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Artificially Increasing Biodiversity

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ABSTRACT

Biodiversity refers to the diversity (existence of many different types of organisms) of animals and plants. There are many different species of organisms on Earth, all of which influence each other. The current situation is thought to be the result of this. Biodiversity is important for all organisms, including humans. Our current diversity has been established through gradual change over many years, and it is thought that new species have emerged and some species have become extinct during that time. However, these phenomena can also be considered evolution that occurs in nature without human intervention. In this article, we discuss new organisms created by humans through genetic manipulation and consider whether such new species should be released into the wild or used to maintain biodiversity.

Key words: Biodiversity, Genetically modified organisms, Artificial genetic disturbance, Gene pollution.

INTRODUCTION

In recent years, usage of the term biodiversity has become more common. Biodiversity refers to the diversity of animals and plants (i.e., the existence of many types of organisms). For example, there are many different species on Earth and they all influence each other[1)]. It is believed that the population of each species is maintained at an appropriate level, and the variety of organisms is preserved through various relationships, such as predation (food chain), food production (nutrients), and decomposition of unnecessary organic matter. Even if these organisms are not directly involved with humans, they can influence them indirectly or euphemistically. Biodiversity is important for all organisms, including humans. The current level of diversity has been established through gradual changes over many years, and it is thought that new species have been created and some species have become extinct during that time, which is a phenomenon that can be thought of as evolution that occurs even if humans are not involved. However, some species become extinct due to environmental changes, and if these environmental changes are caused by humans, then we have a major negative impact on them.

If biodiversity is expressed in the visible characteristics of animals and plants (size, color, shape, classification, etc.), it naturally originates from genetic differences[2)]. It is thought that even within the same species, there is genetic diversity in nature, which is likely to help a single species become less susceptible to disease all at once and to prevent extinction by allowing populations to compensate for each other's weaknesses. This article discusses new organisms created by humans through genetic manipulation, and considers whether such new species should be released into the wild or used to maintain biodiversity.

What is biodiversity?

Earth is made up of inorganic environments (inanimate environments), such as the geosphere, hydrosphere, and atmosphere, and the biosphere (the world inhabited by organisms) is related to these environments[3)]. Many organisms belong to the biosphere and the existence of an interdependent system between organisms and nonliving environments provides food and living spaces for organisms. Life is supported by green plants that convert the inorganic matter in the environment into organic matter using sunlight, while herbivores eat green plants, and carnivores eat herbivores. The excrement and corpses of these organisms are broken down by microorganisms and reused as inorganic matter by plants. Substances in the environment (components of the atmosphere and water) pass through producers (such as plants), consumers (such as herbivores and carnivores), and decomposers (such as soil animals) before circulating back into the environment (the so-called material cycle). This relationship is commonly referred to as a food chain[1)]. A circulation cycle of substances (elements and compounds) and energy exists between organisms and the nonliving environment on Earth, and they interact to form a large ecosystem. This is thought to contribute to the stability and maintenance of Earth's environment.

In other words, biodiversity refers to the coexistence of organisms with different characteristics within a population and the mutual influence of each other. This can ultimately prevent sudden changes and positively affect the planet. Owing to their mutual relationship, they are useful in buffering and alleviating changes in biological populations and contributing to maintaining the natural world. Therefore, maintaining biodiversity is important, even for organisms with which humans have no direct contact. Reducing or eliminating biodiversity for convenience can negatively affect humans.

Human impact on biodiversity

Humans consume many organisms in the food chain, but are rarely consumed themselves. Humans are thought to have strong powers and reign at the top of all organisms on Earth, and their populations may decline rapidly by capturing other organisms for human benefit (not only through the use of food by other organisms but also through various actions). If humans do not consider organisms other than humans, they can easily reduce the number of species and disrupt relationships between organisms[1]. This can occur even when it is not directly intended. Since the Industrial Revolution, which took place from the mid-18th century through the 19th century, humans have achieved industrial development, resulting in a decline in the population of many organisms due to environmental pollution (e.g., air, water, and soil pollution). In recent years, a more notable example of environmental pollution has been global warming, which has reduced or displaced potential habitats for organisms, thereby changing the natural world from its original state. This results from humans acting only with their own development in mind with little regard for other organisms.

