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**PLANT POLLEN AND ITS ROLE IN THE ECOSYSTEM:  
HONEY BEE – HUMAN  
(Review)**

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*The article provides a comprehensive review of the biological significance of pollen as a vital resource for honeybees. Its role in feeding larvae, maintaining the physiological activity of worker bees and ensuring high egg laying of the uterus is revealed. The nutritional and biochemical value of pollen, its nutritional characteristics, and the dependence of its qualitative composition on botanical origin and environmental conditions are considered in detail.*

*For honeybees, pollen is of key importance - it is a source of proteins, fats, minerals and vitamins necessary for larval development, immune defense and adult life. However, due to agrochemistry, reduction of honey and pollen fields, as well as climate change, the availability of high-quality pollen decreases, which weakens bee colonies and reduces the yield of entomophilic crops.*

*Pollen-bearing plants perform not only a fodder, but also an ecological function, contributing to the maintenance of pollinators, restoration of flora and sustainability of agricultural systems. Climate change and urbanization threaten their diversity, so the priority should be to restore flower biotopes and create favorable conditions for pollinators. Organic farming and urban planning that takes into account the needs of bees are the way to sustainable development.*

*The article provides a comprehensive analysis of the historical use of pollen (from ancient civilizations to modern science), while simultaneously reflecting its economic, biological and ecological significance.*

*Current scientific directions of pollen research are outlined, in particular in the field of apitherapy, pharmacology, food safety, biomonitoring of the environment, as well as prospects for using pollen as a functional ingredient in the food industry. The impact of agricultural factors, pesticides, urbanization, and climate change on the pollen base is considered. The role of pollen as an indicator of the environment, paleobotanic resource and a key factor in the stabilization of agroecosystems through the support of pollinator populations is highlighted.*

*Special attention is paid to the need to preserve and develop natural and cultivated pollen-bearing lands as the basis for the stable functioning of bee colonies and the preservation of biodiversity. The paper highlights the interdisciplinary nature of pollen research and justifies the need for further systematic research in this area.*

**Keywords:** bees, plants, nectar-bearing, pollen-bearing, pollen, bee bread, climate change, urbanization.



## ПИЛОК РОСЛИН ТА ЙОГО РОЛЬ У ЕКОСИСТЕМІ: МЕДОНОСНА БДЖОЛА – ЛЮДИНА (Оглядова)

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*У статті здійснено комплексний огляд біологічного значення пилку як життєво важливого ресурсу для медоносних бджіл. Розкрито його роль у живленні личинок, підтриманні фізіологічної активності робочих бджіл та забезпеченні високої яйцекладки матки. Детально розглянуто харчову та біохімічну цінність пилку, особливості його поживності, залежність якісного складу від ботанічного походження та екологічних умов.*

*Для медоносних бджіл пилко має ключове значення - це джерело білків, жирів, мінералів і вітамінів, необхідних для розвитку личинок, імунного захисту та життєдіяльності дорослих особин. Однак через агрохімізацію, зменшення посівних угідь медоносів і пилконосів, а також зміну клімату доступність якісного пилку знижується, що послаблює бджолині сім'ї й зменшує врожайність ентомофільних культур.*

*Пилконосні рослини виконують не лише кормову, а й екологічну функцію, сприяючи підтриманню запилювачів, відновленню флори та стійкості агросистем. Зміна клімату та урбанізація загрожують їхньому різноманіттю, тому пріоритетом має стати відновлення квіткових біотопів і створення сприятливих умов для запилювачів. Органічне землеробство й міське планування, яке враховує потреби бджіл, - шлях до сталого розвитку.*

*В статті здійснено комплексний аналіз історичного використання пилку (з давніх цивілізацій до сучасної науки), одночасно відображено його економічне, біологічне та екологічне значення.*

