance and cynicism, with serious consequences for all the living beings on the planet. We should remember that from space, from where the planet can be seen as a whole, there are no borders.

Pursuing such necessarily ambitious goals, related to our own planetary survival, requires decision-making stability that allows for balanced and sustainable economic development, associated with a

redistribution of wealth. This is what we call progress, social peace and democracy. It is a responsibility of States, but not all practices it, often leading to the lack of an elementary survival prospect. It is when "the poor raids on the home of the rich". It is that sad drama entering our homes daily, when the absence of social peace and even of food resources promotes migration waves heading to Europe and North America, coming from the south. This inhumane show, also counting on walls and barbed wire as actors, is not compatible with settled democratic principles, demanding broad international consensus. This objective must also remain on the international political agenda and should even be one of the central themes of transnational public policies. Interestingly, you can't see barbed wire from space!

In this special issue of the Portuguese Journal of Public Policies, dedicated to sustainable food production, climate changes and ethical treatment of animals, our largest protein suppliers, it is with great satisfaction that we could count on several renowned names in those fields. **Carlos Fiolhais**, university professor, physicist, essayist and an extraordinary influential scientist exposes with simple lucidity essential aspects associated with climate changes and food production. After all, industrialized agriculture is not the source of all evil, but globally that is likely to get worse if scientifically-based changes are not made. The scientific facts here disassembled and explained very clearly allow us to better understand the dimension of these matters. **Manuel Chaveiro Soares**, university professor, agronomist, CEO and successful entrepreneur is someone I greatly admire for his extraordinary scientific vision of society, allowing to maintain the undertaken activities on the way to success. He presents us with unavoidable facts of biotechnological development, which, with its repercussions in terms of pharmaceuticals and food production, without circumventing the matter of environmental impact, show us how it was possible to become currently healthier, feel safer and perhaps even happier. **Fernando Bernardo**, university professor, veterinarian and former General Director of Food and Veterinary Medicine has been, ever since I met him as my professor, someone whose high standards kept my attention and made a very positive impression. Like few others, using its scientific and field knowledge, he presents us with the current panorama of food production in Portugal, in terms of sustainability and, in an integrated manner, in social, economic, cultural and health terms. It is, therefore, a perspective to be taken into account in terms of agri-food policy. **Christiane Souza**, **Flávio Vieites**, **Antônio Castro**, **Luís Martins** and **Cristina Ribeiro de Lima** are also all academics, closely connected to the field and with a common denominator, the true know-how in the field of highly efficient poultry production. Different but complementary experiences have allowed the present vision of poultry production, in its different vocations, in terms of extraordinary technological evolution, socio-economic impact and territorial dynamics, using the example of a great power such as Brazil. Above all, they demonstrate how the production of high biological-value food protein is possible, in a very efficient way, that is, with limited environmental impact. **José Afonso de Almeida**, university professor, veterinarian, soon demonstrated singular skills in academic management, whose expertise would lead him to carry out several top duties in the university organization. Without ever losing his interest for teaching he became a reference for many of us. His contribution to this issue could not be more outstanding. In fact, the moral arena in which we place the other animals, whether for petting, work, sport, leisure or even for eating and dressing proposals, is something that often clashes with modern values that we consider humanistic and civic. However, it is necessary to know the history and animal nature well, in its various ways, to better frame the dimension of the matter. That is what, in a brilliant way, he offers us here.

December 2021

Luís Martins

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Climate Changes and Human Food

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ABSTRACT

With the publication of successive reports by the Intergovernmental Panel on Climate Change of the United Nations, global climate change due to greenhouse gas emissions from human activities is now an indisputable fact. Although only 24% of these emissions are due to agriculture, forestry and land use, these changes, by having consequences on soil quality and biodiversity, affect food production. Some adaptation and mitigation measures will therefore impact our table. This problem will increase with the rise of the world population, which may in this century exceed ten billion people. The goal of eradicating hunger and malnutrition has been pursued through a better use of land based on plant genetics, fertilization, irrigation and mechanization, but, in a world with enormous inequalities, this path must be strengthened. In the field of human nutrition, the progressive replacement of animal proteins by others of plant origin or synthetic equivalents is foreseeable. In Portugal, in spite of great progress in supply favoured by globalization, food insecurity still persists. With the worsening of climate change, which will significantly affect southern Europe, it is likely that the already big dependence on external supply will increase.

Keywords: Climate change, agriculture, population, hunger, food.
JEL classification: Q01, Q18, Q54, Q55, Q56.

1. INTRODUCTION

In 2015, the United Nations - UN pointed out 17 sustainable development goals within the framework of the so-called «2030 Agenda» (UN, 2015). These goals include, in point 2, «the end of world hunger, food security, improved nutrition and the promotion of sustainable agriculture». This point unfolds into several ones, among them 2.4, which refers to climate change:

«By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality.»

The goals 13 («Take urgent action to combat climate change and its impacts in agriculture») and 15 («Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss») emphasize the urgency of the climate challenges that affect our food.

The increase in the world population and the increase in the standard of living of large strata of the population have demanded more and more resources (energy, food, etc.) and, therefore, processes that penalize the environment. Thus, the artificial greenhouse effect that results in the planet's

overheating was accentuated. In recent decades, the need for a global response to this issue has been widely recognized.

This article presents a summary of the issue, focusing on agriculture and human food and making special reference to the Portuguese case.

2. GLOBAL WARMING

The greenhouse effect is a natural phenomenon in the Earth's atmosphere, which ensures an average temperature suitable for life, but its big increase in recent years is causing serious problems to life, including human beings. It is now a scientifically uncontroversial fact that there are global climate changes and that they have an anthropogenic character: they are due to the Earth's warming due to the increase, by human hand, of greenhouse gas (GHG) emissions. The main GHGs are carbon dioxide (CO_2), which is worth 76%, methane (CH_4), which is worth 16%, and nitrous oxide (NO_2), which is worth 6% (IPCC, 2014). Direct GHG emissions come from electricity, heat and other energy production (35%), agriculture, forestry and other land uses (24%), industry (21%), transport (14%) and buildings (6%). Agriculture, which includes livestock and fisheries, is only responsible for 13% of CO_2 emissions, but has a special role in the emission of CH_4 (44% of the total), due to livestock, and NO_2 (81% of the total), due to the use of fertilizers.

The UN created in 1988, as part of its program for the environment and in connection with the World Meteorological Organization, the Intergovernmental Panel on Climate Change - IPCC, whose objective is to gather, analyse and disseminate the available scientific information on climate change, clarifying its causes, effects and risks for the environment and for humanity. To date, the IPCC has produced five reports and some additional documents that alerted to the effects of these changes in areas ranging from meteorology to health, passing through biodiversity and food. The IPCC does not collect environmental data or carry out original research, but it has undertaken an enormous amount of scientific peer-review work, which can be considered the largest meta-analysis of scientific papers ever done.

The information provided by the IPCC, which earned the Nobel Prize for Peace in 2007, has served as a basis for establishing global and national climate policies. The quality and seriousness of the work of that panel, which involves thousands of the most reputable scientists and technicians from various fields, coming from numerous countries, is now well recognized. In the thousands of published pages, it is possible to find errors, which have been always corrected, but the so-called «deniers» of climate change, relatively few but very active in the media, do not have any scientific basis to contradict the IPCC conclusions.

The 1st IPCC report, issued in 1990 (IPPC, 1990), served as the basis for the UN Framework Convention on Climate Change initiated at the «Earth Summit» in Rio de Janeiro, in 1992, which already pointed to emissions of GHG. Based on information from the 2nd report, from 1995, and as a global political response to the climate threat, the Kyoto Protocol was adopted in 1997, which entered into force in 2005: almost all countries in the world, including Portugal, committed then with the reduction of GHG emissions.

It did not take long for the reaction of some industrial sectors and interest groups (namely linked to the fossil fuel sector, forced to reduce their activity), casting doubts on the conclusions of the IPCC, which found echo in some sectors of the population with less scientific culture. In 2004, responding to some controversy in the media, Naomi Oreskes, an American historian of science at the University of California - San Diego (now at the Harvard University), published a study *in Science* in which the scientific consensus on the changes and its human origin was demonstrated (Oreskes, 2004). In this work, she analysed more than 900 articles on climate change published between 1993 and 2003 in international scientific journals. Among those articles there was not even one that disproved the idea that the Earth was warming and that the main causes of that warming were human activities. Oreskes, in a re-analysis (Oreskes, 2007), concluded that: 20% of published scientific articles on climate change explicitly supported the claim that «the Earth's climate is being affected by human activities»; 55% of the articles implicitly supported this idea, either by describing research on the present or future impacts of climate change (50%) or by focusing on measures to mitigate them (5%); and 25% of the articles did not take a position on the subject, because they were paleoclimatic studies or on measurement techniques. The same author developed her arguments about climate denialism in the book written with Eric Conway, *Merchants of Doubt* (Oreskes and Conway, 2010).

In 2006, the film An *Inconvenient Truth*, associated with a book by Al Gore (Gore, 2006), former vice president of the USA, played a very relevant role in alerting public opinion to the issue of climate change.

The 4th IPCC report, released in 2007 (IPCC, 2007), was larger, more detailed and more categorical than the previous ones: it stated that climate warming was unequivocal, given the records of global average temperatures, of melting snow and ice, and sea level rise. As for the causes, the report also left no room for doubt: most of the increase in global average temperature since the mid-20th century was due to the observed increase in human derived GHG concentrations, in particular excessive CO_2 concentrations, that result from the burning of fossil fuels. Since the extent of the increase in the longer term is uncertain, given the great complexity of the issue, several scenarios were drawn up, some more optimistic and others more pessimistic.

The report listed some factors as starting points for these scenarios: Until 2007, 11 of the 12 warmest years since 1850 occurred between 1995 and 2006. The scores in the second half of the 20th century in the northern hemisphere were higher than in any other period of 50 years during the last five centuries. There are natural causes that can contribute to the Earth's thermal evolution, but all of them have been evaluated, having proved to be insufficient to explain the observed temperature increase. The IPCC warned: If GHG search levels did not decrease, as temperatures would rise even higher and faster.

The impacts would not be equal everywhere. In Europe they would be more negative in the countries of the South, including Portugal. Periods of drought and a consequent decrease in agricultural productivity as well as the conquest of the coast by sea are some of the expected consequences of climate change in the country, which were studied by physicist Filipe Duarte Santos and his collaborators in the project «Climate Change in Portugal. Scenarios, Impacts and Adaptation Measures - SIAM», made available were released in 2002 and 2006 (Santos et al., 2002, and Santos and Miranda, 2006).

In 2014 the 5th IPCC report came out (IPCC, 2014). It was on this basis that, in the following year, the Paris Agreement, which succeeded the Kyoto Protocol, was signed at the UN Conference on Climate Change. It was a new agreement to reduce CO_2 emissions, so that the global average temperature would not rise, in the next decades, by more than 2 °C, and the increase should preferably be less than 1.5 °C, relative to pre-industrial levels, which is the threshold for a situation considered catastrophic (we are currently ca. 1 °C above). The Paris Agreement was signed by almost all countries in the world, including Portugal (the US placed themselves out in Donald Trump's term, but came back after the election of Joe Biden).

Here is a summary of the consequences, focused on in the 5th report, of climate change:

- The frequency and severity of droughts is increasing. Extreme droughts, which used to occur once a decade, are occurring twice as often. If temperature rises by 2°C, they may triple.

- Extreme heat waves (such as the one that occurred in the US and Canada in the summer of 2021) are about 5 times more likely with current warming of around 1 °C. With a 2 °C warming, this probability will increase to 14 times. Under these conditions, the maximum temperatures would be almost 3 °C higher than in previous heat waves.

- Although a more intense evaporation of water causes mores dries, hot air can retain more water vapor causing extreme rains (as happened in Germany and China in the summer of 2021). The frequency of major floods has increased by 30%, with more water falling on average.

- Hurricanes are getting stronger, causing more rain. A larger percentage of them are reaching the higher categories of the conventional scale, as well as appearing in latitudes

- Because of the melting of ice in polar regions, the sea level is rising all over the world, causing coastal flooding. If nothing is done, by 2100, severe flooding once in a century will begin to occur annually in more than half of the world's coastal areas.

For an update on the work on climate change in Portugal after the Paris Agreement, see (Silva, 2020).

In the same year as the Paris Agreement, Pope Francis published the encyclical on the environment *Laudato Si'*, in which he defended the need to protect our "common home" (Francisco, 2015). This document was very well received overall, helping to raise public awareness of the problem.

Global warming is today certainly one of the biggest problems in the world, therefore attracting the attention of scientists, politicians and citizens. The 6th IPCC report will be presented in 2022. But since the Paris Agreement, three special reports have been issued. One, in 2018, on global warming

of 1.5 ºC, another, in 2019, on the oceans and the cryosphere, and still another, in the same year, on land, agriculture and food security. The latter, entitled *Climate Change and Land* (IPCC, 2019), prepared by 107 experts from 52 countries, analysed the relationships between global warming, terrestrial ecosystems, soil-dependent production systems and society. The report, which considers soil a «critical resource», emphasizes that climate change affects the various components of food security: availability (production), access (market) and use (nutrition). Several populations, particularly in Africa and Latin America, are forced to move because of food needs. With less land available for agriculture, a more rational use of resources is imperative. The IPCC warns against deforestation, especially in tropical forests (in the Amazon, soy plantations are occupying formerly wooded territory), and against land conversion to bioenergy plantations (biomass is a substitute for fossil fuels), saying that these plantations must be limited, since they imply losses in food production. The same report indicates that plant-based diets are a good way for adapting and mitigating climate change, even recommending a reduction in meat consumption.

In August 2021, the Physical Sciences Group of the IPCC announced its contribution to the 6th report (IPCC, 2021). According to that work, warming is occurring even faster than previously thought: the latest projections show that the 1.5 °C threshold will be reached in the next one or two decades, regardless of the actions taken. António Guterres, Secretary-General of the UN, reacted to the report saying it was a «red alert for humanity»: GHG emissions from burning fossil fuels and other processes are «suffocating» the planet, putting millions of people at risk.

Governments around the world, albeit unevenly, are working today to prevent an average temperature rise above 1.5 °C. The transposition of this «red line» is now seriously considered and feared: in an elevation scenario of 3.5 °C, the probable extinction of up to 70% of all species existing today is predicted (Shah, 2013). One of the biggest problems in the global response to global changes is the positive correlation between energy consumption *per capita* and average income *per capita*. The less developed countries, which naturally intend to develop further, will tend to spend more energy, and it is very difficult, if not impossible, for others to prevent them from doing so.

Adaptation and mitigation measures of global warming are essential. Technologies have been developed and applied for a long time to produce energy from alternative sources to fossil fuels (wind, solar, water, etc.), more sustainable agricultural processes have been practiced, less polluting industries have been created, and vehicles with less or zero emissions have been manufactured. The latest information from the IPCC reinforces the urgency of finding and applying these types of solutions.

Recent popularization books have appeared that provide a more pessimistic view than most previous ones, such as the one written by American journalist David Wallace-Russel, *The Uninhabitable Earth* (Wallace-Russel, 2019): «Each one can choose his own metaphor. We cannot just choose the planet, which is the only one each of us will ever call home.» But there are others which contradict this catastrophic trend, such as the book by environmental activist of the same nationality Michael Shellenberger, *Apocalypse Never* (Shellenberger, 2020), which, not denying climate change, warns against extreme positions: «Environmentalism is, today, the dominant secular religion among middle- and upper-class cultural elites in most developed and developing countries.»

Among the latest books on the climate aimed at the public, that of Bill Gates, founder and former CEO of Microsoft, stands out: *How to Avoid a Climate Disaster* (Gates, 2021). For him, the desired goal of zero GHG emissions requires innovative solutions in several domains, including new nuclear power plants, an idea with which some ecologists now sympathize.

3. WORLD OPULATION AND HUNGER

The Earth's population has been increasing impressively: it was 1 billion in 1804, 2 billion in 1925, 3 billion in 1960, 4 billion in 1975, 5 billion in 1987, 6 billion in 1989, and 7 billion in 2012. It currently stands at 7.9 billion and is expected to reach 8 billion in 2024 (UN, 2019). The UN predicted in 2019 that Earth's inhabitants would be 10.9 billion by the end of this century. However, according to a recent study by the University of Washington, Seattle (Vollset, 2020), the world population will be, by the end of the century, two billion below the UN forecasts. There will be a peak of 9.7 billion around the year 2064, dropping to 8.8 billion in 2100, due to falling birth rates in numerous countries and regions. Portugal is, already today, an example of a dramatic fall in birth rate: due to birth deficit, the Portuguese population, which today is 10.3 million people (Censos, 2021), will fall by half before the end of the century, making Portugal one of the oldest countries in the world. On a global scale, this is

good news for the environment, as there will be less human pressure on it, but on a local scale scarcity of people is a problem.

Demographers estimate that Africa will be the continent where population growth will be most accentuated, taking the place that was once Asia. Meeting the food production needs of African populations poses enormous challenges.

The Food and Agriculture Organization of the UN - FAO has published, in collaboration with other UN institutions, annual reports on nutritional deficiencies in the world. According to the report *The State of Food Security and Nutrition in the World* (FAO, 2021), the number of people suffering from chronic hunger has increased in recent years: 9.9% of the world's population is undernourished. More than half of them (418 million) are in Asia, more than a third (282 million) in Africa, and a smaller portion (60 million) in Latin America and the Caribbean. But there is worse: 30% of the world's population suffers from food insecurity, which can approach hunger. This does not stem from a lack of productive capacity – current agriculture, whose development based on science and technology is quite clear, would be able to meet the world's needs – but rather from inequality in access, due to political, social and economic divisions. In the richest countries, food is plentiful – there is waste and the problem of obesity is alarming –, while in the poorest countries many people do not have the means to ingest enough calories.

In previous FAO reports on Food Security, from 2017 to 2020, the main reasons for the increase of hunger in the world were discussed: climate, conflicts and economic slowdown. Extreme weather conditions are a relevant factor in increasing hunger, as increasing droughts are especially severe in countries where agricultural systems are more sensitive to climate change. There is also a strong correlation between the increase in hunger in certain countries and the economic downturn (due to the financial crisis in 2009 and the pandemic one in 2020). The most recent report, examining prospects for achieving the UN's «Agenda 2030» target of «zero hunger», estimates that this target will fail for 660 million people. Food deficit is one of the biggest problems in the world and, to solve it, widespread progress in agriculture is needed.

4. AGRICULTURE AND FOOD IN THE WORLD

An obvious consequence of global warming is the greater difficulty of agriculture in producing food. On the other hand, the demographic pressure as well as the rise in the standard of living of many populations (the case of China is emblematic) demand an increase in food production.

The rise in temperatures, the changes in the rhythm of the seasons, the reduction of soil moisture and water sources, the increase in superficial evaporation rates, the tendency towards desertification in subtropical areas, changes in the rainfall regime, and changing cycles of carbon, nitrogen and other nutrients are harming agriculture, livestock and forestry in large producing areas and, if nothing is done, will harm them even more. Agricultural activities depend on the stable and predictable climate conditions to which all species have long adapted in the process of evolution. The current climate changes are too large and fast for natural systems to absorb them, leaving a large part of production systems disorganized. For example, changes in the oceans are a major threat to fish, molluscs and crustaceans for consumption. As a result, poverty, hunger and disease are expected to increase, as well as conflicts arising from competition between human groups for declining resources. The increase in the use of pesticides and fertilizers to compensate for the drop in productivity will further contaminate the environment, in addition to raising production costs.

The Earth's temperature and the greater frequency of extreme weather events affect the metabolism of plants and animals, making them more prone to epidemics and growth and reproduction disorders. Within the framework of the indispensable adaptation and mitigation measures, it will be necessary, in agriculture, to change the species that are cultivated in the most affected regions, introducing new varieties, as well as changing the cultivation calendars. The drier areas and coastal areas will be more affected, with the need to transfer cultivation sites.

In addition, it will be increasingly necessary to optimize land use, to resort to organic fertilizers, to use seeds suitable for harsh environments, to protect the land against erosion (a problem which is aggravated by bad weather), and to reduce biomass burning, which are often at the origin of forest fires (a very serious problem in Portugal). On the other hand, benefits for the environment and society are generated by a better control of the losses that occur along the production chains and the waste at the end of these chains, as well as changes in eating habits towards more ecological

regimes, including replacing red meat (beef) by white meat (chicken), reducing meat consumption and diversifying the diet to include more cereals, vegetables, fruits, nuts and seeds.

The result of these measures will vary greatly depending on the region, given the different nature of the soils and, above all, the different response capacity of governments and populations. The ability to apply this type of measures is hampered by technical difficulties and high costs: the more developed countries will be better able to implement them, and measures of international cooperation and solidarity in this sector will be necessary. The duration of the measures is very varied: Wetland, pasture and forest maintenance programs can generate quick benefits, but reforestation and soil recovery are very slow processes.

The considerable challenge to be overcome by 2050 will be to increase food production by around 70% to satisfy the growing number of Earth's inhabitants, but at the same time reduce CO2 emissions. We need, in this as in other aspects, to learn from the past. The American agronomist Norman Borlaug, who received the Nobel Prize for Peace in 1970, was one of the most responsible persons for the so-called «Green Revolution», a set of innovation measurements that took place in agriculture in the 1950s and 1960s, including the adoption of more productive grains, especially wheat and rice, synthetic fertilizers (which unfortunately require burning fossil fuels), controlled irrigation and mechanized farming (which suffer from the same problem). All these techniques made it possible to improve agricultural productivity. The amount of land used in world agriculture has increased by only 8% since 1961, while agricultural production has increased by 300% (Schellenberger, 2020). However, this improvement has taken place mainly in richer countries, not having occurred on a large scale in poorer continents such as Africa: thanks to fertilizers, the agricultural yield of cornfields has increased, in the US, by four times in 70 years, while, in Africa, remained constant (Gates, 2021).

Given the finiteness of resources, the use of land for agriculture does not tend to grow: the objective of sustainable agriculture will therefore be to obtain more food from less land. Farmers' incomes must be fair, and consumers must be secure in what they consume. Although difficult, this is not a utopian goal. To supply all present and future inhabitants of the Earth, it would be enough for all farmers to increase their productivity to the level of those who have the highest income today.

