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INNOVATIVE MULTIFUNCTIONAL CAGE FOR REARING, INTRODUCING, AND TRANSPORTING QUEEN BEES (UKRAINIAN PATENT NO. UA 160776, AUTHOR: OLEKSANDR OLSHANSKYI): A TECHNOLOGICAL BREAKTHROUGH IN COMMERCIAL QUEEN BREEDING AND INDUSTRIAL BEEKEEPING WITH PRACTICAL IMPLEMENTATION IN THE UNITED STATES

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The article presents a scientific and applied analysis of the technological significance of an innovative multifunctional cage for rearing, introducing, and transporting queen bees protected by Ukrainian utility model patent No. UA 160776. The study evaluates the suitability of this design for commercial queen breeding and industrial beekeeping in the United States, where production cycles are characterized by high seasonal intensity, interstate logistics, and elevated sensitivity of queen quality to temperature fluctuations during shipment and introduction. The paper synthesizes professional and research publications concerning the effects of temperature spikes, shipment parameters, cage types (mailing cage, introduction cage, and push-in cage), and delayed-release procedures on queen acceptance, onset of oviposition, survival, and reproductive performance. It is shown that the engineering characteristics of the Olshanskyi cage correspond to major operational requirements of U.S. beekeeping, including ventilation, functional compartmentalization, transport stability, compatibility with introduction procedures, and applicability in work with instrumentally inseminated queens. The article additionally incorporates documentary confirmation of the legal status of the development through a properly captioned figure of the patent certificate. The practical value of the study lies in substantiating the scalable use of the design in industrial queen supply chains in the United States and in other countries with intensive beekeeping models.

Key words: queen breeding, queen introduction cage, queen transportation, industrial beekeeping, patent, United States.

Ольшанський О.І. Інноваційна багатофункціональна клітка для виведення, підсаджування та транспортування бджолиних маток (патент України № UA 160776, автор: Олександр Ольшанський): технологічний прорив у комерційному матковиведенні та промислового бджільництві з практичним впровадженням у США

У статті здійснено науково-прикладний аналіз технологічного значення інноваційної багатофункціональної клітки для виведення, підсаджування та транспортування бджолиних маток, що захищена патентом України № UA 160776. Дослідження спрямовано на оцінювання придатності конструкції до умов комерційного матковиведення та промислового бджільництва Сполучених Штатів Америки, де виробничі процеси характеризуються високою сезонною інтенсивністю, міжштатною логістикою та підвищеною чутливістю якості маток до температурних коливань під час перевезення і підсаджування. Узагальнено дані фахових публікацій щодо впливу температурних піків, параметрів доставки, типів кліток (mailing cage, introduction cage, push-in cage) та процедур контрольованого випуску матки на прийняття матки, початок яйцекладки, виживаність і репродуктивні показники. Показано, що технічні характеристики клітки Ольшанського корелюють із виробничими потребами американського бджільництва: вентиляція, розмежування функціональних відсіків, можливість безпечного транспортування,



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придатність до процедур підсаджування та операцій з інструментально осімененими матками. Окремо введено документальне підтвердження правового статусу розробки через візуальне представлення свідоцтва (патентного документа) як ілюстративного матеріалу. Практична цінність статті полягає в обґрунтуванні можливостей масштабованого використання конструкції в промислових ланцюгах постачання маток у США та в інших країнах з інтенсивними моделями бджільництва.

Ключові слова: бджолине матковиведення, бджолина матка, клітка для підсаджування, транспортування маток, промислове бджільництво, патент, США.

Problem statement. American queen-rearing practice in the segment of rearing, introduction, and transportation of queens is characterised by a set of controllable technological risks. These risks directly determine queen acceptance by the recipient colony. A substantial impact is observed at the stage of initiation of oviposition. Additional effects are recorded as shifts in reproductive indicators and colony stability in early-season production cycles. Cage design functions as a critical variable in U.S. industrial supply chains. Domestic operating conditions transform the queen into a standardised object of professional circulation. This object exhibits high sensitivity to the parameters of transportation and introduction.

Analysis of recent research and publications. The U.S. queen market operates under seasonally compressed timelines and a high concentration of demand, directly associated with migratory pollination and early-spring agricultural cycles. Materials prepared to describe the technological solution outline a spatial concentration of the sector by states (for example, California – 930,000 colonies; Texas – 295,000; Florida – 285,000, etc.), which converts interstate movement of queens and package bees into a routine industrial practice rather than a situational episode. Field and production practice in California evidences seasonal intensification of work in the almond sector: “more than 2 million colonies every February” and the requirement to provide “vigorous laying queens in late winter”, meaning productive queens at the end of winter, when even minor deviations in shipping conditions (delay, overheating, or chilling) rapidly translate into quality losses and financial damage.