*Окреслено актуальні наукові напрями дослідження пилку, зокрема у галузі апітерапії, фармакології, харчової безпеки, біомоніторингу стану довкілля, а також перспективи використання пилку як функціонального інгредієнта в харчовій промисловості. Розглянуто вплив агрофакторів, пестицидів, урбанізації та зміни клімату на пилкову базу. Виділено роль пилку як індикатора довкілля, палеоботанічного ресурсу та ключового фактору стабілізації агроєкосистем через підтримку популяцій запилювачів.*

*Особливу увагу приділено необхідності збереження та розвитку природних і культурних пилконосних угідь як основи стабільного функціонування бджолиних сімей та збереження біорізноманіття. Стаття підкреслює міждисциплінарний характер вивчення пилку та обґрунтовує потребу в подальших системних дослідженнях у цій сфері.*

**Ключові слова:** бджоли, рослини, нектаронос, пилконос, пилко, перга, зміна клімату, урбанізація.



Modernity is marked by dynamic changes that occur regardless of our perception or readiness for them. In such conditions, it is important not only to learn how to respond quickly to challenges, but also to actively act ahead of time. This statement is also quite relevant for beekeeping. This industry is increasingly acquiring a complex production direction, when apiaries produce not only long – known honey and wax, but also other bee products-bee pollen, propolis, royal jelly, bee venom.

Bees and flowering plants have evolved together over millions of years, forming complex interaction mechanisms. This is a classic example of symbiosis: plants provide bees with pollen and nectar as sources of energy and nutrients, and bees, in turn, provide the pollination process, without which the fruiting of most crops is impossible. By collecting pollen, bees bring invaluable benefits to many types of flowering plants, since almost 90% of them cannot exist without pollinating insects, one of the first places among which belongs to bees. Looking for food (pollen and nectar), bees visit the flowers of plants and transfer the stuck pollen to the stigmas of the pistils of other plants, thus carrying out cross-pollination. Disruption of this relationship due to environmental or man-made factors has global negative consequences for food security.

Pollen is not only a means of plant reproduction, but also one of the most important feeds in natural ecosystems. For bees, it plays the role of "animal protein" in the plant world. It is used for feeding larvae, stored in the form of bee bread. Thanks to bees transferring pollen grains from one flower to another, cross-pollination is provided, which is key to maintaining plant genetic diversity and productivity.

Reducing the area of natural biotopes and the predominant use of agrochemicals significantly limit bees' access to high-quality pollen. This creates risks for the physiological state and productivity of honeybees, which directly affects the yield of entomophilic crops and further food security.

Current issues of our time are the study of how much pollen is critical for maintaining brood, immunity and vital activity of adults, and how insufficient nutrition or monotony of pollen negatively affects the strength of the family, reduces the life expectancy of nursing bees and the oviposition of the uterus. The unique biochemical composition and healing properties of pollen justify the need for deeper scientific research.

**The aim** of the study is to analyze the biological significance of pollen in the life of the Bee Family, determine its role as a key source of nutrients for larvae, worker bees and Queens, and outline promising areas for further scientific research on the use of pollen in beekeeping, nutrition and medicine.

**Research materials and methods.** The analysis of scientific literature was carried out in the form of a systematic review study by searching for publications in the databases Scopus, Web of Science, Google Scholar, etc. The review included works in English published in recent years in accordance with certain criteria. The systematization of available scientific data was carried out in order to generalize modern knowledge about bee pollen as a food product, medicine, component of animal feed and a factor of influence on product quality, which will serve as the basis for the formation of its own research methodology in this direction in Ukrainian conditions, taking into account international experience.

**Research results.** Bee pollen is one of the oldest natural products used. In different historical epochs and civilizations, people valued it for its nutritional and healing value. Modern science only confirms the unique properties of pollen, which were used by ancient peoples. The history of pollen use demonstrates that this natural product has not lost its value from ancient times to the present day. It has been used as a nutrient and medicinal product in many cultures, and today science only confirms the unique



properties intuitively discovered by our ancestors. Only the depth of knowledge has changed: from intuitive application to scientifically proven properties.

