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BeeConSel - Joint Effort for Honey Bee Conservation and Selection

DELIVERABLE 1

Situation assessed

BeeConSel is funded by Iceland, Liechtenstein and Norway through the EEA and Norway Grants Fund for Regional Cooperation.

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EXECUTIVE SUMMARY

The main objective of the WP1 “Assessment of current status” is to evaluate as clearly as possible the state of the art of honey bee breeding activities and mating control as a key tool for both conservation and selection in beneficiary partner countries (Croatia, Slovenia and Macedonia). A survey was developed within this work package and deployed among registered and/or queen breeders with significant production capacities in Croatia (HR), Slovenia (SI) and Macedonia (MK). Data were collected, introduced, summarised and presented graphically or tabularly. Another important part of this work package is economic analysis of honey bee queen production and mating which reveals the average cost of queen production and controlled mating of queens and drones. This report, in addition to the conducted survey, contains an overview of the historical and current conditions of honey bee breeding in the project beneficiary countries. With activities in this work package, the current situation is assessed upon the information and data available to the project team.

The survey was conducted on a total of 88 honey bee breeders: 36 from HR, 31 from SI and 21 from MK. The number of interviewed breeders covers more than 70 % of registered breeders in these countries, and therefore the results and conclusions of the survey are relevant and give a unique insight into the current state and perspective of bee breeding and queen production in three beneficiary countries. The aim of the survey was to assess the current status of queen production, breeding and mating control in each of the interviewed breeders. The survey consisted of 59 questions divided into three main parts: I. general information about the breeder (15 questions), II. breeding and queen rearing (24 questions) and III. mating control (21 questions). In the general part, we collected information such as the age and gender structure of breeders, their education and operation size. In the breeding and queen rearing parts, we found out about breeders' breeding experience, traits that they consider to be important for selection, their views on genetic analyses as a tool in their breeding, their production and marketing capacity and the general obstacles they face. In the third part, concerning the mating control, we collected information about mating control and approaches they use, satisfaction level of applied mating control methods, attention they put to drone production and use, and whether they intent to improve the mating control. After collecting questionaries, they were verified by identifying typing

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mistakes and illogical answers and summarized in spreadsheets. The data were analyzed and summarized in graphs and tables.

Economic analysis included 20 honey bee breeders: 4 from HR, 6 from MK, 8 from SI and 2 from Spain (ES). The average cost of production of one mated queen is 42.05 EUR and the average selling price of mated queen is 17.96 EUR. In general, there is a negative difference between the selling and the production price, which at variable costs is -2.50 EUR and at total costs is -24.09 EUR. When we consider the cost of mating and compare production costs of open mating (without strict control from the paternal side) and controlled mating queens, we could see that the production price of queen with control mating is 53.86 EUR, which is two times larger than production price of 27.61 EUR for queen produced with open mating. In the end, with the current prices, control mated queens generate on average -17.58 EUR losses per produced mated queen, while the open mated queens on average generate 17.82 EUR profit per mated queen.

Looking at the main findings of the survey and the economic analysis, we could conclude that breeders have knowledge and skills in technical aspects of queen production, which is shown by the high success of mating, grafting and queen hatching which they achieve. However, survey also revealed that less than 0.1 % of queen bees in all three beneficiary countries are coming from full mating control which may be partly the consequence of much higher costs of controlled mating. When we consider reports from individual countries, where mating control is identified as one of the main challenges in selection progress, it is evident that the BeeConSel project is very relevant and important for improving the current situation. In all three beneficiary countries there are excellent foundations for introduction of controlled mating: breeders are organized in breeders' associations; they have knowledge and skills for queen production and developed system for

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colony performance evaluation and selection. On top of that, breeders are aware of the importance of breeding locally adapted honey bees and of the fact that controlled mating of queens is one of the major aspects to achieve genetic improvement of stock. Most of surveyed breeders will be in business for more than a decade so it is worthwhile to invest time and money to facilitate mating control in the beneficiary countries. However, in order to achieve an increase in controlled mating without significantly affecting the price of the produced queens, breeders need professional and financial assistance in the initiation, organization and implementation of this important aspect of breeding.

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I. CURRENT STATUS IN BENEFICIARY COUNTRIES

Croatia

A brief history of honey bee breeding in Croatia

First written reports on queen production in Croatia are done by the famous beekeeper and lecturer on beekeeping Josip Belčić around 1970. The main problem he identified was the market and he could not sell larger quantities of queens. At that time, beekeepers that were buying queens were buying them from neighbouring Slovenia.

Breeding of honey bees in Croatia in last 20 years is implemented by the Association of Carniolan honey bee Breeders of Croatia (ACB[1]). The association is located in Zagreb and was founded in 1999 to protect and promote common ecological and economic interests, as well as the goals of the association's members, in a form of non-profit organisation. The association is engaged in the breeding of suitable queen bees based on the Act on Breeding of Domestic Animals (NN 115/2018[2]). Breeding is carried out by the ACB in accordance with the official Breeding program[3].

The main goal of the ACB is breeding and conservation of the native honey bee (*Apis mellifera carnica*), and production of productive queens with improved colony performance traits.

The objectives of the ACB are:

- development and improvement of breeding and performance testing of selected queen bees in the territory of the Republic of Croatia;
- taking measures to protect the domestic (native) selected subspecies, population, stock of honey bees;
- implementation of environmental protection measures;

[1] http://pubweb.carnet.hr/matica/
[2] https://narodne-novine.nn.hr/clanci/sluzbeni/full/2018_12_115_2241.html
[3] http://pubweb.carnet.hr/matica/wp-content/uploads/sites/132/2020/12/Uzgojni-program-2020.pdf

- constant concern about the improvement of economic conditions for breeding, health protection of colonies and breeding of native selected queen bees.

The breeding program aims to establish and emphasise the economic qualities of the Carniolan honey bee, respecting its diversity and ecotypes. A very important goal is to standardise the quality of the bred stock with a focus on the traits that will have the most significant economic effects on the overall Carniolan bee population in the Republic of Croatia: productivity increase, high calmness on the comb and gentleness low swarming behaviour, improved wintering ability and disease resistance. Each breeder conducts testing and selection of queens at her/his operation and selects the colonies for breeding the next generation of queens.

Current beekeeping situation in Croatia

According to the data of the Croatian Beekeepers Association (CBA), in 2022 there are 9,182 registered beekeepers with 460,191 honey bee colonies, which gives an average of 50 colonies per beekeeper. The characteristic of beekeeping is extensive and hobbyist production. The percentage of professional beekeepers is small, but it is constantly increasing. According to the data from 2018, a significant number of beekeepers who keep bees with a small number of colonies (up to 30) is 3,024 or 41.5 % of the population and beekeeping is their hobby. In total, they own 52,088 or 14.0 % of the total number of colonies. Over half of the registered beekeepers (3,992) own between 31 and 150 colonies, and they make up 54.8 % of the total number of beekeepers, and they own a total of 255 251 colonies or 68.6 %. Two hundred and sixty-seven registered beekeepers (3.7 % of the total number) have more than 150 bee colonies and are defined as professional beekeepers. Professional beekeepers have a total of 64,663 hives, and their share is 17.4 % of the total number of colonies. The average professional beekeeper works with 242 colonies. Most beekeepers are organised into local beekeepers' associations. The umbrella organisation that brings together the majority of

267

registered beekeepers have more than 150 bee colonies and are defined as professional beekeepers

17.4%

is the share of hives owned by professional beekeepers

242

is the average number of colonies that professional beekeepers have

beekeeping associations and beekeepers in the Republic of Croatia is CBA, which had 6,091 members in 2018.

The estimated annual honey production is based on data on average honey production per colony based on a survey conducted by Beekeepers Association. The total production in 2017 was estimated at 8,128 tons, while the production in 2018 was 7,440 tons of honey which averages around 20 kg of produced honey per colony. The placement of honey on the market depends on the size of the bee farm. Beekeepers with a smaller number of colonies predominantly sell through one of the forms of direct sales (at the place of production, at local markets). As the number of colonies increases, the share of wholesale sales increases. About 3/4 of beekeepers' market bee products through direct sales, while 1/4 of beekeepers participate in wholesale sales. Sales in retail chains and supermarkets are covered by large honey suppliers and packers.

From the point of view of the total number of bee colonies in beekeeping in the Republic of Croatia, the need for the production of queens can be estimated at around 100,000 queens per year, with the replacement of queens every 2 to 3 years. The number of produced queens by members of the breeders' association in 2022. was around 60,000, which gives enough space to increase production.

Current breeding situation in Croatia

The Carniolan honey bee (*Apis mellifera carnica*) is an autochthonous subspecies of honey bees in Croatia and aim of the breeding program is to preserve the uniqueness and promote good economic values, while keeping the biological diversity high. The breeding program is carried out on the original population of bees that are kept and bred throughout the country. The basis of breeding are the apiaries of registered queen producers from which the best colonies are selected for further propagation and reproduction. Each breeder conducts testing on 50 honey bee colonies from which he selects about 10 % of the best for production of next generation. Given that the goal of the breeding program is to protect the native population, and within the framework of recent studies on the

interaction of genotype and the environment, queens bees grown outside the Republic of Croatia are not accepted for breeding by the Breeding program, and the breeding of local populations adapted to the climate, pastures and technology in the territory of Croatia is encouraged.

Queen production was increasing yearly from 1994 until 2002 when subsidies for queen production were terminated. In 2013 subsidies were reinstated and the production of queens from that moment grows, almost yearly. Today, there are 52 registered queen bee breeders from all over the Republic of Croatia, with a population of around 11,000 honey bee colonies, who produced 58,000 queens in 2022.

However, there are a lot of beekeepers that commonly breed queens for their own purposes. Every year registered queen breeder is obliged to send 12 young mated queens for performance testing. Out of these 12 queens, 9 are sent to 3 different apiaries for full performance testing, and three queens are tested in a laboratory for morphological traits (such as the number of spermatozoa in spermatheca and the presence of nosemosis spores in queen and attendant bees). All breeders are obliged to carry out breeding in accordance with the official Breeding program, which is verified by the Ministry of Agriculture, while the control of the implementation of the breeding program is carried out by the Association of Carniolan honey bee queen breeders of Croatia.

Every breeder conducts a performance test on at least 50 colonies every year on the following traits:

- strength of the colony
- honey production
- swarming drive
- disease resistance
- overwintering ability
- gentleness/ defensive behaviour
- calmness (bee behaviour on the comb)

The breeding value is calculated by using the selection index, which combines the score for honey production, swarming behaviour, calmness on the comb and defensive behaviour.

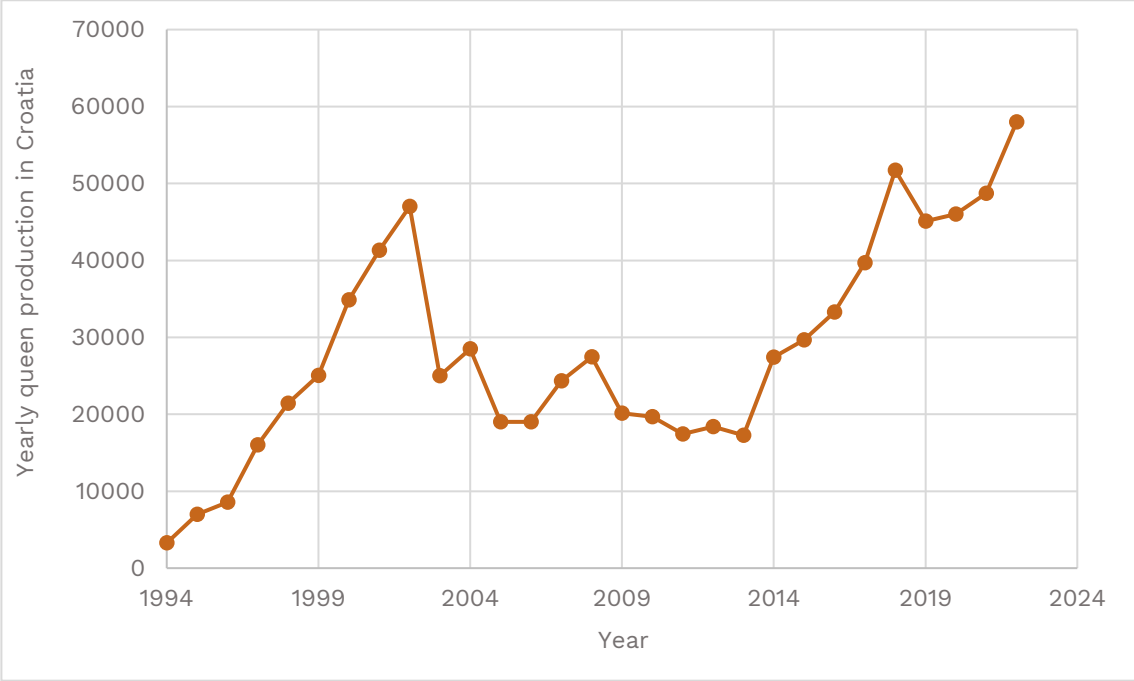


Figure 1. Number of queen bees produced in Croatia from 1994 to 2022. Source: CBA

Challenges facing and perspectives of honey bee breeding in Croatia

One of the most important problems when it comes to honey bee breeding in Croatia is related to mating control. With a lot of experience and available tools, breeders usually face no problems with the technical and management aspects of queen production. However, full mating control is a challenge that currently no breeder can cope with. Most of them have mating stations which are not completely isolated because of a high density of apiaries. Establishing an isolated mating station on some of the islands on the Adriatic coast is costly, and the current price of the queen mated under isolated conditions cannot compensate for the investment of such a mating station. Therefore, future activities and breeding strategies should tend to improve this situation, show the way and provide simple tools and methods of controlled mating that could be used by the majority of breeders without significantly increasing production costs.

Slovenia

A brief history of honey bee breeding in Slovenia

The breeding program in Slovenia was initiated several times in the last century. The current implementation[4] was conceived in 1984 by the late Dr Janez Poklukar, who managed to get it formalized by 1987 and even obtain private funding to support it[5]. The breeding program was placed under the control of the Agricultural Institute of Slovenia. With the redrafting of the animal husbandry law, the breeding programs were transferred to the relevant breeding associations 2010s. In the case of honey bees, the lead went over to the Beekeepers' Association of Slovenia, whereas the Agricultural Institute of Slovenia retained the responsibility to develop, manage and execute the program.

Records from the beginning of 20th century show the efforts of several individuals who traded with queen bees. This includes the establishment of the first mating stations in Kamniška Bistrica (N Slovenia in 1932), Fužine pri Kokri (1938, Central Slovenia), Ukanc (Bohinj, NW Slovenia) and Glažuta (Pohorje, NE Slovenia), both in 1940. After WWII, the beekeepers producing queens organised themselves in a cooperative (COOP). In 1947, COOP board set up a plan to threefold increase the number of mating stations[6] resulting in ten new mating stations by 1969. However, by 2010, there was only one left which ceased operation in 2013. Meanwhile, an animal husbandry law[7] was passed together with several bylaws, which copied guidelines for establishing new mating stations from European beekeeping powers, namely Germany. The concept required a fully isolated mating station to prevent foreign drones and thus maximising genetic gain. However, following the intensive political campaign by the Beekeepers' Association, number of registered colonies almost doubled from 2010 (116,000) to 2021 (213,000) - it turned out to be almost impossible to find an isolated location in Slovenia:

[4] Kozmus P et al. 2018. Rejski program za kranjsko čebelo (2018 - 2023). Čebelarska zveza Slovenije.
[5] Adamič F et al. 1998. Zbornik of stoletnici delovanja Kmetijskega inštituta Slovenije. Kmetijski inštitut Slovenije, Ljubljana.
[6] Naše obveznosti ob prvi petletki. 1947. Slovenski čebelar 49 (9): 252
[7] Zakon o živinoreji, 2002. Official Gazette of RS 18/02

only one new mating station was confirmed in last decade, Rog - Ponikve, which also ceased its operation by 2018.

Traditionally, the most important traits in selection program are gentleness and pigmentation of the abdomen, which both fit into the traditional perception of the local honey bee subspecies. The former has some economic value in decreasing the workload; the abdomen pigmentation, however, has no known link to production performance. However, some breeders are actually using pigmentation as a proof that they are selling pure Carniolan subspecies in their marketing strategy.

Current beekeeping situation in Slovenia

Apiculture in Slovenia is perceived as a one of national traditions. With more than 11,000 registered beekeepers and 213,000 colonies on 20,000 km^2 of country area, formal colony density is one of the highest densities in EU, with more than 10 colonies / km^2! However, in terms of resource harvesting, the colony density is even higher. Most of the colonies (99.9 %) are registered below 1,000 m.a.s.l. and among agricultural crops only 3-6 % provides any kind of food resources to honey bees. After subtracting »useless« areas (high altitude, urbanized areas) and areas covered by crops that do not require pollination (and do not provide food for bees), such as maize, the density is increased to cca 15 colonies/km^2. Such density has several consequences not planned by promotors of beekeeping: difficult disease control, competition for limited resources and relevant to this project, lack of isolated locations available for controlled mating.

Yearly honey yield per colony is one of the lowest in EU, averaging around 9.5 kg per colony with maximum of 2500 tons in 2011 (19.5 kg/colony). In the year 2021 official state-wide production was down to 195 tons (0.9 kg/colony), with untypically bad weather to blame. Regardless of the reason, honey yield shows decreasing trend which pushes beekeepers into diversification of production. Honey bee products (honey, pollen, propolis, royal jelly) still represent most important source of

income, yet the producing and selling of nucleus colonies or apitourism services are now often added to portfolio.

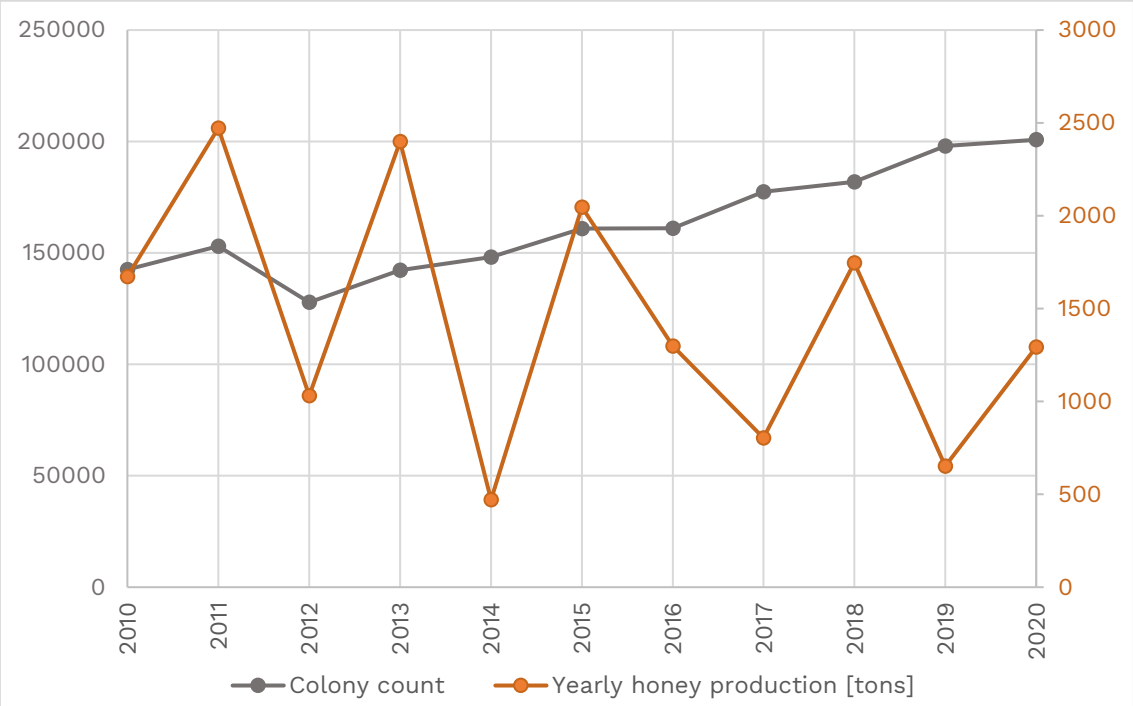


Figure 2. number of registered honey bee colonies (blue) and in honey production (orange). Sources: Administration of Food Safety, Veterinary Sector and Plant Protection & Slovenian Statistical Office.

Current breeding situation in Slovenia

The Slovenian Breeding program is built around the herd book database, managed at the Agricultural Institute of Slovenia. The database shows the increase in the number of reared queens within the breeding program from 26,500 in 2010 to 45,900 queens in 2018 (Fig 3). In the last years, the number is being stable at around 40,000 per year, and 1/3 are exported. There is no data on how many queens that are produced outside the official breeding program; we believe that number is considerable. By participating in the breeding program, the queen breeders get expert help, objective performance testing and zootechnical documents about conformity to the program. Yet the participation in the breeding program is on a volunteer basis, provided that the breeders have the required qualifications, and their beekeeping operation has capacity. Thus, there is about 30-33 registered breeders per year, with only 3-4 women; about 1/3 of them have their operations in NE part of the country (Fig 4), with only one breeder in the submediterranean region of Slovenia.

Thirteen breeders register production of more than 1,000 queens/yearly; there are two or three, depending on the year, that rear more than 5,000 queens per year. With only one functioning mating station, the number of full pedigree queens was naturally low - 555 at its peak, meaning 0.1 % of total production. Only few breeders expressed interest and these queens were meant for market and not to be kept as own stock. With such low numbers, the genetic progress of the managed population in Slovenia is negligible, leaving beekeepers without critical tools to respond to modern challenges.

