BIOLOGICAL, PRODUCTIVE AND SOCIOCULTURAL IMPORTANCE OF HONEY BEES - CONTRIBUTION TO COMMON WELFARE

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ABSTRACT

The coexistence of bees (*Apis* spp.) and humans goes back for millennia. Bees play an irreplaceable role as pollinators of flowering plants (Angiospermae) in ecosystems and thus in maintaining biodiversity. Throughout history, humans have brought honey bees closer to themselves by building them dwellings and providing certain protection in exchange for their products. Today, the honey bee (*Apis mellifera* L.) is primarily needed as a pollinator of many agricultural crops and without them humanity would not be able to produce enough food. The usefulness of bees is also manifested in the form of biological indicators of the conditions in the environment. The importance of bees and their role in human society are intertwined with various segments of society and culture. Bees have a prominent place in literature, religion, culture and art, as well as in everyday life. However, it is not possible to numerically express and materially quantify every individual value attributed to bees. Therefore, due to (lack of) care for their and human's shared environment, the issue of the consequences of the loss of bees is imposed at the level of the number of honeybee colonies as well as at the level of the number of bee species. This complex problem can be viewed more comprehensively from a multidisciplinary and integrative bioethical aspect. In it all contributions of bees are acknowledged, recognizing that the health or illness, wealth or poverty of future generations depend on their protection and enabling the realization of the roles that are both innate and assigned to them.

Keywords: *honey bee Apis mellifera L., biological role, production, sociocultural importance, welfare, integrative bioethics*

INTRODUCTION

Bees have been associated with humans since ancient times. The oldest depiction of bees and humans dates back 12,000 years, and is found in the Cueva de la Arana in Spain. It depicts a man climbing a rock to a bee colony from which he takes honey with a honeycomb [1]. Although the number of bees is small in proportion to the number of insects or all

animal species on Earth, their importance is inversely proportional to this [2]. Bees are important members of certain ecosystems, which is supported by the fact that 87.5 % of flowering plants (Angiospermae) are adapted to pollination by animals, among them mostly insects, particularly bees [3, 4]. Christian Conrad Sprengel (1750 - 1816) is considered the first to have noticed the role of pollination by bees and other insects, which he published in 1793 in Berlin in his work "Nature's Secret Revealed in the Structure and Fertilization of Flowers". Having recognized the important function of pollinators, he made a request that the state must have a permanent fund of honey bee colonies, but his discovery was initially considered fanatical and not accepted [1]. Today, the honey bee (*Apis mellifera* L.) is recognized as the economically most important insect pollinator of agricultural crops worldwide and is crucial for maintaining biodiversity [5], which refers to the millions of unique living beings on Earth in their mutual interaction [6]. Due to their extremely important role as plant pollinators and producers of irreplaceable natural products, honey bees are the link between what has reached the plant through water and soil and the aforementioned bee products. This makes bees irreplaceable biological indicators of environmental conditions and present contamination [7 - 16].

THE ROLE OF HONEY BEES IN POLLINATION

As far as the food for the human species is concerned, bees pollinate about 70 to 75 % of agricultural crops. The Food and Agriculture Organization of the United Nations (FAO) estimates that out of 100 crop species, which provide 90 % of the world's food, 71 are pollinated by bees [17]. They account for 75 to 80 % of the pollination of fruit trees. As pollinators, they increase the yields of these crops, but also contribute to their quality by improving their characteristics such as the shape and size of the fruit and the amount of sugar and acidity. What is important here is that bees visit the flower of one plant species on the same day, and depending on the pasture conditions, they do so on the following days [1, 18]. This was also noted even in ancient times by Aristotle (384 - 322 BC). Pollen from entomophilous plants, those pollinated by insects, is not adapted for air distribution, but is heavier and stickier than pollen from anemophilous plants, those pollinated by the wind. Research on the cherry variety Hedelfinger, conducted at the Karlsruhe-Augustenberg farm by Müller and Degeran, shows that out of 422 flowers per meter of length of ripe fruit with bees as pollinators, there were 156 fruits, and without bees, only three. In the Sam variety, out of 311 flowers per meter of length with bees, there were 103 fruits, and without them, only two. It is stated that four bee colonies per hectare are necessary to ensure adequate pollination of crops [1].