Egyptian written sources mention the use of pollen as a component of medicinal products. The pharaohs used mixtures of pollen, honey, and milk as an elixir of strength and youth. In traditional Chinese medicine, pollen was considered as a means to strengthen the energy of “Qi”, improve digestion and vitality. It was included in many phytocomplexes.

Hippocrates and Pliny The Elder mentioned the medicinal properties of pollen, especially for anemia, general weakness, and as a tonic.

In the Middle Ages, in Europe, it was used as an ingredient in medicinal ointments and teas for diseases of the skin, respiratory tract and general exhaustion. Pollen was believed to help restore strength after wars, epidemics, and famines, although there was no scientific justification at the time.

In the 50s and 70s of the twentieth century, active clinical studies of pollen began in Europe and the first dietary supplements based on them appeared. In modern medicine, pollen is used to maintain immunity, in the treatment of colds, anemia, gastrointestinal diseases, stress and depression ( Li, X. M. et al., 2025; Anjum, S. I. et al., 2024; Alcalá-Orozco, M. et al., 2024; Khalifa, S. A. M. et al., 2021).

Bee pollen has many beneficial properties based on its multi-purpose potential, which is a new trend in the treatment of many complex diseases such as cancer and neurodegeneration (Kacemi, R. et al., 2024).

This unique product is included in masks, creams and tonics due to its antioxidant properties. It is widely used as a functional ingredient in the food industry as part of bars, mixtures for athletes, dietary products (na'aim, N. et al., 2022; Tirla, A. et al., 2023). Bee pollen is a natural product of beekeeping with great potential for use in medicine, and more recently in animal husbandry. Based on scientific studies, it was found that adding bee pollen in the amount of 1-20 g/kg to the diet improves the productivity, reproductive and immune status of animals. In particular, it was found that feeding different doses of bee skin to broiler chickens helps to reduce feed consumption and improve its conversion, thereby increasing their productivity and positively affecting blood parameters (Farg, S. A. et al., 2016). Studying the effect of bee skin on the biochemical parameters of the blood of broiler chickens, we obtained data on a significant decrease in blood glucose, cholesterol and calcium, as well as lower levels of triglycerides, but higher levels of sodium chloride, phosphorus and globulins in broiler chickens compared to the control that improves fattening of chickens (Klaric, I. et al., 2018). The effective effect of feeding Bee legs on the rate of physiological development of rabbits and their productivity was also established (Attia, Y. A. et al., 2011)

Its use as a feed additive can also become a practical nutrition strategy in animal husbandry (Abdelnour S. A. et al., 2019). The inclusion of pollen in food products such as bakery, confectionery and meat products, juices, improves the nutritional and functional properties of the final products (Kostić, A. et al., 2020).

Pollen grain has a complex three-layer structure. EXIN (outer layer) - thick and resistant to chemical, physical and biological effects. Thanks to sporopollenin, exina can persist in the soil for thousands of years, which makes it possible to use pollen analysis in paleobotany. Intexin (inner layer) is a thin and elastic shell that ensures the germination of the pollen tube. Cytoplasm-contains the nucleus, vesicles, energy structures (mitochondria), protein granules, enzymes and vitamins.

Grain sizes vary from 10 to 100 microns, depending on the plant species. The shape changes from rounded to elongated or triangular (Garga, B. et al., 2024). Pollen color is determined by pigments, in particular flavonoids and carotenoids, and can range



from white to dark yellow, red, or even purple (Thakur, M. et al., 2020). The stickiness and stickiness of the surface make it easier for pollen to adhere to the pollinator body. The Botanical origin of pollen is crucial for understanding its textural properties, such as hardness, stickiness, density, firmness, elasticity, cohesion, and chewability (Thakur, M. et al., 2020).

In its composition, pollen contains proteins that make up an average of 20-35% of the mass. The amino acids lysine, methionine, valine, threonine, and phenylalanine in pollen grains are the most important for larval development. Arginine and histidine-play a role in the synthesis of enzymes and hormones (Sommano, S. R. et al., 2020; Bryś, M. S. et al., 2024; Jeannerod, L. et al., 2020; Kostryco, M. et al., 2021).