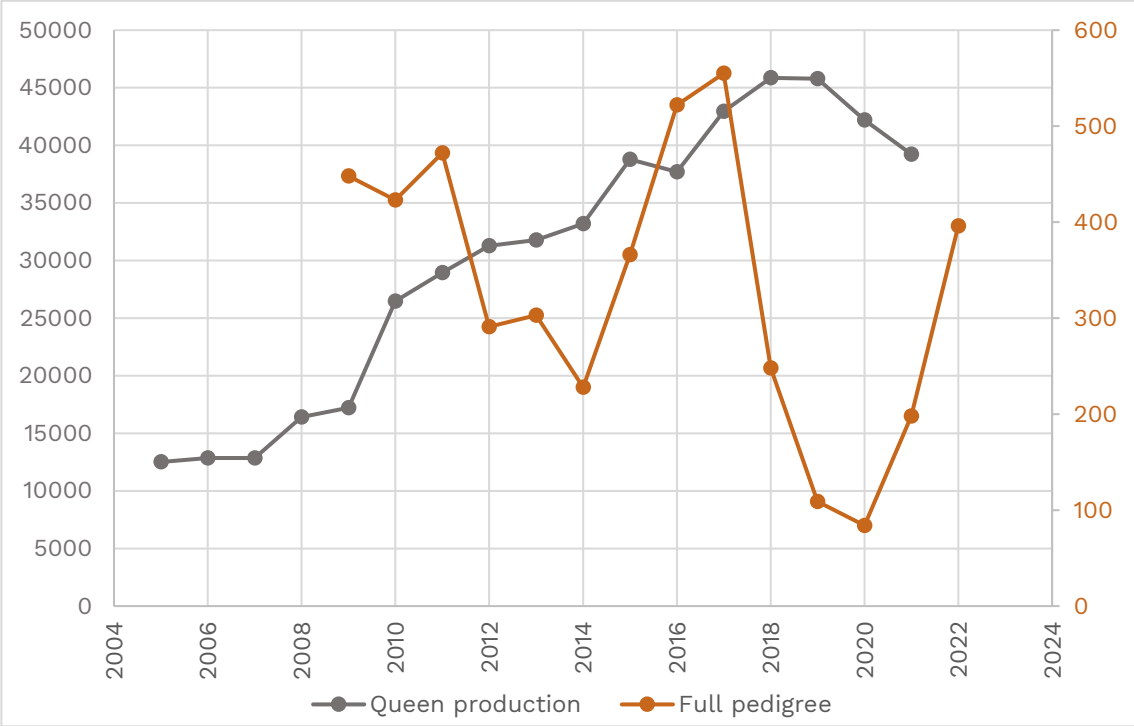


Figure 3. Yearly queen production (blue) and a yearly production of queens with full pedigree - e.g. queens being mated at the mating station (orange). Source: Pedigree Book at Agricultural Institute of Slovenia

The structure of the breeding program differs from the BeeBreed (https://www2.hu-berlin.de/beebreed/ZWS/) scheme which is heavily promoted in some countries: the performance testing is done within the breeders's apiary only, without reference to offset the effect of beekeeper/environment. However, an additional layer is added to assist with selection: about 15 daughters per breeding queens is distributed to independent performance testers (beekeepers) in the following year for progeny testing, in double-blind fashion to evaluate mentioned effects. The weak point of this rather complicated scheme is that until recently, own performance testing by breeders was not coupled with progeny testing; a situation that was remedied recently. The second weakness was bringing

back the successful breeding colonies into the selection. In the last two years, KIS acted as an intermediary in providing the single public mating stations with daughters of breeding queens with outstanding grades as queens as drone-producing colonies.

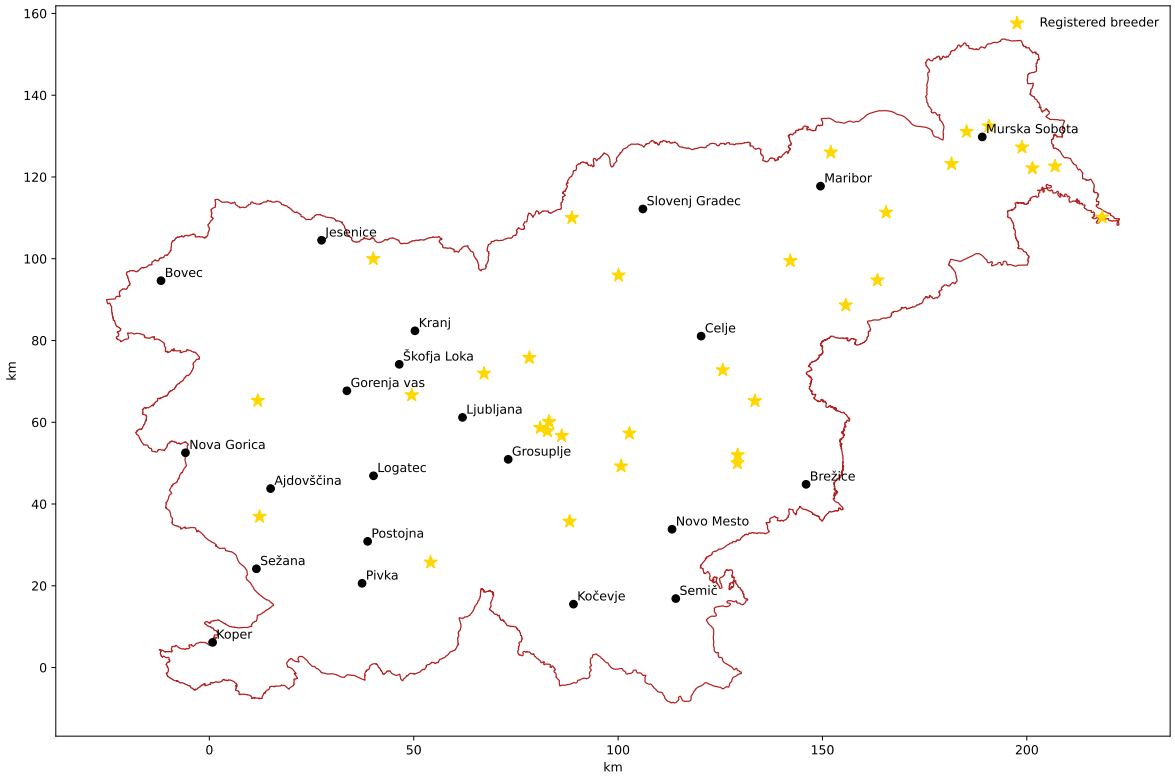


Figure 4. Apiaries of registered breeders in 2022 (yellow asterisks). Major cities in black.

Challenges facing and perspectives of honey bee breeding in Slovenia

There are several challenges that need to be either solved or circumvented to improve the breeding success in Slovenia.

First and foremost is the availability of mating control as a method. The current mating station was shown as not completely isolated; however, there is (yet) no idea how good the location is. Following the results from BeeConSel project, the most optimal approach will be suggested. The second issue is the understanding of the importance of mating control by the queen producers. This issue reduces the drive to implement, use and cooperate at the mating stations.

Third issue is of the administrative nature: the law currently regulating honey bee part of animal husbandry doesn't give any provisions for the mating

stations. At the moment, it is not possible to get financial support through breeding program for a public mating station run by (local) association. Only the breeder (individual) is entitled to file for financial support for the mating station. Consequently, only one mating station as a service to the breeders (without the need to be run by a breeder) exists.

Fourth is a financial motivation for buying more expensive full pedigreed queens from the mating station or paying for instrumental insemination.

Macedonia

A brief history of honey bee breeding in Macedonia

Traditionally honey bee breeding in Macedonia has been in the hands of individual beekeepers who spontaneously selected queens from the colonies that performed best. The selection criteria dominantly included honey production, overall colony vitality, the queen's body size and colony behaviour. Nevertheless, historically, colonies' swarming events were used for rearing queens, and beekeepers supposedly expressed that gentleness was associated with colony performance and fitness. Organised breeding efforts were lacking, and most of the beekeepers purchased young queens from a limited number of beekeepers who were recognised as queen producers with experience in queen rearing. Worth to be mentioned is that there are reports that the Macedonian beekeepers purchased queens or traded for honey, mainly from Slovenia, Croatia and Serbia (ex-Yugoslavian republics), unaware of the importance of local adaptation.

The first attempt for organised queen production in Macedonia was in the 1970's with the establishment of the queen rearing unit (so-called repro-centre) in Demir Kapija under the agricultural combinate Povardarie from Negotino. The repro-centre managed more than 500 honey bee colonies with 8 employed beekeepers, but ceased its activities around 1990's. Until around 2004 the nucleus (new colonies in half-size hive body) production was financially supported by the Ministry of Agriculture (old name), which subsidised the queen production with individual (mainly big-scale) beekeepers responsible for organised production.

In 2004 Apicentar dooel Skopje was registered under the Register for breeding associations in the Ministry of Agriculture, Forestry and Water Management (MAFWE) as the first formal honey bee breeding centre in

Macedonia. The breeding program encompassed international standards for colony assessment, with honey production, colony development and defensive, swarming, and hygienic behaviour being the main traits of breeding interest. With about 100 colonies, the annual production averaged 600 queens, with the highest production of 1,100. However, Apicentar, with the use and propagation of queens from the native origin, had a major role in changing the beekeepers' understanding and knowledge about the existence of native honey bee population, *A. m. macedonica*[8].

Honey bee breeding was formalised for the first time in the Law for Animal Husbandry 07-104/1 from 2008). The law also defined special conservation status of the native Macedonian honey bee population, *A. m. macedonica*. The primary and, subsequently, the secondary legislation regulated the procedures for registration of breeding centres, breeding and queen production and honey cadaster.

In 2011, The Macedonian association for the conservation of the native Macedonian honey bee - MacBee (www.macbee.mk), was established by beekeepers and enthusiasts for the conservation of biodiversity. The main goal was to raise awareness among the beekeeping and general public communities about conserving the native honey bee population. In addition, the association initiated a breeding program for genetic improvement and conservation of the native stock by applying the principles of "conservation by utilisation" and following the international standards of honey bee breeding[9]. In the meantime, three other breeding centres were registered for honey bee breeding and queen production (Table 1).

[8] Ruttner (1988) Biogeography and Taxonomy of Honeybees; Uzunov et al. (2014) Genetic structure of *Apis mellifera macedonica* in the Balkan Peninsula based on microsatellite DNA polymorphism.
[9] Büchler et al. (2013) Standard methods for rearing and selection of Apis mellifera queens; Uzunov, Büchler, Bienefeld (2015) Performance testing protocol.

Table 1. An updated list of formally registered honey bee breeding centres, year of registration, breeding program implementation period, registered production capacity, mating control status and traits of interest.

Name	Implementation period	Registered capacity*	Mating control status	Traits of interest (by priority)
Eko pcela	2013-2017 2018-2021	1200	Partially controlled	Honey production, Vitality Gentleness Swarming tendency
Apicentar	2014-2018 2019-2021	2000	Partially controlled	Vitality, Gentleness, Honey production, Swarming tendency
Stojanovski	2014-2018 2019-2021	2000	Partially controlled	Honey production, Gentleness, Vitality Swarming tendency
Apika	2017-2021	Not defined	Partially controlled	Gentleness, Swarming tendency, Vitality, Honey production

There were no records of the realised production and distribution of queens at centres or the overall country level.

The financial support for the queens reared under breeding programs started in 2010, but due to administrative obstacles mainly associated with the tender procedure, the measure was mostly not implemented effectively.

Extensive research activities related to honey bee breeding in Macedonia have been conducted since 2005, primarily focusing on studying and description of the native honey bee diversity. Historically, the local honey bee population in Macedonia was described and recognized as *A. m. carnica*, similar to the populations in the neighbouring regions such as Serbia, Croatia and Slovenia. However, with the emerging scientific arguments, significant efforts were invested towards confirmation of Ruttner's finding that a separate honey bee population exist in Macedonia, named *A. m. macedonica*.

There were intensive research activities including participating in some of the most prominent research initiatives in the past 15 years (COLOSS GEI study 2014-2018, EU project SMARTBEES 2014-2018, EU project EURBEST 2018-2022). The Faculty of Agricultural Sciences and Food (Ss Cyril and Methodius University in Skopje), alongside MacBee, was the institution conducting or participating in most of the activities, including research on mating control on Snake Island (2008-2014) and pioneer study on Jo Horner

(2017). The Faculty of Agricultural Sciences and Food was also enrolled as an official administrator of the activities related to the programs for the Conservation of Livestock Biodiversity (2011-ongoing) and Genetic improvement (2011-2020), financed under the MAFWE.

Current beekeeping situation in Macedonia

According to the State Statistical Office in Macedonia (SSO) 92,968 honey bee colonies (Figure 5) were registered in 2021, maintaining the overall trend of gradual increase of the number of colonies by year. However, according to the Agency for financial support in agriculture and rural development (AFSARD), the number of honey bee colonies is significantly higher (a case study from 2016 shown in Common Market Organization report[10]).

The country's annual average production of the last decade (2010-2019) slightly surpassed 700 tones in the range from almost 400 to 1,100 (Figure 5). According to SSO data, annual honey consumption in the period 2010-2019 is 0.6 kg per household member and 2.3 kg per household.

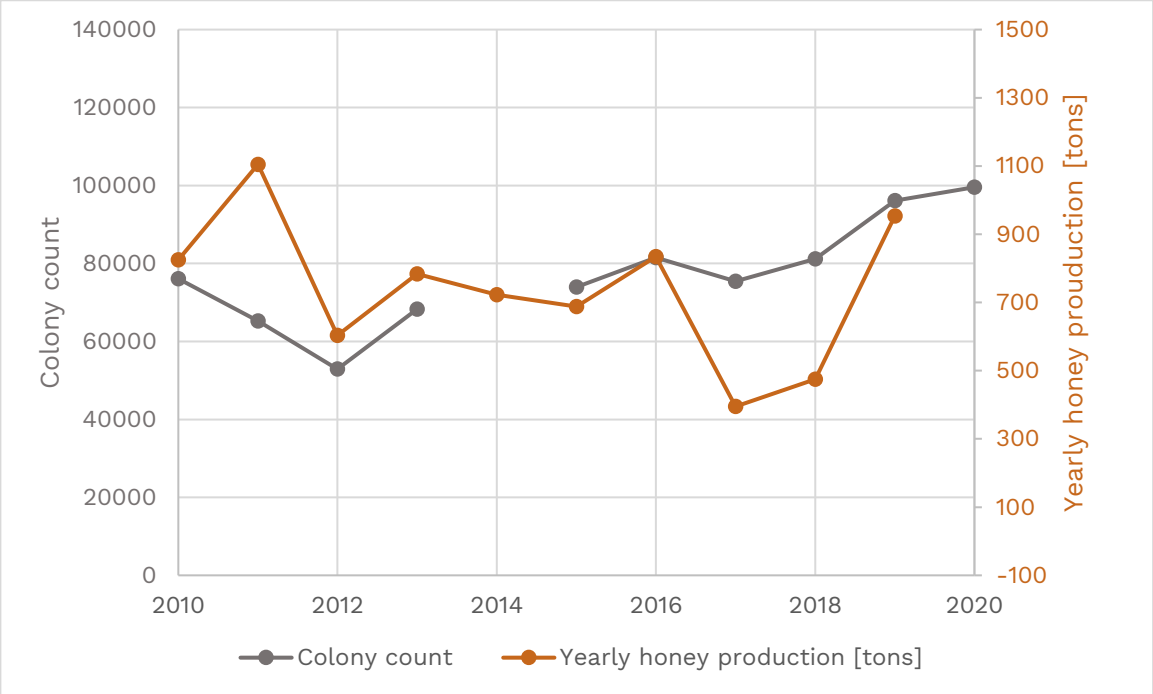


Figure 5. The number of honey bee colonies (blue line) and honey in tones (orange line) from 2010 to 2021. Source: SSO database.

[10] Dimitrov, Uzunov, Simonovska (2021) Common Market Organization report.

For 2019, AFSARD reported 4114 beekeepers, of which 3,124 or more than 75 % belong to operation size categories from 31 to 100 colonies (Table 2). For most beekeepers, beekeeping represents a secondary or semi-commercial occupation, while everything below 30 colonies can be categorized as a hobby. Professional and commercial beekeeping is limited to a small number of beekeepers, mainly keeping more than 150 colonies.

Table 2. Number of beekeepers according to the operation size, number of colonies declared for subsidies, 2019, AFSARD)

Size of operation	<=30	31 to 50	51 to 100	101 to 150	151 >	Total
Number of beekeepers	661	1464	1,660	186	143	4,114
Share from total (%)	16.1	35.5	40.4	4.5	3.5	100

Based on the survey done in 2020[11] on a sample of 56 beekeepers, the average age was 49.6 years, with 58.9 % of them with higher education. Most of the surveyed beekeepers (69.6 %) practice stationary beekeeping, 14.2 % migrate and the remaining portion practice combined beekeeping. Langstroth-Root (LR) hive was dominantly used for 58.9 % of the surveyed beekeepers, followed by Dadant-Blatt (DB) (8.9 %), Farrar (FR) (5.4) and 26.8 % of the beekeepers using another type of hive.

In 2021, SSO reported 11,055 honey bee colonies in organic production, out of which 4,953 colonies were in conversion and 6,102 certified. However, in the last 9 years (2013-2021), there has been a registered positive trend in organic production (Table 3). More than half of the organic beekeepers manage between 51 and 100 colonies, and around one quarter to be with more than 101 colonies[8].

Table 3. The number of honey bee colonies in organic production (2013-2021). Source: SSO database (2022).

Year	2013	2014	2015	2016	2017	2018	2019	2020	2021
Conversion	1,238	1,098	1,404	2,252	2,360	2,257	1,979	4,277	4,953
Certified	4,910	5,074	4,700	5,628	5,304	5,881	7,082	5,552	6,102
Total	**6,148**	**6,172**	**6,104**	**7,880**	**7,664**	**8,138**	**9,061**	**9,829**	**11,055**

The average winter colony losses, monitored in the framework of the international COLOSS network, for the period from the winter season

[11] Dimitrov, Uzunov, Simonovska (2021) Common Market Organization report, MAFWE.

2007/2008 to 2021/2022 is 15.6 % and ranged from 8% in 2015/2016 up to 30.9 % for the winter season 2011/2012[12].

According to AFSARD report (2019), in 2019, beekeepers applied for subsidies when more than half of the total number of restarted beekeepers (52 %) applying for subsidies had less or equal to 50 honey bee colonies, 40 % were from 51 to 100 colonies, and 8 % operated with more than 100 colonies (Table 2).

The current subsidies per honey bee colony for operations with more than 20 colonies is 700 MKD (11.4 EUR). The threshold of minimum of 10 colonies is set for the beekeeping operations in the listed rural areas. However, an additional 50 % per colony is compensated for organic beekeeping. The total value of subsidies in Macedonia per year (2015-2019) is given in Table 4. Beekeepers who purchased queens from the registered breeding centres are eligible to be compensated with 50 % of the price (excluding VAT). For beekeepers classified as young farmers or for areas with limited production capacities, the support is higher. In addition, the registered breeding centres were eligible to apply for subsidies of 1000 MKD (16.3 EUR) per registered colony in the breeding operation.

3.5%

is the share of hives owned by professional beekeepers

700 t

is the country's annual average honey production of the last decade

11,055

honey bee colonies in organic production

Beekeepers are eligible to apply to the National Programme for rural development (investments in honey production, young farmers, support to NGOs, training, etc.) and the IPARD programme.

Table 4. Value of the subsidies according to the number of beehives declared for subsidies in millions, 2015-2019. Source: AFSARD, 2021

	million MKD (EUR)						Total (EUR)
	2015	2016	2017	2018	2019	Total	
Total	125.6 (2)	139.7 (2.3)	134.7 (2.2)	168.3 (2.7)	174.7 (2.8)	742.9	11.8

[12] Uzunov et al., unpublished data.

Current breeding situation in Macedonia

After intensive promotion in the last decade, mainly by Faculty of Agricultural Sciences and Food – Skopje and MacBee beekeeping association, the Macedonian honey bee has been well recognised by the beekeepers as a native population. Moreover, as mentioned before, in the current Law for Animal Husbandry (07-104/1 from 2008), the native honey bee has a special conservatory status. However, social media propaganda and access to the global market motivated many beekeepers to import queens from the non-local origin, dominantly from Carnica, Buckfast and, to some extent, Italian honey bee populations. With the import of non-native stock, its use, and even multiplication and marketing by non-registered breeders, there is a non-reversible process towards hybridisation and genetic erosion of Macedonia's native honey bee population. To counteract the current trend, MacBee association, in cooperation with FASF, launched a massive medium campaign, "Одгледувам македоника, одгледувам наше!" (Figure 6. Eng.: "Breeding macedonica, breeding our own").

Figure 6. A wall and online poster for promoting conservation efforts for A. m. macedonica.

Nevertheless, due to the announced change of the current Law for Animal Husbandry, no breeding centre is enrolled under the National Register for breeding associations Registered (MAFWE).

Currently, only MacBee association continuously runs its systematic breeding program for a decade (five test generations). The current breeding capacity is limited to 13 breeders (testing locations) across the country, totalling 156 testing colonies per testing cycle. The association is the first breeding capacity to introduce estimated breeding values (EBV), following the adapted to honey bees' Best Linear Unbiased Prediction (BLUP) Animal Model. The performance data and pedigree database are developed and maintained under its platform.

Since 2011 the FASF has monitored the diversity of the native honey bee population in Macedonia by morphometrical

and molecular analysis. As a result, besides the evidence of hybridisation in some regions of the country, the native population can be classified as non-endangered.

Challenges facing and perspectives of honey bee breeding in Macedonia

The current main challenge and risk for selective honey bee breeding in Macedonia is the uncontrolled and illegal importation of queens of non-local origins. A lack of recognition of the breeding efforts as well as the absence of a quality and administrative control system alongside a populistic and commercial propagation of non-local genotypes commend the negligence of the native honey bee stock.

Mating control occurred to be the missing element of the breeding programs that crucially incapacitate the genetic improvement of the Macedonian honey bee population. Therefore, the deficiency of established mating control significantly reduces the genetic progress, and the improvement of the native stock, which certainly contribute to lack of recognition and appreciation from the Macedonian beekeepers. Such circumstances encourage the importation of foreign stock, leading to the instigation that leads to genetic erosion of the Macedonian honey bee population.

Finally, there is a lack of effective legislative and financial support to counteract the current position mainly by addressing the challenges related to high investment and running costs, a shortage of topic-specific training, low awareness for the negative consequences of use of non-local stock, and market development.

II. SURVEY ON CURRENT STATUS AMONG HONEY BEE BREEDERS

The main idea of the survey was to access the current status of all parts of breeding: structure of breeders, their success in production and how they deal with mating control. The survey was conducted on a total of 88 queen breeders: 36 from HR, 31 from SI and 21 from MK. Such an extensive survey conducted on most of the registered breeders in Croatia, Slovenia and Macedonia until now has never been performed and it provides valuable information. Here we comment on most relevant questions.