In addition to pollination, honey bees produce: honey, wax, propolis, pollen, royal jelly and venom, natural products indispensable to humanity in nutrition and medicine. However, the benefits of bees as pollinators are many times greater than the benefits of bee products, and their biological role is practically immeasurable [18 - 21]. "Today, when in advanced countries of the world, seed and fruit yields increase several times due to bee pollination, experts claim that this benefit is 100 to 150 times greater than the direct benefit to the beekeeper in honey and wax." [22]. Bees as pollinators and active maintainers of biodiversity many times exceed the benefits they provide in the form of bee products, which in the EU is expressed as 1,280 euros per bee colony [19]. Globally, the annual value of pollination is estimated at hundreds of billions of euros [17]. Therefore, it is not allowed to treat plantations during flowering with agents that are toxic to bees and their brood, and treatment in the period close to flowering should be carried out in the evening, when the bees are not collecting. They are also at risk when agricultural crops are treated against weeds whose flowers are visited by bees, as well as aphids, whose honeydew bees also collect [11, 21].

When considering the importance of honey bees in pollination, it is necessary to mention that about ¼ of the bees in an average well developed colony, which represents about 10,000 workers out of a total of 40,000 workers, are actively involved in pollination. Each of these forager bees makes 12 to 15 flights per day, and must visit, for example, about 100 apple flowers to fill their honey bladder, or about 80 pear flowers to load their foraging basket [8]. Data are also given on an average of 10,000 foragers per colony, each visiting about 1,000 flowers per day, which would represent 10,000,000 sampled sites per day [7]. Although there are data that mention 3,000,000 flowers that bees visit daily [18], mentioned figures indicate that they visit an average of 13,500,000 flowers per colony daily, which is an extremely significant number of flowers visited. This makes them irreplaceable in maintaining the biodiversity of plant species and as biological indicators of the environmental conditions. Honey bees can be called "free self-samplers" since they are a part of nature and the environment where they find everything they essentially need. People keep them out on the open and bees bring them samples from which many indicators of a possible contamination of the environment can be determined [14, 23]. It has been mentioned that the honey bladder has a volume of about 50 mm^3, and it is stated that 1 kg of nectar requires 15,000 full honey bladders, or the same number of flights, so it turns out that 1 kg of honey requires 100,000 to 150,000 flights. As for pollen, one basket can contain 8 to 12 mg. It takes 18 loads of pollen to fill one cell of the honeycomb. In good conditions, bees fly a distance of 1.5 to 2 km, and in poor conditions, 3 to 4 km. They fly to water about 50 times a day [18].

Any change in nature and in the environment can affect bees by a changed or increased mortality rate and/or traces of contamination can be present in bees, their brood and bee products [8, 12]. Bees "have sensitive reactions to impacts harmful to nature" [1].

When environmental contamination occurs, it must first be proven. Then, its possible negative impact on the ecosystem or individual species must be proven. It is stated that "bees are the most appropriate organisms to prove contamination and the degree of its negative impact" [24]. This is because bees live almost everywhere on earth, alongside humans. Bees cover about 7 km^2 of area when collecting nectar, pollen, resinous and balsamic substances (propolis) and water, from which they also bring potential contaminants to the hive. Furthermore, they are sensitive to various biocides such as pesticides. They are called "category one indicator species" because their disappearance is an indicator of serious environmental degradation. Therefore, foraging bees are true "category two indicators", while bee colonies are potential "collectors and accumulators" of contamination and are therefore seen as "category three indicators". Contaminants that enter the hive with nectar, pollen, propolis and water can end up in bee products (collectors) and in larvae and adult bees (accumulators) [24].