The fat fraction of pollen (up to 13%) includes oleic, linoleic, and palmitic fatty acids (Čeksterytė, V. et al., 2023; Liolios, V. et al., 2022; Mayda, N. et al., 2020). The sterols that make up pollen grains, especially beta-sitosterol, are essential for the development of cell membranes in insects, and phospholipids provide nutrient transport.

Pollen contains glucose, fructose, sucrose, as well as fiber and hemicellulose. These compounds provide basic energy and support fermentation when stored as bee bread. Pollen also contains vitamins and more than 25 macro - and microelements that help strengthen vision and immunity, support the nervous system and Metabolism, have an antioxidant effect, participate in enzymatic processes and tissue growth (Sudha, R. et al., 2022; Barbieri, D. et al., 2020; Liolios, V. et al., 2019).

The nutritional value of pollen depends on the type of Plant, time of year, soil and climatic conditions (Li, Q. Q. et al., 2018). For example: dandelion, phacelia – rich in protein; sunflower has a predominant lipid composition; buckwheat, Acacia have a high concentration of antioxidants. The combined collection of pollen from different crops allows bees to form a balanced diet.

The honey bee (*Apis mellifera*) is one of the most important entomophilic pollinators, which plays a key role in agroecosystems. For normal development, growth and maintenance of vital functions, the bee family needs two main sources of nutrients: nectar as a source of energy and pollen – a source of protein, fat, vitamins and minerals. Pollen is of particular importance in the nutrition of larvae and adult nurse bees that ensure the cultivation of brood (Kim, H. et al., 2024).

Pollen for bee larvae is the main and only natural source of protein in the first 3 days of their development, when there is an active formation of tissues and organs. It is during this period that the larvae of all bee castes especially need high-quality protein nutrition, which is provided by bee bread. The larva consumes food in an amount exceeding its own mass by almost 1000 times in 5-6 days (Bryś, M. S. et al., 2021; Kratz, M. et al., 2022; Filipiak, M. 2019). Proteins, amino acids, fats, vitamins and trace elements contained in pollen contribute to intensive cell division, body weight growth and the formation of the immune system of the future bee. Pollen deficiency or poor quality during this critical period can negatively affect the usefulness of larval development, reduce the viability and productivity of adults in the future (Pang, C. et al., 2022; Austin, A. J. et al., 2021; Braglia, C. et al., 2025).

Pollen for Queen Bees is a critical component of nutrition needed to maintain a high level of egg laying. The uterus does not directly consume pollen, but it is the main source of protein for young nurse bees, which produce Royal Jelly-the only food for the uterus during its life. High-quality pollen with a sufficient content of amino acids, vitamins and minerals ensures the active functioning of the hypopharyngeal glands in nursing bees, which determines the intensity of feeding the uterus (Lan, J. et al., 2021; Corby-Harris, V. et al., 2018; Kratz, M. et al., 2024). As a result, the uterus is able to lay between 1,000 and 2,000 eggs daily (Clair, A. L. St. et al., 2022). Insufficient or poor-



quality pollen resource leads to a decrease in royal jelly synthesis, which can lead to a decrease in egg laying, weakening of the family and deterioration of its regenerative ability.

For worker bees, pollen is the main source of protein that determines their physiological development, functional activity, and life expectancy (Lajad, R. et al., 2025). On average, one bee consumes 3 to 4 grams of pollen during its lifetime. Its quality – in particular, the content of essential amino acids – directly affects the strength and viability of the family. protein starvation or monotonous pollen leads to inhibition of gland development, decreased immunity, shortening the life span of worker bees and deterioration of the ability to perform key functions in the hive.

In older bees performing field work, pollen performs a restorative and energetic function, supporting muscle activity, antioxidant protection, and overall endurance. During the period of intensive collection of nectar and pollen, it is especially important to provide a diverse and high-quality pollen base.