General information about the breeder

Q1. Age

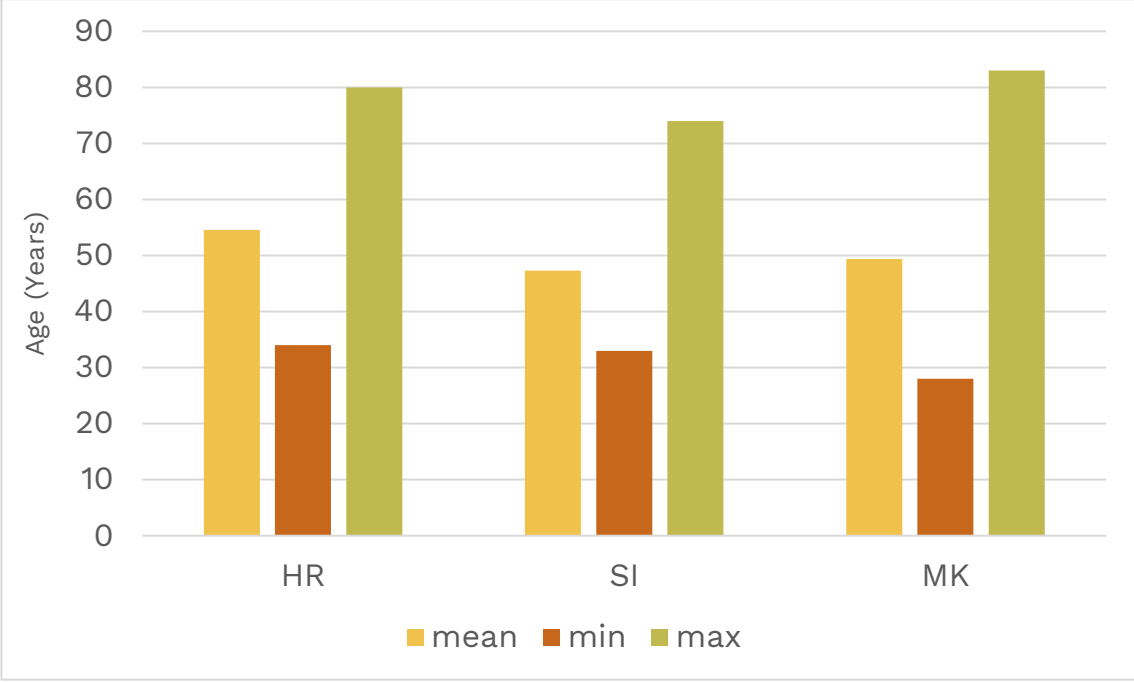


Figure 7. The average age (yellow), the youngest (orange) and the oldest (green) breeder

The average age of breeder in Croatia is 56, in Slovenia 48 and in Macedonia 50, which generally points to the fact that it is necessary a lot of experience to become breeder and it also reflects the general age of beekeepers. However, on the other hand, it is needed to invest efforts in order to involve more young people in the breeding.

Q2. Gender

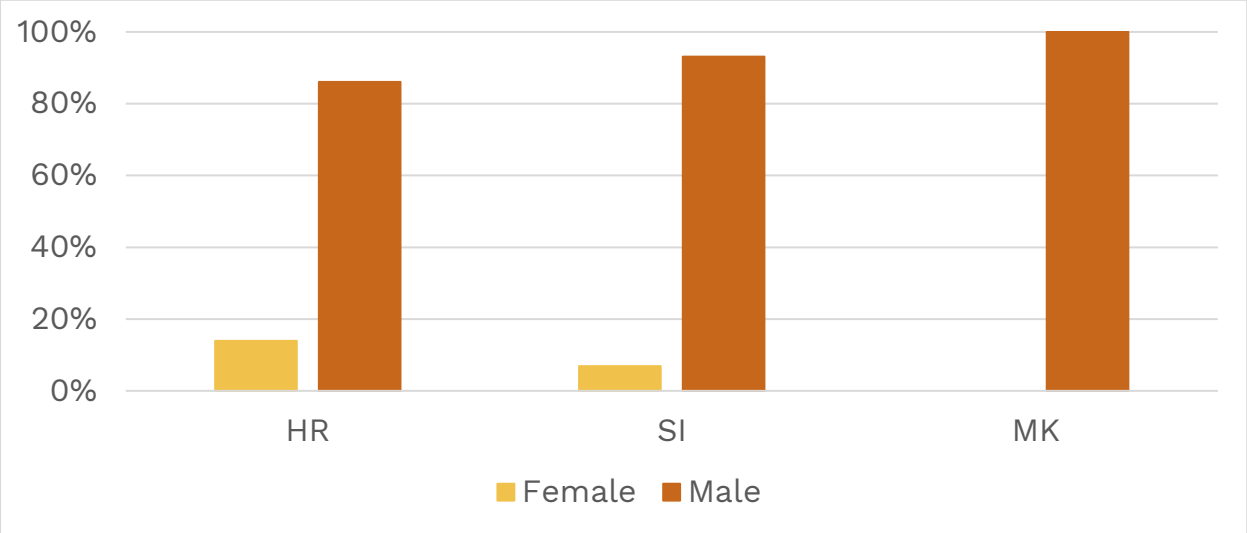


Figure 8. Gender distribution

In all three countries there is a strong sex bias towards males among the breeders, while female population is traditionally much more involved in post-harvesting operations in beekeeping, such as honey packaging, marketing and sales.

Q3. What is your highest level of education?

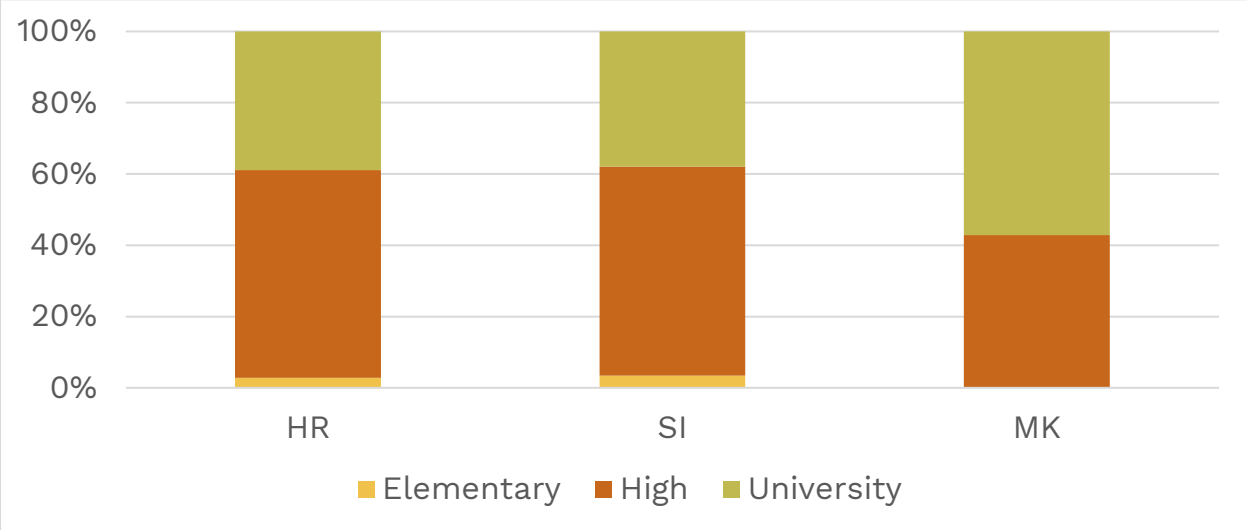


Figure 9. Education of breeders

There are around 40 % of breeders with university degrees in Croatia and Slovenia and almost 60 % in Macedonia. Such an educational structure in the beekeeping sector provides a great basis for the introduction of

contemporary and novel approaches for intensification and improvement of the beekeeping production in all three countries. In fact, that is particularly relevant for breeding, which requires a competency and expertise in biology, genetics and breeding.

Q4. Are you a member of the breeders' association/group?

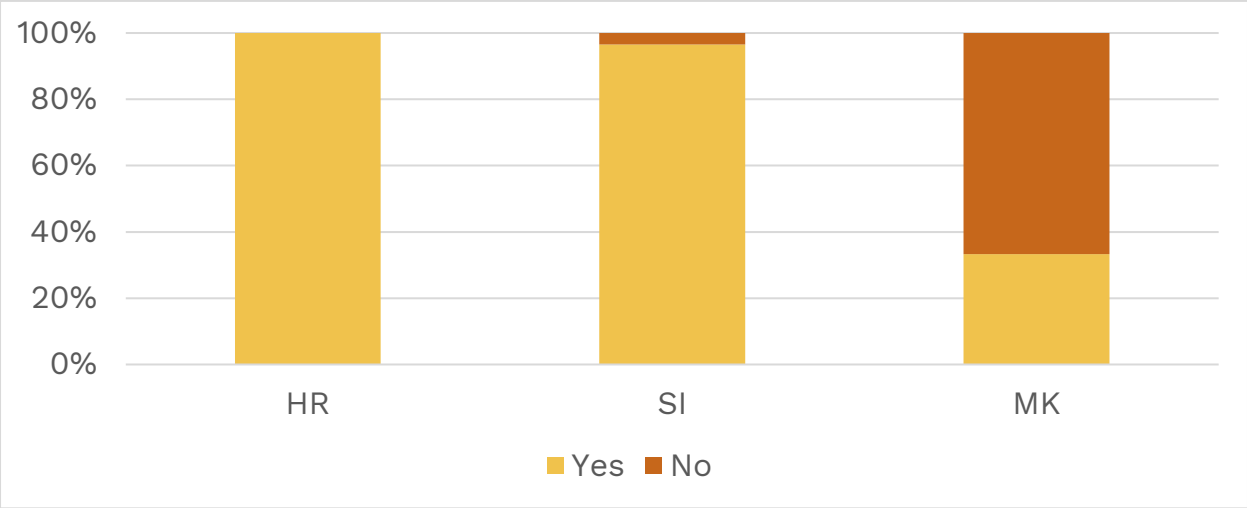


Figure 10. Share of breeders who are members of a Breeding Association (yellow) and who are not (orange)

Interestingly, In HR and SI, almost all breeders are members of a breeding association while in MK only one-third of breeders are in associations. A lack of existing operative National (umbrella) associations in MK might demotivate breeders to be associated with any of the beekeeping organizations. Furthermore, breeding activities (programs) are conducted individually on the operational (company) level without the involvement of any beekeeping association.

Q5. Is your beekeeping operation inherited or did you start by yourself?

Beekeeping is a traditional branch of agriculture that is often passed down from generation to generation. This is clearly seen in Slovenia where almost 60 % of breeder operations are inherited. In HR and MK around 30% of operations are inherited and the higher ratio of newly established beekeeping operations could be a consequence of the socio-economic and transitional conditions (unemployment). Therefore, beekeeping has been attractive due to low start-up investments.

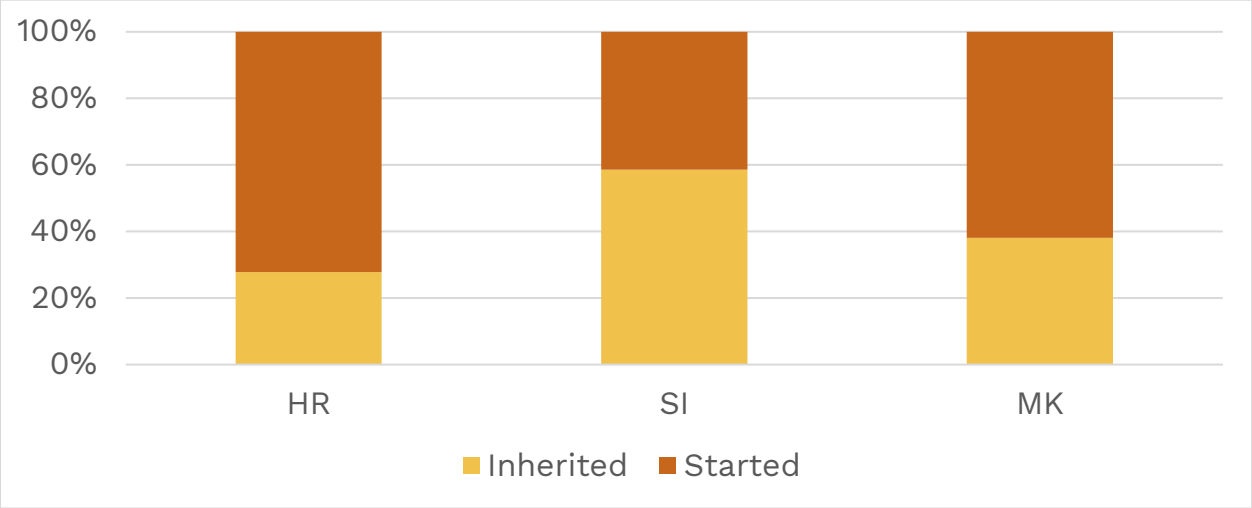


Figure 11. Tradition in beekeeping

Q6. How many years of beekeeping experience do you have?

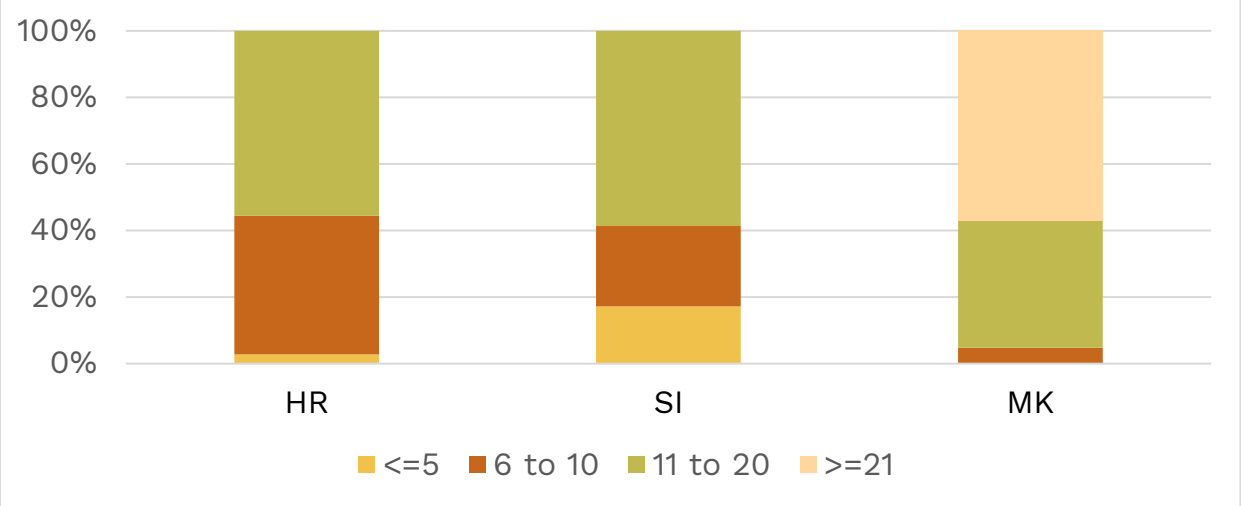


Figure 12. Years of experience in beekeeping

As for experience in beekeeping, it is interesting to point out how more than 50 % of breeders in MK have more than 21 years of experience, while in HR and SI there is not a single breeder with that long experience. Breeding is a specific job that requires a high level of knowledge in beekeeping, so it is not surprising that there are very few breeders who have less than 5 years of experience in beekeeping.

Q7. What types of hives do you use?

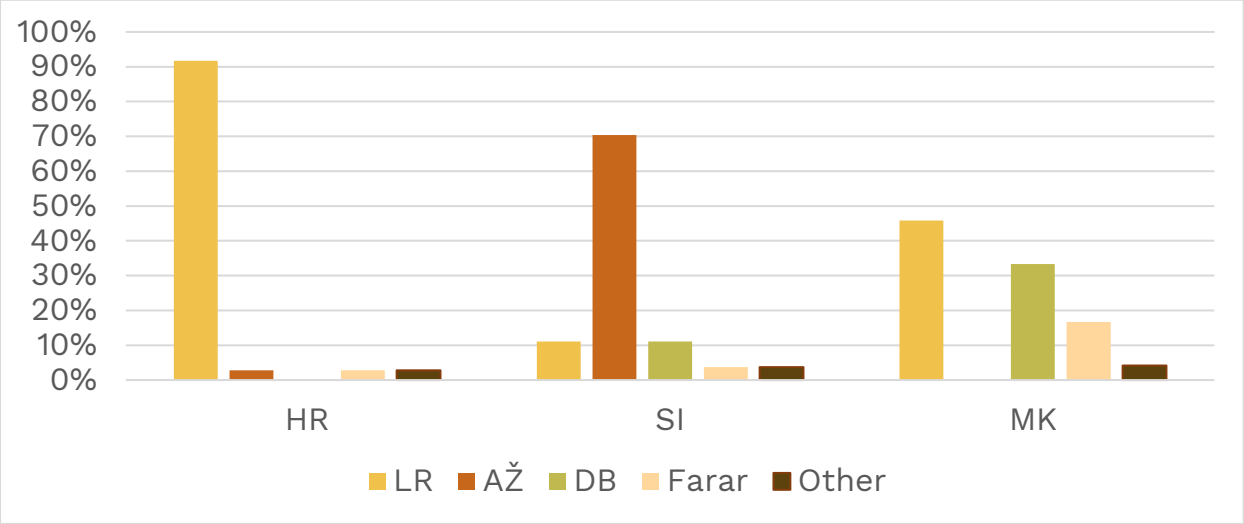


Figure 13. The type of hive used

This question reveals one of the basic differences in beekeeping between these three countries. Breeders in Slovenia use mainly the traditional Slovenian Alberti-Žnidaršič (AŽ) hive, while breeders in Macedonia and Croatia use the Langstroth-Root (LR) and Dadant-Blatt (DB) hives. However, such difference does not particularly affect the queen rearing and breeding.

Q8. How many colonies do you currently operate in total (all colonies including nucleus colonies)?

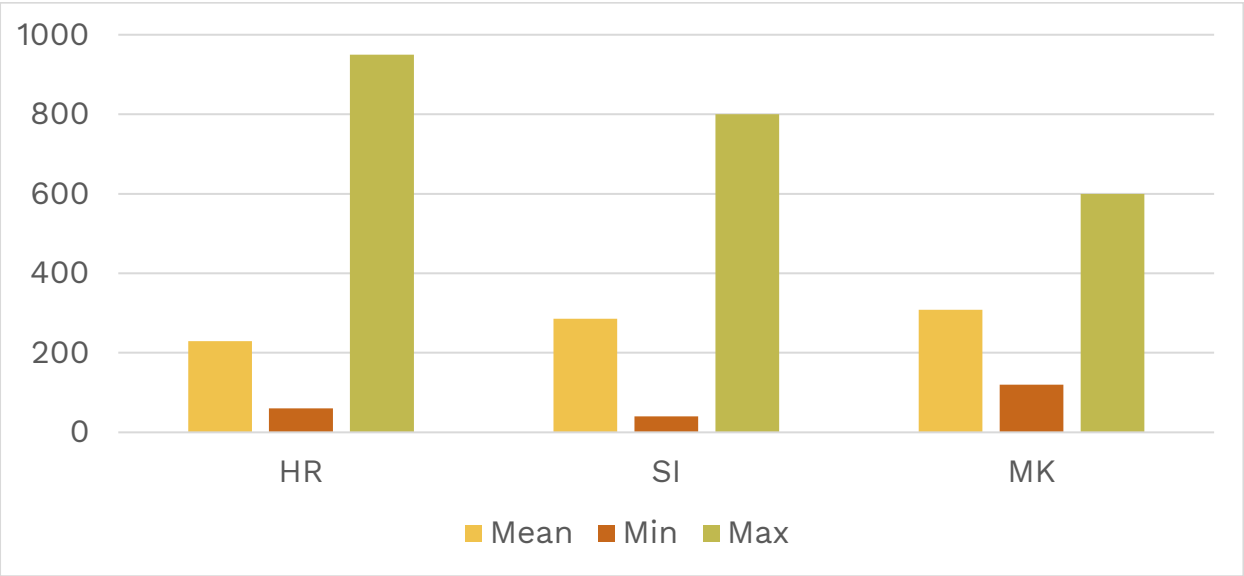


Figure 14. Number of colonies in a beekeeping operation

The mean number of colonies operated by breeder ranges from 200 in HR to 300 in MK, which is around three times more than the average beekeeper in these countries. Since breeders need bigger capacities to organize queen production, testing and mating, it is not surprising that those capacities are significantly higher comparing to the countries' averages of colony numbers per beekeeper.

Q9. What share of your colonies are used for queen production (for all activities concerning queen production)?

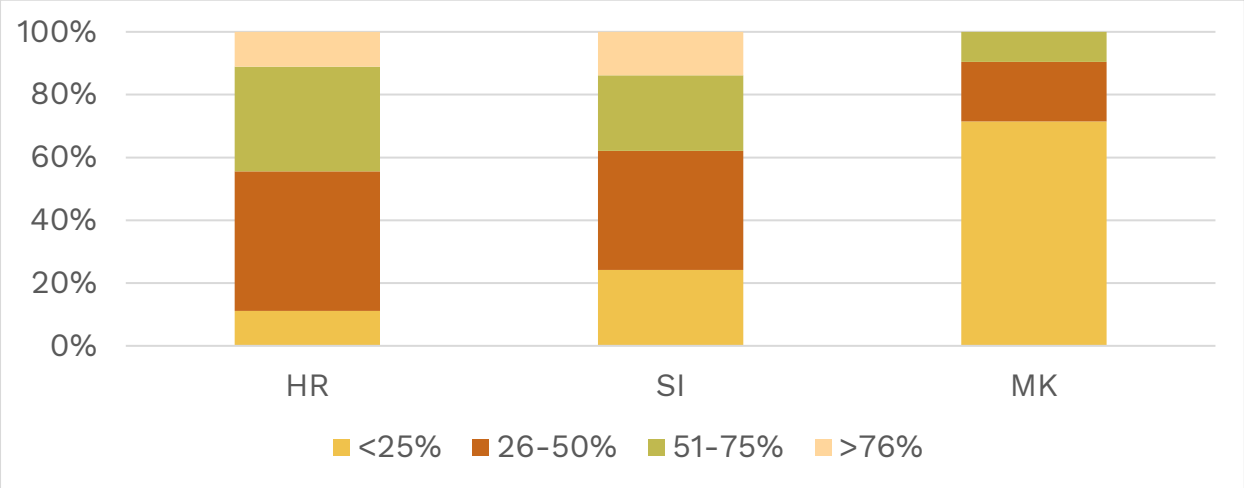


Figure 15. Percentage of colonies used for queen production

In HR and SI, the average breeder uses between 26-50 % of all colonies for queen production. However, in MK most of breeders use less than 25 % of all colonies for queen production, which is probably a consequence of non-developed queen market, lack of export options due to the high price of honey that Macedonian beekeepers realise, and from that aspect, honey as a product represents an important source of income for them.

Q10. On how many localities do you keep bees (number of apiaries)?