Bees play a key role in various ecosystems. The reproduction of many plant species depends on pollination by bees. Then, many other animal species, in addition to bees, depend on plants that survive precisely because of them. Members of the food chain depend on these animals. The soil micropopulation depends on the aforementioned plants. So, the disappearance of bees from the ecosystem creates a "hole" that negatively affects other organisms in their interaction. This is a defect, figuratively speaking, in the three-dimensional web of life, which can continue to spread and have serious consequences. The place of bees in one such system is shown in Figure 1 and their contribution to the maintenance of biodiversity is undeniable.

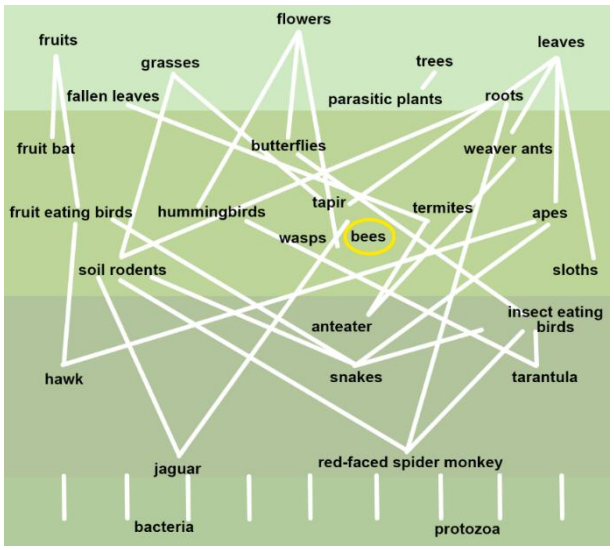

Figure 1. The central place of bees and their connection with other organisms in the ecosystem [25]

Already in the 18th century, more precisely in 1775, the Austro-Hungarian Beekeeping Patent was issued, as the most modern law at the time, which stated: "Beekeeping is exempt from the tax of tenths, no road or bridge tolls may be charged for transport to pasture; beekeeping is exempt from all taxes; subjects may keep bees with an unlimited number of hives; it is forbidden to kill other beekeepers' bees; stealing bees is punishable as a crime; nobles should help poor peasants to benefit greatly from beekeeping schools and so that everyone can acquire at least their first hive." [26]. It is more than obvious that this was a progressive regulation from which something should be learned today and applied to legislation related to bees and the relationship towards them and those who deal with them. The importance of bees and beekeeping was recognized and legally regulated on mentioned territory almost 250 years ago, so it is the right time to raise the same awareness today. Bees as pollinating insects are of great importance in the survival of rare plant species, and many other organisms also benefit from a healthy bee colony [1].

Research shows that bee colonies that live in forests have a positive impact on ensuring the survival of numerous forest species. Therefore, there are some proposals to return honey bees to forests by arranging holes in trees or setting up straw hives. There is also an incentive to increase the number of honey bee and medicinal plant species in forests. Results that are mentioned show that the increased number of honey bee colonies in forests has a positive effect on a larger number of game, among which wild boar is particularly noteworthy, in the range of 3 to 18 %. A 2018 European Parliament resolution confirms that bees are also important indicators of environmental quality [19].

SOCIOCULTURAL ROLE OF HONEY BEES

The importance of honey bees, apart from their biological and economic aspects, is manifested in a special way throughout the history of human civilization, i.e. through different phases of the development of human society, its culture and beliefs. Therefore, the socio-cultural role of bees is indispensable in the context of their overall contribution to humanity. The eventual loss of bees would also lead to the loss of a significant part of the rich and diverse cultural and spiritual heritage, of which only a small part is listed here, in order to provide a complete picture of the extent of the importance of bees to humans.