Fundamental science has been, in the last century, the base of many great innovations. Advances in molecular biology have led to advances in biotechnology with implications for agriculture, namely the improvement of seeds. The issue of Genetically Modified Organisms - GMOs, which allow farmers to increase their production using fewer resources (water, energy, land, fertilizers, etc.) has been much debated around the world. The US, Canada, Brazil and Argentina use GMOs, while the European Union imposes serious restrictions on them. In fact, Europe is self-sufficient in cereals, but it is no longer self-sufficient in the production of soy, whose proteins are used on a large scale in animal feed (the same Europe that refuses to plant GMOs imports GMO soy from America). Certainly, in countries that have adopted biotechnological innovations, production increased 22% and farmers' incomes increased 68%, while pesticide use was reduced by 38% (Klümper and Qaim, 2014). There may be economic, social and political reasons for banning GMOs, but there do not seem to be strong enough scientific reasons (Freedman, 2017).

In the field of livestock, much has been said about the methane emitted by ruminants, such as sheep and cows. In fact, cattle, especially because of the methane emissions, linked to their physiological functioning, contribute in a non-negligible way to the total GHG emissions. The main culprits are sheep (they emit 39.2 kg of CO_2 per kg of food consumed, including post-production processes), followed by cows (27.0 kg), pigs (12.1 kg), farmed salmon (11.9 kg) and, afterwards, turkeys (10.9 kg) and chickens (6.9 kg) (Gerber et al., 2019). Cheese production is usually accounted for separately (13.5 kg). Clearly, white meat has environmental benefits. For comparison, it should be added that rice cultivation emits 2.7 kg of CO_2 per kg consumed and that of tomatoes only 1.1 kg of CO_2. There are other environmental benefits of white meat over red that have to do with efficiency along the food chain: a gram of beef protein requires twice as much animal calories intake as a gram of pork, and 8 times larger than one gram of chicken meat.

In the last two decades, China, due to its economic growth and concomitant changes in the eating habits of its populations, has increased its consumption of meat, while in the European Union this consumption has remained stable and in the US it only rose slightly (Gates, 2021). In the current debate on world food, radical proposals for the abolition of meat consumption have appeared, a goal that is pursued by vegans, but this seems to be an unattainable goal given the great rooting of meat in the most varied gastronomic cultures: for example, only 2% to 4% of Americans are vegetarians, that is, they share a diverse set of diets of which veganism is an extreme and minor case. Moderately

and controlled reduction in meat consumption may be a more viable option. In the lively discussion that has taken place in recent years, ethical arguments in defense of animal life are invoked (Singer, 1975). But when the IPCC says that «if everyone followed a vegan diet as supplied from the land it could be reduced by 70% by 2050» (IPCC, 2019), it may not be clear that this figure refers to the linkages associated with agriculture, so that total CO_2 rises would only decrease by 10% (Shellenberger, 2020).

Other issues in the debate on food choices have to do with health. Does eating less meat benefit human health? Today we know that the consumption of red meat is associated with an increased risk of diabetes and some cancers, while this which is no longer the case with white meat. In fact, North Americans and Europeans have, since the 1970s, increasingly consumed white meat rather than red meat, with benefits both for the environment and for health. A lot of criticism has been made to industrial poultry farming, but, in fact, improvements in genetics and nutrition, in addition to the optimization of facilities, have led to a large increase in this sector, which produces very economical food proteins.

One solution to the supply of animal protein lies in increased consumption of fish (Tyrrell, 2018), a healthy food, but marine resources are limited: overfishing has put many ecosystems at risk, so that the European Union has placed limits on fisheries of many species. Another solution that is beginning to gain visibility is the consumption of insects, which constitute an enormous biomass in the world, although in the West there are cultural obstacles to this food. An alternative protein source that has been increasingly explored is found in algae, which have long been present in the diets of Eastern cultures, but whose consumption in the West is only now starting to increase.

Technological solutions are also available. To reduce environmental impacts, regular steaks and hamburgers can be replaced by vegetarian equivalents, which already exist on the market with similar texture and flavor, or artificial meat, that is, made from stem cells of the species of interest.

A measure that is perfectly within our reach to reduce the ecological footprint of agriculture is to reduce food loss and waste: in the US this waste is estimated at 40% and in Europe at 20%, so there is still a lot to be done in this area.

An interesting scientific policy proposal was made in a recent *Nature* editorial (*Nature*, 2021): the constitution of a panel like the IPCC to carry out a meta-analysis on food systems, studying the relationship between food and health, an issue about which controversy persists. Since scientific knowledge evolves, it is not clear to the common citizen what is the state of the art on the health benefits of food and the comparison of the plurality of diets that are available. In this regard, see the recent study published in *The Lancet* by a group that has been investigating healthy and sustainable diets (Willett et al., 2019).

5. Agriculture and food in Portugal

In Portugal, the consequences of climate change are notorious, due to its warmer climate (very visible in Alentejo, where some of the extreme temperatures in Europe have been recorded), the size of forest areas and the extension of the coastline. The large forest fires that have broken out in Portugal in recent years, especially in the Centre and the South, are probably epiphenomena of global warming, as the large fires in Greece and Turkey, in Europe, and in California, in the US. On the other hand, some storms with heavy rainfall have caused erosion both inland and on the coast. These effects are likely to become more pronounced.

But there are also good news: our climate situation combined with our geography, on the other hand, allow our consumption of alternative energy to be greater than in most countries in Europe and even the world. Portugal has taken a very interesting path in the process of reducing GHG, namely reaching more than half of the electricity to be produced from alternative energy sources.

In clear contrast to the world population, successive censuses have indicated that the Portuguese population is declining (Censos, 2021), with its aging being clear, due to the very small number of children per fertile woman (1.2). The national territory is very unevenly populated, with a huge concentration in Lisbon and a smaller one in Porto. In addition, there is an axis of occupation of the coast between Viana do Castelo and Setúbal and along the Algarve coast, with the interior being increasingly depopulated. The issue of regionalization, a political measure that could lead to a more balanced occupation of the territory, is being discussed, but without any concrete plans for its implementation. The country's development will require not only a demographic strengthening,

which can be achieved with a greater inflow of immigrants, but also a less unequal occupation of the territory.

The eating habits of the Portuguese have evolved with the globalization process, especially after the country's entry into the European Union in 1986. In general, it still weighs a traditional diet, quite diversified according to the region, but which, in the South, is close to the Mediterranean diet, a healthy diet that was, in 2013, considered by the UN the Intangible Heritage of Humanity. National agriculture, which has been greatly reduced with the entry of Portugal into the Union, is currently not enough to satisfy national needs. Indeed, the national economy shows one of the biggest deficits in the food balance in the whole of Europe. Between 2007 and 2017 the situation improved, but little: from -3878 million to -3460 million euros (*Expresso*, 2019). As an example, we can refer to the case of cod, considered a «national dish», which does not exist near the national coast being, to a large extent, imported. In products such as cereals, meat or rice, there will be no way for the country to be self-sufficient. And it is likely, with the worsening of climate change, that this dependence on the outside will increase.

Not everything is negative in the Portuguese food production: in olive oil, an element of the Mediterranean diet, national production exceeds consumption needs, and the same happens in wine. Portugal has, in fact, not only one of the largest but also one of the best olive oil productions in the world, which the Portuguese consume above the European average. The same goes for wine. The Portuguese are also one of the biggest consumers of fish, which is not surprising given the relevance of the sea in the national geography. Any prospective exercise carried out in Portugal in the field of food should include an analysis of the enormous potential of the sea that the country has, given the size of its exclusive economic zone, the 2nd largest in the European Union and the 11th of the world. Climate changes are likely to change some of the species caught.

Despite the integration of Portugal into one of the most developed regions in the world, there are unfortunately still food shortages. A study conducted in 2015-2016 with a sample of the Portuguese population showed that 19.3% of households suffered from food insecurity, which is severe for 1.8% of them (Gregório et al., 2019). These families showed less adherence to the Mediterranean diet and had a higher prevalence of chronic diseases.

6. PREDICTION ERRORS AND INNOVATION

Predictions do not always get it right, with the emergence of innovations based on science and technology being the biggest cause of mismatch. It is interesting to know the reason of some prediction failures in the past.

The issue of population growth and the scarcity of resources on the planet was underlying in the 1960s and 1970s a report by the Club of Rome, a group founded in 1968 to debate the economy, the environment and sustainable development. The report, entitled *The Limits to Growth* (Meadows et al., 1972), was prepared by a team from the Massachusetts Institute of Technology - MIT, led by the American ecologist Donella Meadows. The view presented there was pessimistic: using sophisticated mathematical models, scientists concluded that the planet would not support population growth due to the pressure placed on natural resources, including energy sources, and due to increased pollution. There would be problems in the quality of life, starting with health.

But, decades later, we could confront the conclusions of the «Meadows's report» with reality. Several analysts concluded that the model equations were very sensitive to small variations in some parameters, so their predictions were not reliable. In addition, scientific-technological innovations have been taken place, and they are, by definition, unforeseen.

The fact that we cannot despise the great power of the human capacity to innovate is illustrated by a famous bet that took place in the 1980s. Although its object was materials and not food, it is worth to be remembered. The American biologist and ecologist Paul Ehrlich, professor at Stanford University and one well-known author for his warnings about the effects of population growth and consequent restrictions on the quality of life on Earth, published in 1968 *The Population Bomb*, a book about population growth and its consequences (Ehrlich, 1968), which quickly became a bestseller, having had a sequel, entitled *The Population Explosion* (Ehrlich, 1990). In these works, the author expounded the reasons why we should fear the future, reasons that seemed so obvious that his refusal was difficult: The world population curve was steeply rising, but the existing resources on Earth were obviously finite.

However, Julian Simon, professor of Economics at the University of Maryland, after studying the point raised by Ehrlich, disagreed with him. According to Simon, there could be one or another local problem related to the excess of inhabitants on Earth, but, in the global panorama, there would not be a significant problem. The economist published in *Science* (Simon, 1980) an article in which he criticized the conclusions of the most pessimistic ecologists such as Ehrlich. Simon explained Ehrlich's error when he assumed that, according to the laws of economics, with more people looking for more raw materials and these being limited, their price had to increase: due to advances in the technologies necessary for their extraction and transformation, the price of these resources would not, in the long run, rise, but rather fall. Ehrlich and Simon decided to adopt a concrete example of natural resources to confront their positions. In 1980 they made a bet on the price ten years from now of a set of commonly used metals (copper, chromium, tin, nickel and tungsten): Ehrlich predicted they would be more expensive, while Simon predicted they would get cheaper.

Simon won: Correcting prices to take inflation into account, these metals had indeed gone down in price. As a matter of fact, this correction was practically not necessary because the descent was quite steep. The reasons for the drop-in price supported Simon's thesis: new technologies for detecting and extracting metal deposits had been developed and, in addition, some materials had been replaced by others. New nickel deposits were discovered, chromium was extracted more efficiently, tungsten was replaced by ceramic in kitchen utensils, and copper was replaced by optical fibre, which is made of sand, which is very abundant in the planet.

The most optimistic suggest that, in the environment, agriculture and human nutrition, redeeming innovations will also be possible, as shown by several examples from the past. The big question, as shown by the recent case of the invention of revolutionary vaccines against COVID-19, is that the existence of scientific-technological solutions is not enough: there are economic, social and political issues. Science, being essential, is far from being the only way to open the doors of the future.

7. Conclusions

There is now a scientific consensus on the occurrence of climate change, the demographic increase in the world and the needs of food, complex problems that intersect, although there is naturally some controversy about the extent, solutions and future evolution.

On climate change, there are deniers, but these «enemies of science» do not base their opinions on works published in scientific journals (Marçal and Fiolhais, 2017). From reading the media, the idea may emerge that the scientific community is divided, which is precisely the idea that the obscurantist sectors want to spread. Their stratagem has parallels with the controversies that arose in the past about the harm of tobacco or the hole in the ozone layer. Casting doubt and confusion has always been a strategy followed by people and entities to whom a given action does not interest.

Despite all the knowledge acquired by the scientific community, it has been difficult not only an agreement between governments with a view to adopt measures to reduce GHG emissions, but also their implementation. The richest countries do not want to give up their lifestyle and the poorest countries legitimately want to reach the comfort levels of others. With the slowdown in the world economy caused by the COVID-19 pandemic, there was some relief from the human pressure on the environment, but this relief was very small: it is clearly insufficient given the enormous challenge facing humanity. At the UN Climate Summit (COP-26), held in Glasgow in November 2021, different national and global interests were once again confronting each other, hindering the achievement of big advances. Despite the increase in the world population and its resource consumption requirements, there are solutions to counteract the increase in the concentration of GHG in the atmosphere. They exist, in particular, in the agriculture and human food sector. A whole panoply of possibilities is at our disposal to cover the needs of the world's growing population without unduly increasing our ecological footprint. While individual voluntary measures are certainly useful, political measures that drive changes in large sections of the population will be much the decisive ones. It is true that no single measure taken by a sector or a country can solve the problem: concerted action on a global scale on several fronts, making the best use of science and technology, is necessary. But it is no less certain that, knowing Nature with the scientific method, the human species holds, in his hand, the key to his future.

Portugal, a country particularly affected by climate change and demographic decline, will have to develop its own policies within the general framework of the European Union. The room for

maneuver that exists should be put to good use, making the best use of national resources and characteristics.

REFERENCES

Ehrlich, P. (1968). The Population Bomb, New York: Sierra Club/Ballantine Books, revised 1971, updated 1978, re-issued 1988, 1998, 2008 and 2018.

Ehrlich, P. and Ehrlich, A. (1991). The Population Explosion, New York: Touchtone Books.

Expresso (2019). «Défice comercial alimentar agravou-se em 2018», Expresso 24/7/2019 https://expresso.pt/economia/2019-07-24-Defice-comercial-alimentar-agravou-se-em-2018

FAO et al. (2021). The State of Food Society and nutrition in the world. Transforming Food Systems for Affordable Healthy Diets. Accessed in: 31 August, 2021, in:
http://www.fao.org/documents/card/en/c/cb4474en/

Fiolhais, C. and Marçal, D. (2017). Os Inimigos da Ciência, Lisbon: Gradiva.

Freedman, D. (2017), «Are engineered food evil?», Scientific American, special edition, Winter 2017/2018, 76-81.

Gates, B. (2021). How to Avoid a Climate Disaster: The Solutions We Have and the Breakthroughs We Need. New York: Alfred Knopf.

Gerber, P. et al., (2013). Tackling Climate Change Through Livestock – A global assessment of emissions and mitigation opportunities. Rome: FAO.

Gore, A. (2006). An Inconvenient Truth: The Planetary Emergency of Global Warming and What We Can Do About It. *New York: Rodale Books.*

Gregório, M. et al (2018). «Food Insecurity Is Associated with Low Adherence to the Mediterranean Diet and Adverse Health Conditions in Portuguese Adults», Front Public Health. 6: 38. Accessed in: 31 August, 2021, in:
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5826370/

INE (2021). Censos 2021, Resultados preliminares. Accessed in: 31 August, 2021, in: https://www.ine.pt/scripts/db_censos_2021.html

IPCC (1990). Climate Change: The IPCC 1990 and 1992 Assessments. Accessed in: 31 August, 2021, in:
https://www.ipcc.ch/report/climate-change-the-ipcc-1990-and-1992-assessments/
Syntheses report. https://www.ipcc.ch/report/ar5/syr/

IPCC (2014). AR5 Climate Change 2014: Impacts, Adaptation, and Vulnerability. Accessed in: 31 August, 2021, in:
https://www.ipcc.ch/report/ar5/wg2/

IPCC (2007). Fourth Assessment Report. Accessed in: 31 August, 2021, in: https://www.ipcc.ch/assessment-report/ar4/

IPCC (2019). Climate Change and Land, An IPCC Special Report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems. https://www.ipcc.ch/srccl/

IPCC (2021). AR6 Climate Change 2021: The Physical Science Basis. Accessed in: 31 August, 2021, in:
https://www.ipcc.ch/report/ar6/wg1/

Klümper, W. and Qaim, M. (2014). «A Meta-Analysis of the Impacts of Genetically Modified Crops», PLoS ONE 9(11), e111629. Accessed in: 31 August, 2021, in:
https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0111629

Meadows, D. et al. (1972), The Limits of Growth, A Report for the Club of Rome's. Project on the Predictment of Mankind, New York: Universe Books.

Nature (2021). «Does the fight against hunger need its own IPCC?», Nature, 595, 332. Accessed in: 31 August, 2021, in:
https://www.nature.com/articles/d41586-021-01904-0

Oreskes, N. (2004). "The Scientific Consensus on Climate Change". *Science, 306(5702), 1686.*

Oreskes, N. (2007). «The Scientific Consensus on Climate Change: How Do We Know We're Not Wrong?», in Lloyd, E. and Einsberg, E. (eds.), Climate Modelling, Philosophical and Conceptual Issues, New York: Springer, pp. 31-64. Accessed in: 31 August, 2021, in: https://www.lpl.arizona.edu/sites/default/files/resources/globalwarming/oreskes-chapter-4.pdf

Oreskes, N. and Conway, E. M. (2010). Merchants of Doubt: How a Handful of Scientists Obscured the Truth on Issues from Tobacco Smoke to Global Warming, New York: Bloomsbury Press.

Pope Francis (2015). Encyclical letter on care for our common home, Vatican. Accessed in: 31 August, 2021, in: https://www.vatican.va/content/dam/francesco/pdf/encyclicals/documents/papa-francesco_20150524_enciclica-laudato-si_en.pdf

Santos, F., Forbes, K., Moita, R. (eds.) (2002). Climate Change in Portugal. Scenarios, Impacts and Adaptation Measures - SIAM Project. Gradiva. Lisbon.

Santos, F. and Miranda, P. (eds.) (2006). Alterações Climáticas em Portugal. Cenários, Impactos e Medidas de Adaptação - Projecto SIAM II. Gradiva. Lisbon.

Shah, A. (2014). «Loss of Biodiversity and Extinctions», Global Issues, 19/01/2014. Accessed in: 31 August, 2021, in:
https://www.globalissues.org/article/171/loss-of-biodiversity-and-extinctions

Shellenberger, M. (2020). Apocalypse Never: Why Environmental Alarmism Hurts Us All, Harper. New York. USA.

Silva, J. (coord.). As alterações climáticas. Os desafios para Portugal depois do Acordo de Paris. Colibri. Lisbon.

Simon, J. (1980), «Resources, population, environment. An oversupply of false bad news», Science, nº 4451, 1431-1437. Accessed in: 31 August, 2021, in: https://science.sciencemag.org/content/208/4451/1431

Singer, P. (1975). Animal Liberation: A New Ethics for our Treatment of Animals, New York: Random House.

Tyrrell, J. (2018). «Feeding the world: is fish better than chicken?», Physics World, 10 Apr 2018.

United Nations – UN (2015). Transforming our World: the 2030 Agenda for sustainable development.

United Nations – UN (2019). 2019 Revision of World Population Prospects. Accessed in: 31 August, 2021, in:
https://population.un.org/wpp/ https://www.un.org/ga/search/view_doc.asp?symbol=A/RES/70/1&Lang=E

Vollset, S. et al. (2020). «Fertility, mortality, migration, and population scenarios for 195 countries and territories from 2017 to 2100: a forecasting analysis for the Global Burden of Disease Study», The Lancet 396, nº 10258, 1285-1306. Accessed in: 31 August, 2021, in:
https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(20)30677-2/fulltext

Wallace-Russel, D. (2020). The Uninhabitable Earth. Life after warming. New York: Penguin Random House.

Willett, W. et al. (2019). «Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems», The Lancet, 393, issue 10170, 447-492. Accessed in: 31 August, 2021, in:
https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(18)31788-4/fulltext

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The Biotechnology Contributions to Pharmacology, Agriculture and Environment

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ABSTRACT

In the past four decades, modern biotechnology has experienced extraordinary development, despite the anti-scientific attitudes that emerged after 1960, especially in Europe. Different uses are pointed out in the field of pharmacology, from the production of human insulin to the development of the vaccine against Covid-19. In the agricultural field, the rapid expansion of genetically modified crops is mentioned; European Union is an exception, for populist reasons, in dissonance with scientific advice. The perspectives that recent methods provide to modify plants to remove CO2 from the atmosphere irreversibly are pointed out.

The progress made in the world, and in Portugal, is briefly described, namely concerning health and food, pointing out what still needs to be done to provide well-being to 1 million people who currently live in misery – all of this without, however, increasing the production of greenhouse gases.

Keywords: Modern biotechnology and scientific progress, the enemies of science, peace and growing global prosperity, land degradation and biodiversity, greenhouse gases and clean energy production.
JEL classification: I31, O13, Q15.

1. FROM DNA STRUCTURE TO SYSTEMS AND SYNTHETIC BIOLOGY

On April 25, 1953, James Watson and Francis Crick published in the journal *Nature* one of the most important discoveries in the field of biology: the three-dimensional structure of deoxyribonucleic acid (DNA).

After this relevant discovery, remarkable progress has been made in the field of biotechnology, namely with regard to molecular biology, genetic engineering and synthetic biology.

Thus, great scientific advances have been achieved, providing multiple benefits, mainly in the fields of medicine, agriculture and the environment, not infrequently awakening some controversies.

In the field of pharmacology, remember the launch on the market of human insulin, in 1982, obtained using biotechnology, introducing the human gene of the hormone in a strain of the bacterium *Escherichia coli*. In this way, the inconveniences resulting from obtaining insulin from the swine and bovine pancreas were avoided, in addition to lowering the cost of production. Nevertheless, it caused a first manifestation of rejection by some groups of deep ecology, particularly in Germany. Coincidentally, the same company (Genentech) that produced human insulin from *E.coli* with recombinant DNA, a few years later would produce growth hormone, also using modern biotechnology.

Subsequently, in view of the obvious advantages offered for human health, *Greenpeace* and other environmental groups no longer manifested itself, including regarding an increasing number of biopharmaceuticals (biological drugs, obtained by genetically modified cells for the production of therapeutic proteins, used in particular in the treatment of various types of cancer) and vaccines

(recombinant vaccines, produced by microbes genetically modified to produce the antigenic fraction that matters), for both human and veterinary use, produced using modern biotechnology.