Flower pollen collected by a honey bee and glued together by the secretions of its salivary glands into multi-colored granules 1-3 mm in size is called bee pollen. It got its name due to the method of transporting pollen by the Bee to the hive. For the convenience of carrying pollen grains, the Bee "Combs" pollen directly on the flower or directly in flight with special foot brushes and folds it in the form of small lumps to "baskets" on the back pair of legs, while gluing individual pollen grains together with the secret of its salivary glands, enriching it with enzymes of its glands for the first time.

Pollen from flowering plants is an essential source of nutrients for honeybees, but its availability depends on the season, weather, and variety of flowers. To provide themselves with protein reserves during the entire period of life and, especially during periods of shortage, bees use a unique mechanism for preserving pollen in the form of Bee bread – a product of enzymatic fermentation, which is stored in honeycombs. Freshly picked pollen is hygroscopic, very sensitive to sunlight and after 48 hours. after collection, it begins to lose its consumer qualities. Pollen also contains microorganisms that begin to actively develop and also spoil it.

Bee bread is bee pollen that is mixed with nectar, saliva enzymes, and beneficial microorganisms. In order to quickly preserve pollen, bees immediately fly to the Hive and transfer it to wax cells, tamp it down, and pour a thin layer of honey. Under the influence of nectar, enzymes and enzymes of the pituitary glands, honey, pollen deprived of oxygen access is fermented and turned into bee bread. Thus, lactic acid fermentation takes place, which turns pollen into a stable nutrient product. During fermentation, the pH decreases (up to 4.0–4.2), which prevents the development of pathogenic microflora, increases the bioavailability of amino acids, and increases the content of vitamins (especially Groups B, C, and E). When growing brood (spring – early summer), the need for protein increases tenfold. During this critical period, bee bread provides larvae and young bees with the necessary substances for cell construction and milk production by nursing bees.

Due to its high content of phenolic compounds, enzymes, antioxidants, organic acids and enzymes, bee bread enhances the immunity of bees, helps reduce cases of diseases, especially during the period of family weakening (Oroian, M. et al., 2022). When the bee colony weakens or the number of larvae decreases, the addition of bee bread stimulates the uterus to lay eggs. For humans, bee bread has immunomodulatory, anti-inflammatory and antioxidant properties and is used in dietary supplements (Campos, M. G. et al., 2021).

Rational beekeeping is impossible without a high – quality and diverse food base that provides bees with the necessary nutrients-nectar and pollen. Honeybees are plants



that secrete nectar, a sugary liquid that serves as the basis for honey production. The sugar content of nectar is from 20 to 80%. Honey crops are the basis for the production of commercial honey, and also stimulate active oviposition of the uterus during the period of Intensive Family Development.

Pollen stalks are plants that secrete large amounts of pollen, which is necessary for feeding larvae, synthesizing proteins, and maintaining immunity. Often honeybees and pollen stalks are combined in one plant, but not always.

Pollen from different sources contains different amino acids and minerals, so the diversity of pollen stalks is critical for the formation of strong immunity of the bee family (Conti, I. et al., 2016). Rapeseed, sunflower, buckwheat are commercial pollen – bearing and honey-bearing crops sown taking into account the needs of apiaries. Corn is a weak nectar carrier, but a powerful pollen carrier. Wild honeybees, such as blackberries, raspberries, thistles, and thyme, provide continuous flowering throughout the summer. Medicinal herbs (mint, lemon balm, sage) enrich pollen with phytoncides.

To form a stable feed base, crops should be planned from mixed honeybees: for example, phacelia + Sainfoin + buckwheat. Crop rotation must be carried out with the inclusion of pollen stalks. Honeybee plants and pollen – bearing crops are the basis for the full development of the bee family, honey production and ensuring ecological balance. Their diversity, proper placement and preservation are the key to the stability of apiaries and the productivity of agroecosystems.