On average, breeders in Slovenia have the most apiaries, while breeders in Croatia and Macedonia have fewer apiaries where they keep a larger number of hives. The peculiar technology of breeding (performance testing, queen production, mating, etc), which is not enrolled in the traditional beekeeping practice, requires management of the colonies on multiple locations. It is interesting to note that the largest breeder in Slovenia keeps 800 hives on 35 apiaries (23 hives/apiary), in Croatia 900 hives in 11 apiaries (82 hives/apiary) and in Macedonia 600 hives on 12 apiaries (50 hives/apiary).

Q11. Modality in operation:

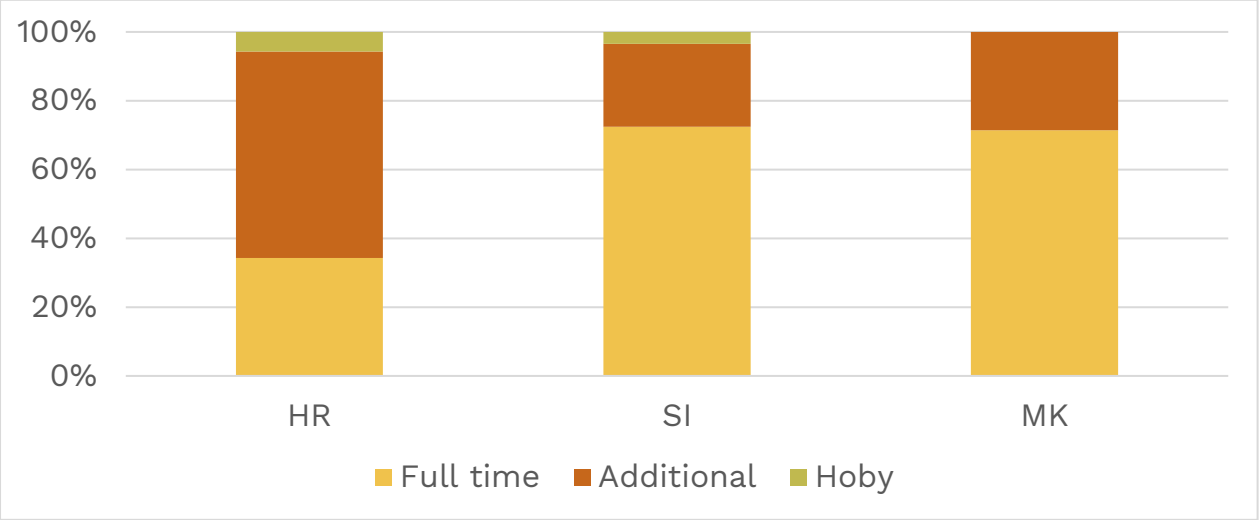


Figure 16. Modality in operation/employment

While the beekeeping and queen rearing as a full-time job is option for one third of the respondents in Croatia, it is much higher in Slovenia and Macedonia where about 70 % do this work professionally. The high percentage of full-time employment in MK is a consequence of the significant rise of prices for the hive products, in particular of honey.

Q12. Do you have certified education in beekeeping (university, course certified on the national level)?

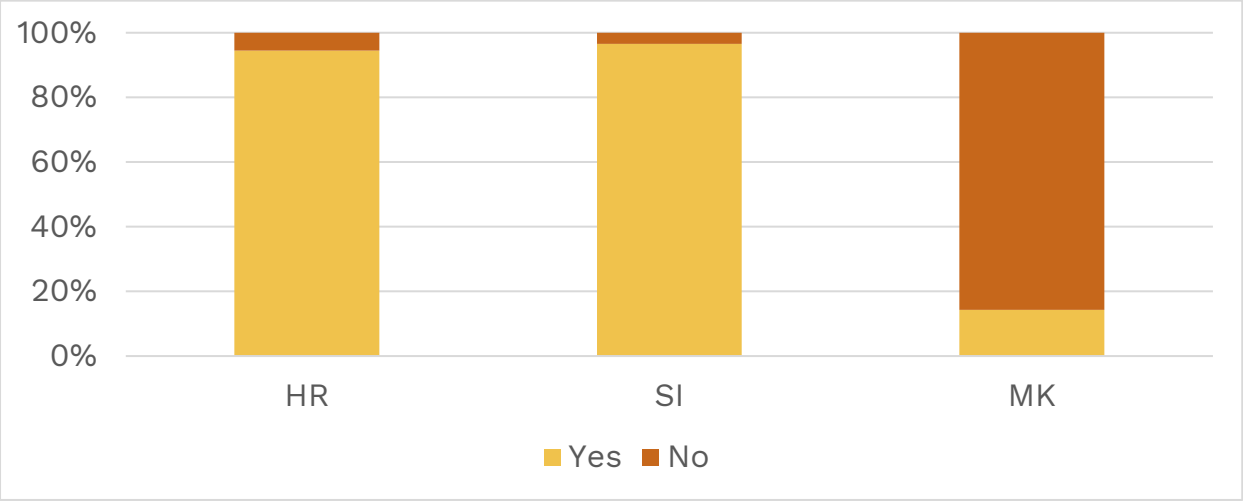


Figure 17. Certified education in beekeeping

The fairly large difference in education in beekeeping between Croatia and Slovenia on the one hand and Macedonia on the other is probably a

consequence of the long tradition of beekeeping courses in Croatia and Slovenia and the lack of extension services and beekeeping schools/capacities in Macedonia.

Q13. Do you have certified education in breeding and selection (university, specialized certified course)?

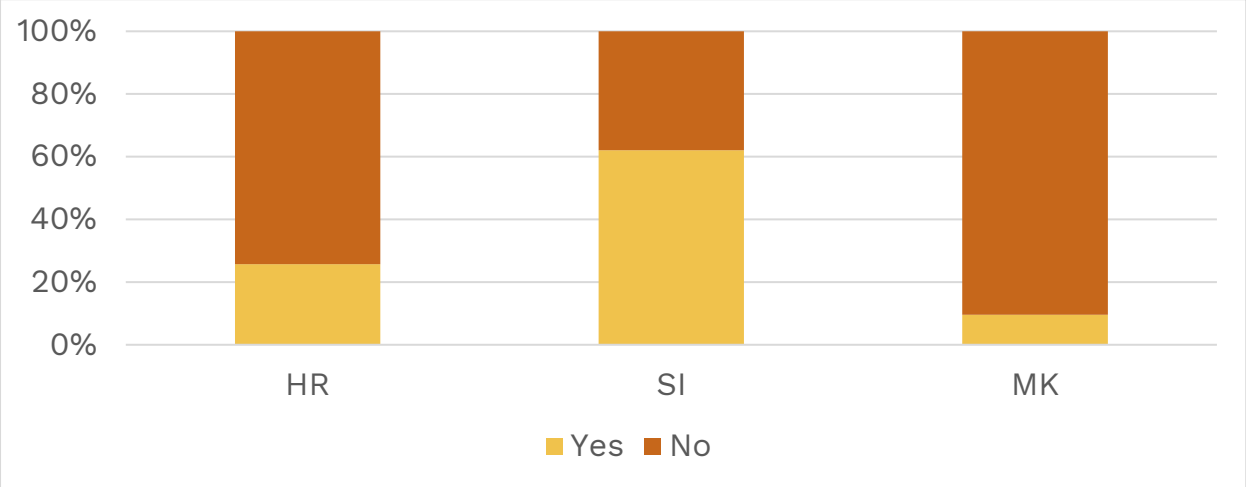


Figure 18. Certified education in honey bee breeding

Low level of certified education in beekeeping and breeding and high percentage of breeders with university level education in MK reveals that it might be the majority of breeders graduated on a university that is not related to animal breeding and agriculture. However, more than 60 % of breeders in Slovenia have certified education in breeding which indicates the existence of a breeding education program in Slovenia.

Q14. Have you been trained for instrumental insemination?

Instrumental insemination has no tradition in these three countries, and breeders do not use this method as an excellent tool to gain fully controlled mating of queens. The high investments related to the required equipment and training is a significant factor for such a low use of instrumental insemination.

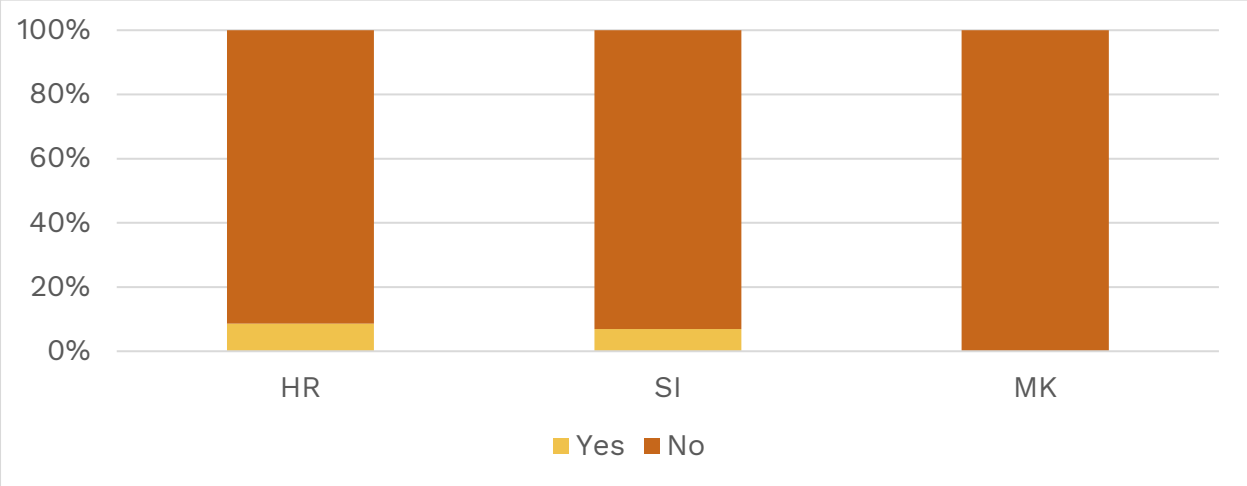


Figure 19. Training and education in instrumental insemination

Q15. How long do you plan to rear queens?

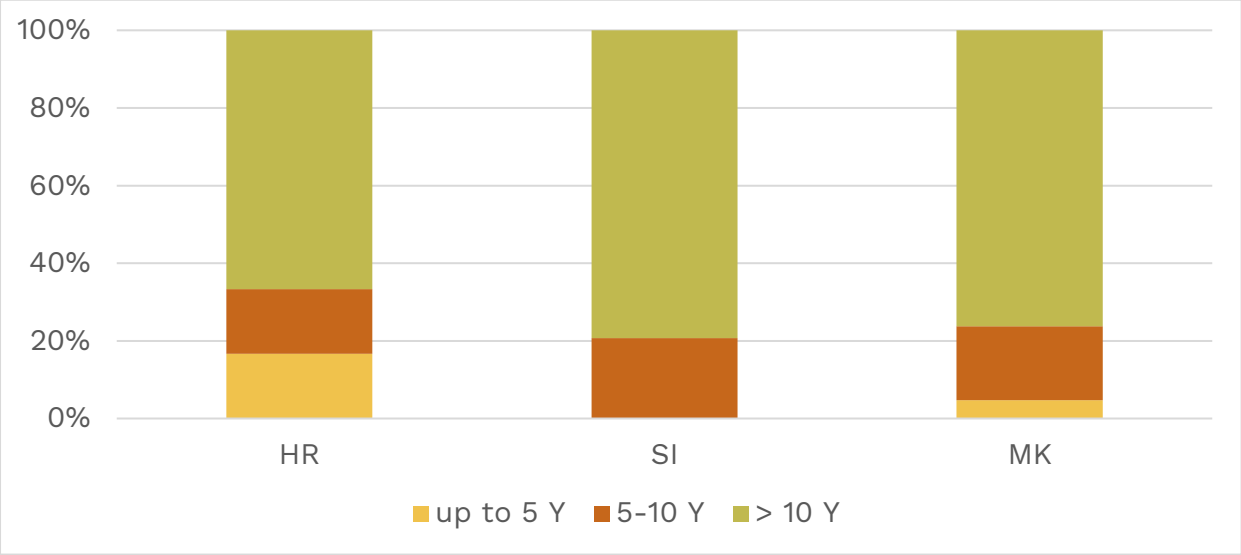


Figure 20. Planned engagement in honey bee breeding

Although the average age of a breeder is around 50 years, in all countries the majority of breeders plan to be engaged in this business for more than 10 years. This justifies all investments and education of breeders, because progress in selection work is achieved only after several generations.

Breeding and queen rearing

Q16. How many years have you continuously run your own breeding/selection?

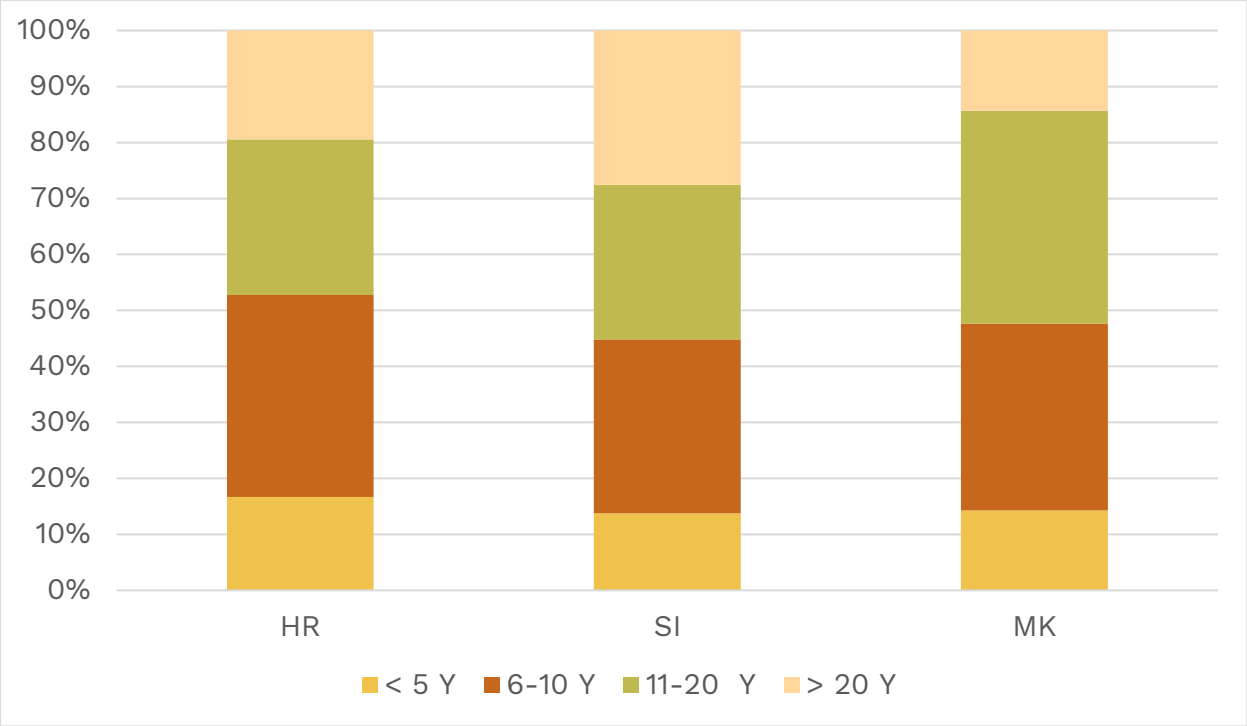


Figure 21. Years of breeding and selection

Beside the long experience in beekeeping in general, half of the breeders have more than 11 years of experience in breeding and selection which represents an excellent basis for improving the existing operations.

Q17. What is your opinion on the existing performance testing methods in your breeding program?

Around 60 % of breeders are satisfied with the current performance testing methods. Still, there are 40 % of breeders that would like to have an improvement in the methods they are obliged to use.

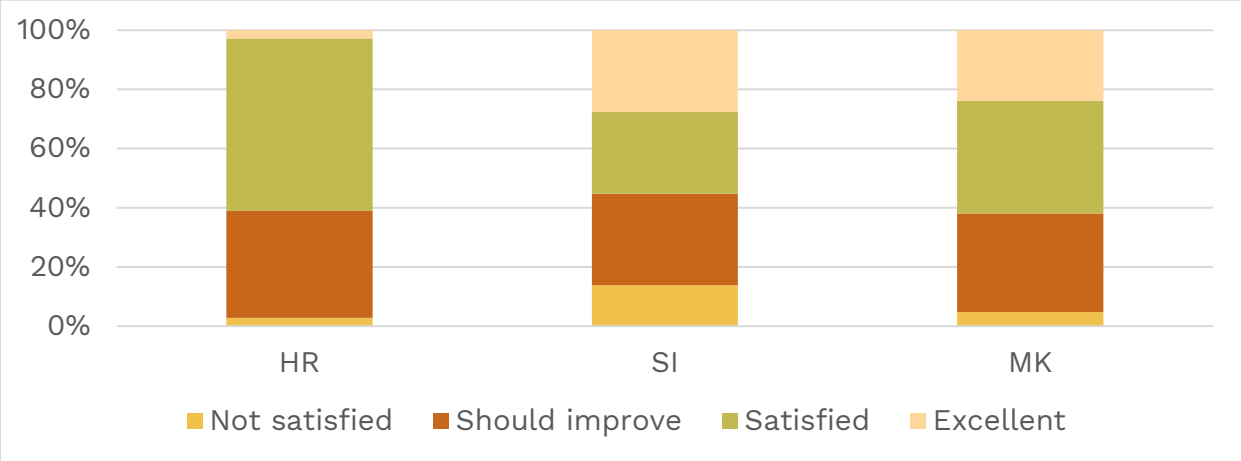


Figure 22. Opinion on the existing performance testing methods

Q18. How important are the following traits to you (1 not important, 4 very important)?

Table 5. The importance of different traits for breeders

		Colony development	Overwintering	Gentleness	Swarming	Honey production	General disease resistance	Hygienic behaviour	Varroa resistance
HR	1	0,00%	0,00%	2,78%	5,71%	0,00%	0,00%	0,00%	0,00%
	2	0,00%	2,86%	2,78%	0,00%	2,78%	0,00%	0,00%	2,78%
	3	11,43%	20,00%	33,33%	45,71%	27,78%	11,11%	11,11%	27,78%
	4	88,57%	77,14%	61,11%	48,57%	69,44%	88,89%	88,89%	69,44%
SI	1	3,45%	0,00%	0,00%	0,00%	3,45%	0,00%	0,00%	0,00%
	2	24,14%	0,00%	0,00%	0,00%	13,79%	6,90%	0,00%	3,45%
	3	62,07%	20,69%	13,79%	27,59%	48,28%	24,14%	17,24%	24,14%
	4	10,34%	79,31%	86,21%	72,41%	34,48%	68,97%	82,76%	72,41%
MK	1	0,00%	0,00%	0,00%	9,52%	0,00%	0,00%	0,00%	0,00%
	2	4,76%	0,00%	9,52%	4,76%	0,00%	0,00%	0,00%	0,00%
	3	19,05%	4,76%	9,52%	33,33%	9,52%	9,52%	23,81%	14,29%
	4	76,19%	95,24%	80,95%	52,38%	90,48%	90,48%	76,19%	85,71%

Table 5 shows the importance of different traits for breeders in different countries. In Croatia breeders see as very important colony development and disease resistance, while swarming was rated mostly as important. Further, in Slovenia gentleness, swarming and hygienic behavior were recognized as very important in many cases, while honey production and colony development seemed less important. Finally, Macedonian breeders see overwintering ability, honey production and disease resistance as very important and swarming behavior little less important. It is possible that the importance of these traits is a consequence of the market or the desire of beekeepers that buy queens. There are speculations about relative unimportance of honey production among Slovenian breeders and the reason

most often recorded is unpredictability seasons in terms of honey production.

Q19. Are there other traits of interest for you (for instance: adaptation to climate change, prolonged brood-rearing season, defense against Vespa velutina, etc.)?

As for other traits, breeders often as a trait of interest highlight climate change adaptation, better production of other products (propolis and royal jelly) and preserving the purity of the subspecies. Beside these, Slovenian breeders seem to be interested in brood size and overwintering of the colonies.

Q20. Do you perform morphometric monitoring of your stock?

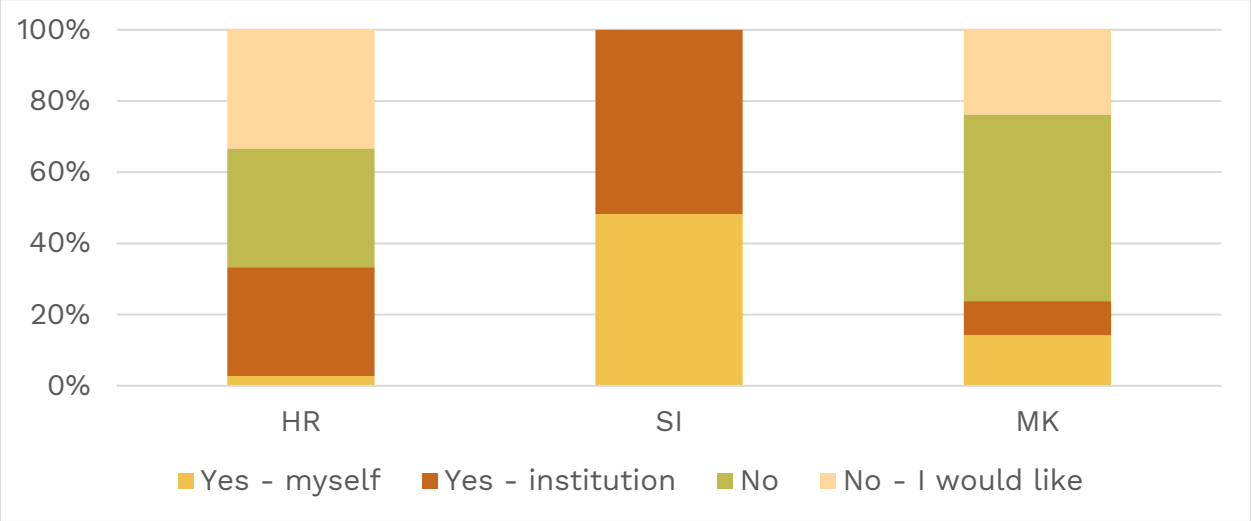


Figure 23. Morphometric analysis of own stock

The graph shows the consequences of the policy pursued by Slovenian beekeeping for a long time – preservation of autochthonous Carniolan bee. Therefore, all breeders in Slovenia carry out morphological analysis of bees, while in the other two countries less than a third of breeders carry out the same analyses. Still, we need to be careful with the interpretation of the data since morphometrics protocols can significantly vary in number of parameters (for instance from one such as Cubital index to a collection of more than 30) as well in complexity of the analysis.

