

Relativity of Environmental Sustainability Illustrated by the Red Queen Hypothesis

Względność zrównowżenia w przyrodzie na przykładzie działania Hipotezy Czerwonej Królowej

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Abstract

The worrying phenomenon of our times is a rapid decline in the biodiversity, that is directly related to the disorder in environmental sustainability. However, the question is whether before the appearance of the *Homo sapiens* there was a greater eco-sustainability? Or maybe even without the presence of the man such state would be rather correlated with some natural processes, that happen independently of our interference? The paper attempts to explain the relativity of environmental sustainability described by the Red Queen Hypothesis (RQH). That model presents competition in nature, which may be extrapolated to all interactions in the world of living organisms. The RQH shows that in the evolutionary terms not keeping pace on the run threatens not only progress but also poses an increasing risk of elimination of a given individual. So in that way environmental sustainability is relative and the model explains the probability of a constant extinction, so in fact a fall.

Key words: nature, Red Queen hypothesis, progress and fall, environmental sustainability and unsustainability, the man

Słowa kluczowe: przyroda, hipoteza Czerwonej Królowej, postęp i upadek, środowiskowe zrównowżenie i jego brak, człowiek

Introduction

All activities of living organisms always take place within some environment. The same applies to the man, as being a part of nature, both in the individual and social dimensions. Nowadays, environmental issues are increasingly exposed, which results from the ecological crisis of the modern world and attempts to repair its adverse effects (Bańka, 2002; Cizek, 2020). Important issue for understanding the idea of environmental sustainability is being aware of the accelerated processes of extinction currently observed on a global scale. However, as J. Weiner (2001) notes, despite such unfavorable trends regarding decline in biodiversity, on the threshold of the 21st. century there have been still existing a multitude of species. Yet, the crisis of environmental sustainability is a fact, connected with the advent of the Anthropocene epoch, that in general describes a human impact on nature. The worrying phenomenon is a rapid decline in the biodiversity, which is affected *inter alia* by anthropogenic climate change. Thus, human activity is at present a major threat to the nature, hence an issue of being responsible for the environment ought to be of the utmost importance (Szyndler, 2022). According to a revolutionary theory of P.J. Crutzen and E.F. Stoermer (2000), *Homo sapiens* and humanity itself has become a crucial geological and ecological force. That means human interference is nowadays particularly visible in the processes of evolution (Bińczyk, 2018). W. Steffen and colleagues (2007), suggest that the Anthropocene began around the early 19th. century with the onset of industrialization, the central feature of which was the enormous expansion in the use of fossil fuels. Nowadays advanced technology allows for the even farther development of tools able to harness the environment

in the previously unknown scale. Mitra and Sameer (2022) state that, such pursuit for a global expansion of the man has become unsustainable as it led to destructive changes in the nature. Even a more advanced notion of the Anthropocene's idea is proposed by B. McKibben (2006), according to which we are living in the era of the *Second Nature*. That is understood as a nature completely produced by the mankind, while the *First Nature* is gone for ever. As a result, the Anthropocene perceived by the man in this way is also synonymous for living in a fear of gradual loss of space to live. The important attempt towards changing that trend has been in 2015 adopting the 17 Sustainable Development Goals by the United Nations within the Agenda 2030. That is an urgent call for action by all countries, in order to cope with the problem of climate changes, and concerning the life both on land and below the water (Meschede, 2020). That is directly related to the subconscious need of the man to get eco-balance (Chmara, 2019).