Seasonal supply of protein and carbohydrate feed to bees is a key factor in maintaining the strength and productivity of the bee family. There are three main active periods: spring, summer and autumn. Also important is the wintering period, when the reserves of honey and bee bread are replenished artificially by the beekeeper. Natural and cultivated honeybees and pollen stalks have different flowering periods, which affects the biorhythms of bees and the distribution of apiary work throughout the year. Planned cultivation of pollen-bearing crops not only stabilizes the feed base, but also increases the efficiency of agroecosystems. The distribution of flower resources over time is of strategic importance for the apiary. It is important to ensure continuous flowering – at least one source of pollen and nectar in each period, taking into account domestic plant varieties adapted to local conditions. It is necessary to sow mixtures of early, medium and late-flowering crops in each zone of the apiary and avoid treatment with agrochemicals during the flowering phase.

Pollination is the transfer of pollen from the anther of the stamen to the stigma of the pistil of the flower, which provides fertilization. In plants with cross-pollination, this process is almost entirely dependent on pollinators. Pollination is one of the most important ecosystem services performed by honeybees in interaction with flowering plants. This process has not only ecological, but also strategic food value. Most crops – from fruit trees to oilseeds and vegetables – need and benefit significantly from insect pollination.

Of all the bees that fly out of the hive, only about 50% of the bees bring pollen, these are pickers, of which about 25% collect only pollen and 25% – both pollen and nectar (Nery, D. et al., 2020). During periods of active brood rearing, up to 30% of collecting bees can be engaged in pollen collection. Pollen flight lasts an average of 20-30 minutes, after which the Bee rests and recovers energy. Scout bees find pollen-bearing plants using their vision, sense of smell, and ultraviolet vision. After returning to the Hive, The Bee performs a dance (mostly "wagging") that transmits information about the direction and distance to the pollen source (Corby-Harris, v. et al., 2018). The worker bee sits on a flower and uses its jaws, front and middle legs to collect pollen grains. Pollen mixes with the secret of the salivary glands and rolls into lumps (pollen legs). The legs



are placed in baskets on the hind legs – special structures with thick hair. The Bee delivers pollen to the honeycomb and transfers it to other workers. Pollen is rammed into cells, moistened with nectar and enzymes – the fermentation process begins (the formation of bee bread). In case of excessive heat or rain, pollen collection stops. Bees collect pollen most intensively in the morning to the middle of the day, when plants actively secrete it.

This process not only ensures the reproduction of plants, but also improves the quality of fruits: larger size, better taste, uniform maturation. Bees are versatile pollinators capable of serving both wild and cultivated entomophilic plants (Cooley, H. et al., 2021; Divekar, P. A. et al., 2024). Such cooperation has evolved over millions of years of evolution and is crucial for both biodiversity and the agricultural economy. According to the FAO, more than 70% of the world's crops improve yields due to bee pollination. For example, the yield of buckwheat increases by 1.5–2 times in the presence of bees. In horticulture, more than 30-60% of fruits are not tied without pollination. The profitability of pollination in many cases exceeds the profit from honey production itself (Khalifa, S. A. M. et al., 2021; Farina, W. M. et al., 2023; Hünicken, P. L. et al., 2022).

Climate change is one of the key threats to the conservation of floral diversity, in particular pollen-bearing plants, which play a crucial role in maintaining pollinator populations (Díaz-Calafat, J. et al., 2025; Neumann, P. et al., 2023; Zapata-Hernández, G. et al., 2024). The loss of such plants reduces the food supply for bees, wild pollinators and threatens the stability of agroecosystems.

Pollen-bearing plants are a fundamental element of the ecosystem network. However, every year, under the influence of global warming, the flowering period shifts, the distribution area decreases and there is a gradual depletion of the floral composition. Changes in the temperature regime lead to early or uneven flowering. Synchronization between the activity of bees and the possibility of collecting obnozhki is disrupted, which reduces the efficiency of pollination. Frequent droughts shorten the flowering period and pollen count. Heavy rains wash away pollen and prevent access to it. Many local pollen carriers are displaced by invasive species that are less nutritious or not at all pollen-bearing. High-altitude and northern species reduce their range, which reduces local biodiversity.