In the past few months, thousands of scientists around the world have endeavored to develop effective and safe vaccines against Covid-19, using different technologies, but all based on biotechnology to activate the immune system to produce antibodies to fight *Severe acute respiratory syndrome* associated coronavirus 2 (*SARS-CoV-2)* infection. From the more conventional ones, using the new inactivated coronavirus as is the case of the Chinese company Sinovac Biotech, to the more innovative ones, in particular: *(i)* by Pfizer/BioNTech and also by Moderna messenger ribonucleic acid (mRNA) technology, in which a protein is produced that will stimulate the immune response and produce antibodies; this technology could revolutionize future immunizations; Pfizer and Moderna coronavirus vaccines were the first-ever vaccines that use mRNA and win approval from the U.S. Food and Drug Administration (USFDA); *(ii)* and also by the University of Oxford, which uses genetic engineering to couple the adenovirus of chimpanzees with parts of the coronavirus, thus stimulating the immune system.

In the agricultural sector, modern biotechnology has also been widely used in the genetic improvement of plants, giving them resistance to herbicides (e.g. Roundup Ready (RR) soy), insecticides (e.g. *Bacillus Thuringiensis* (Bt) corn), improving their nutritional value (e.g. Golden Rice, rich in beta-carotene, precursor to vitamin A), etc. In the world, the area occupied with transgenic crops is approximately 200 M ha.

In agricultural field *Greenpeace's* reaction has been different, even in relation to the production of Golden Rice, despite the obvious effects on the prevention of blindness in two million children per year, occurring mainly in developing countries; in addition, vitamin A deficiency affects the development of children, who often die at 4 or 5 years of age (Roberts, 2018).

The difference in *Greenpeace's* attitude seems to lie in the fact that biopharmaceuticals are produced using a microorganism, while in the case of Golden Rice a plant is used, in which a gene is artificially inserted capable of raising the concentration of beta-carotene – which would also be the first GM crop (genetically modified) to show an improvement in nutritional value. In 2016, more than 100 Nobel Prize laureates – including 41 Nobel Prize winners in Medicine, like James Watson, co-author of the discovery of the structure of DNA – addressed a letter to *Greenpeace* to end their opposition to GMOs (genetically modified organisms) and, in particular, the dissemination of the Golden Rice culture (Achenbach, 2016).

Roberts (2018), Nobel Prize for Medicine in 1993, stresses that «GMO varieties are safer than traditionally bred varieties because they are made in a very precise manner» and «they are subject to many more controls».

In the EU, however, there is a great controversy about GM crops, which has been going on since 1996, when in Europe GM soy was first imported. However, due to the European deficit of vegetable protein, currently more than 30 Mt of GM soy are imported per year for animal feed.

In the EU only in Portugal and Spain, "Bt maize" has been grown since 1998, in an area of approximately 121 thousand ha. This corn is in fact genetically modified by genes from the bacterium *Bacillus Thuringiensis* (Bt), which induces the plant to produce proteins toxic to certain types of insects, namely the European borer. In this way, spraying with synthetic insecticides is avoided, which provides environmental and economic advantages.

It should be noted that the suggestions previously proposed were in line with the decisions taken by the EU two decades ago – *Lisbon European Council* (2000) and *Stockholm European Council* (2001) when it was decided as a strategy for the following decade to make the EU economy, with knowledge-based, as the most competitive and dynamic in the world. This objective was reaffirmed and underlined in 2001, and it was then specified that the strategy implied that efforts should be made in new technologies, especially in biotechnology (sic).

But, contrary to expectations, EU has not been encouraging GM crops.

Also genome editing, called CRISPR-Cas9 or "genetic scissors", discovered in 2012 and which came to revolutionize the scientific world, does not deserve special attention on the part of the EU, namely with regard to genetic improvement of plants. However, in addition to the numerous benefits it brings in the field of medicine, the referred technique also allows in just a few weeks to rewrite the genetic code and, for example, to give plants greater resistance to climate change, pests, and diseases. It should be added that the development of the CRISPR-Cas9 system justified the award of the 2020 Nobel Prize in Chemistry to two scientists: the French Emmanuelle Charpentier and the American Jennifer Doudna.

Regarding the extraordinary advances that have been achieved in the field of modern biotechnology, it should also be noted that a group of American and Israeli scientists – concerned with climate change – recently proposed a strategy to remove CO2 from the atmosphere, using for an innovative technology – which includes powerful methods of synthetic and systems biology (SSB) – that could enable the modification of plants to irreversibly remove CO2 from the atmosphere (DeLisi *et al*., 2020).

The mentioned scientists point out several susceptible examples of application of the mentioned technology, such as: *(i)* changing the relationship between the roots and the aerial part of the plant, to increase the amount of CO2 retained in the soil; *(ii)* increase the photosynthetic efficiency of plants; *(iii)* making the plants more resistant to dryness, modifying the leaves in order to reduce water evaporation; *(iv)* increase the productivity of crops, which will increase sustainability, as less cultivation area is required for a given production.

In addition, the aforementioned scientists suggest other genetic modifications of plants (e.g. wheat) that are of great interest, namely the ability to fix nitrogen, similarly to what happens with legumes, thus being able to consume large amounts of nitrous oxide – a relevant greenhouse gas. They also suggest that bacteria could be modified to use CO2 as a carbon source, instead of carbohydrates.

If it is true that the CRISPR-Cas9 system reveals enormous potential to correct many inherited diseases, it is also true that it can raise questions in the field of ethics, such as the genetic modification of human embryos.

However, in my view, the ethical question does not arise when it comes to plant breeding, as Sir Paul Nurse (2020), geneticist and Nobel Prize winner in Medicine, says: what matters is that all plants are tested for their consumer safety, efficiency and predictable environmental and economic impact, regardless of how they have been improved. Nurse (2020) added: we must consider what science has to say about risks and benefits, regardless of the business interests of companies, the ideological opinions of NGOs, or the financial interests of both.

The current European Commission, however, has pointed out different guidelines, namely with regard to agricultural production, by proposing that 25% of agricultural soils be dedicated to organic production, that the use of fertilizers and pesticides be reduced, and that plants GM are not cultivated – all measures that, in my humble opinion, will not contribute to minimizing climate change: a momentary problem, which is not only solved by reducing CO2 emissions, which will remain in the atmosphere, but also by finding solutions to remove greenhouse gases.

The recommended expansion of the agricultural area dedicated to organic production does not fail to provoke some comments. First, when the Ecological Pact considers that this method of production will ensure consumer confidence, scientific illiteracy of the population is being admitted, since, for example, eggs from free range chickens present a higher health risk that of eggs from hens reared in a conventional manner, therefore housed in hygienic facilities and without contact with rodents and wild birds, often carriers of *Salmonella*; in addition, free-range birds are also more exposed to contamination with avian influenza viruses, of low and high pathogenicity (Koch and Elbers, 2006), which oblige the compulsory slaughter of flocks of poultry and endanger health, reasons why, in certain high-risk situations, the Veterinary authorities determine the mandatory confinement of poultry in certain regions (e.g. following numerous outbreaks of Avian Influenza in EU, on December 4, 2020, as a precaution measure Portuguese Veterinary Authorities forbade the keeping of domestic birds outdoors). In order to eliminate the health risk that avian influenza viruses pose, both for poultry and for humans, different scientists [Perdue and Swayne (2005); Lee *et al*. (2008); Lyall *et al*. (2011); Sid *et al*. (2018); Looi *et al*. (2018)] considered that genetic engineering can increase the resistance of poultry, which would constitute a solution to the problem of avian influenza. However, although this is technically possible, its commercial implementation faces barriers of various kinds (legislative, societal, etc.) as with any new technology. It should be noted, however, that the US Food and Drug Administration approved the salmon for consumption in November 2015, and Canadian authorities came to the same decision six months later. Neither country requires the salmon to be labeled as genetically engineered (Waltz, 2017).

Secondly, the lower productivity in general obtained in the organic production mode leads to higher food prices, which penalizes the poorest population, namely with regard to fruit and vegetables, whose consumption is highly recommended by nutritionists, considering its health benefits, especially with regard to meeting nutritional needs in water-soluble vitamins, various minerals and fiber.

Interestingly, and in view of the above, it is already admitted that, if the market does not freely absorb the food produced in organic production, governments will have to buy it to supply prisons, hospitals and schools – therefore, these costs of unfounded whims they may be borne by taxpayers.

A third observation concerns the largest area needed to produce the same amount of food, which is unfavorable in terms of environmental sustainability.

As a last general comment, I would recall that it is estimated that hunger affects about 831 million people, to which another 132 million will have joined due to the economic crisis resulting from the current pandemic, which leads me to defend the expansion of food aid by affluent countries and, to that end, it is important to increase food production and reduce food waste, particularly in the EU, alongside technical and logistical support for agriculture in the regions most affected by hunger.

With regard to the particular case of Portugal – whose soils with agricultural capacity correspond to only 28% of the continental territory (Cardoso, 1973) and whose trade balance for agricultural and agrifood products has a deficit of the order of 3.7 billion euros – the decrease in food production resulting from the strategy advocated by the European Commission puts our country in an extremely weak situation of food sovereignty.

2. About the credibility of science

Since the 1960s, some discredit has been observed in scientific institutions and, especially in the 21st century, we have witnessed the emergence of certain populist movements that refuse to accept the particularly sharp scientific and technological advances in the post-war period – although scientific knowledge has meanwhile provided very relevant advances, namely by improving health and food, reducing the suffering of populations on a global scale.

Nevertheless, numerous intellectuals also express disdain for science and, in many universities, science is presented not as the search for true explanations, but as just another narrative or myth (Pinker, 2018).

Concerned about anti-scientific sentiment in Britain, in 1985 the Royal Society of London, the oldest scientific society in the world, promoted the assessment of attitudes toward science and technology in the country, concluding that this opposition was due to a lack of knowledge (Sloman and Fernbach, 2017).

However, after a few decades, it was found that the relationship between scientific knowledge and attitude was weak. The opposition to vaccines and GMOs are two examples that illustrate this situation.

In the first case, it should be noted that the anti-vaccine movement has been going strong since the *Lancet* published a study in 1998 linking a common vaccine to autisme (Achenbach, 2015). Only several years later the aforementioned medical journal retracted the study. However, several celebrities promoted an anti-vaccine movement, which came to have a strong societal impact.

With regard to GMOs, already in 2001 I wrote a text, at the invitation of my Agronomy students (Soares, 2001a), explaining that GMOs were tested by responsible entities, such as the aforementioned USFDA, namely regarding their toxicity and allergenicity.

Currently, after two decades, there is no news that the consumption of food containing GMOs has caused harmful effects on human or animal health.

However, after about two decades, in a class of Natural Sciences of the 7th and 8th years, transmitted in Portugal via Tele-school, transgenic foods were also presented as dangerous for health, which motivated a letter of protest written by a biotechnology specialist (Fevereiro, 2020).

3. On progress in the world and in Portugal

In the last seven decades, and for the first time in the history of mankind, there have been no wars between major military powers, which has allowed a growing global prosperity to be achieved, despite the existence of some regional conflicts; during that period, the world average life expectancy at birth rose from 40 to 72 years (in Portugal it is 81 years); hunger has been eradicated in large regions of the world; the world population was on average 8 centimeters higher and tripled in number (from 2.5 to 7.5 billion); the rate of extreme poverty has fallen from 65% to 9% and, as Rosling (2019) pointed out, in the past 20 years this rate has fallen more rapidly than ever before in

history: from 29% to 9% (the author considers that this is the most important change that happened in the world during his life), but extreme poverty still affects more than 800 million people living in a state of misery, causing directly suffering, but also promoting pain in other populations, inasmuch as they constitute a nursery for young people easily attracted by hideous guerrilla movements.

In addition, progress has been made in the world in human rights – although 2 billion people still live in autocratic regimes –, in education in particular for women, in environmental awareness and in the protection of animals.

Inequality in the distribution of wealth is a concern for many, having gained greater prominence after the 2007 recession, becoming a banner of the left. But, as the philosopher Harry Frankfurt argues, «inequality in itself is not morally reprehensible; what is condemnable is *poverty*» (Pinker, 2020). This author recalls that globalization and technology have lifted billions out of poverty, while in developed countries the wealth of the lower classes has not improved significantly; this world movement, however, reduced international inequalities, generated a world middle class and, in fact, also enriched elites, whose financial impact extends globally.

However, when there is an inequality created as a result of the formation of a monopoly situation, I consider that it is a situation that jeopardizes social justice and capitalism itself (Anonymous, 2018). Defending myself private initiative and market economy – because they give dynamism to the economy, bringing progress and prosperity to society –, I believe that monopoly companies are harmful, inasmuch as they lose the incentive to progress in the fields of research, development technological and service provided to consumers (similar to what happened with industrial conditioning, which prevailed in Portugal during the Estado Novo). In my view, the capitalist countries, namely the EU, have not taken the most correct and timely measures in order to prevent the formation of monopoly companies, often acting on a global scale.

In the particular Portuguese case, after the Second World War, there were also economic and social progress that many today have no memory of.

At the end of the 1940s, Portugal was an essentially rural country, with agriculture accounting for around 50% of the active population (but thanks mainly to agricultural mechanization, today it is only around 5%), which means that there was a strong migration to industry and services, both to the Portuguese coast and abroad, leaving behind their homes, which in general did not have drinking water, sewage and electricity – this being essential, namely for the use of the refrigerator and the washing machine, which was classified by the humanist Rosling (2010) as an extraordinary technological invention of the 20th century, for the time it saved families. Then, as a rule, rural people settled for decades in conditions that were also uncomfortable in the suburbs of large cities, such as Lisbon and Paris.

The diet of the Portuguese population was clearly deficient, especially with regard to the consumption of animal protein, corresponding to a state of malnutrition, certainly with variations depending on the purchasing power of consumers and regions (Soares, 2001b), whereas today, according to INE (2020), 36.6% of the adult population is overweight and obesity reaches 16.9% (1.5 million people), which is a serious health problem.

From 1950 to the present, life expectancy at birth has risen from 58 to 81 years, which is largely due to the decrease in the infant mortality rate (in 1950 it was 94.1 deaths per thousand live births and, currently, it has dropped to 2.7 – being below the European average), mainly due to the National Vaccination Plan since 1965, the measures to support maternal and child health from in 1970 and the creation of the National Health System in 1979.

Concomitantly, due to lower infant mortality, the increasing integration of women in the labor market and the launch of the contraceptive pill in the 1960s, births have decreased more and more, which, associated with greater life expectancy, has placed Portugal among the most aged of the world – which put greater pressure on the health system and the financial sustainability of social protection.

With regard to education and teaching, in the last 70 years there have been many and profound transformations, namely since 1960 when the attendance of the 1st cycle became mandatory for both sexes, having been extended to the secondary in 2009. In the Higher education has also seen an «explosion», with this level of training losing the «elitist» character of the past, with emphasis on women, who today are majority in the number of higher education graduates and doctorates (Rosa and Chitas, 2010).

With regard to economic growth, Portugal experienced a «golden period» (1950-1974), with an average annual rate of 5.6% of GDP *per capita*, which was due to strong investment rates (in 1973

reached 36% – one of the highest in the world), namely in cement, chemicals and metalworking industries (Mateus, 1998), in addition to the continuation of the country's electrification process, with preference for hydroelectricity – an undertaking under the responsibility of the State (Rollo, 2011).

In the second half of the 20th century, GDP *per capita* increased 6.9 times and the standard of living of the Portuguese clearly converged with that of their European partners. But in the past two decades it has been clearly disappointing, with an average rate of 0.5% per year, recommending the improvement of institutions and governance, the reduction of context costs and the increase in the attractiveness of foreign investment (Veiga *et al*., 2019). According to these authors, the Portuguese real GDP *per capita* went from US $ 3513 in 1950 to US $ 24,237 in 2000. It should be noted that the slowdown in economic growth mentioned above allowed other EU countries – until three decades ago inserted in a planned economy and then poorer than us –, to overtake us in terms of GDP *per capita*.

To illustrate the impact of Portuguese economic development on the population's well-being, we can see that in 1950 family expenses on food exceeded an average of 60% of total expenditure, while currently they do not reach 20%, now fitting housing and transport also have relatively high percentages.

But, as Rosling (2020) points out, «the ultimate goal of economic growth is individual freedom and culture, and these values are difficult to capture with numbers», but we can say that in Portugal, after 25 November 1975, we live in liberal, multi-party democracy, and we have achieved what the aforementioned author considers the ultimate goal of longer lives: «is to have the freedom to do what we want». As Francisco Sá Carneiro stated four decades ago: «to be a man is to be free, the freedom to think is the freedom to be».

4. Conclusions and proposals based on facts

Previously, I sought to reveal some notable scientific advances that occurred following the discovery of the structure of DNA in 1953 and I pointed out the enormous possibilities that may still be offered by modern biotechnology in the fields of pharmacology, agriculture and environment.

I also referred to the extraordinary prosperity, unparalleled in the history of mankind, which has been recorded in the world for seven decades without war between major military powers, namely with regard to life expectancy at birth and food.

I focused on the particular case of Portugal, stressing the great improvement in the standard of living of the population after the end of World War II, despite the fact that there was an anemic economic growth in the 21st century.

Despite the foregoing, many people, including in the university environment, as mentioned above, consider science as more of a narrative or myth, but use, for example, washing machine, smartphone, computer, travel by plane and resort vaccines and antibiotics, especially when suffering from a bacterial infection (e.g. pneumonia and typhoid fever; my life have been saved in these two situations due to antibiotics) and many more reveal enormous scientific illiteracy.

But, as mentioned earlier, after decades of scientific education, anti-scientific beliefs persist, such as opposition to vaccines, GMOs and food irradiation (as an efficient and safe method to eliminate pathogenic microorganisms), etc.

Sloman and Fernbach (2017) stated that very few of us have a deep understanding of the scientific topics and our opinion depends on our community of knowledge, and unfortunately, communities sometimes get the science wrong.

Lynas (2015) mentioned the importance of lobbies such as *Greenpeace*, the *Center for Food Safety* and other similar organizations to disseminate anti-science attitudes.

Another explanation, which may help to justify the incomprehension expressed by a large part of the population regarding GM foods, can be found in the words of Rosling (2020) when he mentions that, at least in part, the reason why journalists are encouraged to produce prejudiced and exaggeratedly dramatic news, stems from the need to compete for the attention of its consumers, or they lose their

jobs. We all remember the newspaper headlines about «Frankenstein's food», when they referred to GMOs, after their initial import into the EU.

Despite the brief note that precedes it, I personally understand that in the EU the main root of most anti-scientific attitudes lies in policy makers because, whenever they fear losing popularity, they do not heed the opinions issued by the competent scientific entity, created and paid for by the contributors – the European Food Safety Authority (EFSA).

Regarding ignorance, Rosling (2019) was surprised when he found that his global health students – supposedly the best university students in Sweden – revealed a great ignorance about basic facts in the world. In 2015, in Davos, before a thousand people, extremely influential in the world, he was also disappointed with the answers he got to three factual questions – about poverty, population growth and vaccination.

Most Westerners think that the number of poor people is increasing, and that violence, natural disasters and corruption are increasing.

Against these fears, it is important, in my view, to direct our energies towards constructive considerations, based on facts.

As a first fact, I would recall the extraordinary decrease, over the past 20 years, in the number of people living in extreme poverty, on less than $ 1 a day. It is currently around one billion people, which corresponds approximately to the population of Western world – EU, USA and Canada). I consider it a moral imperative to help these people escape poverty through food aid, but mainly by supporting their own development.

As a second fact I point to erosion, a natural process, which has occurred for thousands of years, mainly due to the action of rain and wind, but it can also be caused by forest fires and by the action of man, namely when it removes the vegetal covering that covers the soil, such as, for example, through deforestation and subsequent cultivation, thus being able to favor the reduction of the arable layer and release carbon stored in the soil – it is important to emphasize that the soil organic matter constitutes the main carbon reservoir of terrestrial ecosystems (Hinsinger , 2014).

The rapid expansion of cultivated areas is the main cause of soil degradation, causing significant losses of biodiversity and it is estimated to affect the well-being of at least 3.2 billion people (Kotiaho, 2018). According to this author, the report approved at the 6th session of *The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services*, states that the growing demand for food and biofuels, including animal production developed in modern molds, makes possible to expect a duplication of the consumption of fertilizers and pesticides by 2050.

In order to avoid future agricultural expansions in the indigenous territories, it is suggested, in particular, to obtain greater productivity in the currently cultivated soils, a reduction of food losses (which implies, I add, careful use of pesticides and adequate food storage) and a decreased food waste (UNESCO, 2018).

Given the importance of soil's carbon absorption and storage functions, the avoidance, reduction and reversal of land degradation could provide more than a third of the most cost-effective greenhouse gas mitigation activities needed by 2030 to keep global warming under the 2°C threshold, targeted in the Paris Agreement on climate change, increase food and water security, and contribute to the avoidance of conflict and migration (UNESCO, 2018).

The third fact I would like to address is the rise in the Earth's average temperature, which has risen approximately 0.8°C (1.4°F) since the Industrial Revolution, as well as in the same period the concentration of carbon dioxide (CO_2) in the atmosphere has increased from about 270 parts per million (p.p.m.) to over 400 p.p.m. currently (Pinker, 2018) – with emissions coming mainly from transport, electricity production and heating (it should be noted that 86% of the world's energy is supplied by fossil fuels).

It turns out that the infrared radiation emitted by the Earth is retained by CO_2 and other greenhouse gases, namely methane (CH_4) – released by gas wells without watertightness, by the melting of the pergelisole and by ruminant animals – and nitrous oxide (N_2O).

However, the increase in the concentration of greenhouse gases will cause marked climate change, so there is currently a concern to reduce this emission and, at the same time, retain the CO_2 emitted, without harming economic growth.

Regarding the first aspect, several technological advances have been made that have led to very interesting results. As more controversial, due to its inherent risks, it should be noted that 50 nuclear reactors are under construction, mostly to be installed in China and India, but also in Europe (Finland and United Kingdom); on the other hand, 13 plants were closed, namely in Japan, following the accident in Fukushima in 2011, and, by political option, in South Korea, Germany and Taiwan (World Nuclear Association, 2020). In this regard, it should be noted that, between 2010 and 2019, the cost of producing renewable energies has declined sharply, namely solar photovoltaic (dropped 82%), onshore wind 39% and offshore wind 29%, with a production capacity quadrupling in the world (IRENA, 2020).