Q21. Are you prepared to pay for morphometric analysis of your stock?

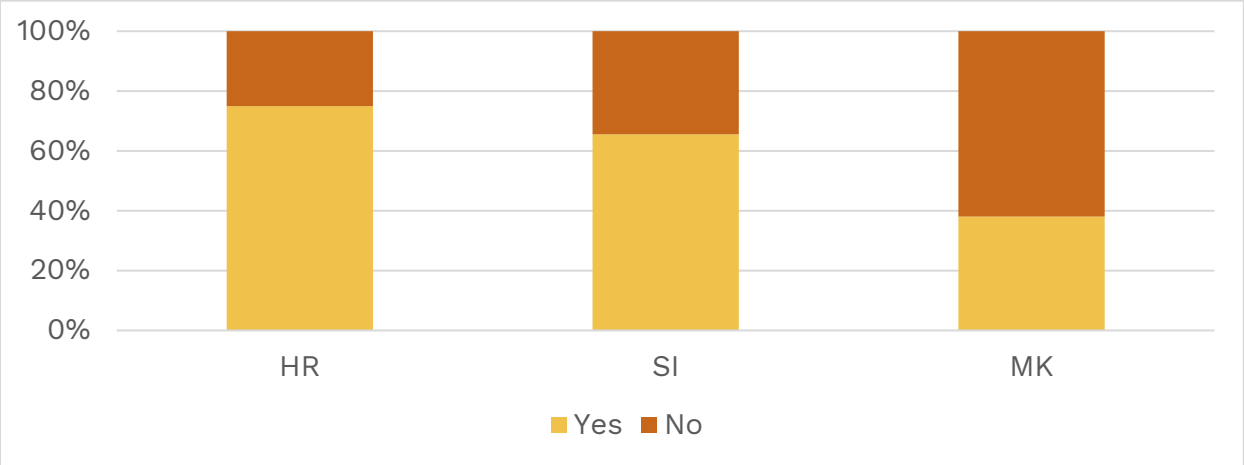


Figure 24. Willingness to pay for morphological analyses

The majority of breeders in HR and SI are ready to pay for morphological analysis of their own stock, while less than 40 % of MK breeders are willing to do the same. The lower readiness for investment in the morphometric analyses in MK might be a result of the low recognition by the local market for such methods to check purity of native bees.

Q22. How important to you is genetic analysis of your stock (analysis for subspecies determination, genetic analysis to improve varroa resistance etc.)

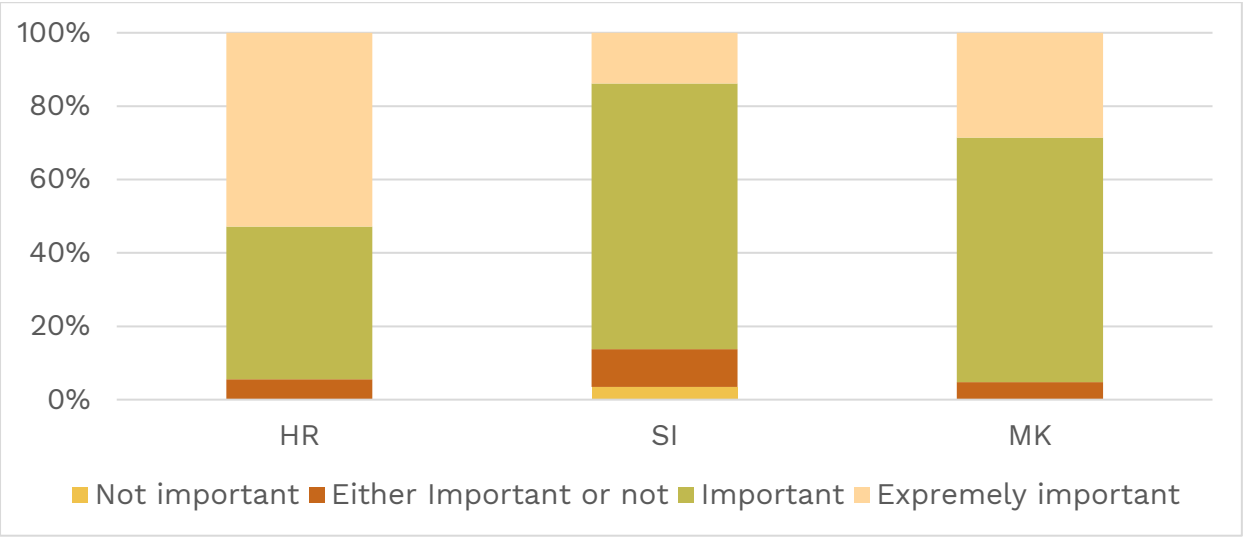


Figure 25. Importance of genetic analysis of own stock

The results showed that the vast majority of breeders see the potential and consider genetic analyses of bees to be important or very important to help determine subspecies or as a tool in the selection for varroa resistance.

Q23. Are you aware of the possibility of genetic analysis of your stock?

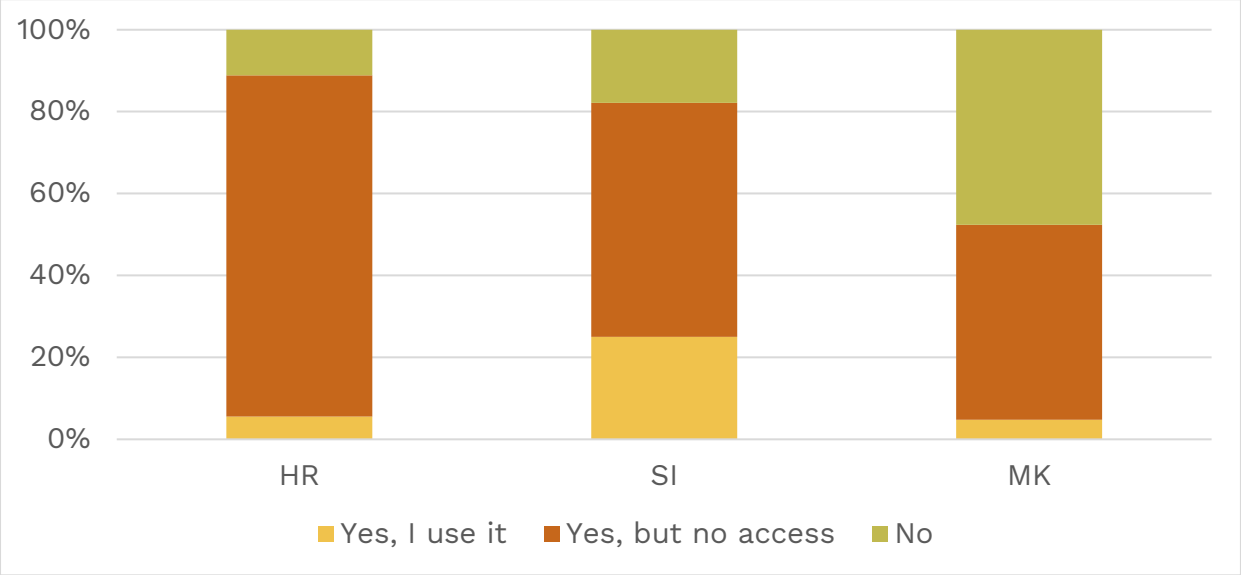


Figure 26. Awareness on the possibility of genetic analysis

In last decade new genetic tools for identifying subspecies and diseases resistance are developed and with this question we aimed to see if breeders are aware of this. Survey showed that more than half of breeders In HR and SI are familiar with this and ready to pay for such an analysis. In MK the proportion of breeders who are familiar with genetic analysis is lower which may be the consequence of low interest that local beekeepers show for traits that may be analysed in this way. This probably also reflects the result of Q25 where is shown that breeders in MK are ready to pay lowest amount of money for genetic analysis of their own stock.

Q24. Are you prepared to pay for the genetic analysis of your stock?

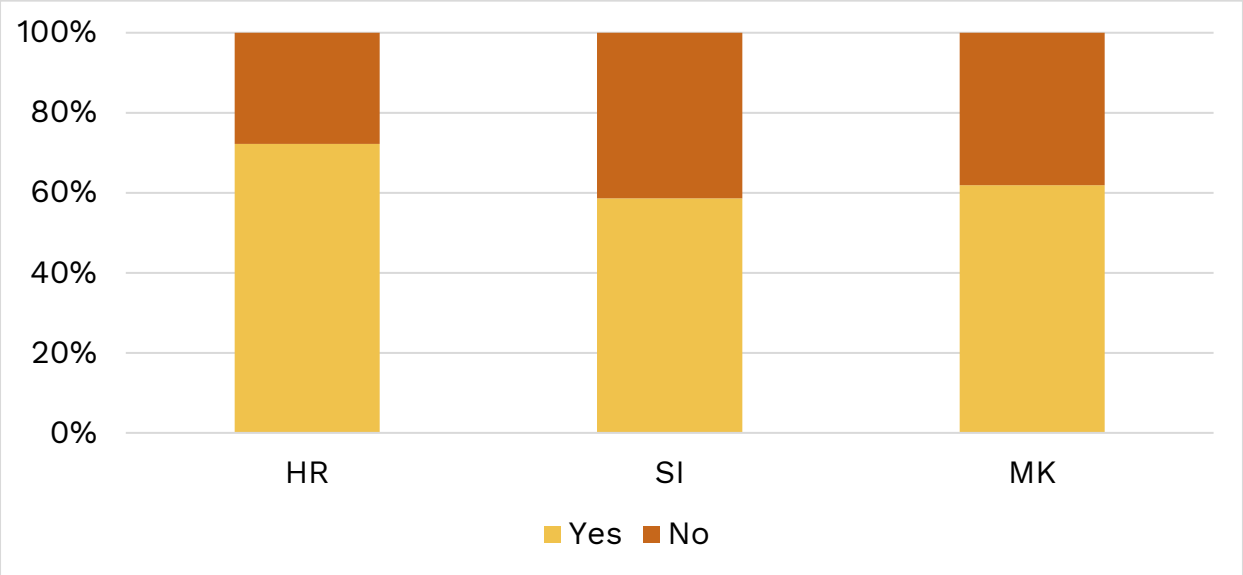


Figure 27. Willingness to pay for genetic analyses

Q25. If you are ready to pay, how much per colony in performance testing?

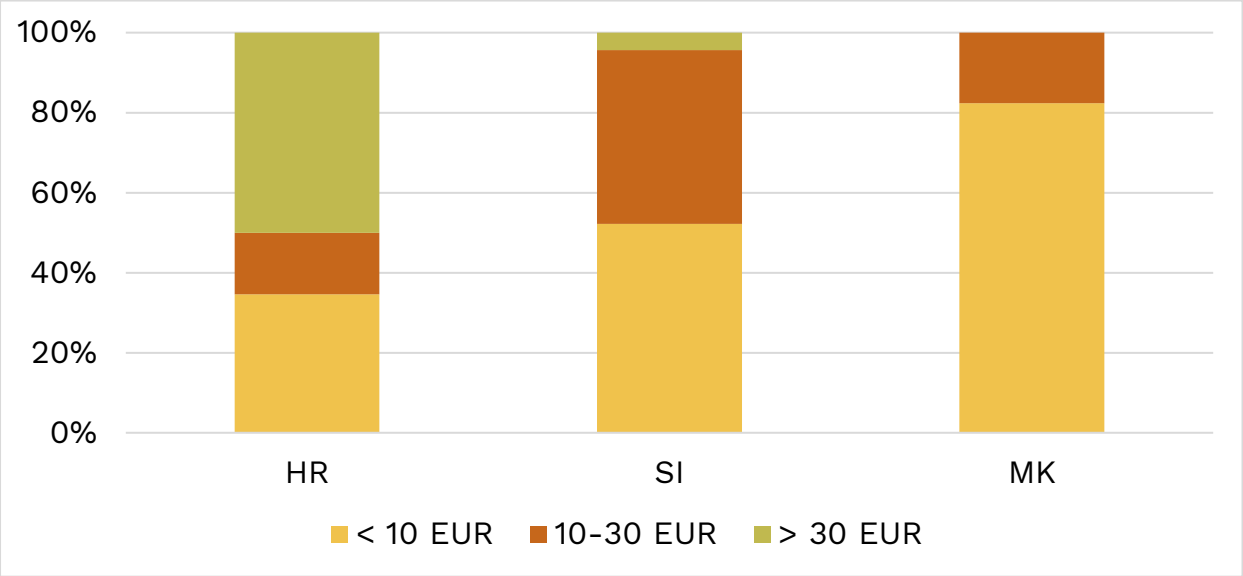


Figure 28. How much breeder would pay for genetic analysis of own stock

It is obvious that the honey bee breeders predominately are ready to pay up to 10 Euros per colony for genetic analysis. For some analyses, 10 Euros can be sufficient for some, but for most of the genetic analyses, it will not cover

the real price of them. Perhaps incentives are needed until it becomes routine and the beekeepers become aware of their benefits.

Q26. How do you select the genotypes for the rearing of the next generation of queens:

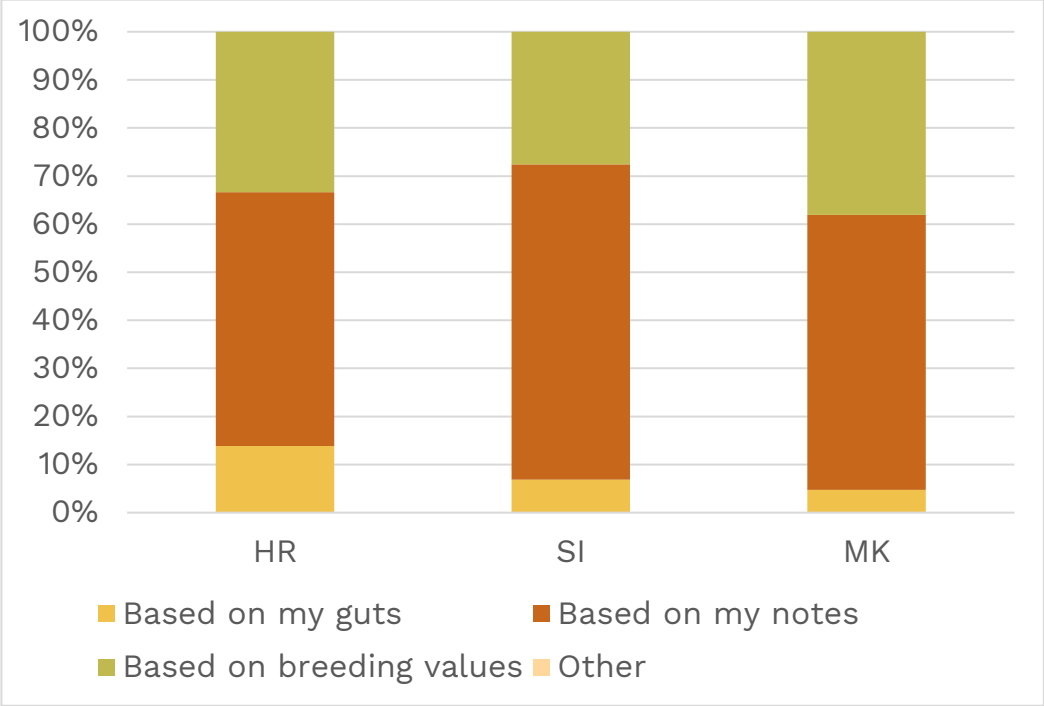


Figure 29. On what is based selection of mother colonies

It is encouraging to conclude that most of breeder select mother colonies based on breeding values and notes they collected during the performance test. They are experienced with data collection and aware on breeding values. This element of breeding cycle is solved which leads to the most difficult and missing element - mating control.

Q27. If BVs are used, then who is doing the expertise (estimation/calculation):

Breeding values in Croatia are mostly obtained by breeders themselves and some by the breeding organization. In Slovenia most of breeding values are obtained by the breeding group while in Macedonia breeding values are equally estimated by breeders, institute and breeders' group.

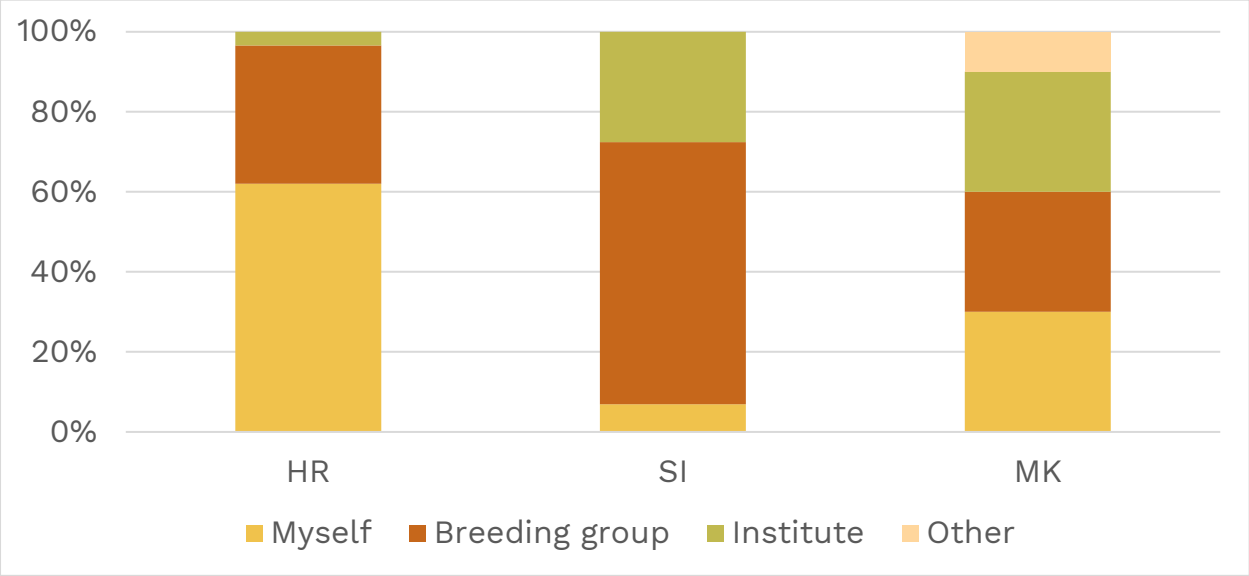


Figure 30. Who calculates breeding values

Q28. On a scale from 1 (low) to 10 (high), mark your opinion about the importance of local adaptation (locally bred bees are better suited for beekeeping).

Figure 31. Importance of local adaptation

Importance on usage of locally adapted honey bees is recognized in all three countries. Such a high awareness for the local adaptation (conservation)

among Macedonian beekeepers/breeder is likely a result of the recent (ca. 15 years) intensive research and promotion done on the local honey bee.

Q29. For queen rearing (grafting), I am using:

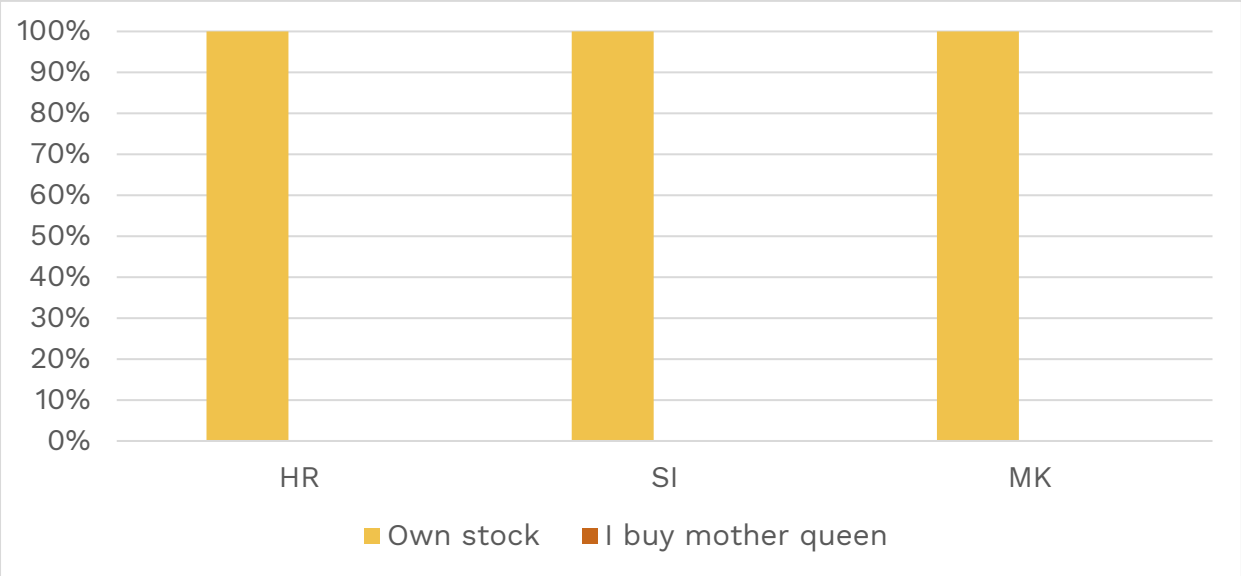


Figure 32. Use of queen mother for grafting

In all three countries, all breeders stated that they use their own stock for rearing new generation of queens. This means that all breeders do some type of selection and breeding and are familiar with all the elements of breeding cycle.

Q30. How many mating nucs do you manage in total during the season?

The highest average of managed mating nucs is in Croatia, followed by Slovenia and in these two countries the production of queens is much higher comparing to Macedonia which justifies these numbers of mating nucs.