Bees have been considered sacred animals and God's messengers, emissaries, servants and even God's little helpers throughout human history. With their eternal buzzing, according to folk tradition, they sing heavenly odes, worshiping God. In ancient Egypt, the hieroglyph for a king, or pharaoh, was a depiction of a bee, or queen bee. They also symbolized "the one who gives life", birth, death and resurrection from the material world. They were believed to have emerged from the tears of the Sun god Ra. In Christianity, bees symbolized purity and innocence, and in the Middle Ages they were an icon of the Mother of God and her innocence, or virginity, because they were considered virgins and believed to reproduce asexually.

In addition, bees symbolized effort, diligence, order, reason, thoughtfulness, cooperation, and

savings. Bees were seen as messengers between people and the gods. Thus, an Indian legend tells of the origin of bees in a cosmic hive beneath the earth, which is actually paradise, and from which they were sent to people to lead them out of nothingness, ignorance, and barbarism. In ancient times, bees carried messages to the other world and were known to be carved into tombstones as a symbol of the immortality of the soul. They were compared to skilled speakers and gifted singers, and there is a legend that tells of bees that brought honeycombs with honey and put it in Plato's mouth in his childhood, indicating his talent. They are a symbol of mellifluous. The god of shepherds, flocks, pastures and forests, Pan, raised and protected bees. The Great Mother, the one who is the mother of the world and who gives life, was also called the Queen of Bees, and her priestesses "Melissae" meaning bees. It is also stated that the Hebrew name for the bee comes from a term meaning "word". Among the Celts, bees represented the secret wisdom of the spiritual world. The Chinese also see them as a symbol of diligence and savings. The symbol of the bee was also found on coins from Ephesus, dating back to the 4th century BC (Figure 2). Among many peoples, the bee is a sacred and blessed being and it is a sin to kill it. That is why people in this region used to say that honey bee does not die in the sense of an animal, but rather in the sense of a human death [26].

Figure 2. Silver coin from Ephesus with a bee motif [27]

In different cultures, honey symbolized immortality, rebirth, but also fertility, prosperity and wealth. It was used in various religious rituals as well as in initiations or introductions. It was placed on the mouth or tongue, and it was added to various perfumes and ointments. Honey was considered an aphrodisiac and was believed to give strength, fertility and manliness. It was offered as a gift and sacrifice to gods, spirits and ancestors and was considered the food of the gods. The dead were buried with honey or it was poured on their graves. Honey was also used for embalming. Bright, pure honey was used for kings. In Christianity, honey symbolizes the works of God and the ministry of Christ and the Word of God. According to one belief, honey "was created from the morning dew and the blush of dawn, as a gift from the gods who spread it on leaves and flowers, and then bees collect it" [26].

The widely known and even colloquially used phrase "a land flowing with milk and honey", which in the historical-biblical record refers to the land of Canaan promised to the Hebrews, denotes the abundance of, among other things, honey and the obvious presence of bees in that society more than 3,000 years ago [28]. The bee and its product, in this context wax, have a special, warm role within Church rituals. Historically, the Church has been one of the largest consumers of beeswax in its liturgy. A ritual within Holy Week, more precisely on Good Friday, when the fire and the Paschal candle are blessed is one of them. At that time, a hymn is sung which says: "From the work of the bees tonight, the Church, through the hands of the ministers, offers you this candle as a holiday gift. We know what it says, while it burns and shines to the honour of God. Its flame has been shared with others, but the light given away has not diminished it, because it is nourished by the fragrant wax collected by the diligent bees." [29]. Since 78.97 % of the population of the Republic of Croatia declared themselves Catholic in the last census and 87.38 % as Christian all together [30], this ritual is widespread and well-known and is of importance to a large part of the population. Therefore, bees are also significant in this context, since they are

directly mentioned, and the candles used should be made from beeswax.

Bees have been present with humans since prehistoric times. They are inseparably linked in a relationship of interdependence. The significance of bees has manifested itself from the existential to the symbolic. Today, more than ever before in human history, this relationship is seriously disrupted by anthropogenic impacts on nature and the environment. Therefore, it is imperative, due to arguments about the harmful effects on bees (heavy metals, pesticides, bee diseases, environmental changes, climate change), and the prominent importance of bees in many ecosystems and the production of sufficient quantities of quality food for humanity, to undertake further research and meaningful protection of these truly special and unique insects [16].