With regard to the progress towards the retention of greenhouse gases and with regard to the role that modern biotechnology can play, namely using the aforementioned methods of synthetic and systems biology (SSB), I finish with the words of Professor Charles DeLisi, from Boston University and lead author of the aforementioned article on the mentioned SSB methods: «Engineers learned long ago how to design and manufacture circuits to perform desired tasks. In the past two decades, biomedical engineers have begun to learn to design and manipulate the circuitry that enables cells to carry out biological processes with enhanced functions: in this case, CO_2 removal.».

REFERENCES

Achenbach, J. (2015). Why science is so hard to believe. The Washington Post, February 12.

Achenbach, J. (2016). 107 Nobel laureates sign letter blasting Greenpeace over GMOs. The Washington Post, June 30.

Anonymous. (2018). The next capitalist revolution. The Economist, November 15.

Cardoso, J. (1973). A Agricultura Portuguesa. Lisboa: Moraes.

DeLisi, C. et al. (2020). The role of synthetic biology in atmospheric greenhouse gas reduction: prospects and challenges. BioDesign Research, volume 2020, Article ID 1016207.

Fevereiro, P. (2020). Aula de ciências da Telescola motiva carta de cientista aos ministros da Educação e da Ciência. Visão, 15 de Maio.

Hinsinger, P. (2014). Soil organic matter content in mediterranean regions (both arable and permanent crops). Padova, Italy: Agriculture & Innovation, pp. 13.

INE. (2020). Inquérito Nacional de Saúde 2019. Lisboa: Instituto Nacional de Estatística.

IRENA. (2020). Renewable power generation costs in 2019. Abu Dhabi: International Renewable Energy Agency, pp. 144.

Koch, G. and Elbers, A. (2006). Outdoor ranging of poultry: a major risk factor for the introduction and development of high-pathogenicity avian influenza. NJAS – Wageningen Journal of Life Sciences, 54(2), 179-194.

Kotiaho, J. (2018). Worsening worldwide land degradation now "critical" undermining well being of 3.2 billion people. University of Jyväskylä, Finland.

Lee, C., W. et al. (2008). Evaluation of chicken-origin (DF-1) and quail-origin (QT-6) fibroblast cell lines for replication of avian influenza viruses. J. Virol. Methods 153, 22-28. doi:10.1016/j.jviromet.2008.06.019.

Looi, F. (2018). Creating disease resistant chickens: a viable solution to avian influenza? Viruses, 10(10), 561-572.

Lyall, J. et al. (2011). Suppression of avian influenza transmission in genetically modified chickens. Science 331, 223-226. doi: 10.1126/science.1198020.

Lynas, M. (2015). Even in 2015, the public doesn't trust scientists. Washington Post, 30 January.

Mateus, A. (1998). Economia Portuguesa. Lisboa. Editorial Verbo.

Nurse, P. (2020). What is life? Understand biology in five steps. Oxford: Ben Martynoga.

Perdue, M., and Swayne, D. (2005). Public health risk from avian influenza viruses. Avian Dis. 49, 317–327. doi: 10.1637/7390-060305R.1.

Pinker, S. (2018). O iluminismo agora. Lisboa: Editorial Presença.

Roberts, R. (2018). The Nobel Laureates' Campaign Supporting GMOs. Journal of Innovation &

Knowledge, 3(2), 61-65.
Rollo, M. (2011). Em prol da eletrificação do País – I. Revista Ingenium, 122.
Rosa, M. and Chitas, P. (2010). Portugal: os Números. Lisboa: Fundação Francisco Manuel dos Santos.
Rosling, H. (2010). The magic washing machine. TED Talk.
Rosling, H. (2019). Factfulness. Lisboa: Temas & Debates.
Sid, H. et al. (2018). Applications of Gene Editing In Chickens: A New Era Is on the Horizon. Front. Genet. 9, 45. doi: 10.3389/fgene.2018.00456.
Sloman, S. and Fernbach, P. (2017). The knowledge illusion. Why we never think alone. New York: Riverhead Books.
Soares, M. Chaveiro. (2001a). Mitos e medos alimentares: três histórias exemplares. In: Riscos Alimentares e Medos Humanos. Publicações Ciência e Vida, Lda.
Soares, M. Chaveiro. (2001b). Evolução da alimentação na Europa e em Portugal contemporâneo. Lisboa: Instituto Superior de Agronomia.
UNESCO. (2018). Worsening land degradation impacts 3.2 billion people worldwide. Accessed in: 4, December, 2020, in:
https://en.unesco.org/news/worsening-land-degradation-impacts-32-billion-people worldwide [Electronic version].
Veiga, F., Alexandre, F. Silva, J., Arezes, P. (2019). Crescimento da Economia Portuguesa. Universidade do Minho, Portugal.
Waltz, E. (2017). First genetically engineered salmon sold in Canada. Nature, 548, 148. doi: 10.1038|nature.2017.22116.
World Nuclear Association. (2020). World Nuclear Performance Report 2020. Accessed in: 2, December, 2020, in:
https://www.world-nuclear.org/our-association/publications/global-trends reports/world-nuclear-performance-report.aspx [Electronic version].
World Nuclear Association. (2020). Plans for New Reactors Worldwide. Accessed in: 2, December, 2020, in:
https://www.world-nuclear.org/information-library/current-and-future-generation/plans-for-new-reactors-worldwide.aspx [Electronic version].

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Modern Food Production and its Sustainability in Portugal

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ABSTRACT

In recent years, the world has been confronted with a number of very serious challenges and threats to the security of humanity: pandemics, terrorism, civil wars, natural disasters, extreme weather events or cyber-attacks. Many threats convene us to a deep reflection on the most appropriate development models that human societies must adopt, in order to protect populations from greater suffering. Many international organizations have been warning about the need to establish strategies, doctrine, objectives, goals, able to grant a positive perspective for the future of humanity. Concerning this, the UN established, in 2015, an agenda to 2030 with a chart of "goals for sustainable development", listing 17 major ones, aiming to guide world development in the next decade. The first two objectives of this list are: to eradicate poverty and to end hunger; two objectives that are interconnected, as with the remaining 15. The European Union also created a strategic plan called "from farm to fork" (Green Deal) with the purpose of framing the future of sustainable development in the agrarian sector in the Union. In 2020, in Portugal was also adopted an agenda (Terra Futura) for the adoption and application of the European "Green Deal".

It is not possible to eradicate hunger without devising multi-vector strategies, integrating social, economic, environmental, cultural and sanitary components. Only with a holistic approach that includes more rationality in the systems of production, distribution and availability of foodstuffs, it will be possible to ensure that all human beings will have a fair access to a balanced, sufficiently diversified and healthy diet, respecting the cultural habits of each society.

Keywords: Food security, agri-food sustainable development, Green Deal, Terra Futura.
JEL classification: O13, Q15, Q18, R10.

1. INTRODUCTION

In Portugal, a century ago, the average life expectancy of human beings did not exceed four dozen years. Over the next six decades, the average longevity of the human species has grown rapidly, and its value has doubled. In other words, in about half a century, humanity has jumped from a way of life with a very limited average life expectancy horizon, which has been with it for more than 2 million years to a time horizon of more than 80 years old.

What is the reason for this extraordinary evolution in the perspective of human life and for this amazing development? The answer is not very complex: widespread access to conditions of environmental hygiene, basic sanitation, more universal access to potable drinking water, primary health care and, above all, access to a balanced and sufficient diet.

By the end of the second millennium more than 80% of the world population had regular access to nutritious and diversified foodstuffs.

This prolongation of longevity had multiple consequences (exponential demographic growth due to the cumulative effect, the need to exploit more natural resources, an increase in the production volumes of tradable goods) that have become also greater challenges for humanity, namely regarding to the supply of foodstuffs to the populations.

The exponential growth of the world population after the First World War was due to the enormous technological advances and developments that occurred in the agricultural and food production systems, namely: the mechanization of agricultural practices; the application of fertilizers and phytopharmaceuticals; the selection and genetic improvement of animals and plants and also due to enormous technological advancements, including robotization and biotechnological progress (Green Revolution) (Gaud, 1968). This growth in the world population doubles every fifty years, generating an equivalent need for a proportional increase in the production volume of foodstuffs (table1).

TABLE 1: WORLD POPULATION MILESTONES (HISTORIC AND PROJECTED)

Population (billion)	1	2	3	4	5	6	7	8	9
Year	1804	1927	1960	1974	1987	1999	2012	2027	2046
Years Elapsed		123	33	14	13	12	13	15	19

Source: United States Census Bureau estimates (Hofstrand, 2011).

The "Green Revolution" achieved its maximum expression by the end of the 20th century, reaching the supreme expression of the Physiocratic doctrine that had emerged with the Industrial Revolution.

The “Green Revolution” allowed humanity to safely access food in adequate quantities and variety, enabling the development of healthy ways of life. In some cases, this abundance has led to exaggerated consumption, which, in turn, has also created new and serious problems, such as morbid obesity, food waste and environmental imbalances.

However, about 20% of the world's population has never managed to reach enough income to escape the circle of poverty and hunger. Currently, it is estimated that about 800 million human beings are hungry, living below the poverty line, with a *per capita* income below 2 USD/day. In this condition of extreme poverty, it is not possible to access the consumption of products of animal origin, except through donations.

By the middle of the 21st century it is estimated that the world's population will reach 9.2 billion people: a gigantic crowd that will only survive if it eats properly. For this to happen it is necessary to produce and distribute foodstuffs in quantities equivalent to twice what was produced in the 1980s of the 20th century. How to achieve this goal without seriously disturbing planet's ecological balance? (FAO, 2009)

By the end of the second decade of the 21st century a significant change in the structure of the global population also occurred: vast majority of the global population started to live permanently in an urban environment, especially in developing countries, where, until then, rural population constituted the majority of the population. This definitive change in humanity social structure also introduced new factors concerning the management of food production and supply. Urban populations, now dominant, and representing more than 93% of the inhabitants in Portugal, have different perspectives concerning the food system compared with the rural population’s vision (Rodrigues. 2008)

Also, the “Computer Revolution” that occurred in during the last 30 years, introduced new elements that influenced, modifying the dominant perceptions about the models of human and societal development. The communication systems created by informatics’ technologies have had a decisive effect on the development of certain perceptions in urban culture also regarding the social and biological function of food.

2. FOOD PRODUCTION AND SUSTAINABLE DEVELOPMENT

The "Green Revolution" catapulted most of humanity into ways of life very different from those that existed before the World War II. As the anguish that was generated by the need for systematic supply of foodstuffs has subsided, humanity has ceased to be concerned with the ancestral difficulty

of regularly access these goods. Without this threat to survival, humanity has been able to use and manage its time, occupying it in other tasks and significantly improve its levels of comfort and well-being: a pattern that corresponds to the current ways of life in developed societies (FAO, 2017).

The intensification and increase in agricultural productivity, combined with the development of agro-industries and modern globalized food distribution systems, have currently enabled humanity to freely access all food products obtained in different geographical regions of the world, scrambling the traditional effects associated to the seasonal cycles or to the climatic zones.

According to the forecasts of international organizations dealing with agricultural production issues (UN, FAO, WHO, OIE), over the next three decades it will be necessary to increase the volume of current agricultural production by one third, to make in view of the growing food needs generated by demographic evolution (COM, 2017).

Having in mind that availability of cultivable soil for agricultural crops and the promotion of plant and animal productivity are not infinite, it is necessary to conceive and implement systems for the promoting and use of existing resources, aiming that food does not become in a future not far, a resources that accentuates the inequalities between those who have it plenty as they are rich and those who, due to the lack of access, die of starvation, as they are poor. Without a more equitative partition of the available food resources, sustainability is also not possible.

Up to World War II, while human population was predominantly rural, scarcity of access to a greater diversity of foodstuffs was mitigated by self-production and self-supply. Now, that the overwhelming majority of the population is urban, with no links connecting them to the countryside, the access to food is strictly dependent on acquisitions, that is, on purchasing power; the same is to say, of income wealth.

In order to prevent this foreseeable effect, and to safeguard democratic access to food, international recognition of foodstuffs as a "global public good" is imperative, as a status that will allow it to be given attributes of greater social justice (equity) in the access to those goods.

The inevitable intensification of agricultural cultures, the increase in their productivity, resulting from that previous referred necessities, can lead to: i) unruly uses of soils; ii) water resources misuses and iii) more plant protection products (Eurostat, 2018) causing eventual reductions in biodiversity and consequent disturbances in the ecosystems.

In order to mitigate or prevent those possible negative impacts, public policies have been stated and implemented whose objectives are aimed at countering the possible adverse effects that the intensification of agriculture has on natural ecosystems, namely: permaculture, organic production and integrated protection.

Producing food at fair prices, in sufficient quantity and variety for all, profitable and without causing serious impacts on ecosystems (sustainability), are one of the greatest challenges that humanity has to face in the coming decades.

Driven by these concerns, European Union leaders published in 2019 the "Green Deal", a public policy guiding pact that aims to make the EU economy sustainable, proposing to turn climate and environmental challenges into opportunities in all areas of interventions and making the energy transition fair and inclusive for all.

Sustainability is a complex balance, integrating several interdependent variables, namely social, energy, economic and environmental issues (UN, 2015).

In social terms, it is crucial to have respect for human rights as a starting point, given that human beings are themselves important elements of the environment. However, it is absolutely essential that human activities generate income without which the economic development does not occur and whenever the economy stops developing, people's living conditions deteriorate.

To improve economic income it is essential to use and consume energy. However, certain forms of energy production and their use are able to cause environmental damage and in a degraded environment human beings are threatened in terms of health and even survival, economy does not develop, and future is unsustainable. Sustainability system applies to any enterprise, regardless of its scale or dimension, and for any human activity to be sustainable, it must be socially fair, ecologically correct, economically viable and culturally respectful.

3. THE PORTUGUESE MODEL

Unlike what happens with the regions of the globe where agriculture is based on the cultivation of extensive monocultures (cereals, vegetables, oilseeds, fruit trees), Portugal has rooted a secular agricultural tradition of enormous diversity of agro-cultures and ways of farming. This peculiarity accrues from multiple factors: topographic, orographic, soil structure and composition, climatic dynamics, rainfall regime, land structure and, above all, an ancient rural accomplishment that conditions soil use (Costa e Castro, 1900).

The traditional model of Portuguese agricultural development is now threatened due to the depopulation of the rural world and the consequent lack of labour in the mini-smallholding areas, which has led, in the last decades, to the abandonment and vacancy of the territory and subsequent alteration in the land ownership structure (Rosário, 2004). Throughout the second half of the 20th century, the Portuguese rural population evolved drastically, from around 40% of active labour in the 1950s to a scant 7% in the change of the millennium (Rodrigues, 2008). These changes definitely mark the solutions that the country has to continue to keep primary production (agriculture, livestock and fisheries) active (INE, 2017). Agrarian production experienced a strong reorganization, leveraged in the associative structures of the production sectors and in strong investments provided by European Financial funds made available since the mid-80s of the 20th century.

In the past 30 years, the agrarian production paradigm has changed radically: the dominant self-supply (small local quantities) has been replaced by a business vision in the management of agricultural production. In some sectors these changes have been dramatic. For example, in the case of the dairy industry, it has moved from 80,000 dairy cows farms, existing in the early 1990s, to around 8,000 dairy holdings in the past 10 years. The artisanal micro-sprayed farms were followed by the professional hyper-concentration: In terms of management and income, there was a giant qualitative step; in terms of environmental impacts, the new farm structure of this sector also created new problems (INE, 2017).

The robotization of agricultural and livestock practices is now a reality that is gradually being installed in the production systems of the primary sector, offsetting the difficulty resulting from the progressive shortage of labour on these activities (The World Bank, 2021).

All the extraordinary progress recorded in the last decades in the agrarian sector, can be seen in three fundamental dimensions simultaneously: the obtaining of economic income, respect for the environmental and socially fair balance. These dimensions are the central axis of Sustainability.

No agricultural production system is sustainable if it is ecologically incorrect, economically unfeasible or disrespectful of cultural diversity and unfair to any segment of society.

In order to consolidate an agricultural policy in line with the perspectives of modernity, incorporating the references of the UN's sustainable development objectives and the strategy of the European Union's "Green Deal", the "Agenda for Sustainable Development" was approved in Portugal on October 10, 2020. Innovation for Agriculture 20 - 30 "(Terra Futura) is a document that aims to outline national public policies for the development of Portuguese agriculture in the next decade.

The "Agenda - Terra Futura" was approved through a Resolution of the Council of Ministers (Nr. 86/2020 of 10/10) stating a view, aiming the promotion of an "Agriculture that is even more sustainable, competitive, innovative, issuing and receiving knowledge". In that document, it is assumed that, national agriculture is closer to the consumer, incorporating values associated with the territory and its identity, "hand in hand" with the environment and respect for biodiversity. It is also mentioned that a more digital, more technologically and socially inclusive agriculture, is intended.

The "Terra Futura" strategy begins by recognizing that currently the systems of agricultural production and foodstuffs, and of the food itself, have earned increasing interest on the part of the population, especially issues related to food security and their role in promoting food access, health and well-being. It also mentions that there is a greater public concern about the issues of the management of rural spaces, the preservation of biodiversity, the challenges posed by climate dynamics and the subsequent need to promote adaptations and seek for contributions, so that it could be possible to mitigate the corresponding impacts.

The subsidiary role played by Agriculture in the development of other sectors of economic activity is not forgotten, such as in machinery in the plant protection field, veterinary medicine, biocides and fertilizer industries, and in a wide range of agricultural service providers (drivers, managers, agronomists, veterinarians, auxiliary technical staff). In addition it is intended to be an invaluable complement to activities related to Tourism and Gastronomic routes.

It is also recognized the important role that Agriculture and Forestry productions play in decarbonising the atmosphere, with the vegetative development of plants, and especially those with faster growth, being the most efficient vanishing way of greenhouse gases (carbon dioxide, oxide nitrous, ammonia, sulphur oxides and methane) (Pordata, 2018).

The Resolution creates an Interministerial Council and an Advisory Council, which ensure the overall coordination of the Agenda and its monitoring. The first consists of 14 public bodies, related to Agriculture, the Economy, the digital transition, Finance, Justice, Planning, Administrative Modernization, Science and Technology in addition to the areas of Education, Health and Environment; the second includes representatives of stakeholders and other socio-professional sectors with an impact on Agriculture and agribusiness, as well as consumer representatives.

The Agenda "Terra Futura" lists the main challenges, commitments and trends of the agricultural and agri-food sector in Portugal, as well as the global perspectives, postulating that – "demographic growth is still, and will continue to be, in the future, a driving factor in food demand" (Pordata, 2019).

In some regions of Globe or in certain segments of society, especially those that are developing, there will still be increases in the *per capita* consumption indicator. These elements are configured as enhancers of human development, making the increase in global trade even more urgent (OECD, 2018). For this, it is crucial that in some regions of the globe in emerging economies, the growth of individual income must be promoted, with greater expansion of the middle classes and the acceleration of the urbanization rate. This trend in social development will inevitably lead to consumption of larger quantities of foodstuffs and also of higher value products. These perspectives have led the Food and Agriculture Organization of the United Nations (FAO) to estimate that global food demand will increase between 30% and 40% by 2050, especially in developing areas with emerging economies (FAO, 2009).

In the text of the "Agenda - Terra Viva" it is admitted that changes in consumer behaviour and preferences will occur, especially in more developed societies, as a result of new cultural habits developed by more urban societies, including more concerns with issues of health protection in association with population aging. Concerns about environmental issues, animal welfare issues, protection of natural resources and climate dynamics are also incorporated. While in developing societies, due to the increase in household income, consumption of products such as meat and dairy products will increase, in developed societies consumers will have growing concerns about environmental protection, with the fight against food waste, giving greater preference to foodstuffs obtained from organic production systems and to products formulated in order to convince users that they are nutritionally more balanced.

The agri-food sector will have a particularly dynamic role in raising the awareness of producers and consumers about the need to provide nutritious food, diversified in order to allow a nutritionally balanced diet, carried out based on conscious, healthy choices and incorporating values related to the environmental protection, namely regarding the impact of production and distribution systems, on "carbon neutrality".

The challenges that the agri-food sector faces in the next thirty years have paradigmatic contours: on one hand it is essential to increase the global availability of food, with greater volumes, greater productivity and greater diversity; on the other hand, compliance with health and safety standards in the food chain, animal welfare, the preservation of ecosystems and the biodiversity must be guaranteed, through accessible and effective practices, not forgetting the need to incorporate concerns about social justice. It is evident that the materialization of these principles cannot be achieved without innovative technologies and the most advanced communication mechanisms or, perhaps, a most aggressive advertising.

4. Conclusions

In times when emotional marketing has captured the public perceptions and when those with many assets will do everything to get even more accumulation of wealth, the general public faces many perplexities, projected on multiple concerns that are changing and evolving in a very accelerated and unchecked way through different social segments. The digital revolution is a tool that allows everybody to easily use the mechanisms of the emotional marketing to condition various behaviours, including food systems. Those who live connected to social networks have an intuitive perception of

reality, or rather of a reality that is shown to them, not having time to access the truth, through the analysis of the relevant scientific data. With that, they lose analytical capacity and critical spirit.

Science brought knowledge and mastery over basic needs, but it did not create a "new man", capable of leading a peaceful, healthy and just life, even if it involve a lot of effort to reach so.

Nowadays, the world population is going through moments that challenge and call for the use of the best it has. Recently, many definitive lessons have been learned and very relevant learning has been achieved. Perhaps the greatest has been the rediscovery of how food production and distribution are decisive for the survival of mankind.

However, it is absolutely essential that human activities generate income, without which it would not possible to achieve economic and social development. Whenever the economy stops developing, people's living conditions deteriorate. To obtain economic income it is essential to use and consume energy. However, certain forms of energy production and use cause degradation in the environment and a degraded environment is more of a threat to life; the economy does not develop; the future is unsustainable.

Scientific advances are not always sufficient to meet the legitimate expectations of human development, that is, for each of us. Public policies do not always give a clear answer, because they are often hijacked in the web of interests, circumventing aspirations to improve living conditions or even human survival. These circumstances create perplexities that hinder human development and civilization progress.

To indoctrinate and structure the dominant thinking on agricultural and agri-food development issues, some international organizations, such as the UN (Sustainable Development Goals) and the European Union (Green Deal and “From Farm to Fork” strategy) (RRN, 2019) have published the basic principles on the need to implement sustainable development models.