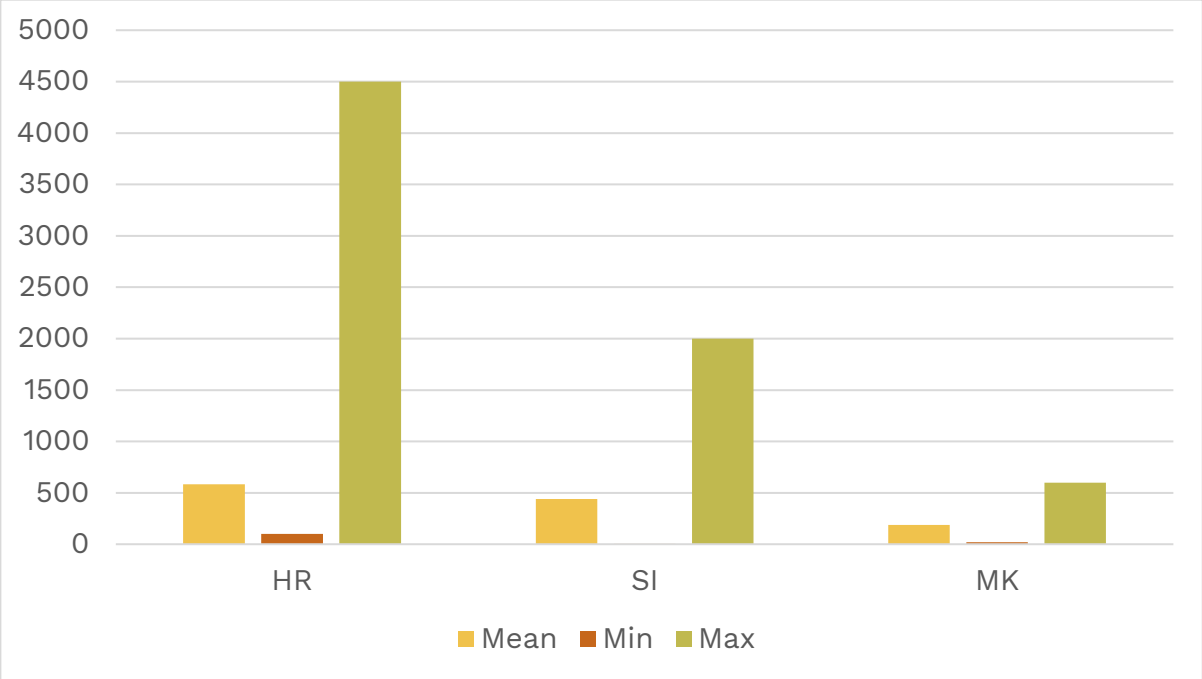


Figure 33. The mean, minimum and maximum number of mating boxes used in a season.

Q31. What type of mating nucs do you use (several possible answers):

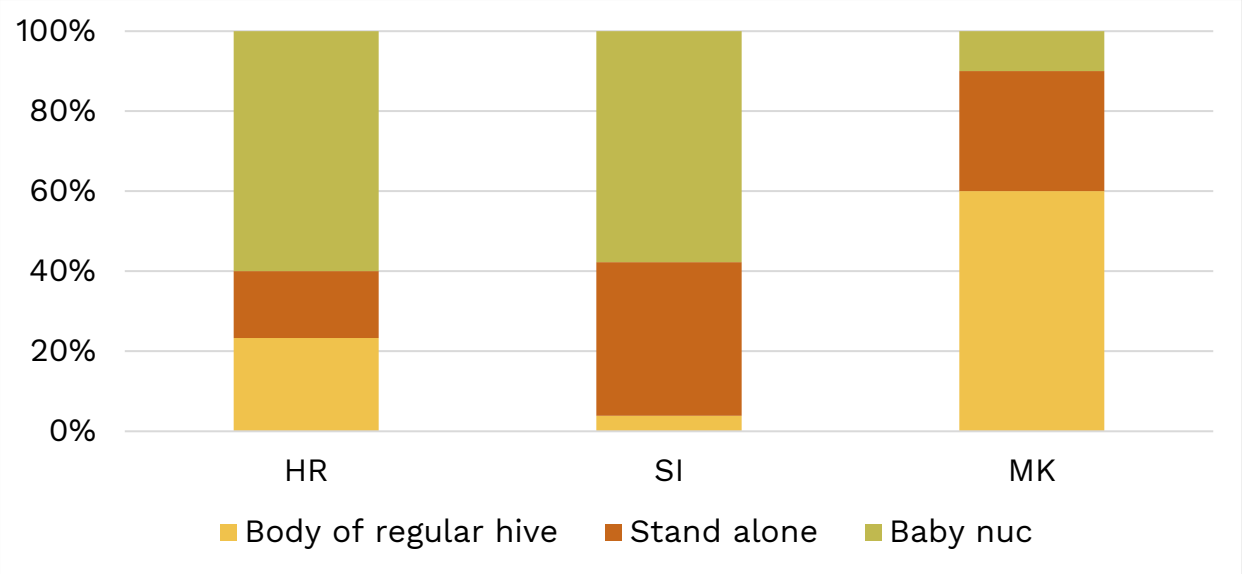


Figure 34. Type of mating boxes used for queen production

The most common mating nuc in HR and SI is a small baby nuc, while in MK is the body of the regular hive divided.

Q32. The capacity of production (per year)

The mean breeder capacity of queen cells production ranges from 922 in MK to 1,849 in SI and 2,674 in HR. The mean production of open mated queens is 292, 1,360 and 1,436 in MK, SI and HR. There are only few instrumentally inseminated queens (4 in SI and 7 in HR).

Q33-35. Do you know what the average success of grafting, queen hatching and queen mating (in percentage)?

Table 6. Average success of grafting, queen hatching and queen mating in three countries.

	Success of grafting	Success of queens hatching from queen cells	Success of queen mating
HR	74	86	73
SI	74	87	73
MK	81	84	74

The average acceptance of grafted larvae, hatched queens and success of mating is very similar between three countries and represents a very reliable data of these results. This could be partly explained by the similar literature and practices used by breeders in these three countries. Also, this high mean result shows that breeders are familiar with methodology and technology for rearing queen bees.

Q36. Barriers to rearing and selling more queens

In all three countries the main reason why, breeders do not increase production is that they are satisfied with the current production. The second most common reason is shortage of time and labour staff. In MK, besides the trend of price increase of the hive products (honey), the reported low demand from the market affects the queen production.

Figure 35. Main barriers for breeders to produce more queens

Mating control

In this set of questions, we aimed to explore how familiar breeders are with controlled mating of queens, do they use it and how much attention they put on drone producing colonies.

Q37. Do you practice any mating control?

This is perhaps the most important result of the entire survey, showing that most of the breeders do not use controlled mating of queens. The part that does, however, do not have any insight in to efficacy of their mating control. In our own evaluation of their answers, we concluded that the contribution of this so-called mating control is actually close to 0, with an exception of 0.1 % of queens produced yearly in Slovenia with full pedigree that are actually mated on the mating station of unknown quality. Considering the importance of controlled mating to achieve progress in selection, it is obvious that this is one of the most important aspects of breeding that needs to be improved in all three countries. Breeders have overcome most of the technological problems that arise in production (Table 2) and they need support to improve controlled mating of queens with desired drones.

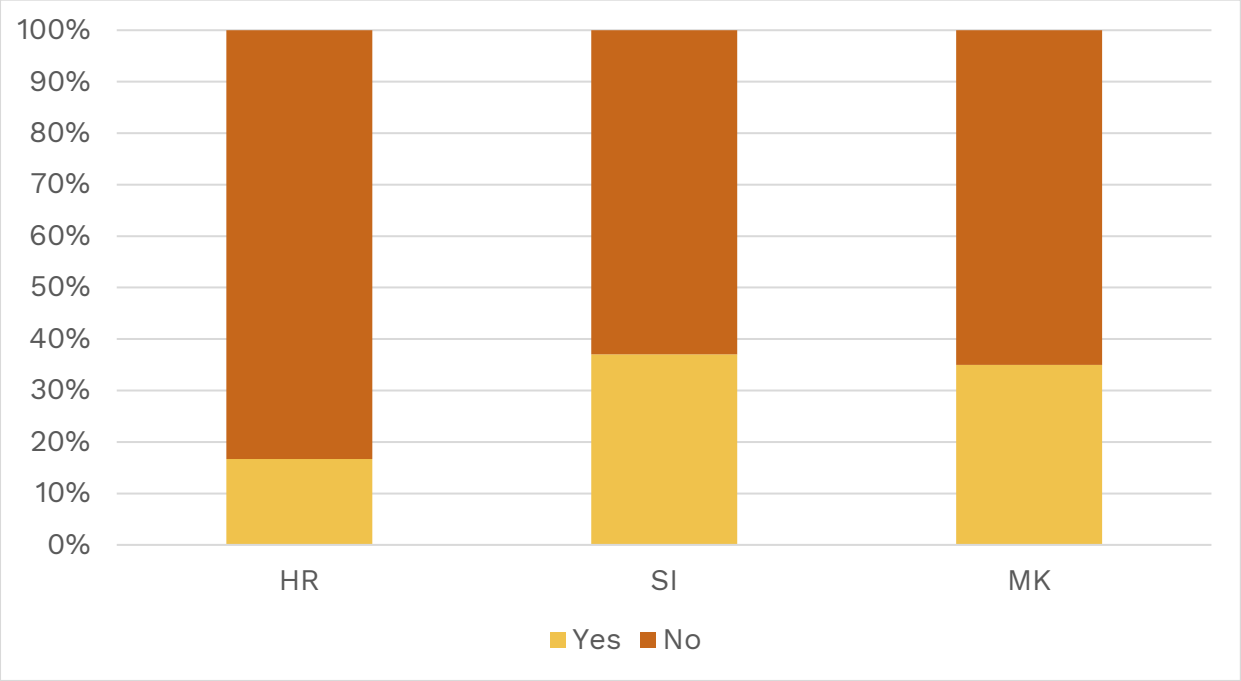


Figure 36. Controlled mating of queens

Q38. Do you know how far away the nearest apiary (with other queen origins than yours) is from your mating station?

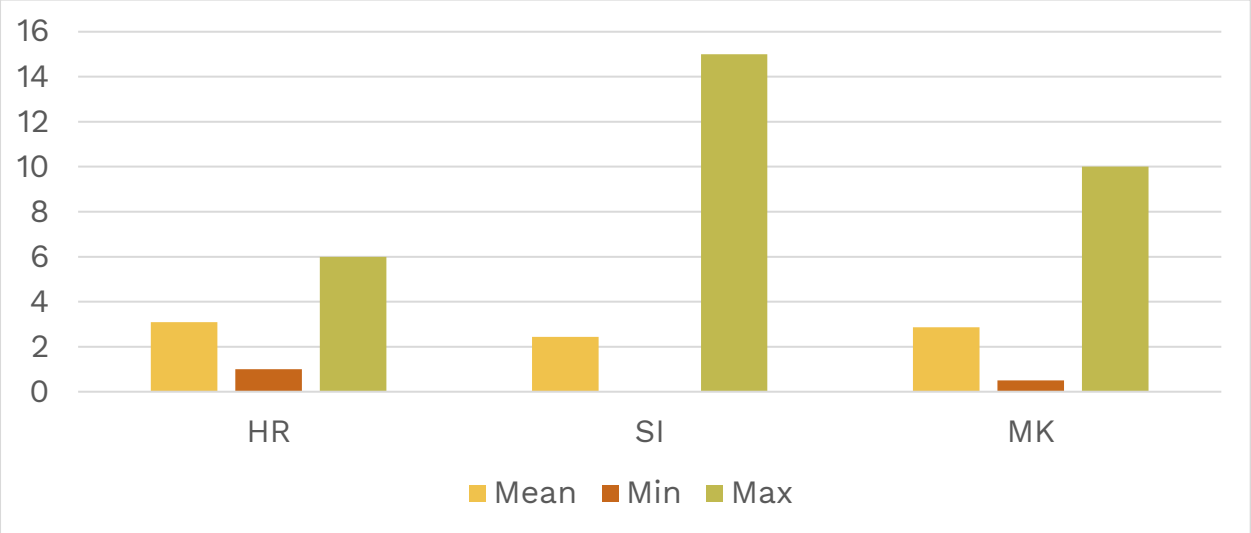


Figure 37. The distance (km) of the nearest apiary from the mating station

The average distance of the nearest apiary from the mating station in all three countries is between 2-3 km. This for sure does not allow the controlled mating of queens. Only few mating stations, which have distance

from the nearest apiary more than 7-8 km, are recognized as a potential place to have fully controlled mating.

Q39. Your mating station is isolated by

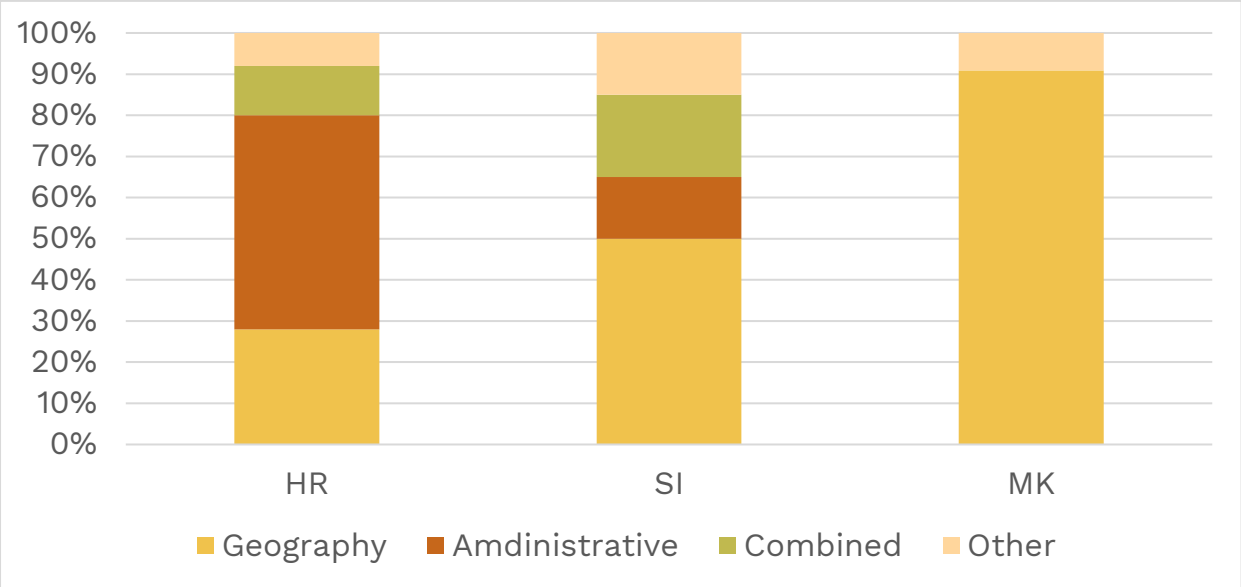


Figure 38. Isolation of the mating station

Q40. Do you use selected drone-producing colonies at your mating station?

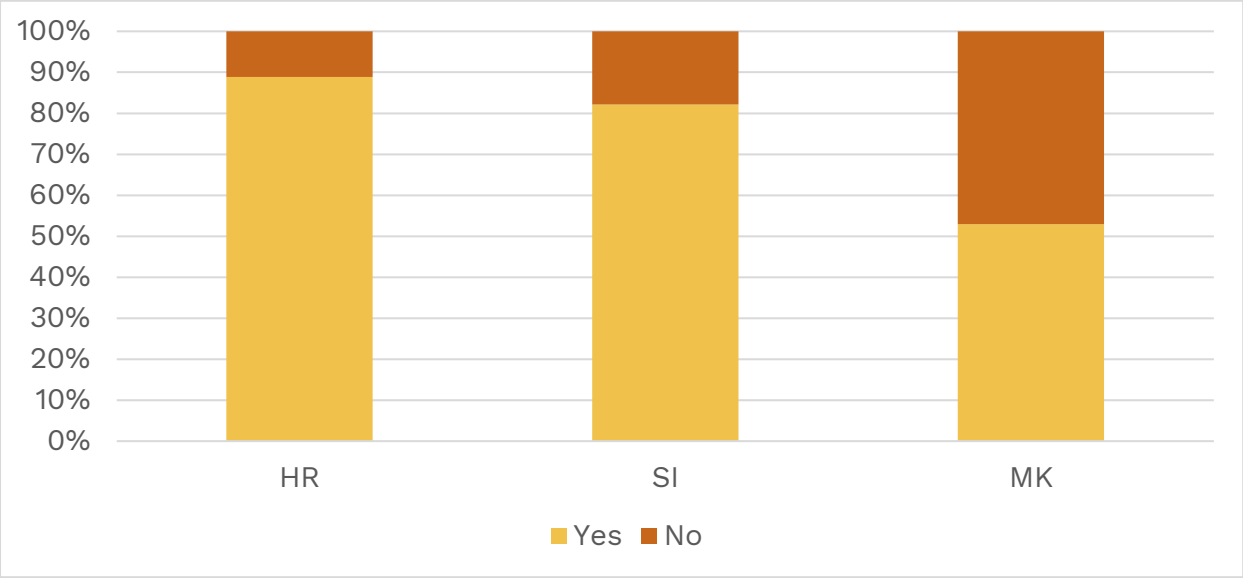


Figure 39. Does breeder use drone producing colonies?

Although most of breeders don't have access to the isolated places to establish isolated mating station, most of them most are aware on the importance of drones on the mating station and use selected drone producing colonies.

Q41. How many drone colonies do you manage at the mating station?

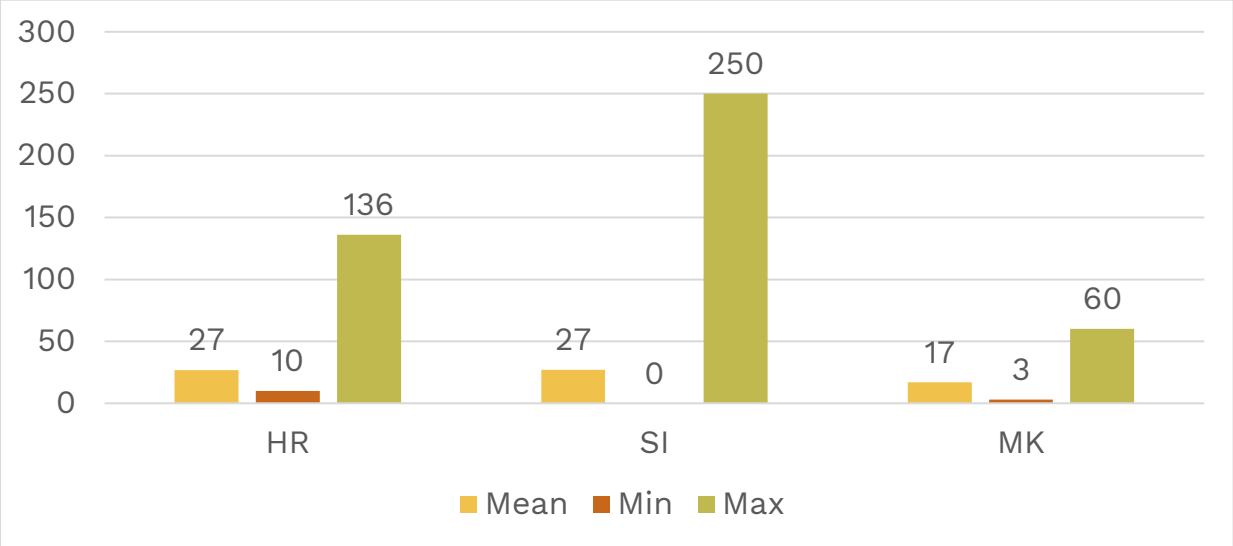


Figure 40. The number of drone producing colonies on the mating station

The average number of drone producing colonies is the same in Croatia and Slovenia, and lower in Macedonia.

Q42. Location of drone colonies with regard to the mating station

In all three countries most of drone producing colonies are located in the mating station. In Slovenia there is one third of breeders that keep drone producing colonies 1-2 km away from the mating station.

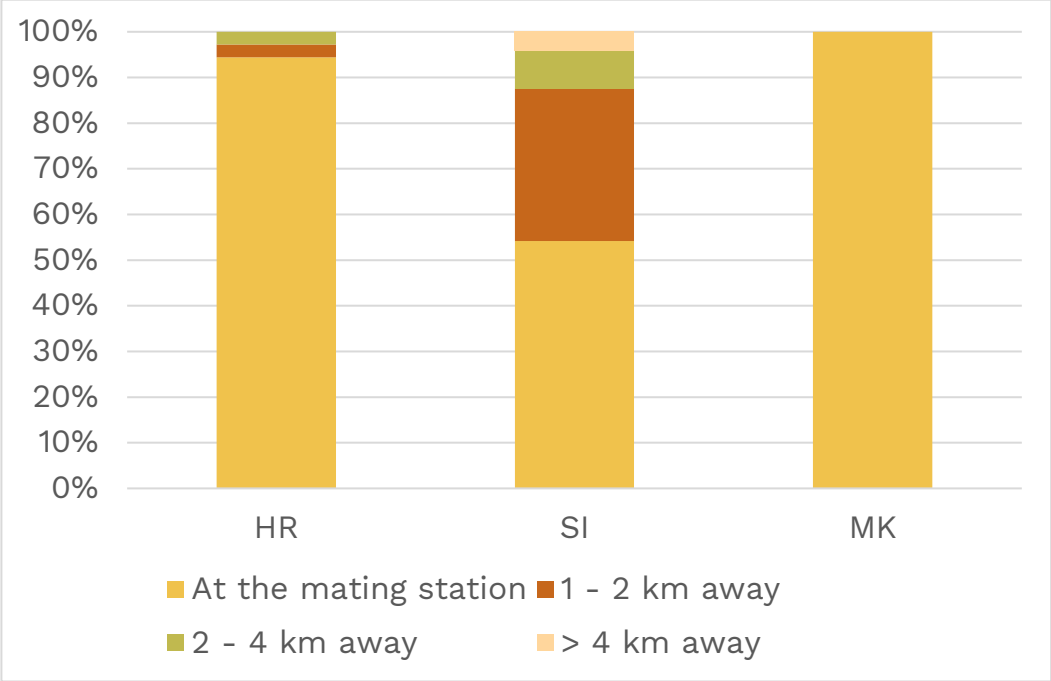


Figure 41. Location of drone producing colonies in regard to the mating station

Q43. Are your mating boxes drone-free?

Figure 42. Presence of drones in mating boxes

In Slovenia and Macedonia, most of breeders do not pay attention on the presence of drones in the mating boxes, while in Croatia half of breeders say that mating boxes are free of foreign drones. This answer also reveals that breeders still need an education on the importance of controlled mating and why it is needed to know the origin of drones on the mating station.

Q44. What are the perceptions of local beekeepers regarding the presence of the mating station in their area?