In recent years, humans have been able to create new species through genetic manipulation[2].

Its main uses include crops (plants) for food, fresh flowers for luxury items, and the development of disease model animals to establish new treatment methods. Vegetables that are resistant to cold damage (low-temperature environments) and pesticides produce substances in their bodies that repel pests, and ornamental plants with flowers in colors that do not exist in nature are already in practical use, distributed on the market, and available to the general public (Table 1). Although not everyone will directly use it, this technology can also be applied to animals and mice with cancer, killifish that can detect water pollution, and sheep that may alleviate food shortages have been created in laboratories. Compared with plants, animals can move on their own, and there is a risk that they may migrate into the natural world unless they are kept under strict control. In that case, it cannot be denied that there is a possibility that new creatures that did not originally exist in the wild will be born through interbreeding with wild animals. This is called artificial genetic disturbance (or gene pollution) and is generally thought to have a negative impact on the natural world. If the animal is a mammal, artificially creating a new breed may be ethically or religiously problematic. Their creation and use for medical and other purposes are permitted only in closed spaces such as laboratories.

What is genetic modification and gene editing?

Genetic manipulation includes gene modification and editing, which can create new species (to be precise, genotype changes; however, this does not necessarily mean that the phenotype, such as the body's mechanisms, will change). Gene modifications change the quality and quantity of proteins produced by an organism. Consequently, an organism can acquire new properties it did not previously possess. Gene modification is a technology that extracts genes with useful properties from other organisms and artificially incorporates them into plants that require these properties[4]. This technology makes it possible to use genes of organisms that cannot be crossbred in nature, making it possible to create crops (plants) with characteristics previously thought impossible to breed through conventional crossbreeding by pollination[2].

However, gene editing differs slightly from gene modifications. Gene modification involves adding or replacing genes from another organism, whereas gene editing involves the removal of part of an existing gene or the introduction of duplicates. This technology intentionally causes organisms to express characteristics that differ from the genes they originally possessed. The difference lies in whether genes are added from outside or whether the original genes are edited. If the original property is considered a disadvantage for humans, the gene will be removed; if it is considered an advantage, it will be introduced in large quantities and amplified. Gene editing involves adding or removing genes to enhance, weaken, or eliminate their effects. It is known that changes in the original genetic information due to external stimuli, such as gene modifications (e.g., single nucleotide polymorphisms in DNA due to radiation), can occur in nature, and organisms with new characteristics can arise as mutations. It is also believed that biological diversity emerged over long periods is due to this[2].

Such technologies merely genetically modify crops and livestock to give them new properties convenient for humans; essentially, no similar species exist in nature[4]. If humans want to prevent artificial genetic disturbances to the natural world, they must avoid releasing genetically modified organisms into the natural world. Plants cannot move on their own, but pollen can move easily. Therefore, it is necessary to grow them in a limited area, such as a vinyl greenhouse, or to consider or control the air pressure and wind direction to contain the pollen of genetically modified plants so that they do not escape into the natural world. Compared to animals, plants can move independently and migrate to various places and can potentially interbreed with different species living in

the wild (but only closely related species); therefore, they are limited to growing and being observed in, for example, laboratories, aquariums, and fields, which can be managed by humans.

If new genetically modified organisms migrate into the wild

As mentioned at the beginning, it is generally believed that population balance in the natural world is maintained through interactions between many organisms (excluding kept livestock, farmed organisms, pets, crops, and other creatures whose movements are restricted by humans). Biodiversity is the basis for the relationships that maintain this balance.

In other words, it does not include sudden changes in the balance of organisms in the natural world due to human manipulation or influence. When creating a new species of organism, accidentally releasing it into the natural world implies that human intervention adds to the balance of organisms in the natural world. The population of wild animals (endemic species) in the natural world is expected to fluctuate (mainly decrease) owing to competition for food. This is not typically interpreted positively[2]. Genetic disturbances occur through interbreeding of closely related species; as a result, new species may be born without human intervention. Therefore, it is generally considered a flawed idea to allow genetically modified organisms to interact with wild species. Similar examples include when a pet escapes from an area with few other organisms or when pollen from a horticultural plant is dispersed. It is not just the release of new creatures into the natural world that is wrong. Any human action that changes the number of wild creatures, even if indirectly, is destructive. Humans are a type of organism on Earth; however, because we have a strong influence on other organisms or because we act in the interests of other humans, these actions are associated with risks and responsibilities.