In line with these international perspectives, a strategy called “Terra Futura” was launched in Portugal in 2019, which encompasses the components that can make national agriculture grow, innovating it and impregnating it with sustainability characteristics so that future generations can safely inherit it.

In the future, farmers worldwide will continue to fully assume their social role as true “landscape gardeners”, generators of an environment dominated by the balance between what is produced and what is consumed, with no place for unnecessary waste and unruly land use, water and natural resources.

All of these efforts will have to converge to give a more supportive, cohesive and fair sense to the human being existence. If this convergence does not occur, threats to the survival of our species, now dominant on the planet may arise.

REFERENCES

COM (2019). Global food supply and demand: Consumer trends and trade challenges. September, European Commission. Brussels, Belgium (pp-12). Accessed in: 15, March, 2021, in: https://ec.europa.eu/info/sites/info/files/food-farming- fisheries/farming/documents/market-brief-food-challenges-sep2019_en.pdf

COM (2017). Comunicação da Comissão ao Parlamento Europeu, ao Conselho, ao Comité Económico e Social Europeu e ao Comité das Regiões: O futuro da alimentação e da agricultura. Brussels, Belgium (pp-28). Accessed in: 15, March, 2021, in: https://eur-lex.europa.eu/legal-content/PT/TXT/PDF/?uri=CELEX:52017DC0713&from=PT

Costa, B.C.C. and Castro, L. (Ed.) (1900). Portugal au point de vue agricole. Grande Commission organizatrice de la Representation portugaise à l’Exposition Universelle de 1900. Lisbonne, Portugal (p968).

Eurostat (2018). Pesticide sales. Accessed in: 8, March, 2021, in: https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=aei_fm_salpest09&lang=en

FAO (2017). The future of food and agriculture: alternative pathways to 2050. Rome, Italy. pp.163. Accessed in 8, March, 2021, in: http://www.fao.org/3/i6583e/i6583e.pdf

FAO (2019). World Food and Agriculture Statistical Pocketbook. Rome, Italy. pp. 248. Accessed in: 9, March, 2021, in: http://www.fao.org/3/ca6463en/ca6463en.pdf

FAO (2009). How to Feed the World in 2050. FAO. Rome, Italy. pp.35. Accessed in: 9, March, 2021, in: http://www.fao.org/fileadmin/templates/wsfs/docs/expert_paper/How_to_Feed_the_World_in_2050.pdf

Gaud, W. (1968). The Green Revolution: Accomplishments and Apprehensions. AgBioWorld. Accessed in: 8, August, 2011, in: http://www.agbioworld.org/biotech-info/topics/borlaug/borlaug-green.html

Hofstrand, D. (2011). Can the World Feed Nine Billion People by 2050? AgMRC Renewable Energy & Climate Change Newsletter November. Accessed in: 8, December, 2011, in: https://www.agmrc.org/renewable-energy/renewable-energy-climate-change-report/renewable-energy-climate-change-report/november-2011-newsletter/can-the-world-feed-nine-billion-people-by-2050

INE (2017). Inquérito à Estrutura das Explorações Agrícolas, 2016. INE, I. P. Lisboa, Portugal. pp. 50.

OECD (2019). OECD-FAO Agricultural Outlook 2019-2028, Stat. Paris, France. Accessed in: 2, February, 2021, in: https://stats.oecd.org/Index.aspx?datasetcode=HIGH_AGLINK_2019

Pordata (2018). Emissões de gases com efeito de estufa: total e por alguns setores de emissões de gases, valores de 2017, Lisboa, Portugal. Accessed in: 2, February, 2021, in: https://www.pordata.pt/Portugal/Emiss%C3%B5es+de+gases-1081-8824

Pordata (2019). Valor acrescentado bruto: total e por sector de atividade económica (Euro), valores de 2018. Lisboa, Portugal.

Rodriges, T. (2008). História da população portuguesa: Das longas permanências à conquista da modernidade. CEPESE e Ed. Afrontamento. Porto, Portugal. pp. 581.

Rosário, L. (2004). Indicadores de Desertificação para Portugal Continental, Ed. ICNF. Lisboa, Portugal. pp. 59.

RRN (2019). Do prado ao prato. Rede Rural Nacional. Accessed in: 2, March, 2021, in: http://www.rederural.gov.pt/images/destaques/Farm_to_fork_pt.pdf.pdf

The World Bank (2021). Employment in agriculture (% of total employment), Washington, USA. Accessed in: 10, March, 2021, in: https://data.worldbank.org/indicator/SL.AGR.EMPL.ZS

UN (2015). Transforming our World: The 2030 Agenda for Sustainable Development. Ed UN, NewYork, USA. pp. 41. Accessed in: 24, November, 2017, in: https://sdgs.un.org/publications/transforming-our-world-2030-agenda-sustainable-development-17981

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Technological, Socioeconomic and Territorial Dynamics of Poultry Sector in Brazil – An Example of Efficient High Quality Protein Production

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ABSTRACT

Poultry farming is an important segment of Brazilian agribusiness, generating jobs and income, as well as providing important products to the population. This study aimed at understanding the technological, socioeconomic and territorial dynamics of poultry and egg production in Brazil. The methodology employed was the bibliographic survey with information obtained from documental sources. Numerous changes have occurred in beef and egg laying aviculture; equipment and installations were altered with the advent of technology, which provided favorable conditions for the avian husbandry, altered zootechnical indices allowed the promotion of better animal welfare, improved productivity and, consequently, the economic results of this activity. It was found that Brazilian companies in the poultry sector are mostly located in the southern, southeastern and central-western regions, with the predominance of the integration system. Brazilian small and medium producers have different characteristics and demands regarding social, economic, educational and cultural conditions. Thus, technical assistance and rural extension assumes an important role. The complexity of poultry agro-industrial system has a strong impact on the

economic dynamics of the regions in which this activity is installed, with a clear reflex on human developmental indicators.

Keywords: Poultry industry, rural development, technologies.
JEL classification: O30, O32, O33, Q00, Q16.

RESUMO

A avicultura constitui importante segmento do agronegócio brasileiro, gerador de empregos e renda, bem como fornecedor de importantes produtos à população. Objetivou-se compreender as dinâmicas tecnológicas, socioeconómicas e territoriais da produção de aves e de ovos no Brasil. A metodologia adotada foi o estudo bibliográfico, sendo as informações obtidas em fontes documentais. Inúmeras modificações ocorreram na avicultura de carne e de postura; equipamentos e instalações foram alterados com o advento da tecnologia, que propiciou condições favoráveis à criação das aves, alterou os índices zootécnicos, permitiu promover maior bem-estar animal, melhorar a produtividade e, consequentemente, os resultados económicos da atividade. Verificou-se que as empresas brasileiras do setor avícola estão localizadas maioritariamente nas regiões sul, sudeste e centro-oeste, com o predomínio do sistema de integração. Os pequenos e médios produtores no Brasil apresentam características e demandas distintas, em termos de condições sociais, económicas, educacionais e culturais. Desse modo, revela-se de elevada importância a assistência técnica e a extensão rural. A complexidade do sistema agroindustrial avícola repercute-se fortemente na dinâmica económica das regiões, nas quais essa atividade está instalada, com evidente reflexo nos indicadores de desenvolvimento humano.

Palavras-chave: Desenvolvimento rural, indústria avícola, tecnologias.
Classificação JEL: O30, O32, O33, Q00, Q16.

1. INTRODUCTION

Brazil is one of the major food producers in the world and has great aptitude for agricultural activities. The country has many natural characteristics such as climate, territorial and culture which confers advantages in terms of sustainability (Brazilian Association of Animal Protein – BAAP, 2021). The favorable climate ensures the availability of inputs – grains, water and soil, small energetic consumption in productive systems, in addition to better animal welfare conditions (BAAP, 2021).

Agribusiness is an important sector of Brazilian economy which comprises all operations including all pahses from production, storage, processing and distribution of agricultural products (Gonçalves et al., 2018). In the last years, it was responsible for a relevant percentage of the gross domestic product – GDP, for job generation and population income, as well as for Brazilian exports as consequence of technological development (Moreti et al., 2021).

Changes in Brazilian rural space have ocurred quite intensively during the agricultural modernization process favoring the expansion in technology at the foundations of farming production (Pessetti et al., 2019). Technological changes have expanded the possibilities of increasing productivity, goods supply, in addition to making farming more profitable (Schmidt, 2019). Among animal husbandries, poultry meat and egg production stand out. Advances in Brazilian poultry were due to the introduction of innovations in the fields of genetics, nutrition, management, health systems, ambience, installations and equipments (Vasconcelos et al., 2015; Vogado et al., 2016; Schmidt & Silva, 2018).

In 2015, the United Nations Organization established 17 objectives of sustainable development (OSD) of the planet which are to be met until 2030 (UN, 2015). Especifically, poultry farming supplies six of these objectives (Gunnarsson et al., 2020): zero hunger (OSD2) – generate high quality products, low cost to the population; good health conditions and welfare (OSD3) – good management production practices aiming animal welfare; high quality education (OSD4) – to capacitate in order to assure high quality and sustainable production; industry, innovation and infrastructure (OSD9) – to support innovative and sustainable industrialization; climatic action (OSD13) – reduction of greenhouse gases and other emissions; life on Earth (OSD15). The main challenges of sustainable modern poultry production consist in the emission of greenhouse gases, loss of biodiversity and scarcity of finite

natural resources (Gunnarsson et al., 2020). In order to achieve sustainable poultry production, such challenges must be overcome.

In 2020, egg production surpassed 53 billions of units while broiler meat production was 13.84 millions of tons, keeping Brazil in the position of largest exporter and third largest poultry meat producer. The *per capita* consumption of poultry meat was 45.27 kg and 251 units of eggs (BAAP, 2021). According to the Brazilian Ministry of Agriculture, Livestock and Supply – MAPA/MALS, the exports of poultry meat from 2019/2020 to 2029/2030 can increase on average 3.0% annualy with the total amount produced in Brazil reaching 21 milions of tons. Furthermore, with the projected total population of 215 milion individuals in 2028, the estimated poultry meat consumption per individual per year is 61.80 kg (Brasil, 2020).

It is worth mentioning that technology in farming directly contributes to reducing poverty and developing more efficient productive systems (Silva et al., 2021). However, in order to assure rural development with food and social economic security of communities and/or farmers, in addition to technology, it is necessary to have access to public policies and technical assistance. The search for sustainable rural development represents one of the major challenges of mankind, since it is necessary to produce increasingly more at the expanse of conservative technologies of soil, water, flora and fauna and to reduce the impacts in the environment (EMBRAPA, 2017).

Based on the described context, this review aims to understand the technological, socioeconomic and territorial dynamics in poultry farming and egg production in Brazil as a current example of highly efficient high quality protein production.

2. Poultry and egg productive chains in Brazil

The evolution and expansion of Brazilian industrial poultry from the year 2000 dealt with the new dynamics in rural spaces influenced by comercial and productive demands (Procópio & Lima, 2020). Progress in poultry industry has been intimately associated with the integration system between agroindustries and producers with an increment in technology in this sector and consequent gains in productivity (Pereira et al., 2019). The development of Brazilian poultry sector has sustained itself through a combination of quality of healthy products, the adopted sustainability standards and the hybrid governance system adopted system used by the slaughtering companies with big rural corporations and thousands of small units of family farming production (Caldas et al., 2020).

The success of poultry farming is a consequence of the adoption of new technologies, the process of industrial restructure in this sector in Brazil, the use of an efficient research and developmental system (P&D), wide scale organization and evolution of poultry management techniques, nutrition and health (Souza et al. 2021). Currently, Brazilian poultry farming offers a wide range of products directed to distinct income ranges in order to meet the demands of feasibility and convenience not only to the internal market but also to different countries (Cielo et al., 2019).

Poultry production has a remarkable feature that distinguishes it from other farming activities: the existing relations between the productive unit and the industry, with emphasis on the integration that occurs by means of contracts (Giarola & Carvalho Júnior, 2020). Such integration consists in a partnership between rural producers, in this case, poultry farmers and the agroindustries (Nogueira & Jesus, 2013). This system is based in the supply of chicks (one day old) by the agroindustry, rations, drugs, vaccines, technical and veterinarian assistance to the farmers which should in turn fatten the animals and prepare them for the slaughtering industries (Nogueira & Jesus, 2013). It is important to mention that farmers should provide the necessary installations and equipments to perform the productive activities.

The integrating companies control a great deal of the process of poultry production, have their own research, developmental and innovation centers (PD&I), where products and procedures are developed, tested, adapted and validated. At these centers (PD&I), experiments involving health, nutrition, management and genetics as well as development and testing of equipments provided by the partnership of the suppliers are performed (Bassi & Silva (2017).

The vertically coordinated process provides the Brazilian poultry farming a reduction in the production costs, adoption of better tecnologies, greater quality and process innovations, strict health control measures, adaptation ability to the demands, tracking of the entire productive process and assurance of food safety for the market consumers (Vasconcelos et al., 2015; Giarola & Carvalho Junior, 2020). Guareski et al. (2019) highlighted the importance of integration for the development of

the local economy by providing diverse activities, increasing the producer's income and reducing rural exodus.

Jung & Zanelatto (2020) have indicated that the integration can be observed under two aspects that differ in relation to the buyer and seller, being: 1) the slaughterhouses/integrating companies regulate the characteristics of the job organization at the rural properties; 2) also, the control of job flow, decision comand by the integrator and the poultry farmer having no control of the productive process. There is plenty of debate over the advantages and disadvantages of integrated production; however, the fact is that as in all segments of agribusiness, the activity has risks and it is up to the producer to evaluate these risks (Guareski et al. 2019).

Among the advantages of the integration of Brazilian poultry industry are: i) safety in poultry sales at a value previously agreed; ii) job generation and monthly income to the farmers and their families; iii) skilled labor; greater productivity as a result of technical assistance provided by the agroindustry and iv) possibility of increase in the income of the aggregate from comercialization of the activities residues – chicken bedding such as organic fertilizer (Souza et al., 2021). As disadvantages, is the observed dependency of the farmers on the integrated partnership which restricts the trade of poultry products to other companies; also, the farmers need to constantly invest in technologies, which is an imposed requirement to maintain the partnership (Souza et al., 2021).

Unlike poultry farming, in the egg productive chain in Brazil, little use of integration is made and the poultry farmer is both the producer and processor of eggs; there is a verticalization of the industry with small companies, many of which are organized under private individuals comprising both poultry farming and processing (Amaral et al., 2016). In this specific case, the farmer is responsible for making businnes decisions (Silva, 2019).

There are two important segments divided into distinct systems in Brazilian egg laying poultry: 1) technical, with large scale production and technological improvements in genetics, nutrition, health, physical strucuture of production, logistics and animal wellfare, and 2) alternative or conventional, with low technological level, family administration and oriented towards local trade (Pimentel et al., 2016). The intensive, more efficient, productive systems prevail in both meat and egg poultry farming in Brazil. The reason for this can be atributted to corn and soybean meal supply, the main ingredientes used in poultry feeding, as well as the low costs when compared to other world players, display relative advantage – favorable climate conditions, inputs, genetics, use of technological resources (Cardoso & Santana, 2016). The productive model to be adopted and the use of technical, management and technological tools will be decisive in the productive and economical efficiencies of the avian business. Next, considerations regarding technological, social and territorial dynamics of Brazilian poultry are discussed.

3. TECHNOLOGICAL DYNAMICS OF BRAZILIAN POULTRY

Several modifications have occurred in poultry meat and egg laying industries and equipments and installations have been altered through technology. Such fact has facilitated favorable conditions in poultry farming, changed zootechnical indices, allowed better animal welfare since it improved productivity and consequently the economical results of the activity (Souza et al., 2020).

According to Schmidt & Silva (2018), in the 1960's, genetics improvement programs evaluated the number of incubated eggs and the hatching rate, and feed conversion during the decades of 1970 and 1980. From 1990 onwards, research focused in the installations and equipments, which expressed a concern with animal welfare. Such studies/evaluations became relevant with the increase in sanitary requirements and regulations directed towards environment preservation (Schmidt & Silva, 2018).

The environment and animal welfare became fundamental in poultry activity and the search for improvements in these areas became a constant (Vasconcelos et al., 2015; 2016) which led to the advent of acclimatized birdhouses with more technical equipments, automatic feeders, negative ventilation (exhaust fans), nebulizers, temperature monitoring, humidity and automatic ventilation (Vasconcelos et al., 2016).

Abreu & Abreu (2011) emphasized that introduction of many technologies and its adaptions led to the emergence of several poultry productive systems, each with its own peculiarities; this became a great challenge for the ambience of these poultry farming systems. Researchers stated that in order to face these challenges, four points should be considered by poultry professionals: 1) knowledge of

poultry physiology; 2) bioclimate diagnosis of the microregion production or the implantation of poultry system; 3) use of basic concepts of ambience and 4) typification detailing of productive systems.

Poultry production involves many interdependent aspects including several and continuous challenges. The rising demand in poultry products and market has led to an intense pressure in all chain sectors to enhance the growth rate, feed efficiency, sanitary status and chain sustainability (Bassi & Silva, 2017).

Recent technological progress in Brazilian meat poultry farming can be clearly demonstrated by the change in zootechnical indices. The productive cycle, mortality and feed conversion have reduced over the decades while poultry weight has increased. In 1980, a 35 day old meat broiler had an average weight of 1.4 kilograms (kg) and a feed conversion – FC of 2.3; in 2010, these values reached 2.4 kg and 1.5 for FC (Siegel, 2014 cited by Yamawaki, 2021). In addition, there was an increase of almost 10% in total poultry carcass and breast yield, as well as reduction in fat percentage and an increase in animal rusticity which contributed to a greater lot viability (Siegel, 2014 cited by Yamawaki, 2021). As to the egg production, the results were also exceptional with productive indices surpassing 340 eggs at 80 weeks of age; this represents more than twice the value obtained in the 1940 decade, when a 70 week old housed bird produced 134 eggs (Espíndola, 2012).

Santos et al. (2018) analyzed the effects of automation technology in two production aviaries of fertile eggs (manual and automated) integrated to a company of the poultry field in Brazil. The results of this study showed that even with the initial high investment of the automated aviary, the profits were significantly higher (55,62%) than those obtained by the manual aviary (18,15%). The inovation of the equipment used in the automated aviary brought comfort to the birds and led to an increase in production and quality of the hatchable eggs. Researchers concluded that investment in technology contributes to improvement in egg quality and, consequently, makes it possible to obtain better economic results.

Reati et al. (2020) compared the zootechnical performance of different lineages of meat poultry (Cobb Slow; Cobb Fast e Hubbard), ventilation systems (positive and negative) and types of aviaries (conventional/yellow canvas; blue house and dark house). The birds Habbard and Cobb Slow showed better productive efficiency than the Cobb Fast. The best zootechnical results were obtained with the systems that provided better ambience, that is, with negative ventilation and luminosity control (dark and blue house).

Several modifications have ocurred in meat and laying poultry farming; equipments and installations were altered with the advent of technology (Souza et al., 2020). Such fact allowed favorable conditions in poultry farming, altered zootechnical indexes, promoted better animal welfare which in turn improved productivity and consequently the economic results of the activity (Souza et al., 2020).

This remarkable improvement in production efficiency also helps meeting the UN 2030 Agenda goals, especially regarding the need for high quality food protein as agricultural progress is definitely needed in order to avoid the deficit of food availability yet expected for 2030 (FAO, 2021).

4. Socio and territorial dynamics in Brazilian poultry farming

Brazilian companies of the avian sector are primarily located in the Southern, Southeastern and Central-Western regions with a predominance of the integration system (BAAP, 2021). The integrated model protects the producer from the adversities of the market, generates stable income with a remarkable influence in the life quality of the producing families (BAAP, 2021). At the same time, the growth of this activity with the use of new productive technologies has encouraged producer professionalization as well as the interest of new generations, familiar succession and settlement of man in the field (BAAP, 2021).

Poultry farming consists of complex activities which involves a long chain of costs either upstream or downstream (Santos Filho et al., 2016). In addition to the animal production and slaughter, there is downstream of distribution, wholesale and retail sectors and upstream of transportation, technical assistance, constructions, machine and equipments manufactures. Such complexity strongly impacts the economic dynamics of the regions in which this activity is installed, with a conspicuous reflex in human development indices (Santos Filho et al., 2016).

Social sustainability of broiler chicken production was evaluated in a *dark house* system in the region of Grande Dourados, Mato Grosso do Sul State, Brazil (Souza et al. 2019) The tool employed by

reseachers was the Social Impact System of Farming Activities, which consists in an instrument that integrates 16 indicators divided into four areas: job, economy, health, management and administration. In general, the results showed that avian properties (n=5) reached final indices of social impact superior to the baseline (0.70) established by the system, which indicated a positive social impact. The net income index was 0.93 in all studied establishments; such finding can be atributed to the use of *dark house* system with a greater control over ambience**,** installations and feed conversion, which reflected in the profit. However, health and management aspects displayed a negative impact as result of the incidence of vector focus of endemic diseases, the lack of care with safety and occupational health (hazardous and unsafe) and concern with access to sports and leisure activities. Furthermore, as a result from exclusive dedication to the activity, the lack of market investment, among other reasons (Souza et al., 2019).

The poultry chain comprises the industry sector in addition to being fomented by other activities such as grain production, especially corn and soybean, which are raw materials in Brazil fundamental in poultry nutrition (Fagundes et al., 2018). Industry is the link that creates the greatest number of formal Jobs and better remunerates the workers (Fagundes et al., 2018).

The constant search for competitiveness in poultry farming makes imperative the use of scale production associated to top technologies (Dacroce et al. 2018). Pimentel et al. (2016) analyzed the benefits that innovation has brought to egg chain production. Researchers have concluded that the adoption of technical production system enables the increase in productivity, making possible to accommodate more birds per shed, in addition to generating high quality products, since the eggs can be taken immediately for processing (automated equipments) without any human interference, and a smaller labor demand.

It is noteworthy to mention that in addition to constant updates, poultry farmers should make high investments in their productive systems. Thus, credit access determines the beginning and maintenance of the farmers in the activity, since many do not have resources in order to adjust themselves and need to seek available credit lines such as The Agriculture Modernization Program and Preservation of Natural Resources – Moderagro, The Incentive Program of Technology Innovation in Farm Production – Ioagro, among others (Belusso & Hespanhol, 2010; Dacroce et al., 2018).