However, mankind has become a harmful force to nature since the beginning of agriculture in the Fertile Crescent, historically situated in the present Middle East. That was the very first region where settled farming emerged, resulting from modification of natural vegetation, by growing newly domesticated plants as crops, and then breeding livestock. Although its very local extent, it was in fact an early attempt to interfere with the sustainable development. Thereafter, human thought has been looped by agro-logistics, which led to exploitation of resources, as well as an increasing global warming (Morton, 2016). The farther advance of human population and a present overpopulation of the Earth, is also associated with the growth of agriculture, and expansion of areas occupied by the animal and plant production. A characteristic feature of the 21st. century is also that people want to live a better quality lives, which also makes us interact more aggressively with the natural environment. This is because economic development entails an increase in the consumption of natural resources. The man managed to transform permanently about 75% of the land and exploit over 60% of the oceans. Moreover, consequences of farther greenhouse gas emissions affect the increase in the global warming. Still, both the European continent and Poland, as a part of it, are characterized by considerable diversity of natural landscapes. This is illustrated by abundance of existing so-called patterns of semi-natural landscape features, especially in areas with extensive agricultural production (Edwards et al., 1999). However, the fact remains that in recent decades, species previously identified as common have become rare as a result of more intensive agricultural production (Krebs et al., 1999; Robinson, Sutherland, 2002). Such decline in the biodiversity of agroecosystems is evident in many countries of the European Union, which is also related to the type of functioning agricultural policy (Donald et al., 2002). The increase in agricultural land areas leads to dramatic changes in the structure of landscape, which is now becoming more uniform, and seminatural habitats characterized by rich biodiversity become smaller and more isolated, due to cultural landscape fragmentation (Duelli, Obrist, 2003). Thus taking all of that into consideration, is it actually possible to maintain the idea of environmental sustainability in such a reality that drives the farther human impact on the nature? Or maybe even without the presence of the man such stability would be rather correlated with some natural processes that happen independently of our interference? The paper attempts to explain relativity of environmental sustainability described by the Red Queen Hypothesis.

Mechanisms of evolution and their references to the social sciences

Currently the theory of evolution may be an abundant source of inspiration for the social sciences and humanities. Evolutionism is presented there as a set of various theories describing the development of societies and progress that takes place in their lives. According to A. Gecow (2014), nowadays we can even observe an invasion of biological methods and concepts that are used in areas not related to biology. Putting together the achievements of such different areas of science can help to understand the place and role of a man in nature. The very term evolution, although inseparably associated with Charles Darwin, is in fact a philosophical concept proposed by Herbert Spencer. The latter was a 19th. century representative of organicism and evolutionism in the social sciences in which he popularized this approach. In Spencer's *Principles of Biology* an original concept of evolutionary development was introduced, which he understood as a change from indefinite, incoherent unity to definite, coherent heterogeneity through constant differentiation (Kwaśnicki, 2021). Therefore, evolution in that case is considered as a process synonymous with progress, and gains in efficiency towards a certain ideal state. The expression *survival of the fittest* has been also coined by Spencer, however it is Darwin who is often credited for that till this day. The revolutionary theory of evolution by natural selection, was in fact the unplanned result of Charles Darwin's travel around the world. His observations during a five-year long journey have changed the paradigm of the species stability into the evolutionary paradigm (Szafer, 1959). However, Darwin decided to publish his revolutionary concept after many years of hesitation, and was finally encouraged to do so after reading various works from seemingly distant fields of knowledge. One of them was *An Essay on the Principles of Population* by Thomas Malthus, where there was formulated the idea of limiting the birth rate (Bołdyrew, 2009). The conclusion of that thesis was that a significant part of the poorest population remained at similar level, despite the high potential and actual fertility in this group. It was caused, similarly like in the nature, by various determinants limiting increase, among which the most important was the food shortage (Krokos, 1997). Also in natural environment due to the limited capacity of all habitats only some organisms can survive to the breeding period, which means that such

individuals are best suited to natural conditions existing at a given time and place (Szafer, 1959). Such connection of evolutionism with the broadly understood social science, was possible due to application of reasoning by analogy. Evolutionary theories referring to darwinism can be seen there as attempts to study the impact of biological evolution on human culture and society. It can also be considered the beginning of a thought or theory developed in subsequent years regarding the idea of natural selection, but also later in the economics of biology (Zalega, 2015). That indicate the mechanisms which create the sustainability of the environment or on the contrary, those disturbing such balance.