The situation in Ukraine regarding Honey and pollen crops is also complicated by the fact that the number of other animals has significantly decreased over the past decade. This negatively affected the number of crops of plants that met other animal species in the needs of feed, and bees – nectar and pollen. As practice shows, agriculture in Ukraine today is focused not on grain, feed and protein crops, but on food and industrial crops. In agricultural enterprises, there is a suboptimal structure of the feed wedge, unbalanced feed rations, poor feed quality, violation of technological conditions during the harvesting and harvesting of feed, low yield of forage crops, etc. Due attention is not paid to the primary seed production of fodder crops.

All this leads to a decrease in the volume of bee bread in the hives, a deterioration in the quality of pollen composition, a decrease in immunity and life expectancy of bees, a weakening of the spring start of the apiary due to the lack of early pollen carriers, a violation of the biological balance between wild and domestic pollinators – competition for limited resources.

Modern farming technologies involve the widespread use of fertilizers, pesticides and herbicides that directly or indirectly affect the quality and quantity of pollen formation in plants. Intensive farming involves the use of dozens of chemicals – fungicides, insecticides, desiccant growth regulators (pre-sowing plant dryers to accelerate maturation). Although these agents are designed to increase crop yields, they often have side effects on entomophilic plants and bees (Omelchun, Y. et al., 2023;



Migdał, P. et al., 2018). In particular, pesticides can reduce the level of pollen formation, alter the qualitative composition of pollen, and even have a toxic effect on collecting bees, which has far-reaching environmental and economic consequences (Omelchun, Y. A. et al., 2025). Some systemic substances (neonicotinoids) accumulate in nectar and pollen. They inhibit the enzymatic activity of the flower, which leads to a decrease in the amount of pollen or its sterility. Fungicides disrupt the microbiota of flowers, which is important for the formation of normal pollen and nectar.

Toxic pollen can cause poisoning of young bees feeding on larvae. The activity of the hypopharyngeal glands decreases – the production of royal jelly and feed for worker bees is disrupted. Pollen and nectar from treated plants and plantings can cause acute poisoning, when most flying bees die, as well as chronic ones. Due to the accumulation of sublethal doses of pesticides in Perga and Honey, an increase in the concentration of the latter in bee products due to a decrease in moisture during Nest ventilation, the family's immunity worsens, sensitivity to diseases increases, and the death of bees from chronic poisoning is observed. Pesticides in pollen can disrupt the orientation of bees in flight, which leads to the loss of working flying individuals. It was found that even at acceptable levels of pesticide residues in pollen (1-5 micrograms/kg), bees can experience behavioral changes, navigation disorders, and a decrease in life expectancy (Sadia, H. et al., 2024; Abay, Z. et al., 2023). In regions with high chemicalization of Agriculture, failures in Brood development and a decrease in winter survival are recorded 3-4 times more often.

The rapid expansion of urban areas is accompanied by the displacement of natural ecosystems, in particular flower beds, which are critical for pollinators (Guenat, S. et al., 2019). Urbanization causes fragmentation of the environment, loss of food resources for bees, and a decrease in the number of wild plant species. The increase in areas for construction, infrastructure, roads and industry is accompanied by the displacement of natural vegetation. Particularly vulnerable are the flower environments that provide a food base for honeybees, various species of solitary bees and bumblebees, butterflies, and many other pollinators. Their disappearance leads to the loss of ecosystem connections and threatens the functioning of even agricultural systems (Marshman, J. et al., 2019; Muñoz-Urias, A. et al., 2025).