Small poultry farmers find it difficult to remain in the integrated systems due to precarious work conditions and acquired debts to modernize poultry farming; therefore, they give up acting in industrial poultry (Nogueira & Jesus, 2013). In several Brazilian States, mainly in regions outside industrial farming circuit, there is an appeal for consumption and production of meat and eggs in differentiated systems, such as free range chickens (Camusso et al., 2021), alternatives and/or agriecological. Free range poultry farming allows small and medium producers the opportunity for insertion in a profitable activity, in addition to promoting familiar agriculture and animal production based on agriecological principles (Santana et al., 2020).

According to Maas et al. (2019), several rural producers are interested in investing in new technologies with differentiated productive systems; however, some give up due to difficulty in acquiring financial resources or also to the lack of technical knowledge in the activity and market conditions.

The small and medium Brazilian producers/farmers show distinct characteristics and demands in terms of social, economical, educational and cultural conditions (Silva et al., 2020). Therefore, it is important to highlight the role of Technical Assistance and Rural Extension (ATER) provided by the Brazilian Federal Government. Rural Extension is an educational and transforming tool based on learning and participative actions, which allows the farmer and extensionist to reflect and act upon the current reality by using basic sustainability principles, that is, social, environmental and economical aspects focused on familiar agriculture and rural farmland (Santos et al., 2018a).

Agriecological poultry farming displays a certain degree of complexity since the system should be seen under an holistic and systemic view, that is, to interrelate knowledge of animal and vegetable production and by following the recommendations established by the specific legislation (Lima et al., 2019). Thus, technical knowledge becomes fundamental as to the forms of eggs and meat production. Cordeiro et al. (2008) analyzed a familiar egg production business and found inadequate management in animal water and ration supplies and also in the egg collection, which implicated in higher costs with feeding and is a cause of production instability. According to the researchers, the problems emerged from poor technical capacitation of personnel involved in the activity. Such result demonstrates the importance of ATER in the scope of knowledge and technology diffusion.

Silva et al. (2018) described some benefits of ATER on agriecological basis: i) changes in feeding habits and in the producers health protection; ii) impact reduction in the monopoly of input companies; iii) minimization of reliance of the familiar farmers facing these monopolies; iv) technology exchange; v) farmer considering rural credit as an investment rather than a simple debt and vi) increase in the environmental perception and concern with preservation of the environment.

Poultry consumers are becoming more demanding as to regular supply, quality, promptness, feasibility and competitive prices; thus, well organized low transaction cost agroindustrial systems have better chance in augmenting their share in the market (Oliveira et al., 2008). In this context, not only should the participants of industrial poultry be taken into account but also those linked to alternative poutry farming and its differentiated products – small and/or medium poultry farmers and their families.

Souza et al. (2020) pointed out that sustainability in poultry chain is a great challenge since all participating links should conduct sustainable actions, that is, to produce and preserve natural resources, to promote animal health and welfare as well as to support a balanced economical and technical profitability.

5. Final remarks

Poultry farming is an important segment of Brazilian economy, by generating jobs and income as well as supplying important products (meat and eggs) to the population. The largest companies of the poultry sector are located in southern, southeastern and central-western regions of Brazil with large scale productions and a prevalence of the integration system. In this scope, in addition to continuous updates in different areas (management, nutrition, health care, environment, installations, technology), poultry farmers should make high investments in the productive systems, that is, the challenges are quite diverse and incessant.

Brazilian small and medium producers display distinct characteristics and demands in terms of social, economical, educational and cultural conditions. Thus, technical assistance and rural extension become relevant as well as the aquisition of financial resources/access to credit line. The complexity of poultry agroindustrial system strongly impacts the economic dynamics of the regions in which this activity is installed, with conspicuous reflex in human developmental indices.

The ongoing progressive improvement in poultry farming conditions, from the avian genetic background to the shed infrastructures and environmental control equipment, not forgeting a special focus on bird management and sanitation, will continue improving production efficiency as well as food security and safety, playing simultaneously a not environmental-neglegible role of the production of high quality food protein.

References

Abreu, V. and Abreu, P. (2011). Os desafios da ambiência sobre os sistemas de aves no Brasil. Revista Brasileira de Zootecnia, 40, 1-14.

Amaral, G.; Guimarães, D.; Nascimento, J.; Custodio, S. (2016). Avicultura de postura: estrutura da cadeia produtiva, panorama do setor no Brasil e no mundo e o apoio do BNDES. BNDES Setorial, 43, 167-207.

Associação Brasileira de Proteína Animal – ABPA/BAAP (2021). Relatório Anual 2021. São Paulo-SP: ABPA. p75.

Bassi, N. and Silva, C. (2017). Oportunidades e desafios em PD&I na cadeia produtiva de frangos de corte. Avicultura Industrial, ed. 1271, 109(10), 16-21.

Belusso, D. and Hespanhol, A. (2010). A Evolução da avicultura industrial brasileira e seus efeitos territoriais. Revista Percurso - NEMO, 2(1), 25-51.

Brasil, Ministério da Agricultura, Pecuária e Abastecimento – MAPA/MALS (2020). Brasil Projeções do Agronegócio 2019/2020 a 2029/2030. 11.ed. Brasília-DF: Mapa. p102.

Caldas, E.; Lima, A.; Lara, L. (2020). Análise econômica da produção avícola de corte por gênero em diferentes estruturas de governança. Organizações Rurais & Agroindustriais, 22, e1641.

Camusso, D.; Santos, J.; Viagi, A. (2021). Monitoramento ambiental baseado na tecnologia Internet das Coisas para pequenos avicultores. Brazilian Journal of Development, 7(5), 51132-51146.

Cardoso, D. and Santana, R. (2018). Sustentabilidade na produção de aves e suínos no Brasil. In: Borges Júnior, A.; Campos, R.; Leite, R. Perspectivas para agropecuária. Goiânia-GO: Kelps. p524.

Cielo, I. et al. (2019). Importância socioeconômica da integração avícola para os produtores da mesorregião oeste do Paraná. Desenvolvimento em Questão, 17(49), 329-347.
Cordeiro, A.; Almeida, C.; Severino, M. (2008). Viabilidade da produção de ovos em empreendimento familiar no município de Porto Estrela-MT. In: XXVIII Encontro Nacional de Engenharia de Produção – ENEGEP. A integração de cadeias produtivas com a abordagem da manufatura sustentável. Rio de Janeiro-RJ: ENEGEP, p14.
Dacroce, N.; Leismann, E.; HOFER, E. (2018). Panorama dos pequenos produtores avícolas diante de novas tecnologias, biossegurança e exigências ambientais. Revista em Agronegócio e Meio Ambiente, 11(2), 431-456.
Empresa Brasileira de Pesquisa Agropecuária – Embrapa (2017). Embrapa em números. Brasília-DF: Embrapa. p140.
Espíndola, C. (2012). Trajetórias do progresso técnico na cadeia produtiva de carne de frango do Brasil. Geosul, 27(53), 89-113.
Fagundes, M. et al. (2018). A contribuição da avicultura de corte para o desenvolvimento do Mato Grosso do Sul. Revista Brasileira de Desenvolvimento Regional, 6(1), 109-136.
FAO et al. (2021). The State of Food Society and nutrition in the world. Transforming Food Systems for Affordable Healthy Diets, (Accessed in: 30 August, 2021, in: http://www.fao.org/documents/card/en/c/cb4474en/
Giarola, P.; Carvalho Júnior, L. (2020). Um retrato da cadeia produtiva de carne avícola em Santa Catarina e no Brasil no início do século XXI. Revista Americana de Empreendedorismo e Inovação, 2(2), 141-150.
Gonçalves, J. et al. (2018). Reflexões atualizadas sobre o contexto do agronegócio brasileiro. Agroalimentaria, 24(46), 89-101.
Guareski, A.; Zachow, M., Fachin, G., Ribeiro, W. (2019). Sistema contratual de integração: vantagens e desvantagens percebidas pelos produtores de frangos de corte na região de Cafelândia – Paraná. Revista de Gestão e Organizações Cooperativas, 6(11), 43-60.
Gunnarsson, S. et al. Systematic mapping of research on farm-level sustainability in egg and chicken meat production. Sustainability, 12, 3033, 2020.
Jung; G. and Zanelatto, J. (2020). Trajetória das relações de trabalho entre avicultores integrados e frigoríficos no sul do Brasil (1970-2016). Interações, 21(2), 405-417.
Lima, K.; Matos, M.; Souza, M. (2019). Produção de aves em sistema de base agroecológica. Vértices, 21(2), 205-219.
Maas, D. et al. (2019). Análise da viabilidade financeira na implantação de um aviário automatizado para produção de ovos. Revista Gest@o.Org, 17(2), 103-115.
Moreti, M. et al. (2021). Inteligência artificial no agronegócio e os desafios para a proteção da propriedade intelectual. Cadernos de Prospecção, 14(1), 60-77.
Nogueira, C. and Jesus, E. (2013). A pequena produção avícola familiar e o sistema de integração no oeste catarinense: “uma prisão de portas abertas”. Caderno CRH, 26(67), 123-138.
Oliveira, A.; Nogueira Filho, A.; Evangelista, F. (2008). A avicultura industrial no Nordeste: aspectos econômicos e organizacionais. Série Documentos do Etene n. 23. Fortaleza. Banco do Nordeste, p160.
Pereira, J.; Castro, A. ; Del Grossi, M. (2019). Análise de desempenho da cadeia produtiva de carne de frango no estado de São Paulo. Revista Científica Rural, 21(1), 165-178.
Pessetti, M. et al. (2019). Evolução e dinâmica da produção de galináceos na microrregião de Guaporé/RS. Espaço Aberto, 9(2): 119-135. DOI: 10.36403/espacoaberto.2019.28051.
Pimentel, D.; Queiroz, T.; Pigatto, G. (2016). Inovação em processo na cadeia produtiva de ovos: mudanças nos equipamentos de acomodação de aves poedeiras. In: I Simpósio em Gestão do Agronegócio, Jaboticabal-SP: 8 a 10 de junho de 2016. Inserção do Agronegócio Brasileiro nas Cadeias Globais: Desafios Gerenciais e Tecnológicos. Jaboticabal-SP, p15.
Procópio, D. and Lima, H. (2020). Avaliação conjuntural da avicultura no Brasil. Research, Society and Development, 9(3), e47932312.
Reati, L. et al. (2020). Desempenho de frangos de corte criados na região oeste do Paraná em relação à linhagem e sistemas de produção. Revista Acadêmica Ciência Animal, 18, e18014.
Santana, M. et al. (2020). Diagnóstico socioeconômico e produtivo da avicultura caipira no estado do Acre. Revista de Agroecologia no Semiárido, 4(5), 10-22.
Santos, R. et al. (2018a). Extensão rural na agricultura familiar: as características de uma família agrícola no município de Santana, Amapá, Brasil. Revista Ciência em Extensão, 14(4), 97-112.
Santos, T. et al. (2018). Reflexos da tecnologia de automação nos resultados econômicos de aviários integrados a uma empresa do ramo avícola. Custos e @gronegócio on line, 14(2), 53-72.

Santos Filho, J. et al. (2016). Potencial do Matopiba na produção de aves e suínos. Revista de Política Agrícola, ano XXV, 2, 90-102.
Schmidt, N.S. and Silva, C.L. (2018). Pesquisa e desenvolvimento na cadeia produtiva de frangos de corte no Brasil. Revista de Economia e Sociologia Rural, 56(3), 467-482.
Schmidt, G. (2019). Tendências tecnológicas na agropecuária. Avicultura Industrial, 6(1689), 24-26.
Silva, K.; Bergamasco, S.; Souza-Esquerdo, V. (2018). Assistência Técnica e Extensão Rural no Vale do Ribeira Paranaense. Revista Brasileira de Desenvolvimento Regional, 6(2), 103-124.
Silva, I. (2019). Sistemas de produção de galinhas poedeiras no Brasil. p40. Accessed in: 8, July, 2021 in: http://www.sectordialogues.org/documentos/proyectos/adjuntos/b26c49_X-GUIA-GALINHAS-2019.pdf
Silva, A. et al. (2020). Agroindustrialização de frango caipira no estado do Maranhão: caracterização socioeconômica de agricultores familiares e elaboração de planta baixa. Brazilian Journal of Development, 6(7), 43131-43146.
Silva, L. et al. (2021). Contribuição da tecnologia agropecuária para a superação da pobreza na Amazônia. Revista Grifos, 30(54), 112-118.
Souza, C. et al. (2020). Tecnologia e sustentabilidade na cadeia avícola brasileira. p.239-267. In: LANA, R.P. et al. Anais de Palestras X Simpósio Brasileiro de Agropecuária Sustentável – SIMBRAS, 16 a 18 de setembro de 2020. Viçosa-MG: Os Editores. p438.
Souza, S. et al. (2019). Sustentabilidade social na produção de frango de corte em sistema dark house: um estudo multicaso. IGepec, 23(2), 84-101.
Souza, S. et al. (2021). Fatores críticos de sucesso na produção de frango de corte a partir da percepção do produtor integrado da região da Grande Dourados/MS. Revista de Economia e Sociologia Rural, 59(3), e226679.
United Nations – UN (2015). Transforming our World: the 2030 Agenda 2030 for sustainable development. Accessed in: 31, August, 2021 in: https://www.un.org/ga/search/view_doc.asp?symbol=A/RES/70/1&Lang=E
Vasconcelos, M. et al. (2015). Trajetória tecnológica da cadeia produtiva do frango de corte no Brasil. Iniciação Científica CESUMAR, 17(1), 15-27.
Vasconcelos, M.; Bassi, N.; Silva, C. (2016). Caracterização das tecnologias e inovação na cadeia produtiva do frango de corte no Brasil. In: Costa, R.S.; Guerra, J.B.S.O.A.; Dias, T. Debates interdisciplinares VII. Palhoça-SC: Editora Unisul. p373.
Vogado, G. et al. (2016). Evolução da avicultura brasileira. Evolução da avicultura brasileira. Nucleus Animalium, 8(1), 49-58.
Yamawaki, R. (2021). Manejo final em frangos de corte: como extrair ao máximo o que a tecnologia da climatização oferece frente ao desempenho do frango moderno. p.43-47. In: Anais do 21º Simpósio Brasil Sul de Avicultura e 12º Brasil Sul Poultry Fair, 06 a 08 de abril de 2021. p62. Chapecó, SC- Brasil On-line.

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Opening the Door of Our Moral Arena to Non-human Animals

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"If I could make everyone in the world see one film, I'd make them see EARTHLINGS."
Peter Singer, author Animal Liberation
http://www.nationearth.com/earthlings-1/

ABSTRACT

The overwhelmingly preponderant use of animals in society, since the dawn of civilization, has unquestionably been agricultural, through the concept of husbandry. The advent of intensive farming and large-scale animal use in biomedical research resulted in huge amount of sentient animal suffering. Society became aware of that reality through the mass media, animal welfare activists and philosophers. In the 1970s and 1980s, development of study techniques enabled enormous advances in the knowledge of animal cognition and led to the conclusion that sentience is more universal than initially assumed, and social ethics began to demand moral consideration to those sentient beings and that the welfare of sentient animals used by man be protected through legislation. Today, all mammals and birds, mollusks like octopus and crustaceans of the Decapoda Order (lobsters, crabs ...) are known to be sentient beings. Animal wellbeing, respecting their *telos* and *ethos,* emerged as a moral norm to guide animal use. Man's ethics must not end with man but should extend to all beings and to the planet. He must regain the consciousness of the great chain of life from which he cannot be separated. Man should respect all living creatures, allowing them to enter His moral arena.

Keywords: Animal consciousness, animal ethics, animal welfare, sentience, social ethics.
JEL classification: Q19.

1. INTRODUCTION

At the beginning of the Neolithic period, with the discovery of fire, man became sedentary and gave rise to agriculture, characterized by the domestication of plants and animals. Cattle, sheep, goats (for 10 000 years), pigs (for 9000 years) dromedary and donkey (for 6000 years), horse (for 5500 years in the Eurasian steppes), Asian buffalo (for 4000 years), reindeer (for 1000 years), etc. The domestication of birds is more recent: the goose, the chicken and the duck, 4500, 3500, and 3000 years ago, respectively). More recently, the turkey just 500 years ago in Mexico, etc. (Teletchea, 2019).

The set of animals that were domesticated by man to increase their production, agricultural services, domestic, commercial, or industrial consumption is called livestock (gado in portuguese) and their raising is known as pecuary (borrowed from Portuguese pecuária). *Pecus* means "head of livestock" (cabeça de gado in Portuguese). The word has the same Latin root as "pecunia" (coin, money). In ancient Rome, animals raised for slaughter were also used as a store of value.

Livestock production (pecuary) is one of the oldest known professions. In the early stages of livestock production (animal husbandry), man remained nomadic, and most of the time led his domesticated herds on their wanderings, no longer looking for game, but for new pastures to feed the herd.

2. ANTICRUELTY: HISTORICAL BASIS FOR ETHICAL TREATMENT OF ANIMALS

For most of human history (in fact, for all but the past 100 years), agriculture has been rooted in animal husbandry (animals raised in open or extensive system). Husbandry meant, in essence, care, i.e. putting one's animals into the best possible environment for their biological needs and natures, and then augmenting their natural ability to flourish with protection from predation, provision of food and water during famine and drought, help in birthing, medical attention, etc. Half a century ago, family farms were prevalent. Animals grazed on pasture, breathing fresh air and feeling sunshine on their backs. During inclement weather, they were sheltered in straw-bedded barns. Husbandry was a fair contract between humans and animals, benefiting both sides of this relationship (Rollin, 2002).

Under such conditions, animal productivity and welfare were inextricably bound together, and good welfare was linked to the self-interest of owners. If the animals' natures were not met, they did not produce. If they produced, it was because their needs were met, physical and psychological. In husbandry, a producer did well if and only if the animals did well, so productivity was tied to welfare. Thus, no social ethic was needed to ensure proper animal treatment; only the anticruelty designed to deal with sadists and psychopaths was needed to augment husbandry. Self-interest virtually assured good treatment (Rollin, 2004). Since biblical times that limited social ethic has forbidden deliberate, willful, sadistic, deviant, purposeless, unnecessary infliction of pain and suffering on animals, or outrageous neglect, such as not feeding or watering. Things remained so until the nineteenth century; the animals of the Western world were legally protected only in the quality of privately owned property. Legally speaking, the animals themselves had no protection.

3. THE RENAISSANCE AND ENLIGHTENMENT PERIODS

The Renaissance period was marked by René Descartes' mechanistic vision, which promoted the false dualism of the mind (res cogitans) separated from the body (res externa), and the belief that animals had no mind, and therefore reacted automatically, reflexively to external stimuli. For Descartes, only man was conscious; animals were insensitive machines. Such "mechanomorphization" of nonhuman animals became the scientific consensus, against empirical and common-sense evidence that animals experienced emotional states (Adamson and Edwards, 2018). This Cartesian vision persisted in the scientific community until the first half of the 20th century and was responsible for keeping animals out of the moral arena of Man, contributing to much animal cruelty and suffering, mainly in research laboratories. (For more details, please access https://withoutconsent.peta.org/#top).

The Cartesian vision was only overshadowed by the Enlightenment, in the 18th century, (the century of the French and American revolutions, of the declaration of human and citizen rights, and of the abolition of slavery in Portugal (1761) and France (1794). The certainty of animal thought is affirmed throughout subsequent empiricist British philosophy, with Jeremy Bentham and John Stuart Mill drawing moral consequences from animals' ability to feel pain and thus of necessity their being included in the scope of utilitarian moral concern. Bentham's famous remark was (cited by Rollin, 2007):

> "Other animals, which, on account of their interests having been neglected by the insensibility of the ancient jurists, stand degraded into the class of things. ... The day has been, I grieve it to say in many places it is not yet past, in which the greater part of the species, under the denomination of slaves, have been treated ... upon the same footing as ... animals are still. The day may come, when the rest of the animal creation may acquire those rights which never could have been withholden from them but by the hand of tyranny. The French have already discovered that the blackness of skin is no reason why a human being should be abandoned without redress to the caprice of a tormentor. It may come one day to be recognized that the number of legs, the villosity of the skin, or the termination of the os sacrum, are reasons

equally insufficient for abandoning a sensitive being to the same fate. What else is it that should trace the insuperable line? Is it the faculty of reason, or perhaps, the faculty of discourse? ... The question is not, Can they reason? nor, Can they talk? but, Can they suffer? Why should the law refuse its protection to any sensitive being? ... The time will come when humanity will extend its mantle over everything which breathes..."

4. DARWIN`S NON-PHILOSOPHICAL VIEW OF ANIMALS

The empirical evidence of positive and negative feelings in animals had a very strong impetus with the research conducted by Darwin in the nineteenth century on the evolution of species and natural selection. In his book "The Expression of Emotions in Man and Animal", Darwin (1897) concludes that differences between species are differences in degree, not in quality. "We have found, Darwin wrote, that the senses and intuitions, the various emotions and faculties - such as love, memory, attention and curiosity, imitation, reason, etc., of which man is proud, can be found, in inchoate form, and even well developed, in some cases, in the lower animals". His book "The Descent of Man", with its emphasis on the continuity between our species and the rest of the animal kingdom, indicates a new approach to ethics (Adamson and Edwards, 2018).

Despite Darwin's work, and opposition from other scientists and philosophers to Cartesian dualism, and mechanistic reductionism, resistance to accepting that animals have minds and emotions remained for more than three hundred years after Descartes, especially in scientific, biomedical circles and others, related to the use and abuse of animals, in part due to even deeper religious and cultural attitudes towards non-human life (Fox, no date -1).

5. FIRST HALF OF THE 20TH CENTURY – STILL A VACUUM IN ANIMAL PROTECTION REGULATION ACTIVITY

Until the 30`s and 40`s of the 20th century, animal husbandry continued to be based primarily on the natural regime (the so-called Animal Husbandry, extensive or open system of production), animal treatment continued to raise no moral issue, and animals did not have legal protection. Social ethics regarding animals used in a specific way, particularly that relating to the production of animals for human consumption, continued to be summed up in anti-cruelty ethics. This had already been advocated by Hippocrates, Plutarch and Pythagoras, 500 years before Christ! (Adamson and Edwards, 2018).