The Red Queen Hypothesis and the concept of progress in nature

For the description of the processes of progress in nature, as well as the opposite state, which could be described as a *fall*, evolutionary biologists use the Red Queen Hypothesis (RQH). It concerns all types of interactions between organisms under conditions of competition. Consequently, all species in order to survive must constantly adapt, and evolve. As J. Weiner wrote (1999), this hypothesis was introduced into science in 1973, by the American evolutionary biologist Leigh Van Valen. He provided evidence from fossil record data that probability of extinction within any group remains constant through time. The RQH explain such pattern involving component members of several major taxonomic groups. Thus, species do not only evolve, but they also coevolve with other species. As a result of that strategy, when thinking about adaptation to the environment, there must be considered other species as a major part of such external world. So, every organism tries to improve the fitness. However, in doing so it modifies the evolutionary response from the partners of interaction. That is why the whole ecological network will also change, triggering further responses (Sole, 2022). The name of the hypothesis was taken from Lewis Carroll's *Through the Looking-Glass*, where in order to stay in the same place, one must run as fast as it is possible. In this story, the Red Queen gave to Alice a piece of advice: *it takes all the running you can do, to stay in the same place* (Carroll, 1999). That can be translated into biological realities in terms of adaptation and progress: here you have to run as fast as you can to remain in the same position. However, if you want to go elsewhere (farther), you have to run twice as fast. It also follows from this statement that not keeping pace on the run, threatens not only a lack of progress, but also poses an increasing risk of elimination of the participant of a given interaction, and therefore his downfall.

Moreover, the theory of Red Queen was also used to explain the dynamics of some host – parasite systems (Decaestecker et al., 2007). Thus, coevolutionary relationships may play the role in the maintenance of e.g. the sexual reproduction. Especially crucial, but also dangerous in such race are parasites, mainly because of the their great number. Moreover, according to M. Ridley (1993), parasites and their hosts are connected by the *unbreakable evolutionary embrace*. That means the more successful parasites are, which is related to the number of infected hosts, the bigger are the hosts' chances depending on the quality of the defense mechanisms. Leverage is changing on both sides, and the more threatened a given participant of such interaction is, the more intense will be its competitiveness, manifested in creating some new adaptations. However, in the world of the Red Queen there is a constant competition, so in fact nobody wins, but at best one side may gain a little time, thanks to a temporary advantage over the opponent. Thus, it seems that perfect adaptation to the natural environment is just impossible. The explanation for such problem is that the environment from the point of view of a specific species is constantly changing for the worse. This is due to mechanisms of evolution, that tend to introduce new adaptations all the time. That is why the RQH shows the concept of relativity of all progress in nature. In the natural environment less flexible species are excluded faster, and their gene pools are eliminated over time.

The essence of this theory can be captured by the statement that any increase in adjustment for individuals of one species, consisting of improving the ability to avoid competition in the form of parasitism, but also predation, entails a decline in adaptation for many other species competing for the same resources. That is why individuals of each species in order to keep up with others must constantly change the genetic program (Krzanowska et al., 1997). As mentioned, L. Van Valen (1973) noted, that in any group that occupies the same adaptive landscape, the probability of survival is independent of age throughout its existence, and all organisms have an equal probability of extinction. Biological progress and decline have manifested itself at different levels. This may go through competition between individuals from the same species, but also refer to different competing species. Therefore, what follows from this model is a prediction that even if species achieve better environmental adaptation as a result of getting improvements acquired through evolution, their chance of survival will not improve. That is because their competitors in this race also constantly enhance their mechanisms for adaptation, by *arming* themselves. That is why, a chance of extinction – *fall* for the organisms is the same all the time, and in biology we cannot speak of the concept of progress, especially if it is perceived as a transition from less to more biologically advanced forms. The basis for the entire theory is down to *the evolutionary arms race*, where models: host – parasite, but also prey – predator constantly evolve together, to reach some sort of uneasy balance. As a result, different taxonomic groups of species are continually changing, yet they are not getting relatively better in a competitive sense through time. Instead, they are metaphorically running in place and not getting anywhere: like the eponymous Red Queen (Strotz et al., 2018). In the context of above problem, it remains an open question if this evolutionary model illustrates