Past examples of genetic disturbance

Genetic disturbances have caused problems in many cases. However, this does not mean that only new species created by humans can cause problems. Simply changing the areas in which organisms live due to human intervention can disrupt the balance of organisms in the natural world and alter the number of species that originally existed. Global warming may also be a trigger.

Chrysanthemum shiwogiku is distributed along the coasts of southern Tokushima Prefecture, southeastern Kochi Prefecture, and Wakayama prefecture[5]. *Chrysanthemum pacificum* is found on the coasts of the eastern Kii Peninsula, Shizuoka Prefecture, and Boso Peninsula, which are further eastward. Both *C. shiwogiku* and *C. pacificum* lack ray-shaped petals that look like petals, which is a major difference from other chrysanthemums. However, *C. shiwogiku* which lacks ray petals, was occasionally found to possess ray petals. *C. shiwogiku* with ray petals, is the result of hybridization with cultivated chrysanthemums. If cultivated chrysanthemums are close to wild chrysanthemums, insects carry pollen and create hybrids. Chrysanthemums are particularly prone to hybridization, and wild chrysanthemums can easily hybridize with one another. Thus, unexpected genetic contamination may have occurred.

Medaka (killifish, *Oryzias latipes*) is one of the most common freshwater fish native to Japan. It is a popular fish that is almost always seen in ornamental fish shops; however, in recent years, it has become rare to see it outdoors in rivers and other places. Recently, the habitat of wild medaka has rapidly disappeared, and it has been listed as an endangered species on the 1999 Red List by the Environment Agency[6]. The ease of distribution and breeding as an ornamental fish has been a disadvantage, as it has led to genetic disturbances because people release it carelessly, and new species have been created, similar to *C. shiwogiku* mentioned above, which has the opposite effect of preserving the original species.

Similarly, Genji fireflies (*Nipponoluciola cruciata*) are rarely observed in the wild. Different genotypes of fireflies live in eastern and western Japan, as well as in the Kyushu region. However, as a result of individuals that have been captured and bred by humans escaping, genetic disturbances have occurred, resulting in the creation of further species through hybridization.

News of the sale and possession of glowing medaka has been reported many times in Japan. Technology to produce medaka glow can be achieved by modifying the genes encoding fluorescent proteins, such as GFP[7]. Many researchers have previously introduced genes for fluorescent proteins at the same time as the target gene to confirm the introduction and expression of the target gene (e.g., one related to the disease they are investigating). If this experiment is successful, it is possible to create an individual in which the introduced genes are co-expressed and part of the organism glows with GFP (Table 1). The original purpose was not to make the medaka glow, but to serve as a tool to confirm the introduction of another gene. Such creatures must not be allowed outside the laboratory and cannot be kept alive for any purpose other than their intended purpose, nor can they be given away or sold. Such actions violate the Law Concerning the Conservation and Sustainable Use of Biological Diversity through Regulations on the Use of Living Modified Organisms (Cartagena Protocol on Biosafety)[4]. If such creatures were accidentally released into a river, there is a possibility that genetic changes would occur that would not occur naturally. This is because luminescence itself does not exist in nature (the property of a completely different species of organism has been imparted to the laboratory). Furthermore, recent research has indicated the possibility that other changes involving multiple genes may occur, which may affect properties other than glowing.

CONCLUSION

The general idea is that genetically modified organisms associated with humans are not released into the natural environment. It is also true that organisms whose genes have been modified by humans, mainly genetically modified crops, have already been put into practical use and distributed on the market, albeit within a limited range. In terms of the level of selective breeding of crops or artificial insemination of livestock, mutations that would occur over a long period in nature are being changed by humans in a much shorter period into patterns that are only convenient for humans. However, there is still little knowledge, and whether they can coexist with other organisms (native species) in the natural world is not fully understood.