However, at the beginning of the 20th century, the social concern to protect animals from cruelty seems to derive from at least two moral sources: One is the utilitarian idea that suffering is bad, and that suffering does not become less bad just because it is experienced by a being of another species. This was the idea expressed very forcefully by Jeremy Bentham. The other source is the idea that our moral character matters and that cruelty to animals is an expression of bad moral character. This idea was clearly stated by Immanuel Kant (Potter Jr., 2005).

6. SECOND HALF OF THE 20TH CENTURY - INTENSIFICATION OF ANIMAL PRODUCTION AND MEDICAL RESEARCH IRREMEDIABLY COMPROMISED ANIMAL HEALTH AND WELFARE

The intensification of animal production emerged as a response to the need to produce cheap animal foods, in large quantities, to meet the needs of an increasingly urban population – resulting from the rural exodus, which had already started at the end of the 19th century – and that grew dramatically in the post-war period – the so-called "baby boom". The facilitating factor was the scientific and technological development verified at that time. In universities, the traditional teaching of "how to take care of animals" became teaching of "the application of industrial methods to animal production" to increase the efficiency and productivity of the "animal machine" (Rollin, 2006). Productivity made possible through technological tools such as antibiotics, biotechnologies, artificial selection, overcoming biological capacity, high specialization, growth hormones, steroids, and other growth promoters. Intensive systems, with extreme overcrowding and deprivation of natural behaviours have broken the traditional close relationship with man, isolated animals from their natural environment, and seriously compromised animal health and irremediably their welfare. In this model, one no longer needed to keep animals happy to keep them productive. Consider the egg industry. If one had tried 100 years ago to raise chickens in cages, 100 000 to a building, all the birds

would have died of disease within a month. Today, however, with the help of technological fixes, birds produce, even though almost all considerations relevant to their wellbeing are thwarted. In these operations, individual bird productivity is less than it would be for the same bird under husbandry conditions, but productivity of the operation as a whole is assured. Cramming 6 chickens into a small cage reduces productivity per bird, but increases productivity per cage; in the end, chickens are cheap, and cages are expensive (Rollin, 2002).

The overcoming of biological capacity through artificial selection exploited the "*telos*" – the biological purpose – of many species with devastating effects on well-being. Ethical questioning was absent from this equation. Psychological stress and immunosuppression resulting from the animal's perceived lack of well-being, create pathogenic conditions for the proliferation of "domestogenic" infectious and contagious as well as production diseases (Fox, 1984). The indispensable use of antibiotics in immune-depressed organisms mutated and selected resistant bacterial strains with enormous repercussions on human health.

Less known to the public, but equally devastating, were the environmental consequences of the large quantities of manure and other waste production heavily contaminated with pathogens resistant to antibiotics, pharmaceuticals, nitrogen, phosphorus, etc. However, from the point of view of animal production efficiency this was an economic success story: in just 30 years, between 1945 and 1975, it increased 5 times. Nowadays, over 66 billion chickens are slaughtered for meat in the world each year. In 2020 the United States produced 9,2 billion animals, but this number represents only 18 percent of global output, 110 million tons per annum (Source: FAOstat). As of April 2021, China was home to the largest number of pigs of any country with 406 million heads. That year, the European Union and United States were second and third in the list, with over 150 and 77 million heads respectively. Human predation currently affects trillions of fish and molluscs, using sophisticated detection and capture techniques, with enormous impacts on marine ecosystems.

Ethical questioning was also absent in other forms of animal use, particularly in biomedical research. Research laboratories have turned into worlds of fear and anxiety, of animal pain, anguish and agony, particularly in the United States and Soviet Union. Examples are experiences in the field of experimental psychology, namely those of the infamous Harry Harlow in which monkeys were abducted from their mothers to be raised in absolute isolation for two years – from which they emerged intensely disturbed with intense psychological suffering; experiments in which rats were repeatedly half-drowned and dogs subjected to inescapably repeated electric shocks to provoke states of learned helplessness; the inhumane Draize Eye and Skin tests which involve holding rabbits in full body restraints so that chemicals can be dripped in their eye or spread on their shaved and scraped skin; poisoning millions of mice and rats in tests of lethal drug doses; Crash tests were carried out by mechanically throwing various types of live animals against cement walls (Franco, 2013; Phelps, 2007; Heneson, 1980). See also PETA WITHOUT CONSENT (https: //withoutconsent.peta.org/#top).

Millions of birds suffer miserably each year in government, university, and private corporation laboratories, especially considering the huge numbers of chickens, turkeys, ducks, quails, and pigeons being used in agricultural research throughout the world, in addition to the increasing experimental use of adult chickens and chicken embryos to replace mammalian species in basic and biomedical research. Slaughter experiments are also routinely performed on live chickens, turkeys, ducks, ostriches and emus, in which these birds are subjected to varying levels of electric shock in order to test the effect of various voltages on their muscle tissue for the meat industry (Davis, 2003).

Even at the level of using animals as objects of affection, the lack of knowledge about the nature and needs of such animals often led to lives lacking in well-being. Although the owner wants the best for the animal, it can, through ignorance and unintentionally, treat the animal to compromise their health or well-being – for example, treating it as a human being rather than an animal of the species in question, with the needs inherent to its "ethos", its own nature (Fox, no date -1).

Despite the 18th century ethical and philosophical considerations, advocating the legal protection of sensitive animals, and despite the evolution of knowledge on animal nature, in the 19th century with Darwin, why this denial in placing animals in the "moral arena" of man? The answer can only be one: resistance to accepting that animals have minds and emotions (after all, the perpetuation of the Cartesian shadow in the scientific community) (Rollin, 2016). The Animal Welfare Act (retrieved in 21 sept. 2021 from https://awahistory.nal.usda.gov/search/5238085), signed into law in 1966, the only Federal law in the United States that regulates the treatment of animals in research, exhibition, transport, and by dealers, included all warm-blooded animals in legislation, but did not recognize rats (genus Rattus), neither mice (genus Mus) and birds (i.e. 95% of the animals used in the research!) as

"animals". What is even more tragic is that researchers accepted the idiocy of this claim, and these (and other "non-animals") could then be used in the most reprehensible ways in all sorts of invasive investigations. The lobbies' argument was that it would be too expensive to regulate the huge numbers of animals! (Rollin, 2004).

6.1 Growing social concern for animal welfare

The social perception of how animals were treated began to change in the second half of the 20th century, due to a variety of social and conceptual reasons, namely (Rollin, 2004): i) the dramatic changes that have taken place in animal production – the rise of intensive systems after World War II; ii) the development and impact on society, of information conveyed by radio, cinema, and the press, and iii) the strong arguments of philosophers and celebrities in favour of raising the moral status of animals.

The “siege” of science to the moral consideration of animals used in biomedical research began to be broken by public opinion in the wake of news and images conveyed by the media. In 1954, the Federation of Universities for Animal Welfare in the United Kingdom (UFAW) sponsored research into the progress of human techniques in the laboratory. On the centenary of the publication of Darwin's "Origin of Species", William Russell and Rex Burch (1959) published the book "The Principles of Human Experimental Technique", where they introduced the famous principle of the 3 Rs (Replace-Reduce-Refine), which was subsequently enriched, and adopted almost universally in legislation relating to the protection of animals used for scientific purposes.

In the field of animal production, social passivity regarding the way animals were exploited was broken in 1964, with the book "Animal Machines", by Mrs. Ruth Harrison (1963) (an animal welfare activist from the United Kingdom), which constituted a denunciation of the inhumane conditions in which animals lived on intensive farms. Ruth Harrison was inspired by another great lady, Rachel Carson, marine biologist, (considered the forerunner of the environmental movement), who had edited two years earlier, in 1962, the famous book "Silent Spring" (Carson, 2002), where the harmful effect of pesticides in the environment, particularly in birds, was denounced, which contained the kernel of social revolution.

In reaction to the book "Animal Machines", the UK Government entrusted, in 1965, a Commission, chaired by Prof. Roger Brambell, to investigate the welfare conditions of intensively exploited animals. Their Report (Brambell, 1965) encompassed the idea that animals are sentient beings – that they can suffer physically and emotionally, incorporated the concept of behavioural needs, and led to the development of the science of animal welfare and the bases for its regulation. The 85-page Brambell Report enunciated the 5 freedoms as ideal states for animal welfare:

1. Free from hunger and thirst (by ready access to fresh water and diet to maintain health and vigour);
2. Free from discomfort (by providing an appropriate environment including shelter and a comfortable resting area);
3. Free from pain, injury or illness (by prevention or rapid diagnosis and treatment);
4. Free from fear and distress (by ensuring conditions and treatment which avoid mental suffering), and,
5. Free to express most normal behaviour (by providing sufficient space, proper facilities and company of the animal’s own kind).

Only 14 years later, in 1979, were these "5 freedoms" incorporated by the UK "Farm Animal Welfare Council" (replaced in 2011 by The Farm Animal Welfare Committee). These developments took place fundamentally in the European space and, always later, in the United States.

Fraser et al. (1997) note three overlapping ethical concerns expressed by the public for the welfare of animals raised for food. These are: 1. Animals should lead natural lives through the development and use of their natural adaptations and capabilities; 2. Animals should feel well by being free from prolonged and intense fear, pain, and other negative states and by experiencing normal pleasures, and 3. Animals should function well in the sense of satisfactory health, growth, and normal functioning of physiological and behavioural systems.

In developing countries, mainly in Africa and Asia, traditional animal production theoretically constituted a framework of traditional coexistence between man and his animals, enhancing animal welfare. However, millions of animals suffer from seasonal hunger, die of thirst and numerous diseases that often spread to wildlife with devastating consequences. The suffering of millions of animals is worsened by chronic overgrazing and lack of proper veterinary care. In these countries, livestock are subjected to long walks, often without access to food and water, to the slaughterhouses where are still slaughtered inhumanely. In India, religious prejudice against cow slaughter means the death of millions of animals from starvation and disease, left to their sad fate because they are no longer productive (Fox, no date -2). In most of those countries the suffering of animals goes hand in hand with the suffering of humans, who live in poverty and degraded environments. In these countries, the well-being of humans is an urgent imperative, without which it is impossible to attend to animal welfare and environmental health. There is an inseparable union between animal, human and environmental health – one health – a concept introduced long ago by Calvin W. Schwabe (1984).

6.2. The philosophers at the forefront of the effort to place animals in the moral arena of Man

The philosophers were at the forefront of the fight for the protection of animals against inhuman uses. The best known to the public are undoubtedly Peter Singer and Tom Regan, although other great figures such as Gary Francioni, Bernard Rollin and Steve Sapontzis have dedicated their lives to arguing for the protection of animals used by man. Singer (2000), Australian philosopher living in the US, author of numerous books, including one published in 1975 for non-specialized audiences, entitled "Animal Liberation", introduced into popular language the concepts of "equality", "equal consideration of interests", "speciesism", and "sentience", concepts that have shaped much of the ongoing ethical debate about the uses of nonhuman animals by humans. In the 1st chapter of that book, Singer defines the idea of "equality" as the "equal consideration of interests". Equality, Singer said, is not a fact or an assertion, but a moral idea. Men are very different from each other, but when we say that all men are equal, we mean that everyone deserves equal consideration of interests. Speciesism is, says Singer, a prejudice or prejudiced attitude towards members of one's own species or of other species. The "speciesist" ignores or weighs differently the interests of animals belonging to other species, just as the racist, or the sexist, ignores, or weighs differently, the interests of men of other races or women. Speciesism, racism, sexism all has the same logical basis: the non-consideration of interests. For Singer, sensitivity is the necessary and sufficient condition for having interests. Thus, the only true criterion to consider when determining our behaviour towards other animals is their ability to feel pleasure and pain (sentience) and not intellectual qualities or physical differences. “The discrimination based on belonging to the species (or “speciesism”) is what underlies the exploitation of animals by man. It expresses itself by refusing "to extend the fundamental principle of equal consideration to members of other species". For Singer, since the sentience is satisfied, the principle of equality must also be applied to the interests of nonhuman animals. This allows us to state that human beings have duty to consider the interests of other animals impartially to the detriment of their interests as minor, since their indiscriminate exploration is unjustifiable in the scope of morality. We should emphasize that Singer is a utilitarian (welfarist), not an abolitionist. For Singer men can use other non-human animals under certain conditions (Singer, 2011).

Tom Regan (1983), a philosopher at the University of Colorado, in his book "The Case for Animal Rights", instituted the view on animal rights and who is considered to be the founder of the Veganist movement; In that book, Regan argues that at least some kinds of non-human animals have moral rights because they are the "subjects-of-a-life," and that these rights adhere to them whether or not they are recognized. The common attribute of humans, Regan says, is not rationality but a life that interests us; each one of us is “a subject of a lifetime”, which interests us, regardless of the interest we have or not for others. Animals, too, are "subjects-of-a-life", they have intrinsic value, not merely instrumental value. This argument is frequently cited in European legislation, but without the same abolitionist consequences claimed by Regan. We must assign moral rights to all "subjects-of-a-life", whether human or non-human. For Regan the legal ownership of non-human animals should be abolished (abolitionism). We do not, therefore, have the right to use other animals for utilitarian purposes.

Another notable abolitionist is Gary Francioni, known for his work on animal rights theory (Francioni, 1996; 2009). His work has focused on three issues: the property status of animals, the differences between animal rights and animal welfare, and a theory of animal rights based on sentience alone,

rather than on any other cognitive characteristics. Francioni claims that non-human sentient animals require only one right: the right not to be considered property of humans.

Steve Sapontzis, a philosopher at California State University, in his 1987 book "Morals, Reason, and Animals" (Sapontzis, 1987) argued that non-human animals have interests, and that it is the existence of interests that justifies their inclusion in the moral community. Sapontzis (1988) played a prominent role in the fight against the use of animals in research.

Different views on the moral status of animals are summarized by Oscar Horta (2013). The Western social ethics, which came to prevail regarding the use of animals by man, is the utilitarian one, supported by many authors (Fox, 1983; Rollin, 2004; 2016). Bernard Rollin explain and justifies society's moral obligation to animals in terms of the common sense metaphysics and ethics of Aristotle's concept of *"telos". Telos* as the inherent purpose of each thing, the ultimate reason for each thing being the way it is, whether created that way by human beings or nature. Nonhuman animals also have a *"telos" or "nature"* and the freedom to act in accord with this nature is an essential component of an animal's welfare. In "Animal Rights and Human Morality", Rollin (2006) describes the *telos* of an animal (in this case a spider) as: "a nature, a function, a set of activities intrinsic to it, evolutionarily determined and genetically imprinted, that constitutes its "living spiderness." The dog has the canine nature (dogness), the pig has swine nature (pigness), etc. The great challenge for ethologists lies in defining the characteristics inherent to each animal nature.

We can state in a simplified way the so-called utilitarian vision – also known as welfarist –, that of well-being: it is morally acceptable to use non-human sentient animals for our benefit if the ends are not trivial (sport hunting, circus and other entertainment are not ethically acceptable) and that animals enjoy a life with well-being (well-being from the animal's point of view). If animals must be slaughtered in a morally justified manner, then a 3rd condition is imposed: that they be slaughtered, or euthanized, without inflicting unnecessary suffering.

> Note: The term "slaughter" refers exclusively to the killing animals for human consumption. Slaughter is NOT humane euthanasia. "Euthanasia" is defined as a gentle, painless death provided to prevent suffering, slaughter is a brutal and terrifying end for animals (Rollin, 2017).

6.3. Is it morally acceptable to cause death or harm to an animal? If so, under what conditions?

Animal rights should be given equal consideration to the rights of a human being, but it is important to recognize that this does not necessarily imply equal treatment or that the animal's interests are given the same weight or value as essential human interests (Fox, 1983). The sphere of formation and wish fulfilment open to an adult human is dramatically larger than that of a non-human animal. This different weight or value provides (I quote Michael Fox) "the ethical basis for determining when the death or harm of an animal (causing it suffering or depriving it of certain basic needs) is morally justifiable. The killing of an animal may be ethically acceptable only when there are no reasonable alternatives, as when the animal is: (a) incurably ill and is experiencing great suffering; (b) so deformed or otherwise incapacitated as to be incapable of living without great suffering; (c) endangering the lives of human beings, or causing a severe and unnatural ecological impact, thus endangering the lives of other living creatures; (d) other instances not directly beneficial to the animal arise when its products (meat, fur, etc.) are essential for human well-being and there are no alternatives that are less costly; (e) when we must minimize environmental costs or suffering of other animals, or (f) when the knowledge gained from killing it (as in some biomedical research) is essential for human health or for the benefit of other animals. Causing an animal to suffer physically or psychologically is ethically acceptable only when there are no alternatives, and such treatment is essential to human survival and overall health (as distinct from purely economic or other materialistic benefit) or promises to alleviate a significant degree of suffering in man or in other animals (as in medical or veterinary research). Subjecting an animal to deprivation or frustration of certain basic needs is only acceptable when such treatment is essential to the welfare of the animal itself, or essential to the fundamental welfare of human beings or other animals, and there are no alternatives to using animals to achieve these goals. Fundamental welfare implies consideration directly relevant to human health, safety and survival, not inessential comforts, economic benefits, or knowledge for its own sake".

6.4. 2nd half of the 20th century - Sentience, animal welfare and the evolution of social ethics

In the 2nd half of the 20th century there was a great interest in research in the field of sentience and animal welfare (see "Encyclopedia of Animal Rights and Animal Welfare, 2nd edition, 2009" and "The Animal Ethics Reader 3rd Edition" (Armstrong and Botzler, 2017). The great difficulties in studying the minds of animals were linked to the fact that they do not verbally inform us about their wishes, and their behaviour tends to be misinterpreted through the anthropomorphic prism. However, in the 70s/80s of the 20th century, the development of more detailed and sophisticated behaviour study techniques, associated with the development of neuroethology, with the use of new methods of investigation of brain mechanisms, particularly functional magnetic resonance, allowed ethologists, cognitive neuroscientists, neuropharmacologists, neurophysiologists and neuroanatomists, enormous advances in the knowledge of animal cognition. Some iconic figures are known to the general public: Marian Dawkins (2012), author of the simplest definition of animal welfare – "it's about animals enjoying good health and getting what they want"- ; Jane Goodall who dedicated her life to studying chimpanzees in Gombe National Park, Tanzania; Joseph leDoux (2020), a neuroscientist who has devoted most of his work to identifying the biological bases of emotion and memory and the brain mechanisms of fear and anxiety; Nathan Emery (2006), neuroscientist and cognitive psychology researcher who demonstrated that the brains of birds, particularly corvids, have the capacity for, among others, self-recognition, mental time travel, empathy and discernment; Lori Marino (2002; 2017), neuroscientist and ethologist, known for her research on the evolution of the brain, self-awareness and intelligence in dolphins and whales, primates and farm animals, and Donald Broom (2014), cognitive and behavioural neuroscientist, animal behaviour and welfare specialist, well known to veterinary students. We should consider here also the great neuroscientist António Damásio and his most emblematic works that came to demonstrate that emotions and feelings are a direct perception of our own physical states – in opposition to Cartesian dualism – (Damasio, 2011). In the "Book of Consciousness" Damasio (2010) tells us that "the mind emerges from a functioning brain", but "the brain only makes the mind conscious if it receives information from the whole body". That is: Without the body, the brain is unable to express consciousness.

In 2012, a group of distinguished researchers from California Institute of Technology, Massachusetts Institute of Technology and the Max Planck Institute for Brain Research (Frankfurt) met in Cambridge to take stock of the knowledge of consciousness in man and non-human animals. The upshot of the meeting was the Cambridge Declaration on Consciousness (https:// philiplow.foundation /consciousness/), which was publicly proclaimed by three eminent neuroscientists, like David Edelman, from the Neurosciences Institute in La Jolla, California, Philip Low, from the Stanford University, and Christof Koch, from the California Institute of Technology. The declaration concludes that “non-human animals have the neuroanatomical, neurochemical, and neurophysiological substrates of conscious states along with the capacity to exhibit intentional behaviours. Consequently, the weight of evidence indicates that humans are not unique in possessing the neurological substrates that generate consciousness. Non-human animals, including all mammals and birds, and many other creatures, including octopuses, also possess these neurological substrates.” The declaration is not aimed at scientists, as its author, Low, said prior to the declaration: “We came to a consensus that now was perhaps the time to make a statement for the public… It might be obvious to everybody in this room that animals have consciousness; it is not obvious to the rest of the world". Animals are conscious and should be treated as such. Now that scientists have belatedly declared that mammals, birds and many other animals are conscious, it is time for society to act. All too often, scientific knowledge about animal cognition is not recognized in welfare laws.

7. Recent findings on animal cognition - Sentience is everywhere

The most recent findings from studies of animal cognition are summarized in Donald Broom's recent book "Sentience and Animal Welfare (2014)". Sentience is now considered to require other abilities in addition to the ability to have positive and negative feelings as considered by Jeremy Bentham and Peter Singer. Being sentient also presupposes the possession of some ability to: 1. evaluate the actions of others towards himself and third parties; 2. to recall some of their own actions and their consequences, and 3. to assess the risks and benefits and to have feelings, and to have some degree of conscience. All vertebrates and some invertebrates such as cephalopods (octopus) and other molluscs, as well as crustaceans of the decapod order (lobsters, crabs...) meet this definition (Broom, 2014; Elwood, 2012).

We retrieve from the above cited Donald Broom's book, some findings from studies of animal cognition:

1. Hardly any ability can be considered uniquely human (Darwin had already made a similar repair);
2. Quasi-human levels of consciousness have been demonstrated most markedly in African gray parrots and corvids;
3. Self-awareness has been demonstrated in humans, and in many other animals (chimpanzees, capuchin monkeys, pigs, elephants, dolphins, parrots, crows, magpies, blankets...);
4. In addition to humans, there are metacognition abilities (abilities to think about their own thoughts and feelings – know what they know) in many birds (corvids, parrots) and mammals (monkeys, dolphins, pigs...);
5. The concept of future events is evident from work on many farm, companion and other animals!;
6. Tools use, and other comparatively complex innovative behaviours, have been demonstrated in many species of primates, birds and fish;
7. The best brains of birds allow for greater cognitive abilities than the brain of any mammal other than man (*), and
8. Cognition in cephalopods, jumping spiders, ants and bees is much more sophisticated than previously thought. As Frans de Waal (2017), a well-known ethologist, said, we cannot put cognition on a simple scale, because all animals are very smart at what they need to do to survive.