Construction and asphaltting destroy areas rich in pollen plants. Traditional biotopes (slopes, edges, coastal zones) where endemic species grew are being destroyed. Even if vegetation persists, its isolation from other ecosystems reduces the availability of pollen and nectar for insects. Urban parks and lawns mostly contain ornamental varieties that do not produce enough pollen or are sterile. The displacement of autochthonous species by exotics reduces the ecological value of green areas. A decrease in the number of forage plants leads to a decrease in the population of wild bees and butterflies (Neumann, A. E. et al., 2024). Urbanization creates thermal islands that disrupt the seasonality of flowering and the biorhythms of insects. Exposure to air pollution and noise changes pollinator behavior, reducing pollination efficiency (Guenat, S. et al., 2023; Genuchten, E. et al., 2023). Landscaping buildings with pollen species (lavender, sage, mint) helps create urban "islands of flowers". Planning continuous strips with honeybees between parks, squares and courtyards facilitates the movement of pollinators (Brasil, S. et al., 2023) public campaigns to create "Bee Gardens" promote biodiversity among citizens.

In the context of modern transformation of agricultural landscapes and reduction of wild flowering plants, it is necessary to introduce targeted methods for improving the feed base (Al-Ghamdi, A. A. et al., 2023). One of the most effective ways is to grow annual and perennial pollen-bearing crops. Taking into account the intensification of



Agriculture, the reduction of wild flora and the impact of climate change, sowing special honey-and pollen-bearing plants is becoming an obligatory element of modern apiary practice.

In the context of the general decline in the number of natural pollinators, there is a growing interest in ecological agriculture as an alternative model of agricultural production that contributes to the conservation of biodiversity (Wintermantel, D. et al., 2019). However, intensive farming, the destruction of wild flora and the widespread use of agrochemicals lead to a reduction in the population of bees, bumblebees, butterflies and other pollinators. One of the promising solutions is ecological (organic) farming, which minimizes interference in the environment and contributes to the preservation of entomofauna.

The main principles of ecological (organic) farming are the rejection of pesticides, herbicides and synthetic mineral fertilizers, maintaining soil fertility through crop rotations, green manure, compost, preserving natural flora in the form of wild flower strips, buffer zones (Ecological Farming: The Seven Principles of a Food System that has People at its Heart. Greenpeace International Netherlands, 2022). In farms with an organic approach, 30-50% more pollinator species are recorded compared to traditional ones. Crop productivity in the presence of a large number of pollinators increases by 10-20% even without the use of fertilizers.

**Discussion.** The analysis of information sources covers a wide range of issues related to the production and use of bee pollen, including its history, global production, diversity, nutritional and feed value for humans and animals.

Concluding the review of known sources on the peculiarities of the production and use of bee pollen as a priority food product, Medical means and component of feed additives in the conditions of climate change, modern farming technology, urbanization, it should be noted that these factors will continue to affect many areas in the entire chain of pollen production (bee pollen) and bee bread, and therefore the selection and expansion of areas of nectarinosiv and pollen carriers adapted to the influence of negative factors becomes particularly relevant.

Encouraging producers to resume cultivation of nectar and pollen carriers is based on the high potential of Ukraine in the form of acreage for these crops, which indicates its prospects. In the face of climate change and active urbanization, this is an important advantage. Equally important is the search for opportunities to grow annuals and perennials in the city, which will facilitate the movement of pollinators.

Compliance with important rules of organic production, introduction of targeted methods to improve the food supply, expansion of the areas of wild flowering plants will increase the number of bees, which in turn will ensure the pollination process, without which the fruiting of most crops is impossible. This will allow you to get enough pollen in a timely manner, which will contribute to obtaining high-quality food and preserving the health and productive longevity of people and animals.

**Conclusions.** The importance of plant pollen collected by bees (bee pollen) goes beyond beekeeping, covering the fields of Ecology, Biochemistry, Pharmacology, food safety, and agricultural science. However, despite numerous studies, a number of aspects remain insufficiently studied, which opens up broad prospects for scientists. The study of pollen is an extremely promising scientific field. Pollen is not only a source of protein for bees, but also a valuable natural product with a unique biochemical composition that can affect the physiological processes of both insects and the human body.

Thus, pollen remains a relevant object of research, which opens up wide opportunities for science and practical application in beekeeping and beyond.



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