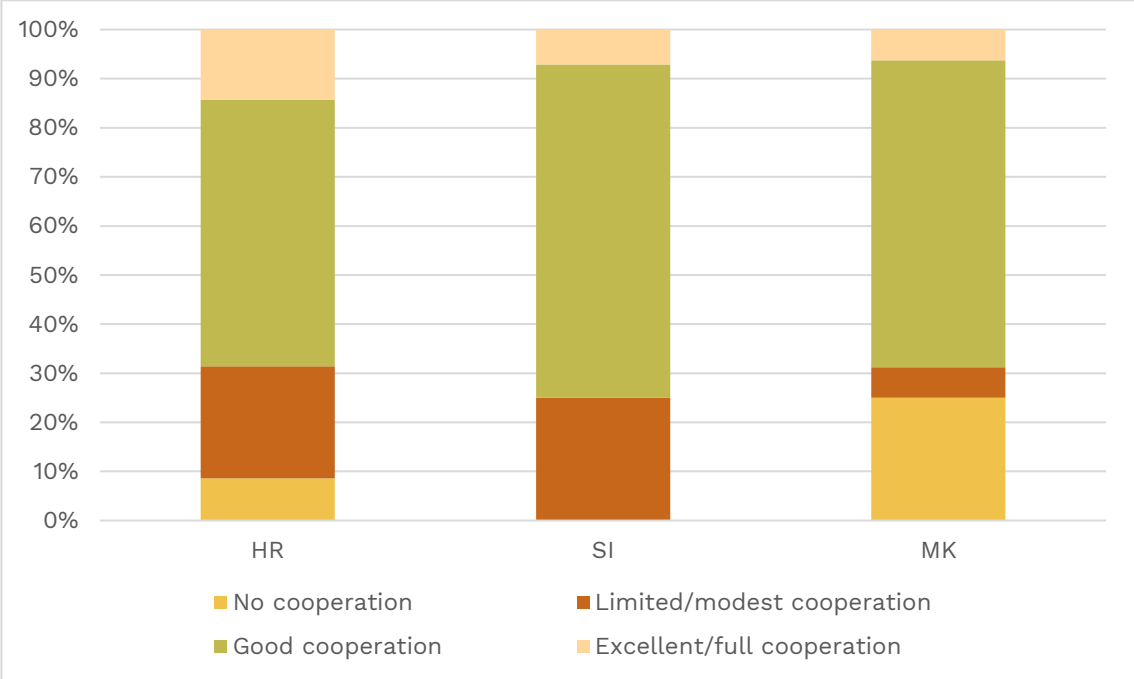


Figure 43. Perception of local beekeepers on the presence of mating station

Q45. How do you cooperate with those beekeepers who are in the radius of the mating station (cca 10 km)?

Local beekeepers in the area where the mating stations are located are not complaining neither are very supportive, however in all countries most of breeders have good cooperation with the local beekeepers which is very important predisposition for spreading genetic material among neighboring beekeepers.

Q46. How satisfied are you with the level of mating control in your mating station?

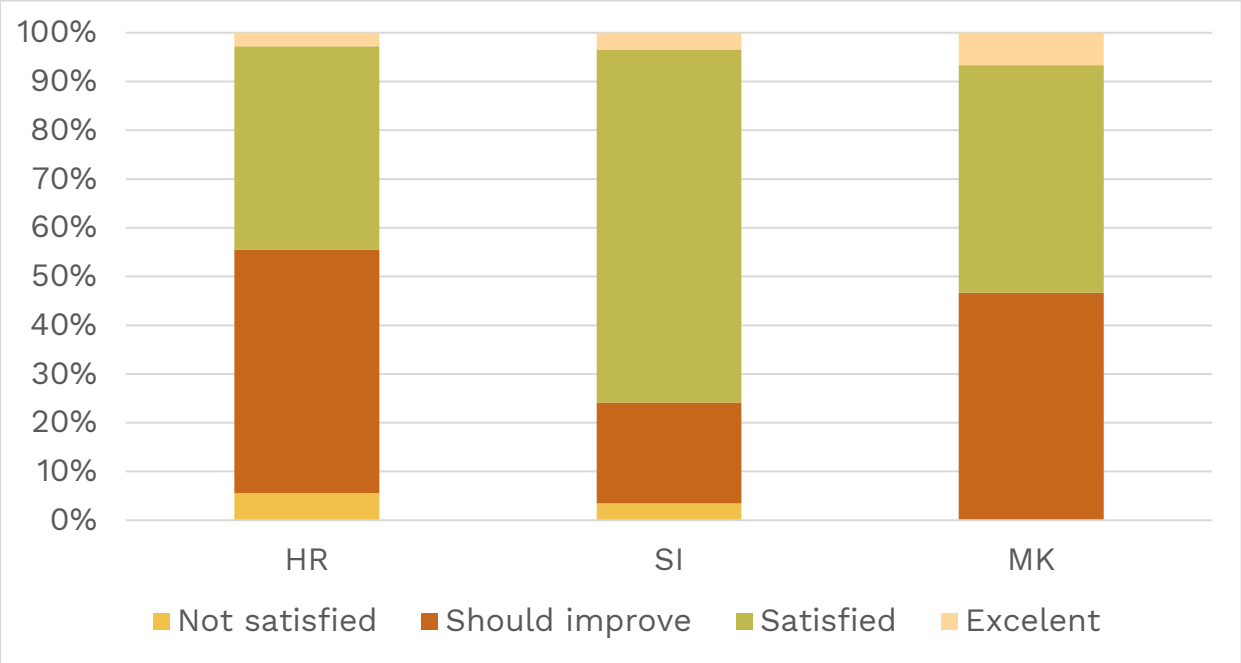


Figure 44. Satisfaction of breeders with the mating control

It is interesting to notice here that half or even more breeders are satisfied with the mating control at their operation, although very high percentage of breeders in all countries stated in question 37. that there is no mating control at their mating station. This indicates that there is need for specialized training to understand the relevance of mating control.

Q47. How do you think mating control could be improved in your location?

On this question breeders gave several comments which could be merged into few general ones:

- by isolating the mating station more strictly by administration
- increase the number of drones on the mating station
- by cooperation with local beekeepers
- limit migratory beekeeping in surroundings of mating yards

Q48. Would you be interested in using a fully controlled mating station if it is provided by a breeding group?

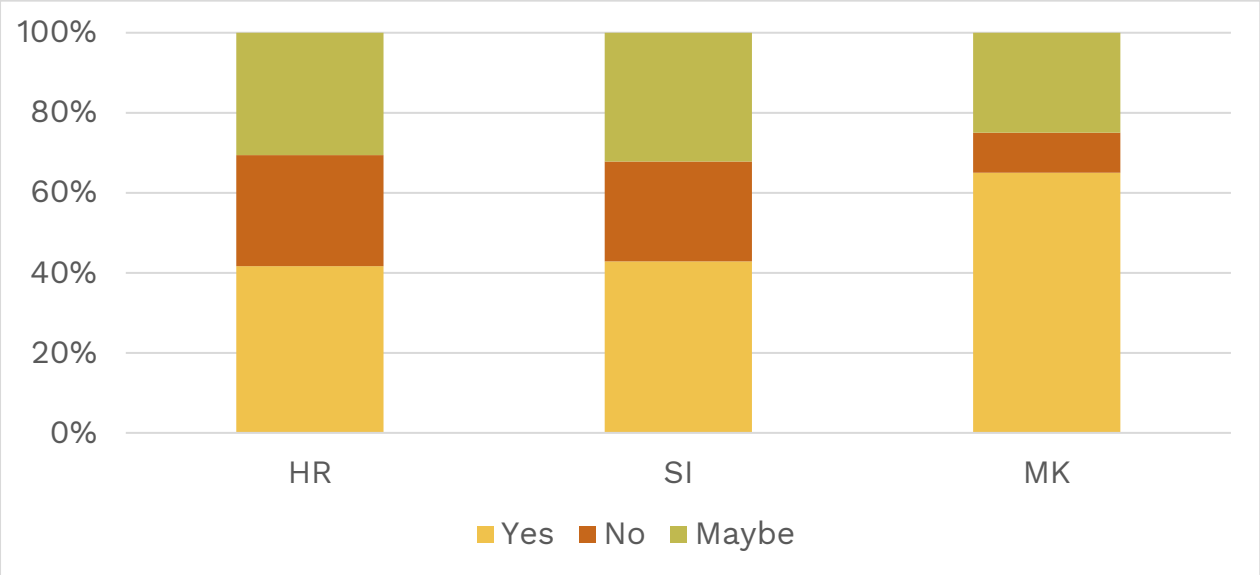


Figure 45. Interest by breeders on usage of fully controlled mating station

An interest showed by almost one third of breeders on usage of isolated mating station clearly shows which are some of the steps that may be taken in the future to improve mating control.

III. ECONOMIC ASPECTS OF HONEY BEE QUEEN PRODUCTION AND MATING

Beekeeping is a significant source of income and an important economic activity for beekeepers' family. Still, as in most cases it is practise by hobbyists' beekeepers, it is not perceived as important economic sector and there is lack of knowledge and research in line with the economic aspects of beekeeping.

Honey is by far the most important apicultural product and is globally traded (García, 2018) and in this manner the economic analyses are predominantly oriented towards honey production. Lately, the other honey bee and by-products have become more interest for production and taken a higher market share and can have a higher economic result, as: pollen, propolis, royal jelly, and beeswax plays. Honey bee colonies, nucleus and packages also are important trade products.

In the last 15 years, research has focused more on the value of the ecosystem services that beekeeping provides for agriculture and biodiversity rather than on the profitability of beekeeping farms. Honey bees are economically important managed pollinators for crops and wild plants (Breeze, Bailey, Balcombe, & Potts, 2011; Gallai, Salles, Settele, & Vaissière, 2009; Klein, et al., 2007). Keeping in mind that the total number of beekeepers in EU is around 606 thousand, China estimates are around 308 thousand (Tang, et al., 2020), USA with 212 thousand, Turkey with around 60 thousand (Kandemir, 2003; Çakmak & Sevencakmak, 2016), Canada with 10 thousand, there is a significant socio-economic impact of beekeeping on family income and security.

Still, losses of honey bee colonies, caused by multifaceted factors, with the predominant influence of *Varroa destructor* (Le Conte, 2010; Guzmán-Novoa E., 2010) and queen issues such as queen health and queen age (Genersch E., 2010; Spleen A. M., 2013; Liu Z., 2016) have extensive economic consequences.

A study in three European countries, focused on estimate the direct economic impact of winter honey bee colony losses on the apicultural sector, extrapolation on national level showed that in Austria the estimated economic losses were 32,031,305 EUR, in Czech Republic 21,400,401 EUR and in Macedonia 3,038,741 EUR (Popovska Stojanov, et al., 2021). Honey bee colony losses can be compensated, which results in rather stable or even increasing numbers of colonies managed in certain regions (Brodschneider, R.; Brus, J.; Danihlík, J., 2019; Moritz & Erler, 2016; Van Engelsdorp & Meixner, 2010).

In 2017, the EU initiated the EurBeST study (EurBeST, 2022) to explore possibilities for increasing the varroa resistance of commercially available honey bees by selective breeding and analyses ways to improve beekeepers' access to resistant material. To our knowledge, this was the first study addressing the economic aspects of breeding for genetic improvement of honey bee stock, in particular those incurring through selection towards improved varroa resistance. The EurBeST study concludes that selective breeding of honey bees is an efficient way to increase productivity, reduce colony losses, improve honey bee health and enable profitable operations. The queen producers, often recognized as multiplicators of the breeding success, need to enhanced cooperation with the performance testers and scientific breeding centres to substantially improve the genetic traits of reproductive material and to ensure that breeding stock with good local adaptation is made available to the final customers, the beekeeper.

In this manner, the BeeConSel project is continuation of all previous activities in line with improved selection honey bee colonies, with special emphasizes of the mating as impart part of the selection and queen production process. The project will also contribute towards greater economical understanding of the queen production and mating process, as crucial basis for future business development of selection activities and greater institutional and financial support.

Methodology and approach

Methodology

The methodology of calculation of the costs for queen production and mating costs, is based on the calculation of costs for queen rearing and mating cost based on the Cost of Production (CoP). As an economic indicator, cost of production (CoP) or production price is the average cost of production for producing one unit of product (1 mated queen). At the same time CoP is presenting the minimum selling price (break-even price) as a break-even point in order to manage production without losses covering all costs of production. The methodology for CoP of queen production and mating CoP are calculated using tailor-made develop methodology for the purpose of project, which is following the general standard methodology used in different relevant literature (for example, see Ciaian et al., 2013; Kay et al., 2014; FAO, 2016).

The cost of production and total costs of production are calculate based on:

CoP = TC / Y
CoP - Cost of production (in EUR/queen)
TC - Total cost (in EUR)
Y – Produced/Mated queens (produced queen)

The total costs represent the sum of variable and fixed queen CoP.

TC = VC + FC
VC - Variable cost (in EUR)
FC - Fixed cost (in EUR)

The variable yearly costs are the sum of the direct costs used for queen rearing as: labour, transportation, feeding, protection from pathogens and required equipment), marketing and other costs.

The value of fixed costs is calculated based on the costs of depreciation of the assets for queen production and mating.

D = VA x DR
D - Annual depreciation (in EUR)
VA - Value of the asset (in EUR)
DR - Depreciation rate (in %, DR = 1 ÷ Years of assets utilization)

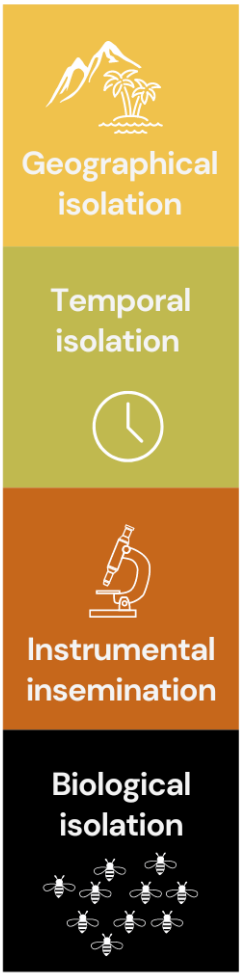
Additionally, the cost of lost honey and performance testing cost are added as a fixed cost of queen production. The cost of lost honey is calculated

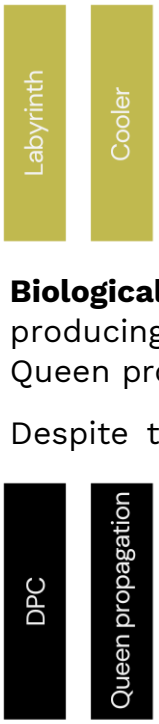
based on 30 % loss of honey yields and price of the honey, while the performance test costs are calculated as number of queens provided for testing and selling price of the mated queens.

In order to be possible to estimate the benefits of selection and mating, calculation of extra benefit and extra income is performed. The calculation of selection and mating benefits is based on the average annual increase of honey production for control mated and selected queens of 0.27 kg per hive or in total 6 kg in 22nd year of selection and 0.06 kg per hive or in total 1.4 kg in 22nd year for not selected (Hoppe et al., 2020; Bienefeld, 2016) and price of the honey.

Approach

Tailor-made questionnaire was designed to use in the personal interview and electronic Excel version of the questionnaire for entering the data was developed (See Annex 1 and Annex 2). The interviews were performed with queen producers by country coordinators, based on the normal/typical year of production or in average some typical production results in the last 5 years. Additional information and expert estimation were use in later phase of economic analysis.





Six mating models were defined as potential for mating control and will be tested as: **Geographical isolation** (lowland, mountain, island, peninsula), Instrumental insemination, two version of **Temporal isolation - Jo Horner** (Temporal isolation with cooler and Temporal isolation with labyrinth) and two versions of **Biological isolation** (Biological isolation with drone producing colonies - DPC and Biological isolation with Queen propagation).

Despite that only Geographical and Drone saturation are perceived as modes for massive propagation of genetic selection, and Instrumental insemination and Temporal isolation are more breeders' independent solution and not much linked with the possibility as a service, the economic part focused on collecting and calculation of all cost and income from queen production and mating, with later comparison and analysis of differences between different mating control models, investment for establishment of different mating models,

change of queen producers production technology (change of »business as usual« scenario) and potential to provide different mating control models as services.

Sample

The sample consists of 20 queen producers, out of which 9 are producing with open mating and 11 with controled mating. Largest sample comes from Slovenia (SI, 8 cases) and Macedonia (MK, 6 cases), while Croatia (HR) and Spain (ES) are with 4 and 2 cases.

Table 7. Samples included in the survey

Country	Open mating	Geographic isolation	Biological isolation	Isolation Cooler	Isolation Labyrinth	Total cases
HR	2		2			4
ES	1	1				2
MK	1	1	2	1	1	6
SI	5	3				8
Total	**9**	**5**	**4**	**1**	**1**	**20**

Cost of queen production

The average queen CoP, based on all 20 queen producers' cases are 42,05 EUR per 1 mated queen, ranging from minimum 11.61 (case in Croatia) to maximum 123.44 EUR (case in Slovenia). The highest share of the queen production price are the costs for depreciation (34 %), labour (23 %), loss honey (14 %) and purchased queens and honey bee packages (13 %). Feeding costs are around 8 % of total costs, while labour and other transport to bee yard, performance testing, insurance and Income taxes are around 5 % each. Highest variation can be noticed in case of depreciation, purchased queens and honey bee packages and labour.

Table 8. Average queen CoP per 1 mated queen, in EUR

	Min	Max	Average	StD
Purchased queens and bee packages	0.23	19.05	5.33	8.09
Labour	1.60	35.00	9.56	6.32

Feeding	0.63	12.50	3.42	3.49
Labour and other transport to bee yard	0.09	8.75	2.08	1.52
Protection (Disease treatment) and Veterinary services	0.15	7.02	1.20	1.65
Equipment (1-year use)	0.01	1.90	0.54	0.56
Package, transport, labelling	0.13	0.66	0.32	0.15
Water, electricity, heating	0.05	5.25	0.77	0.50
Promotion and marketing	0.03	2.50	0.82	0.74
Insurance and Income tax	0.07	4.96	2.22	2.10
Other costs (administration, telephone, accounting, etc.)	0.14	2.08	0.67	0.67
Variable queen CoP	**6.87**	**55.66**	**20.46**	**12.35**
Average fixed costs (depreciation)	0.76	72.42	14.31	18.28
Lost honey production	0.65	14.18	5.73	4.39
Performance testing	0.06	15.26	2.38	2.25
Total queen CoP	**11.61**	**123.44**	**42.05**	**25.52**

This average selling price of one mated queen is 17,96 EUR, with lowest price of 8,70 EUR (case in Croatia) and highest price of 35,00 EUR (case in Macedonia).

Table 9. Difference between average selling and production price per 1 mated queen, in EUR

	Min	Max	Average	StD
Selling price queens	8.70	35.00	17.96	8.10
Difference selling and production price at variable cost	**-40.40**	**12.44**	**-2.50**	**9.08**
Difference selling and production price at total cost	**-108.18**	**1.45**	**-24.09**	**20.88**

On average, the difference between the selling price and the production price at variable costs is negative with -2.50 EUR and -24.09 EUR full production price at total costs, as a result of the high production costs and a low selling price per queen. Out of 20 cases, 11 cases have positive difference and higher selling price compared with production price calculated only on the basis of variable costs, while only 2 cases (both in Macedonia) have higher selling price compared with the production price at total cost.

The lower selling price in comparing with the full production price of mated queens, has impact on the queen production business profitability. On average, the income from queen production, including income from queens, but also the additional income from honey, colonies, nucleus and mating boxes is 40.39 EUR per one mated queen, which compared with the costs of 42.05 EUR, results with average losses of 1.65 EUR per mated queen.[13]

Table 10. Average loss/profit per 1 mated queen, in EUR

	Min	Max	Average	StD
Total income honey	1.53	33.09	13.37	10.25
Total income queens	8.70	35.00	18.92	8.57
Additional income (colonies, nucleus, mating boxes)	1.00	71.43	13.50	22.32
Total income of queen production	**11.23**	**108.67**	**40.39**	**22.97**
Total cost of queen production	**11.61**	**123.44**	**42.05**	**25.52**
Average loss/profit	**-103.20**	**64.31**	**-1.65**	**28.46**

Anyhow, taking in consideration the income from subsidies, which is in average 7.24 EUR per mated queen from 10 cases which are receiving subsidies, on average the queen producers work with 1.97 EUR profit per mated queen (

13 It should be noticed that half of the cases generate profit and the other half generate losses. In general, the main impact on average loss results is one extreme case in Slovenia with losses of -103.20 EUR per mated queen, primary as result of control mating and highly costly production, mating and selection costs. If exclude this case, other cases on average show profit with 3.69 EUR per mated queen.

Annex 3. Table 1. Average loss/profit per 1 mated queen including subsidies, in EUR).

Compared based on country cases, on average Macedonia has the highest production costs and production price of mated queen of 49.81 EUR,[14] while at the same time Croatia has the lowest production price of 22.04 EUR.

Table 11. Average queen CoP per 1 mated queen by country, in EUR

	HR	ES	MK	SI
Purchased queens and bee packages	0.80	12.70	-	0.23
Labour	5.19	6.51	12.83	10.04
Feeding	1.97	6.35	6.38	1.20
Labour and other transport to bee yard	1.69	-	2.12	2.25
Protection (Disease treatment) and Veterinary services	0.73	3.75	1.18	0.75
Equipment (1-year use)	0.24	1.90	0.42	0.43
Package, transport, labelling	0.38	0.32	0.26	0.38
Water, electricity, heating	0.62	0.12	0.14	1.47
Promotion and marketing	0.25	-	1.30	0.58
Insurance and Income tax	0.19	3.03	1.80	3.30
Other costs (administration, telephone, accounting, etc.)	0.66	1.93	0.17	0.42
Variable queen CoP	**11.64**	**36.60**	**25.08**	**17.37**
Average fixed costs (depreciation)	4.84	1.86	21.34	16.88
Lost honey production	5.37	1.23	3.11	9.00
Performance testing	0.20	6.05	0.56	4.09
Total queen CoP	**22.04**	**45.75**	**49.81**	**45.30**

14 Macedonia is the country with most control and experimental cases (5) of mating and only one with open, which has impact on average results and higher production costs.

Observing the cost structure, in case of Croatia largest share of the cost are labour, depreciation and lost honey production around 25 % each, in Spain it is purchased honey bee packages with 33 % of total cost and in case of Macedonia and Slovenia it is depreciation with almost half of the total cost and labour costs with more than 24 %.