(*) How is it that such small brains are capable of such feats? The reason was found by Olkowicz et. al. (2016). This Hungarian researcher found that birds have a number of neurons in the forebrain similar to that of primates. As birds followed an evolutionary process, parallel to that of mammals from the radiation of vertebrates, it can be said that nature used a strategy of miniaturization in beings that must remain light in order to fly.

At present, as already mentioned, sentience is proven in all vertebrates and some invertebrates such as cephalopods (which includes the octopus) and other molluscs as well as crustaceans of the decapod order (lobsters, crabs...). Since it is a social consensus that we are obliged, because of our dignity and human integrity, to avoid causing harm or suffering to any sentient (conscious) being or to the biospheric ecosystem, when such damage or injury can be avoided, we must then give them moral consideration which justifies their legal protection if they are used in experimentation, for food or other purposes. All those species, except crustaceans of the decapod order, are included in the legislation of many countries for the protection of animals used for scientific purposes, as are also included in protective legislation for animals with livestock interest, animals in transport, animals at slaughter, companion animals and animals in zoological parks.

8. THE 21ST: THE CENTURY OF REGULATION OF THE PRODUCTION AND USE OF ANIMALS BY HUMANS.

The 21st century will hopefully be the century of regulation of the production and use of animals by humans. The laws are intended to reaffirm that the interests of animals that count for themselves must be considered, not just the interests that result for us from their use. And, like all ethical rights, it accepts that some benefits of unruly exploitation will be lost and that there is a cost to protect the nature of animals.

If there were no regulations, farmers would do what is economically most rational: achieve maximum productivity. The main political opposition to the demand to safeguard the interests of animals, which result from their very natures, comes from the economic sector that sees any change in the "status quo" as an economic threat. The cost could, for example, be the increase in food prices. But, as the Federation of European Veterinarians, the forerunner of Community Animal Welfare, stated more than 40 years ago, this is a small price for a society to pay to ensure the proper treatment of beings worthy of moral consideration. We need better laws and effective enforcement

and justice for all beings. "While we strive to end the child sex trade, organ trafficking, female genital mutilation and disenfranchisement of indigenous peoples (genocide) the end of other forms of terrorizing and harming the children of other species, including whaling, trophy hunting, fur trapping, bull fighting and dog fights, along with puppy breeding mills, factory farms, commercial laboratory animal testing, wildlife poaching, trafficking, trade and habitat destruction (ecocide) must also be addressed nationally and internationally. Progress on one front (the human) will not succeed without progress on the other front – animals and the environment – because respect for life is a boundless ethic. It must be absolute, or it is not at all. Our indebtedness to all life on Earth that helps sustain our own calls for trans-species egalitarianism and accepting the moral duty of responsible care for the health and well-being of that Earth community of which our own is an interdependent part" (Fox, 2016).

8.1. What is at stake when legislating for the protection of animals?

In human society, although the interest of the majority prevails over individual interests, the same society ensures that certain individual interests, considered essential to human beings, to human nature, are not violated. These are the human rights, which are based on plausible assumptions as to what is essential to being human (Rollin, 2004). It is this notion that society introduces in order to generate new moral notions about the treatment of animals in today's world. Unnecessary cruelty is no longer the issue. Also avoiding causing pain and suffering is no longer a sufficient notion. The dominant movement in society claims that animals, and their natures and interests, are not totally submerged for the sake of the general well-being of humans, and society tries to achieve this goal through legislation (Rollin, 2004). Animals have an intrinsic nature and specific interests (needs, desires, etc.), they have intentions or purposes, and they have intrinsic value independent of the extrinsic values we might impose on them. These interests, these needs and desires, can be interpreted as their rights. The frustration of these interests matters as much to animals as the frustration of free expression and freedom matters to human beings, which gives them the right to fair treatment and moral concern (Fox, 1983). The dominant ethical movement is, as Bernard Rollin puts it, to preserve the common sense perception that "the fish must swim and the birds must fly" and that they suffer if they don't (Rollin, 2016). Each species has its own nature, the dog the canine nature, the horse the equine nature, the pig the swine nature, etc., each nature being characterized by a set of different traits, interests - different needs and wants - whose expression is essential to the well-being felt by the animal. In other words, the rights of the dog are very different from those of the turtle, or the horse, or the mouse. However, the suffering resulting from the violation of these rights is no greater in the horse than in the mouse (Fox, 1983).

A major aspect of animal rights philosophy which has been seriously overlooked, because of the instant polarization of this issue into animal versus human rights, is that animals of the same species, or of the same degree of sentience, should be treated with the same degree of humaneness (since they can all suffer similarly). There are no moral or ethical grounds for considering otherwise, and there is certainly no scientific reason why they should be treated differently. The only reasons why similar animals are treated differently are primarily economic (Rollin, 2004).

Respecting animal rights means avoiding unnecessary or unjustifiable death, physical or psychological suffering, or the deprivation or frustration of their basic physical, emotional, and social needs. The argument that animals have rights is based on more than philosophical presumption or moral reasoning. It is based on ecological evidence that they are, like us, an integral part of the biosphere, and on the physiological and psychological affinities that many animal species have with us. The fact that we are dominant and control them, or that we consider ourselves superior to them, are not valid reasons for denying animals equal and fair consideration. Such rights are, however, relative rather than absolute (i.e., presumptive). For example, a domestic animal's desire to be free may have to be inhibited for its own good and for the good of society. However, it would be a violation of that animal's rights to keep it continually confined in a small cage or chained with a short chain (which amounts to cruel and unnecessary deprivation) (Fox, 1983).

Animal rights vary according to the context of their relationship with other beings, human and non-human. For example, the right to freedom of a domestic animal has more restrictions or qualifications than the right to freedom of a wild animal. Another example concerns the right to life of a parasite that endangers the life of its host compared to the lives of members of an endangered species (Fox, 1983).

The dominant ethical view is not aimed at abolishing the use of animals by humans, but rather at abolishing the use of animals in ways that go against their natures. If animals are to be used for food and work, they must, as has traditionally been the case, live lives that respect their natures. If animals are to be used to investigate nature and cure diseases for human or animal benefit, they must not suffer in the process (Rollin, 2016). The dominant ethics is based on the view that what we do to animals is important to them, just as what we do to human beings is important to us and, consequently, by virtue of our humanity, human dignity and integrity, we are obligated to respect their nature in our treatment and use of animals as we do in our treatment and use of humans. And because respect for animal nature is no longer automatic, as it was in traditional livestock production (animal husbandry), society demands that such respect be codified in law.

Of course, "animal rights" activists advocate the abolition of the use of non-human animals by humans. Yet such an ethical view is still a minority in contemporary society and concentrating on this view could eclipse the prevailing issue in society, which is the effort to restrict, not abolish, the use of animals. There are many compelling reasons for veganism: to end the exploitation of billions of nonhuman animals killed for human use year after year; to reverse the environmental devastation consequent to that exploitation; to avoid the associated personal and societal costs to human health. However, 67 years after the founding of The Vegan Society (The Vegan Society, the world's first, was founded in the UK in 1944, see "The Vegan Society History" - https://www.vegansociety.com/about-us/history), 103 years after the founding of the International Vegetarian Union (IVU) (see International Vegetarian Union, "History of the International Vegetarian Union" - https://ivu.org/history-legacy-pages.html), and after hundreds of years of compassionate and eloquent questioning of the morality of using other animals (Walters and Portmess, 1999), we are still a long way from inhabiting a vegan world. A peaceable vegan future, in which nonhuman exploitation is ended, is therefore a utopian challenge to the prevailing order of things (Cole and Morgan, 2011). It is clear that promoting veganism is not simply a matter of argument and persuasion; rational arguments about benefits to nonhuman and human animals and our shared environment favors vegan solutions. However, Simon Lumsden (in: Cole and Morgan, 2011) suggests that rational arguments, obvious or not, are insufficient: "There are no good reasons for eating meat in the West," but "within western culture eating meat is something that does not require justification". While the case for veganism may therefore be beyond debate in the contemporary West, for many people, living as a vegan is not a worthwhile consideration because of the taken-for-granted norms of using other animals, or in other words, because of the ongoing normalization of speciesism - due to the cultural reproduction of speciesism – and of the role of denial in obscuring exploitation in the Western culture. Only the growing consumer demand for humanely raised products seems to have the potential to improve the lives of animals used for meat.

9. CONCLUSION

The veterinarian and the zootechnician must have a holistic view of the animal world, in which health depends on the well-being perceived by the animal. Health considered as a state of complete physical, mental, and social well-being, not just the absence of diseases. It is essential to pay attention to the interrelations and interdependencies between an animal's "*ethos*" (that is, its intrinsic nature), its "*telos*" (its natural biological purpose), and its "*ecos*" or environment that is biologically more adequate to it. These are the bioethical and scientific parameters and indices of animal welfare. The wellbeing felt by the animal is optimized when "ethos", "telos" and "ecos" are in synergy. The dislocations of these spheres result in suffering and anguish (Fox, no date -1). Animal health depends upon animal well-being, the bioethical and scientific parameters and indices of which include provision of an environment (the *ecos*) that is optimal for animals' basic physical, behavioural, and psychological requirements (their ethos, or spirits), and which maximizes animals' telos, their natural, ecological purpose and biological value and role (Fox, 2001). Human imposed and directed influences on animals' *ecos* include housing/husbandry conditions and standards of care and environmental quality; on animals' *telos* include economic, cultural and other human values and interests; and on animals' *ethos*, as affected by selective breeding, genetic engineering as well as early handling and socialization, or lack thereof. These three spheres of animal life, *ethos*, *ecos* and *telos* translate into the mind-body-organism-environment interfaces that provide a more holistic paradigm for addressing animal health and welfare concerns (Fox, no date -1).

The intrinsic nature of an animal is the basis for rights, from which the ethical codes may be deduced. Nonhuman beings should be as much a part of our community of moral concern as humans. They are

an inseparable part of the ecological community of our planet. The ethical codes are both spiritual and practical, originating from the highest tenets of humane, compassionate, and responsible conduct. They bespeak a reverence for life (Schweitzer, 2014), cast within the framework of ecologically sound and unselfish planetary stewardship, upon which our survival depends and through which the quality and diversity of all life on earth may be protected and enhanced for the "greater good" (Fox, 1983). The lack of regard and concern for the intrinsic nature, worth and "rights" of animals is a metaphor for the lack of empathy (Bekoff, 2008), care, knowledge, respect, and responsibility that humans have for their own kind, be they of the same or opposite sex, or of a different race, socioeconomic class, political, religious, or other belief or value system. "Man's ethics must not end with man, but should extend to the universe. He must regain the consciousness of the great chain of life from which he cannot be separated. He must understand that all creation has its value. Life should only be negated when it is for a higher value and purpose – not merely in selfish or thoughtless actions. What then results for man is not only a deepening of relationships, but a widening of relationships" (Schweitzer, 2014).

Man must feel empathy and respect for all living creatures, allowing them to enter His moral arena.

REFERENCES

Adamson, P. and Edwards, G. (2018). Animals: A History. Oxford Scholarship Online Publ., 2018. ISBN: 9780199375967. Accessed in: 4 September, 2021 in:
https://oxford.universitypressscholarship.com/view/10.1093/oso/9780199375967.001.0001/oso-9780199375967

Armstrong, S. J. and Botzler, R. G. (eds.) (2017). The Animal Ethics Reader, 3 ed., New York and England: Routledge, 2017. ISBN 9781315688718.

Bentham, J. (1948). An Introduction to the Principles of Morals and Legislation. Image-based PDF made from scans of the original book. Accessed in: 8, July, 2021 in: https://oll.libertyfund.org/title/bentham-an-introduction-to-the-principles-of-morals-and-legislation#preview.

Bekoff, M. (2008). Why "Good Welfare" Isn't "Good Enough": Minding Animals and Increasing Our Compassionate Footprint. Annual Review of Biomedical Sciences, 10, T1-T14. Accessed in: 9, September, 2021 in: https://www.wellbeingintlstudiesrepository.org/cgi/viewcontent.cgi?article=1060&context=acwp_awap.

Brambell, R. (1965). Report of the Technical Committee to Enquire into the Welfare of Animals kept under intensive Livestock Husbandry Systems. Accessed in: 22, September, 2021 in: https://edepot.wur.nl/134379.

Broom, D. (2014). Sentience and Animal Welfare E-Book. Wallingford: CABI. ISBN: 9781789244519.

Cambridge Declaration on Consciousness. Accessed in: 3, September, 2021 in: https://philiplow.foundation/consciousness/.

Carson, R. (2002). Silent Spring, eBook Kindle. Mariner Books, Anniversary edition, october 2002. ISBN: 9780141912295.

Cole, M. and Morgan, K. (2011). Veganism Contra Speciesism: Beyond Debate. The Brock Review, Volume 12, No. 1. Accessed in: 17, September, 2021 in: https://journals.library.brocku.ca/index.php/brockreview/article/view/568

Damasio, A. (2010). O Livro da Consciência. Temas e Debates, 2010. ISBN: 9789896441203.

Damasio, A. (2011). O Erro de Descartes. Temas e Debates, 2011. ISBN: 9789896441630.

Davis, K. (2003). The Experimental Use of Chickens and Other Birds in Biomedical and Agricultural Research. United Poultry Concerns. Accessed in: 3, September, 2021 in:
https://www.upc-online.org/experimentation/experimental.htm.

Darwin, C. (1897). The Expression of the Emotions in Man and Animals. New York D. Appleton and Company. Authorized Edition. Accessed in: 1, September, 2021 in:
http://darwin-online.org.uk/converted/pdf/1897_Expression_F1152.pdf.

Dawkins, M. (2012). Animal Suffering: The Science of Animal Welfare (Science Paperbacks) 1st ed., eBook Kindle. Springer, 2012. ISBN: 9789400959057.

de Waal, F. (2017). Are We Smart Enough to Know How Smart Animals Are? ISBN: 0393353664. Accessed in: 5, September, 2021 in: https://www.academia.edu/40901977/Are_We_Smart_Enough_to_Know_How_Smart_Animals_Are_Book_Details_Series_Are_We_Smart_Enough_to_Know_How_Smart_Animals_Are.

Elwood, R. (2012). Evidence for pain in decapod crustaceans. Animal Welfare, 21(S2), 23-27.
Emery, N. (2006). Cognitive ornithology: the evolution of avian intelligence. Philosophical Transactions of The Royal Society B Biological Sciences, 361, 23-43. Accessed in: 17, September, 2021 in: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1626540/
Emery, N. Accessed in: 5, September, 2021 in: https://scholar.google.com/citations?user=9BFt47IAAAAJ&hl=en.
Encyclopedia of Animal Rights and Animal Welfare, 2nd ed, eBook Kindle (2009). Greenwood. Accessed in: 1, September, 2021 in: https://www.academia.edu/31479474/Encyclopedia_of_Animal_Rights_and_Animal_Welfare.
FAOstat. Accessed in: 1, September, 2021 in: https://www.fao.org/faostat/en/#home
Fox, M. (no date -1). Mental Effects on Physical Health: The Mind-Body Connection. Accessed in: 21, September, 2021 in:
https://drfoxonehealth.com/post/mental-effects-on-physical-health-the-mind-body-connection/.
Fox, M.W. (no date -2). How Animals Suffer Around the World. Accessed in: 21, September, 2021 in:
https://drfoxonehealth.com/post/how-animals-suffer-around-the-world/.
Fox, M. (1983). Humane ethics and animal rights. International Journal for the Study of Animal Problems, 4(4), 286-289. Accessed in: 5, September, 2021 in: https://www.wellbeingintlstudiesrepository.org/cgi/viewcontent.cgi?article=1003&context=v4_ijsap.
Fox, M. (1984). Farm Animals: Husbandry, Behavior and Veterinary Practice. Univ Park Pr. ISBN-10: 0839117698.
Fox, M. (2016). Animals & Nature First: Creating New Covenants with Animals & Nature, eBook Kindle. Mozart & Reason Wolfe Ltd / One Health Vision Press, 1st ed. ISBN: 9781466269569
Francioni, G. (1996). Rain Without Thunder: The Ideology of the Animal Rights Movement, eBook. Kindle (ed.). Temple University Press. ISBN: 9781566394611.
Francioni, G. (2009). Animals as Persons: Essays on the Abolition of Animal Exploitation, eBook. Kindle (ed.). Columbia University Press. ISBN: 9780231139519.
Franco, N. (2013). Animal Experiments in Biomedical Research: A Historical Perspective. Animals, 3, 238-273. Accessed in: 5, September, 2021 in: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4495509/
Fraser, D., Weary, D., Pajor, E., and Milligan, B. (1997). A scientific conception of animal welfare that reflects ethical concerns. Animal Welfare, 6 (3), 187-205. Accessed in: 1, September, 2021 in: https://www.wellbeingintlstudiesrepository.org/cgi/viewcontent.cgi?article=1000&context=ethawel
Harrison, R. (2013). Animal Machines Reissued and Updated Edition, eBook. Kindle (ed.). CABI. ISBN: 9781780642987.
Heneson, N. (1980). Live Animals in Car Crash Studies. International Journal for the Study of Animal Problems, 1(4), 214-217. Accessed in: 1, September, 2021 in: https://www.wellbeingintlstudiesrepository.org/cgi/viewcontent.cgi?article=1018&context=acwp_arte.
Horta. O. (2013). The Moral Status of Animals. Published in LaFollette, Hugh (ed.), International Encyclopedia of Ethics, Hoboken: Wiley Blackwell (2013), 292-302. Accessed in: 4, September, 2021 in: https://www.academia.edu/11579468/The_Moral_Status_of_Animals
Jane Goodall – Uma vida dedicada ao estudo dos chimpanzés selvagens de África. (2019). National Geographic. Edição portuguesa. ISSN 2182-5459.
LeDoux, J. (2020). O Cérebro Consciente. Temas e Debates. ISBN: 9789896446031.
Marino, L. Accessed in: 5, September, 2021 in: https://scholar.google.com/citations?user=2JtgJ1MAAAAJ&hl=en.
Marino, L. (2002). Convergence of Complex Cognitive Abilities in Cetaceans and Primates. Brain, Behavior and Evolution, 59:21-32. Accessed in: 12 September, 2021 in: https://www.researchgate.net/publication/11277927_Convergence_of_Complex_Cognitive_Abilities_in_Cetaceans_and_Primates
Marino, L. (2017). Thinking chickens: a review of cognition, emotion, and behavior in the domestic chicken. Anim Cogn 20, 127-147 (2017). Accessed in: September 19, 2021 in: https://link.springer.com/article/10.1007/s10071-016-1064-4
Olkowicz, S., Kocourek, M., Lučan, R., Porteš, M., Fitch, W., Herculano-Houzel, S., et al. (2016). Birds have primate-like numbers of neurons in the forebrain (2016). Accessed in: 6, September, 2021 in: https://www.pnas.org/content/pnas/113/26/7255.full.pdf.
PETA WITHOUT CONSENT. Accessed in: 24, September, 2021 in: https://withoutconsent.peta.org/#top.
Phelps, N. (2007). The Longest Struggle: Animal Advocacy from Pythagoras to Peta, eBook. Kindle (ed.). Lantern Books. ISBN: 9781590561270. Accessed in: 4, September, 2021 in:

https://www.academia.edu/10903373/The_longest_struggle_animal_advocacy_from_Pythagoras_to_PETA_Norm_Phelps.
Potter Jr., N. (2005). Kant on Duties to Animals. Faculty Publications - Department of Philosophy. 18. Accessed in: 17, September, 2021 in: https://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1017&context=philosfacpub
Regan, T. (2004). The Case for Animal Rights. University of California Press. ISBN: 9780520243866
Rollin, B. (2002). An ethicist's commentary on equating productivity and welfare. Can Vet J, 43(2), 83.
Rollin, B. (2004). Annual Meeting Keynote Address: Animal agriculture and emerging social ethics for animals. J Anim Sci, 82, 955-964
Rollin, B. (2006). Animal Rights & Human Morality, eBook. Kindle. Prometheus Books, 3rd ed. ISBN 9781615922116
Rollin, B. (2007). Animal mind: science, philosophy, and ethics. The Journal of Ethics, 11(3), 253-274. https://doi.org/10.1007/s10892-007-9018-3
Rollin, B. (2017). Ethics and Euthanasia. In Part Nine, Chapter 79, The Animal Ethic Reader, eBook. Kindle, 3rd ed. Routledge.
Rollin, B. (2016). A New Basis for Animal Ethics: Telos and Common Sense, eBook. Kindle (Ed.), University of Missouri, 1st ed. ISBN: 9780826221018.
Russel, W. and Burch, R. (1959). The principles of humane experimental technique, eBook. London, Methuen. Accessed in: 1, September, 2021 in:
https://caat.jhsph.edu/principles/the-principles-of-humane-experimental-technique.
Sapontzis, S. (1987). Morals, Reason, And Animals. Temple University Press, USA. ISBN: 9780877229612
Sapontzis, S. (1988). On justifying the exploitation of animals in research. The Journal of Medicine and Philosophy, 13, 177-196. doi: https://doi.org/10.1093/jmp/13.2.177.
Schwabe, C. (1984). Veterinary Medicine and Human Health. 3rd ed. Williams & Wilkins (Baltimore). ISBN: 9780683075946.
Schweitzer, A. (2014). Reverence for Life: The Ethics of Albert Schweitzer for the Twenty-First Century. Open Road Media Pub. eText ISBN: 9781497675742.
Singer, P. (2000). Libertação Animal (ed.). Via Optima, Oficina Editorial, Lda. ISBN 9729360146.
Singer, P. (2011). Practical Ethics, 3rd ed., eBook. Kindle. Cambridge University Press. ISBN: 9780521707688.
Teletchea, F. (2019). Animal Domestication: A Brief Overview. In Animal domestication. Ed. Fabrice Teletchea, IntechOPen, eBook (PDF) ISBN: 978-1-83881-134-1. Accessed in: 8, September, 2021 in:
https://www.researchgate.net/publication/333675584_Animal_Domestication_A_Brief_Overview.
The Animal Welfare Act, Accessed in: 3, September, 2021 in: https://awahistory.nal.usda.gov/search/5238085.
Walters, K. (ed.) and Portmess, L. (1999). Ethical Vegetarianism: From Pythagoras to Peter Singer. State University of New York Press. ISBN: 9780791440445.