Identification of previously unresolved parts of the general problem. American professional discourse consolidates three basic cage types—mailing cage, introduction cage, and push-in cage—and the selection of cage type, the method of delayed release (a candy plug or manual release), the presence and number of attendant bees, and the thermal profile of shipment constitute operationalised determinants used to explain variation in queen acceptance, onset of oviposition, survival, and sperm-quality indicators [1–3]. Institutional codification of these practices in the United States is supported by extension documents: Purdue Extension (E-277) systematises common models and formats (including Benton, California mini, JZ-BZ, and push-in), as well as recommendations on placement, screen type, and the organisation of preliminary contact through a barrier [7]. A historical retrospective of the institutionalisation of material means of introduction is reflected in USDA Agriculture Handbook 335, “Beekeeping in the United States”, where the mailing of queens in cages and the use of a candy plug are recorded as a standard for delayed release, indicating the long-term reproduction of these practices within U.S. production culture [10].

Formulation of the objectives of the article. A key problem area for the United States lies in the fact that logistics-related risks have not only a behavioural but also a reproductive dimension. In PLOS ONE, J. S. Pettis, N. Rice, C. Joselow, D. vanEngelsdorp, and W. Chaimanee note that “during shipment queens are exposed to temperature spikes (<8 and > 40°C)”, emphasising the consequence that such spikes “can kill 50% or more of

the sperm” in the queen’s spermatheca [1]. A field-experimental study by J. M. Withrow, J. S. Pettis, and D. R. Tarry (*Journal of Economic Entomology*) links the temperature conditions of package-bee transportation to subsequent problems of queen establishment and premature queen loss, stressing that part of colony management problems is associated with reduced reproductive quality of queens [2]. Decomposition of shipping into components in *Apidologie* (A. Rousseau, E. Houle, P. Giovenazzo, et al.) specifies the role of abiotic factors and attendant bees; the authors state that “both low and high temperatures significantly decrease sperm viability”, thereby translating requirements for cage ventilation, attendant-bee capacity, and packaging thermal insulation into a unified production configuration rather than “secondary accessories” [3]. Consequently, within U.S. conditions the cage performs the function of an instrument of biosecurity, managed social contact, and logistics stabilisation: it mediates thermoregulation, care by attendant bees, and the pace and method by which the queen is permitted access to the recipient colony [1–3].

Presentation of the main research material with full substantiation of the obtained scientific results. The normative-organisational dimension of the problem is expressed in a gap between codified recommendations and field variability of introduction procedures. K. Given’s document (Purdue Extension, E-277) warns: “Queens may be rejected, injured, or killed by the colony during the introduction process”, thereby legitimising the cage as a means to reduce queen losses and colony destabilisation [7]. At the same time, the corpus of controlled comparative studies in which “cage type” is the central variable remains limited; the classic work of T. I. Szabo (*Journal of Apicultural Research*, 1978) is illustrative, comparing push-in and mailing cages [4]. The regional factor of Africanized populations in the United States increases the risk of queen rejection; in field data from Arizona, E. Guzmán-Novoa, R. E. Page Jr, and A. Correa-Benitez (*American Bee Journal*, 1997) describe the Benton mailing cage as a standard introduction tool with high acceptance rates for European queens in colonies of different types [5]. Contrasting material by E. M. Holmes et al. (*Journal of Insect Science*, 2023) on introducing queen cells into queenright colonies (in honey supers) demonstrates a low probability of successful requeening in the presence of an existing queen, reinforcing the conclusion that controlled introduction of queen material is necessary in situations where colony tolerance constitutes a high-risk variable [6].

Documentary confirmation of the state registration of the utility model is presented in Fig. 1. The certificate confirms the registration in the State Register of Utility Models of Ukraine of patent No. 160776 for the utility model "Multifunctional cage for the introduction, transportation, and rearing of honey bee queens" (registration date: 08.10.2025), which is relevant for the legal substantiation of the use of this design as an object of technological implementation in international beekeeping practice.