CONSEQUENCES OF THE LOSS OF BEES – BIOETHICAL CONTEXT

The definition of bioethics tells us about the comprehensiveness and scope of the interaction between humans and the living world: "Bioethics is an open area of encounter and dialogue between different sciences and activities, and different approaches and worldviews, which come together to articulate, discuss and resolve ethical issues related to life, to life as a whole and in each of its parts, to life in all its forms, stages, phases and manifestations." [31]. Čović (2004) formulated it this way: "It is simply a newly opened area of research and thinking in which the moral and civilizational aspects of those problems imposed by the modern progress of science and technology are considered". Therefore: "As a newly opened area of thinking, bioethics must integrate diverse approaches and contributions to solving a wide range of problems, from those specific ones that arise in medical and research practice to those ultimate ones that concern human survival." He concludes that: "now, when it has closed the circle of its objectivity in the widest range, it could be defined as the ethics of life." [32]. What distinguishes the integrative bioethical concept is inter-, trans- and multidisciplinarity, where a certain problem is viewed on the same platform from multiple perspectives, which contributes to its more comprehensive solution. "The methodological pattern of pluriperspectivism, which was developed as part of the project of integrative bioethics, introduces cultural perspectives into the new paradigm of knowledge and thereby, in contrast to the technoscientific reduction of knowledge, establishes a culture of knowledge or knowledge as culture." [33].

At the beginning of the industrial revolution, there was a warning from Friedrich Engels (1950): "Let us not flatter ourselves too much about our human victories over nature. For every such victory, nature takes revenge on us. True, each of them has, in the first place, the consequences on which we had counted, but in the second and third place it has quite different, unforeseen consequences, which often cancel out the first ones. The people who in Mesopotamia, Greece, Asia Minor and elsewhere cleared the forests in order to obtain land, did not even dream that they were thereby laying the foundations for the present desolation of those countries, depriving them, together with the forests, of the centres for collecting and retaining water. When the Alpine Italians cleared the fir forests on the southern slopes of the mountains, so carefully guarded on the northern slopes, they did not even suspect that they were thereby cutting off the roots of mountain cattle breeding in their region; still less did they suspect that they were thereby drying up their mountain springs for the major part of the year, so that during the rains these springs could pour down onto the plains even more furiously floods. The people who spread the potato throughout Europe did not know that with the starchy tubers they were also spreading scrofula. And so the facts remind us at every step that we do not rule nature at all as a conqueror rules a foreign people, as someone standing outside of nature, but that with our flesh, blood and brain we belong to it and stand in its midst, and that all our power over it consists in the fact that we have the advantage over all other creatures

of being able to know and correctly apply its laws." [34].

E. O. Wilson (2009), a world-renowned biologist and entomologist, wrote the following regarding the destruction of the natural environment and its pollution leading to the extinction of species: "Most flowering plants left without pollinators would cease to reproduce. Most herbaceous plant species would fall into a spiral of extinction. Insect-pollinated shrubs and trees would survive for a few more years, in rare cases for a few centuries. […] Wars for control of increasingly scarce resources, suffering, and a head-on descent into medieval barbarism are reaching levels never before seen in human history. […] That is what I want to say with my scenario: be careful with pesticides. Don't even think about reducing the insect world. We would be making a serious mistake by allowing even a single one of the millions of species on Earth to become extinct." [35].

Spürgin (2018) nicely adds by saying: "The loss or reduction of the bee population, from whose work and abundance many of these species directly or indirectly benefit, would undoubtedly accelerate this development even further." [1]. Indeed, the three-dimensional network of connections between microorganisms, plants, animals and humans would not be the same without bees. Without them, this interdependence would leave an empty space in the niches of the ecosystem. The loss of bees from natural food chains and reproduction would directly and indirectly harm the plant and animal organisms that depend on them. Over time, this deficiency would certainly be compensated for in some way in nature, but until then, noticeable losses would be suffered that humanity would hardly be able to overcome. This is emphasized and summarized by Brown and Paxton (2009) when they say: "bees are essential for a healthy planet, as well as for a healthy human population" [4].