environmental sustainability, or maybe quite the opposite – a constant unsustainability? Phenomenon of competition is universal for the nature and it is based on the assumption made by M. Ridley (1993), that the greatest enemies for all living organisms are other organisms, that compete for the same, limited resources. As it follows, the occurrence of the Red Queen model is common in nature, but it may be also extrapolated to all human interactions, that perfectly fit into that general pattern as well (Musiał, Musiał, 2021).

Progression versus fall and the idea of environmental sustainability for the man

One of the most important events for the existence of life since its inception has been the production of oxygen by early living organisms. However, at the same time that led to the first ecological catastrophe in Earth's history, that occurred about 2-2.5 billion years ago. Most of the bacteria thriving on the Earth during that time were anaerobic, which means they metabolized their food without oxygen. Transition from anaerobic organism to aerobic happened extremely slowly, as it took up to 2 billion years to reach the level of oxygen we have today. That episode of dying out, was a mass extinction for the anaerobic organisms, due to transformed environments on Earth, and is today called the Great Oxygenation Event (Olejarz et al., 2021). That first biotic crisis was at the same time one of the most deadly disasters in the history of the planet, but also a major turning point, as made possible the evolution of animals, which needed oxygen to exist at all (Weiner, 1999). New explosion of life, this time in a completely different form, occurred at the beginning of the Phanerozoic, which started about 600 million years ago, and is still a current eon in the geologic time scale. So as J. Weiner (2001) notices, life on the Earth from the very beginning of its existence has been constantly changing the shape and strategies, and therefore it has evolved, *ipso facto* the Red Queen model has been working since the outset of the life.

As already mentioned, the extinction of entire genera or even families of animals and plants in the history of the Earth was associated with changing of the external environmental conditions to which these organisms were strongly adapted (Krzanowska et al., 1997). They died out because they couldn't run beyond their strength in an evolutionary sense, that is to adjust to rapidly changing environmental conditions, as has happened in certain emergencies situations. Decline of such species was caused by various types of geological catastrophes recorded in the history of the planet. There have been a number of such episodes during the Phanerozoic, and the most authors accept the five substantial mass extinctions since the Cambrian. The 5th. event of mass extinction, in the end of the Cretaceous geological period involved the demise of dinosaurs (*Dinosauria*). On the contrary, example of animals that have been successfully coping for millions of years both with a constantly changing environment and the competition with other species are octopuses (*Octopoda*). By many researchers they are considered the most unusual invertebrates living on Earth. This group is evolutionarily very old and has been inhabiting the Earth for over 500 million years, a large part of the Phanerozoic. For visualizing how long is that, useful may be a comparison with the dinosaurs, that became a dominant group of vertebrates around 200 million years. Back then, *Octopoda* had lived and diversified in the oceans for hundreds of millions of years. They survived also several mass extinctions, including Ordovician, Devonian and Permian, as well as the Cretaceous – from the late Mesozoic Era, when the *Age of Reptiles* has come to its end. The reason for the fall of the latter was their extreme adaptation to the ecological niches that had existed before the catastrophe. Such perfect adaptation, which also means *narrow specialization*, in consequence doomed dinosaurs to extinction in the event of disappearance or transformation of their old habitats. Perhaps, the source of success (progress) for an extremely intelligent group of invertebrates, like octopuses, were on the other hand the effective adaptations concerning their cooperation skills with other species of predators in order to capture the victim (Sampaio et al., 2020).