Practices of introducing instrumentally inseminated queens in the United States are treated as procedures of heightened technological responsibility. The standard by S. W. Cobey et al. (“Standard methods for instrumental insemination of *Apis mellifera* queens”) defines the push-in cage as a recommended means for introducing a newly inseminated queen with attachment to a comb area and specified holding periods [8]. The applied guide by K. Anton (SARE) reproduces this logic in the format of production training [9]. An additional set of parameters that materially affects the outcome accumulates in professional communication on BeeSource (candy density and moisture, cage orientation, duration of queenlessness, compatibility with JZ-BZ systems and queen-cell protectors), indicating the high significance of micro-conditions of user practice and strengthening demand for designs that reduce the sensitivity of the introduction operation to variation in beekeeper actions [11][12].



Fig. 1. Certificate (Ukrainian utility model patent No. 160776) for a multifunctional cage for introducing, transporting, and rearing queen bees

Practical use of the Olshansky cage in U.S. conditions may be interpreted as an attempt to align the engineering characteristics of the introduction carrier with risks that are typological for the United States: temperature extremes during delivery, controllability of social contact, and reproducibility of procedures across different operations [1–3] [7]. The claims of utility model No. 160776 describe the design as a multifunctional cage for the introduction, transportation, and rearing of honey bee queens, with a rectangular cross-section body; a queen compartment connected through openings to a feed compartment; a bee entrance opening; lateral ventilation openings; and a removable, horizontal top lid [13]. Manufacture of the body and lid from durable transparent food-grade plastic is specified, as is the geometry of an elongated inverted trapezoidal prism, along with the presence of an additional compartment for placing queen cells in the instrumental insemination procedure [13]. The second claim introduces external lateral support projections for connecting cages to one another when stacked vertically, which is constructively relevant for batch circulation of queens in production supply chains [13]. In this interpretation, the cage serves as a material instrument for reducing losses at the stages of introduction and transportation, and for procedures with elevated technological sensitivity, including the

introduction of newly inseminated queens [8][13]. The analytical synthesis of the correlation between the principal production risks of the U.S. queen market and the corresponding functional characteristics of the multifunctional cage for introducing, transporting, and rearing queen bees is presented in Table 1.

Table 1

Correlation between U.S. production risks and the functional characteristics of the multifunctional cage for introducing, transporting, and rearing queen bees

Production risk/operational problem in the USA	Indicator affected by the risk	Functional requirement for the cage	Structural feature of the multifunctional cage described in the article	Expected applied effect
Temperature fluctuations during interstate transportation	Queen survival, sperm viability, and subsequent reproductive quality	Provision of air exchange and reduced sensitivity to overheating or overcooling during shipment	Side ventilation openings; suitability for safe transportation; body made of durable transparent food-grade plastic	Greater transport stability and reduced risk of loss of queen quality
Risk of queen rejection or injury during introduction	Level of queen acceptance by the recipient colony	Provision of controlled contact between the queen, accompanying bees, and the recipient colony	Separation of functional compartments; queen compartment connected to the feeding compartment; opening for bee entry	Reduced tension during introduction and increased probability of queen acceptance
Variability of controlled queen release procedures across different beekeeping practices	Adaptation time, onset of egg laying, and procedural reproducibility	Compatibility with different queen introduction procedures and ease of handling	Removable horizontal top cover; functional subdivision of the internal space; suitability for introduction procedures	Easier standardization of working operations and lower dependence on the beekeeper's individual technique
Increased technological complexity of working with instrumentally inseminated queens	Preservation of reproductive quality and successful queen introduction after insemination	Presence of a specialized space for delicate operations and compatibility with procedures in this category	Additional compartment for placing queen cells in instrumental insemination procedures; suitability for operations involving instrumentally inseminated queens	Expansion of the cage's application in specialized queen rearing
High seasonal intensity and batch-based circulation of queens in industrial supply chains	Operational stability of circulation and convenience of serial use	Suitability for batch movement and compact placement within the production process	External lateral support projections for connecting cages during vertical stacking	Improved logistical convenience and suitability for serial use
Need to combine transportation, temporary holding, and queen introduction in a single device	Continuity of operations and reduction in the number of queen transfers	Multifunctionality of the design without changing the carrier at different stages of work	The cage is defined as multifunctional for queen rearing, transportation, and queen introduction	Reduction in the number of manipulations with the queen and lower technological losses within the production cycle

Source: compiled by the author.

Conclusions and prospects for further research. The described cage design demonstrates features of technological adaptability to the conditions of commercial queen breeding and industrial logistics in the United States, as well as to introduction procedures with increased requirements for preserving the reproductive quality of queens. A promising direction for further research is the conduct of controlled comparative trials with the recording of queen acceptance rates, time to onset of oviposition, survival, and colony stability under different temperature and transportation regimes.

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