People should be aware that bees are a valuable and unique example from which human society learns and applies in everyday life. Thus, the hexagonal structure of the honeycomb is studied and used in architecture and construction, in engineering and technology, for example in the production of thermal insulation as well as in the production of spacecraft. "If we want good for ourselves and for the bees, if we want a society of solidarity and subsidiarity, let's try to learn something from the bees and start behaving (communicating) and working for the good of all - exactly as the bees do. The bee lives for the colony, helps without asking for anything in return, is ready for sacrifice, renunciation and a change of role. In itself and within its community, it has objectified and connected morality and ethics, communication science, engineering and technology, politics, construction, chemistry, biology, physics, medicine, the food industry, etc. The bee has no knowledge or understanding, but in some way it acts and connects in an interdisciplinary and interactive, even integrative way." [36].

Honey bees, with their conformation and structure and their products, have served as a source of knowledge and concrete benefits to humans. However, "In addition to the material benefits of beekeeping, it provides humans with entertainment, mental satisfaction and happiness. […] Dealing with bees not only gives people pleasure, but it also has a positive effect on human health. Beekeepers regularly live longer, as shown by many surveys conducted around the world." [22].

Bees, through beekeeping, are beneficial in therapy, that is, in treating and helping people with disabilities, the elderly, as well as in educating children. Beekeeping thus helps with physical problems and illnesses, as well as psychological and social ones. For example, it helps with practicing fine movements and motor skills, with multiple sclerosis, and individuals with post-traumatic stress. Beekeeping in the form of such apitherapies also connects healthy and sick people, old and young, enables volunteering and has a positive effect on lonely, isolated and depressed people. It also serves to express creativity. The effects of apitherapy have a positive impact on health, improving the quality of life and opening up new opportunities. They are physical, psychological, working and social in

nature, often in synergy [37]. Just being in nature and working with other beings through learning and empathy brings positive effects on the overall health of a person and their environment [38].

A special and world-famous conservationist of animal species on the verge of extinction Gerard Durrell pointed out: "The world is as delicate and complex as a spider's web. If you touch one thread, you send tremors through all the other threads. We don't just touch the web, we tear big holes in it." [39]. Therefore, it is obvious that minds whose thoughts and concerns are on the same track of responsibility towards the human environment and life as a whole complement and confirm each other, so Spürgin (2018) summarises: "Everything is closely connected, and honey bees play a very important role in the overall structure of nature." [1]. The disappearance of bees would mean an irreversible disruption to the fabric of life on Earth, with consequences that, despite all the enlightened roles of bees, we certainly cannot fully comprehend [40].

CONCLUSION

The biological, productive and sociocultural importance of honey bees lies in multiple benefits and cannot always be attributed to material or monetary value:

i. maintaining biodiversity through pollination,
ii. producing large quantities of quality food for humans and animals,
iii. producing irreplaceable bee products,
iv. monitoring the condition and changes in the environment due to anthropogenic activity,
v. positive impact on physical health through the consumption of bee products,
vi. positive impact on physical health through beekeeping,
vii. positive impact on mental health through occupational and social (api)therapy,
viii. positive impact on overall health through spending time outdoors and in nature,
ix. expanding knowledge in the field of engineering, structures and materials,
x. expanding knowledge about the interconnectedness and complexity of processes in the living world.

All of this would be lost if bees became extremely endangered or extinct, which is more than a direct appeal and sufficient reason for their planned protection. After all, people are entrusted with the health or illness of future generations. Man decides how he will relate to the health of all people, which is inextricably linked to the health of the environment and its individual components, and in this context, also to the health of bees, as evidenced by a comprehensive integrative, interdisciplinary and multidisciplinary bioethical context.

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