Although the constant struggle between all organisms has been seen as the endless race, in fact that resulted in increasing of the Earth's biodiversity. According to J. Weiner (1999), at the threshold of the third millennium, the total biodiversity of our planet has been estimated at between 5 and 50 millions of species. That huge discrepancies and uncertainty of assessment indicate that our knowledge is still insufficient, especially in the case of organisms inhabiting isolated and poorly accessible habitats, such as the depths of the ocean. There should be added, that estimated number of organisms currently inhabiting the Earth is only suggested, and probably does not exceed one percent of all species that have lived on our planet through the last 3.5 billions of years. Biological complexity from a scientific perspective is a consequence of usually relatively simple phenomena, which was at the very beginning in a metaphorical term the *arms race* between nucleic acids. A tautological generalization is therefore to say that out of the entire genetic pool, organisms who survived were by chance best adapted to the specific environment at a given time. There are plenty of documented cases of plant and animal species disappearance, thus it may be concluded that they weren't properly adapted to the existing habitats at the particular time. Those five events of mass dying out of the Earth's biodiversity, have been caused by various natural phenomena, and species extinction was a natural process. Most of the organisms that have ever lived on Earth are already extinct, without any human intervention. Due to the existence of mechanisms of evolution, the biodiversity on our planet had been changing millions of years before the *Homo sapiens* emerged. Yet, it seems to be a well-confirmed fact that due to the expansion of human civilization, the rate of species extinction has significantly accelerated in relation to the natural background.

By looking at the history of biodiversity, J. Weiner (2001) points to the fact, that the current, so anthropogenic decline in a number of species is only an episode of little importance for the biosphere. However, a question can be asked how the constant lack of the environmental sustainability may affect the future civilization of a man. Nowadays the distressing phenomenon of a rapid decline in biodiversity is observed, and we are actually facing the 6th. mass extinction. Such symptoms are visible in almost all existing habitats and are influenced by very different factors mainly caused by the dominance of humans. As G. Ceballos and colleagues (2020) note, thousands of populations of critically endangered vertebrate animal species have been lost during the last century. The speeding of such crisis is still increasing, because of the growth of global population of *Homo sapiens*, and the consumption rate as well. However, this time extinction may be underway entirely caused by humans (Cowie et al., 2022). E. Kolbert (2014) in *The Sixth Extinction. An Unnatural History*, presents the mounting evidence that the Earth is currently at the start or perhaps even in the midst of such major episode of mass extinction. As R.H. Cowie and associates (2022) note, according to opinions of some researchers current biotic crisis may be even accepted as a new trajectory of evolution. That is due to the fact, that the man, despite being only a part of nature, desires to manipulate it, in order to pursue his own and very selfish goals. The *Homo sapiens* contributes to the disorder in nature and environmental sustainability in various ways. The intensification of agricultural production has even led to the process of extinction of various types of native livestock breeds, that in fact had been previously selected by the man himself. Yet, the genetic resources of such breeds are the basic biological capital for the livestock production, ensuring food security and sustainable rural development. According to G. Polak and colleagues (2021), native breeds of livestock, despite their unique characteristics and adaptability to local, specific environmental conditions are currently threatened largely due to their diminishing use, resulting of lower profitability. For example, in Poland on a large scale are bred the Holstein-Friesian cattle, which is not native but provide a better production results than the old breeds. As a result e.g. the Polish Red or White-backed cattle are critically endangered.

On the other hand, there are also some voices that deny existing evidences for the 6th. great biotic crisis. They just consider the problem as exaggerated by the conservation and biodiversity scientists, in order to attract greater public and political attention to the biodiversity loss. Also, there have appeared some statements that, as the man is a part of the natural world, human-caused extinctions are a natural phenomenon, and a part of the evolutionary trajectory of life on the Earth (Briggs, 2017; Thomas, 2017). So, in a way, the latter are environmentally sustainable. It was even suggested by C.D. Thomas (2017) in *Inheritors of the Earth*, that the rate of evolution, and therefore speciation is now increasing in the face of changes caused by *Homo sapiens*. Notwithstanding, Cowie and associates (2017) point that there is a mounting evidence that extinction rate is in fact not normal, and the exponential rise in the human population and in human impacts on the natural world are abnormally rapid. The conclusion of such reasoning is that *Homo sapiens* is not just another species evolving in the face of external influences, because of having a conscious choice regarding the future of mankind and of the Earth's biodiversity as well. W. Sztumski (2021) notes that, the possibility of survival of humans depends on the victories over nature. So, in the evolution of *Homo sapiens* there is a constant growth of destruction of the external and internal environment, proportionally to the progress of civilization. The same as illustrated in the Red Queen model, the human environment changes constantly and requires updating. Moreover, despite of creating *the complementary whole*, the human environment does not have to be in symbiosis with the rest of the nature.