Based on our knowledge, some new species created by humans could be treated at the same level as wild species. Seeds of genetically modified crops that are already in practical use are usually not collected and are discarded everywhere. However, this is not considered a particular problem. Depending on the type of genetic mutation, it can be considered that environmental effects are not a problem even today; however, it is possible that these have not yet been noticed. We believe that if we consider whether genetic mutations caused by humans can occur in the same manner in nature without human intervention, we can determine how to deal with them and the range of restrictions (such as those that may occur as a result of linked genetic mutations between closely related species).

It is also true that many humans hold the old-fashioned idea that artificially created products should or should not be used, even if they lead to the protection of endangered species. Unless these beliefs are carefully explained and understood, it may be impossible to allow artificially created varieties to interact freely in the natural world, or to treat them at the same level as wild species. Even if this leads to the protection of endangered species, humans should not create clones or increase the populations of these species based on human thinking. Therefore, they should not be immediately released into the natural world.

Genetic modifications, such as those in Table 1, can be considered convenient manipulations for humans to treat diseases, address food shortages, and gradually confirm technological innovations. Although there seems to be no problem at present if organisms are maintained in restricted locations such as laboratories, factories, or farms, it will cause genetic disturbance and economic problems, such as fluctuations in food quantities, and may eventually become an international issue if they are introduced into the wild; therefore, biodiversity should not be easily disturbed. There is still insufficient information on what kinds of changes are dangerous, and we are still in the process of gathering that knowledge. In the future, there may be days when newly created species are commonly observed. In other words, the conclusion of this article is that it is impossible to draw any conclusions based solely on the current scientific information.

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Table 1 Examples of organisms born through genetic modification

Species	Features added	Possible influence on the outside world	Explanation
Rabbit	Glowing body surface.	× (If it can be contained in a laboratory)	This is a fish species that has been engineered to contain a gene for a luminescent protein extracted from a jellyfish. Luminescent genes are introduced to make it easier to conduct medical research (for example, when multiple genes are introduced, the introduction can be confirmed by luminescence). There are also examples of this being done with medaka.
Salmon	Easy to grow.	○ (If it is farmed in the ocean)	By incorporating the genes of king salmon and ocean bout salmon into Atlantic salmon, their growth rate is nearly doubled. They have already been sold for consumption in the United States and Canada. All of the salmon are sterile females, which prevents damage to the ecosystem if they escape and become wild.
Pig	Decomposes phosphorus compounds and makes phosphorus available for use by the body.	△ (If the breeding area can be limited and isolated)	They have been modified to produce phytase, which can break down phosphorus compounds in the body. Pigs cannot break down phosphorus compounds. Therefore, even if consumed through food, they cannot digest them, and the phosphorus compounds end up in their urine, which can lead to water pollution and other problems. In addition, it is necessary to separately provide phosphorus necessary for survival.
Goat	Produce milk containing anticoagulants.	△ (If the breeding area can be limited and isolated)	As a result of genetic modification, goats can secrete milk containing atrim. Atrim is a raw material for human antithrombin, a component in human blood that prevents blood clotting. Goats will then act as factories to produce human medicines.
Sheep/Goat	Make them chimeric organisms.	× (If it can be contained in a laboratory)	An intermediate animal was created by fusing an embryo taken from a fertilized sheep egg with an embryo taken from a fertilized goat egg. Currently, it has little industrial or research value, and the purpose was simply to create this chimeric organism.
Mouse	Deleted (knocked out) a specific gene.	△ (If the breeding area can be limited and isolated, it is easier to escape because it is a smaller animal than rabbits)	A knockout animal is an animal in which a specific gene has been intentionally deleted (knocked out). By knocking out one or more of countless genes, we observe what symptoms occur in the animal. As a further application, humans can create diseased animals to help develop treatments for humans.
Carnation	Grow blue flowers.	○ (If pollen scatters around)	Enzyme genes obtained from petunias and pansies are introduced into carnations to create flower colors that do not exist naturally. Similarly, blue-flowered roses were later created.
Rice	Contains carotene.	○ (If pollen scatters around)	By introducing genes from daffodils and the bacterium Erwinia into rice, the rice was modified to contain carotene, a provitamin of vitamin A, in its own body. It is said that 2.4 billion humans in the world eat rice, but if they only eat rice and have no access to other foods, they will develop a serious vitamin A deficiency. A lack of vitamin A weakens the immune system, inhibits blood production and skeletal growth, and can even lead to vision loss.

Based on the contents of reference 7).

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