The idea of sustainable development notices the existence of global problems and the related threats for human existence, which is supported by more efficient cognition measures, concerning possibilities of detecting the potential and actual threats and dangers faced by the contemporary world (Bukrejewski et al., 2019). The universalism of the Red Queen model means that all organisms, including people are constantly threatened with extinction. Thus, this hypothesis also explains the reasons of the mass extinctions episodes' occurrence. Apart from constant competition, the latter are generated by various factors, e.g. a geological or cosmic catastrophes, such as in the case of Cretaceous extinctions. However, in the critical situations, only *random organisms* are able to survive, because the extremely specialized species die out as first, as a result of the disappearance of their old habitats. The early mammals from the time of the Cretaceous biotic crisis were considered such random species. After the dinosaurs had died out, new and different ecological niches became available, and they could be successfully occupied by very different taxonomic groups. In fact, mammals, including *Homo sapiens* itself, could dominate only thanks to that catastrophe, and therefore for them it was rather a factor generating progress. In such a context, environmental sustainability may seem even unfavorable for us as a species. That is because, as if not for the 5th. mass extinction event from more than 60 million years ago, most likely intelligence would have developed in some other taxonomic group than the *Homo sapiens*. What is more, mammals probably would have never come to domination. Thus, it would have been for us unsustainable. But it also means that our environment is only temporary, and changing swiftly, so the future may not be very propitious. Let this remain a warning, because in some crisis situations the nature will recover after some time, however it is rather doubtful whether this will be a source of progress for the humankind. Perhaps, in order to survive we ought to learn from the strategies used by the octopuses, and become as flexible as it is possible, while at the same time cooperate with other organisms living on the Earth next to us. According to Bukrajewski et al. (2019), the idea of sustainable development is actually a plan

of changes. We can learn that also from the Red Queen model, because the environment around us is constantly transforming. However, at the same time due to the relativity of such modifications, any progress may be perceived as rather utopian.

Conclusions

In order to understand the significance of the idea of sustainable development, it is crucial to be aware of the accelerated processes of extinction currently observed on a global scale. Not only is there noted a fast species loss, but the processes of speciation cannot keep up with that decline as well. The whole discussion around the loss of the biodiversity and necessity of maintaining the environmental sustainability may also have some references to the Red Queen model. As the *Homo sapiens* is nowadays a dominant force in nature, the decline in the rest of the biological diversity may be explained by *not keeping up with adaptations in the evolutionary race*. Thus, the further development of our civilization may be in fact responsible for the 6th. mass extinction. But there is also the truth that the nature itself, which in fact is for the man an opponent in such race, is also improving its adaptations. That is because the evolution of one side, always forces the changes of the other party. The well known fact is that, even after the greatest biotic crisis the diversity of life is reborn ultimately. However, we have no answer for the question whether the man will also find himself in such a new reality. Then, life may have already a completely different form, adapted to the new environmentally sustainable conditions, as the constant *arms race* forces continuous changes. Like any other sphere of human activity, also agriculture is nothing but a competition with nature for various resources, such as a space, water, etc. Therefore, the Anthropocene can be understood as living in a fear, that ahead of us will be just less, and less sustainability. Sadly, in this context the Red Queen model has a rather pessimistic tone, as any equilibrium will be temporary, and therefore relative. Such unsustainability is seen as a constant changing or evolving of all the living creatures on Earth as quick as possible, in order to not fall in the evolutionary sense.

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