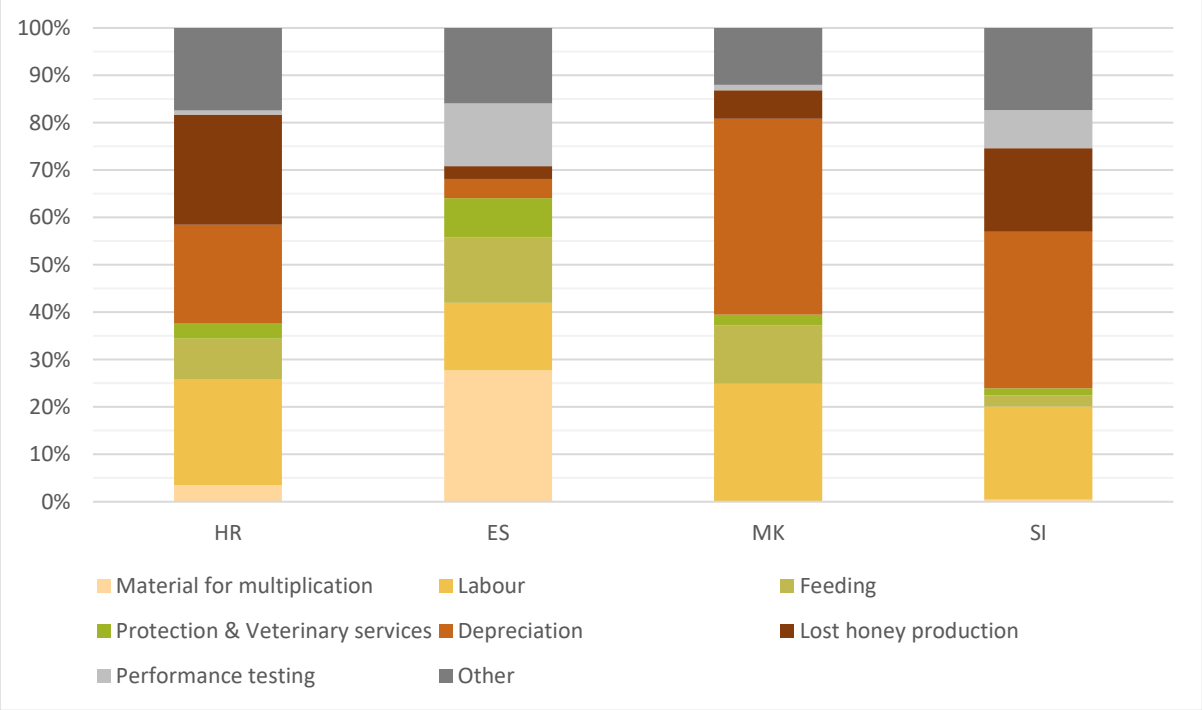


Figure 46. Share of the different costs in total queen production cost by country.

The effects of controlled mating on the CoP can be clearly seen in Table 5. The production price of control mated queen is 53.86 EUR, which is two times larger than production price of 27.61 EUR for open mated queen.

Table 12. Average queen CoP per 1 mated queen mating method, in EUR

	Open	Control
Purchased queens and bee packages	2.46	9.64
Labour	5.74	12.68
Feeding	2.60	4.09
Labour and other transport to bee yard	1.40	2.55
Protection (Disease treatment) and Veterinary services	1.45	1.01
Equipment (1-year use)	0.52	0.56

Package, transport, labelling	0.30	0.33
Water, electricity, heating	0.90	0.68
Promotion and marketing	0.48	1.01
Insurance and Income tax	2.17	2.27
Other costs (administration, telephone, accounting, etc.)	0.69	0.64
Variable queen CoP	**14.83**	**25.07**
Average fixed costs (depreciation)	4.68	22.19
Lost honey production	7.29	4.46
Performance testing	1.06	3.92
Total queen CoP	**27.61**	**53.86**

The highest difference between production costs of queen produced in open vs. controlled mating are in depreciation: in case of controlled mating is depreciation is 22.19 EUR and is almost 5 times higher compared to depreciation in open mating as result of higher value and use of assets, labour (12.68 EUR) and feeding (4.09 EUR). These values are twice as high as in open mating, purchased queens and honey bee packages (9.64 EUR)[15]. In addition, the results show that queens produced with control mating require less cost in veterinary protection and lower lost honey production probably as a result of better selection efforts and increased colony hygienic behaviour, but higher costs for performance testing as a more frequently and higher number of queens provided for testing.

Observed by the share of different costs, the highest share of costs for queens produced without control mating took lost honey (23 %), labour (18 %) and other costs (20 %), while in the case of queens produced with control mating it is depreciation (34 %), labour (19 %) and purchased queens and honey bee packages (15 %).

Looking from the perspective of queen selling and production price, Spain on average has the highest selling price of 27.75 EUR per queen, while Croatia has the lowest with 9.66 EUR. Based on the mating method, the average selling price of control mated queen is 19.71 EUR, which is insignificantly higher than the price of 15.82 EUR of queen open mated, taking in

[15] This is primarily as result from Spain two cases where it is normal to purchase mating box for the needs of mating, but also as a marketing strategy to sell queens packed in the mating box.

consideration the high production costs for control mated queens and much higher production price.

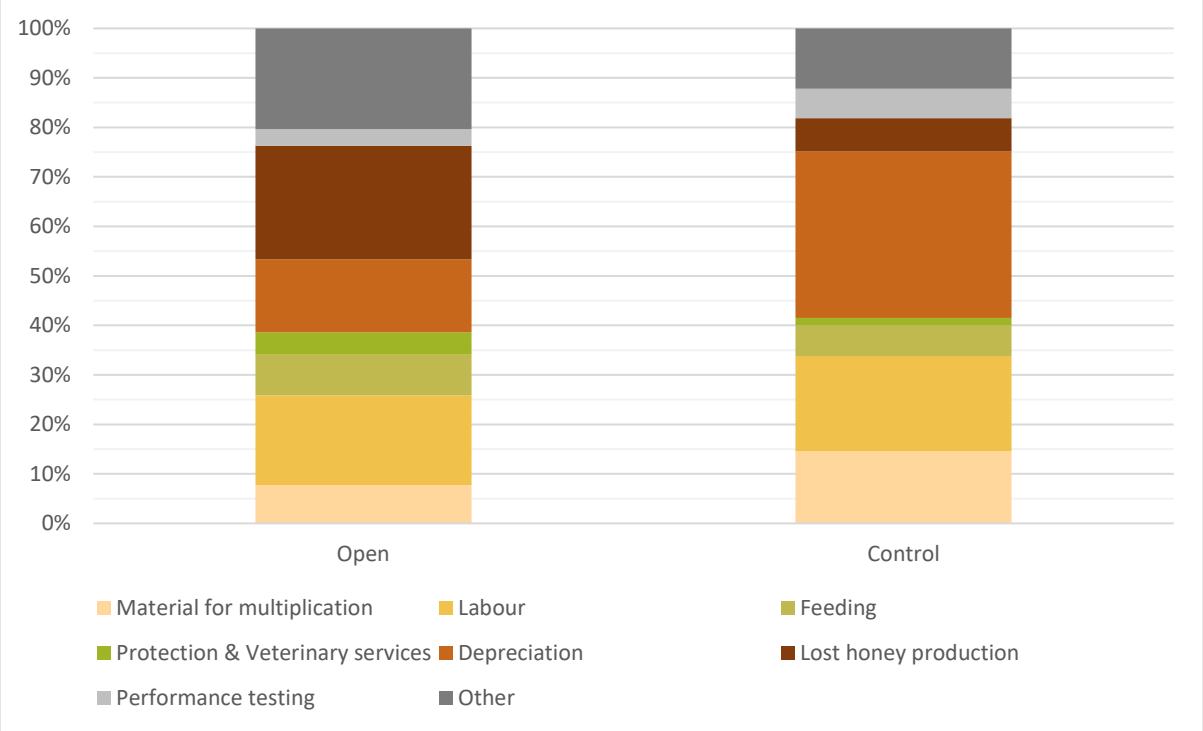


Figure 47. Share of the different costs in total queen production cost per mating method.

Figure 48 shows the average queen selling price, difference of selling and production price calculated on the basis of variable costs and full production price on the basis of total costs by mating method, country and in average for all cases. It can be noticed, that in almost all cases, excluding open mating at variable cost, the production price is higher than the selling price of queens and the income based on these prices is not sufficient to cover the production costs.

The highest negative difference is in the case of controlled mating, where the production prices are higher for 34.15 EUR or almost two and half times compared with the average selling price of control mated queens. On contrary, in case of the queens with open mating, the negative difference between the selling and production price are lowest (-11.79 EUR), selling price cannot cover all production costs, but can covered the variable cost of queen production (

Annex 3. Table 2. Difference between average selling and production price per 1 mated queen by mating method, in EUR).

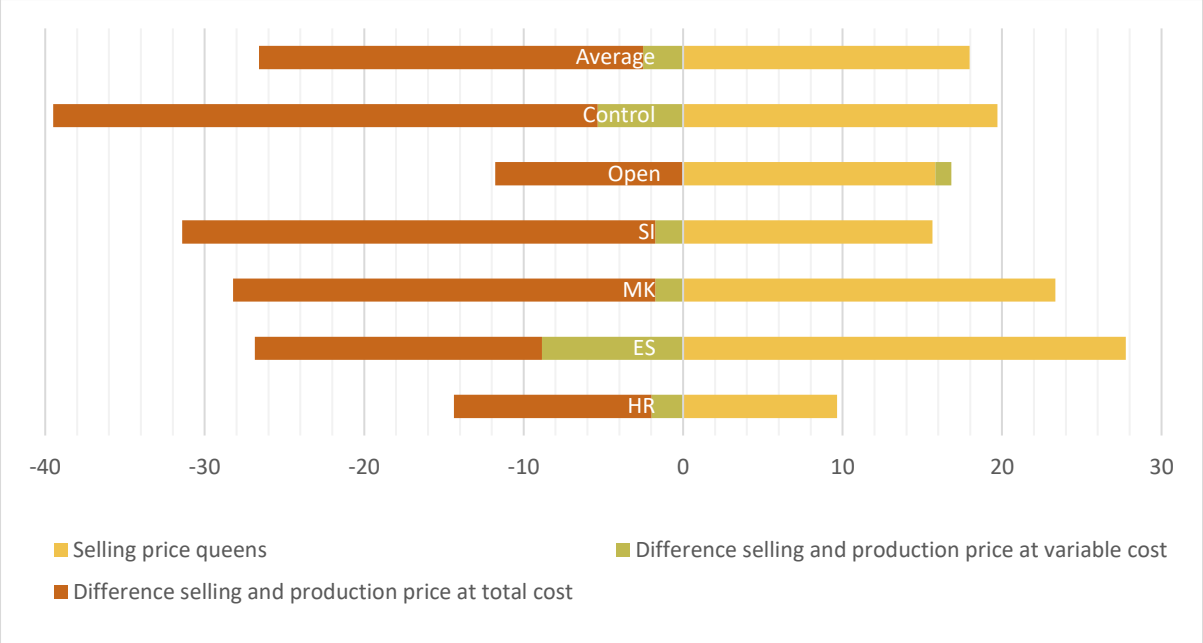


Figure 48. Difference between average selling and production price per 1 mated queen, in EUR

Compared by countries, the lowest negative difference is evidence in Croatia with average -12.39 EUR lower selling price compared with the total production price and highest in case of Slovenia with -29.67 EUR lowest selling price (

Annex 3. Table 3. Difference between average selling and production price per 1 mated queen by country, in EURTable 3. Difference between average selling and production price per 1 mated queen by country, in EUR).

This negative differences and lower selling prices have direct impact on queen production profitability (Figure 49). The total cost of producing the mated queens with control mating of 53.86 EUR per queen are for 17.58 EUR higher than the total income (queens, honey and additional income). This means, that in average the control mated queens generate -17.58 EUR losses per produced mated queen. At the same time, open mated approach, has higher income and in average 17.82 EUR profit per mated queen (

Annex 3. Table 4 Average loss/profit per 1 mated queen, open vs. control mating, in EURTable 4 Average loss/profit per 1 mated queen, open vs. control mating, in EUR).

The highest profit is noticed in case of Spain with average 48.43 EUR per mated queen, primary as result of extra gain income from added value of queens sold in packages. Croatia has modest profit of 3.22 EUR per produced queen, while at the same time Slovenia has modest losses of -4.48 EUR per queen. Macedonia is country with the highest losses of -17.82 EUR per queen as a result of high production costs in experimental models for Biological isolation (

Annex 3. Table 5 Average loss/profit per 1 mated queen by country, in EUR).

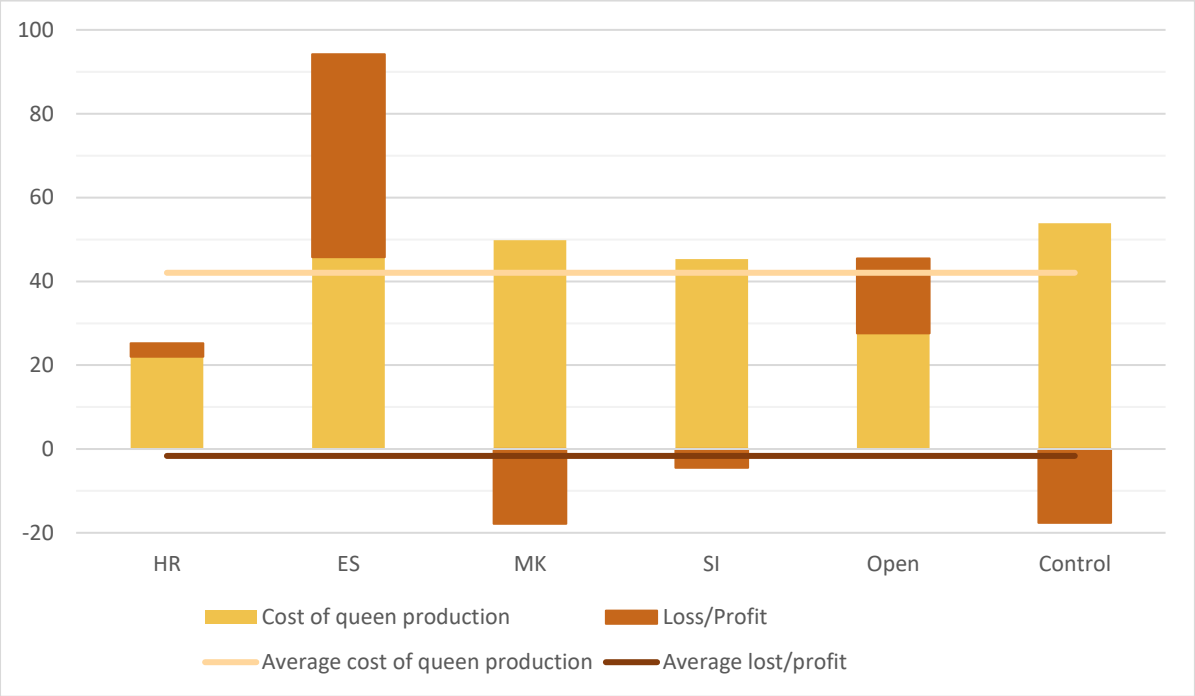


Figure 49. Average loss/profit per 1 mated queen, in EUR

Cost of mating

Mating parameters

The average use of mating capacity is 52 % or almost only half of the total potential capacity (Figure 50), while the average mating success ratio is 69 % (

Annex 3. Table 6 Mating capacity and results). Macedonia is the country with lowest used mating capacity of only 34 %, mainly as consequence that half of the cases are experimental models for control mating, which also has an impact on lower (47 %) average use of mating capacity of control mating group. At the same time, Spain has the highest use of potential capacity of 78 % (

Annex 3. Table 7 Mating capacity and results by mating method; Table 8 Mating capacity and results by country).

Regarding mating success ratio, Croatia and Macedonia are in line with the average success ratio of all cases, Slovenia is lower than the general average (66 %), while Spain has higher success ratio (83 %).

Observed by the mating method, control mated queens have lower mating success than general average (67 %), while the queens open mating have higher (71 %).

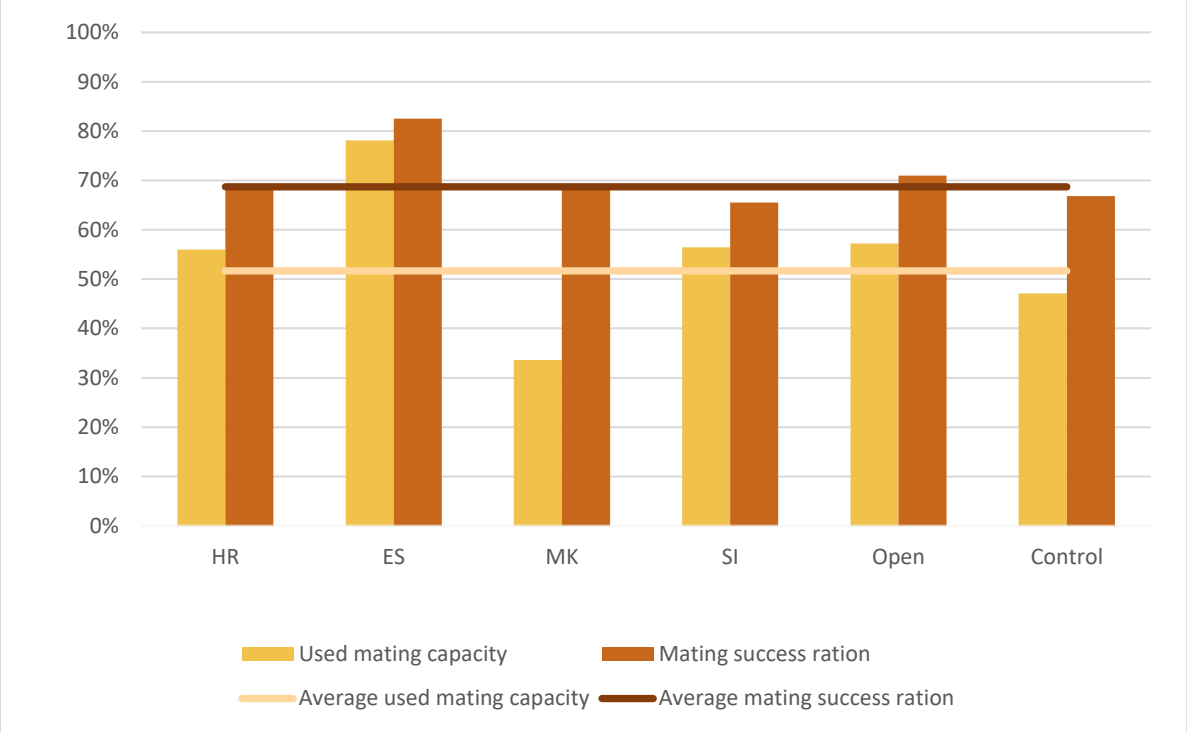


Figure 50. Mating capacity and mating success ratio.

Calculated lost queens based on the mating success ratio, show on average 0.49 lost queen per one mated queen or in general one lost queen on two mated queens (Figure 51). Excluding Spain which in average has only 0.21 lost queens or one lost queen on five produced queen, other countries and mating methods are in the range of average.

Observing through the mating environment and surrounding, Slovenia cases are the ones with the greatest number of colonies existing in the radius of 5 km from the mating station and in average there are 3 colonies per one mated queen (2.85). As it is expected, the control mated cases, especially having in mind the mating with isolation, in average have much less colonies in the surrounding or around 1 colony per one mated queen (0.84), while the open

mating control cases this figure is twice as high and it is around 2 colonies per one mated queen (1.90).

Mating success ratio and lost queens, including the number of colonies in radius of 5 km, have a direct impact on the improving the mating control and providing mating as services through generation of additional cost of queen production and mating (See Chapter Additional cost of queen production and mating service).

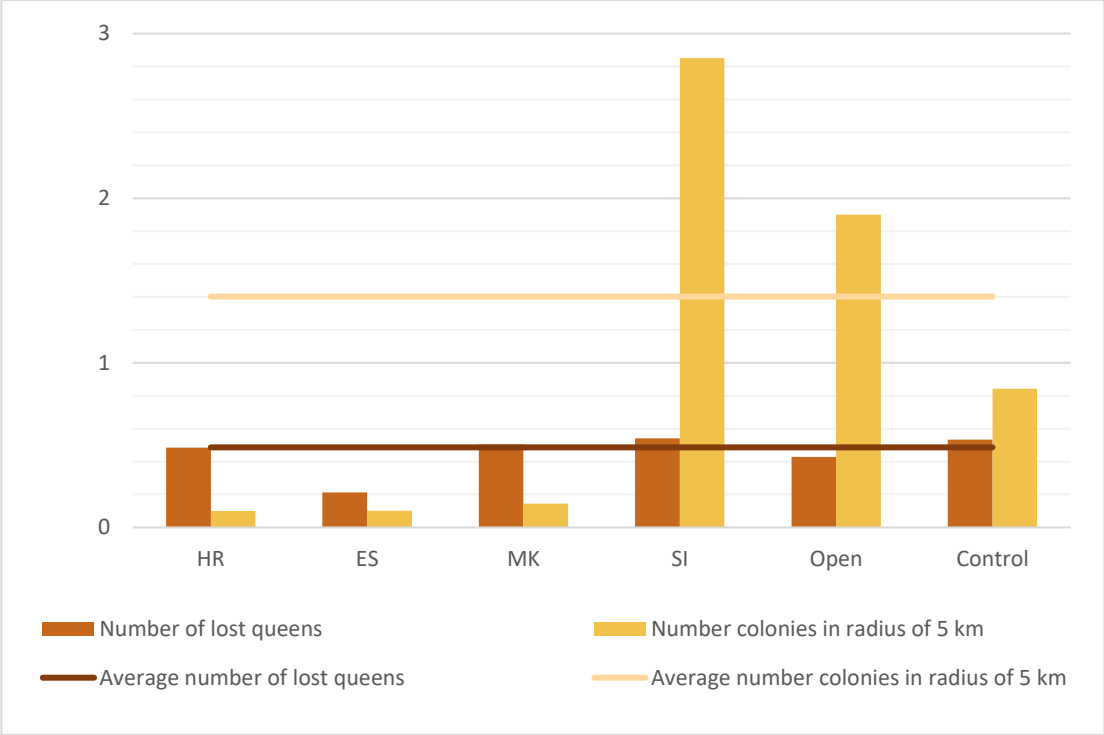


Figure 51. Lost queens and number of colonies in radius of 5 km per one mated queen.

Mating cost

The average mating cost for all cases is 13.77 EUR per mated queen, which represent share of 28 % of total cost of queen production. The highest share of mating costs are the depreciation of assets (29 %) and labour (20 %).[16]

Table 13. Average mating costs per one mated queen, in EUR

	Min	Max	Average	StD

[16] The other costs have significant share of 36% from total costs, but this is average based on only 2 cases from Slovenia who are practicing buying dry bees for filling the mating box (in average 3 kg for 20 nucleus).

Labour cost	0.60	17.50	4.44	4.14
Land concession (rent)	0.01	5.80	0.82	0.19
Electricity	0.02	2.50	0.91	1.38
Other costs	7.50	8.44	7.97	-
Transport costs	0.00	20.56	1.71	0.90
Variable cost mating	**0.68**	**42.27**	**7.46**	**5.01**
Mating depreciation costs	0.16	34.30	6.32	10.48
Total cost mating	**0.84**	**54.79**	**13.77**	**14.31**
Share of mating costs in total queen production costs	**5%**	**68%**	**28%**	**20%**

In analysis based on country cases, Macedonia has the highest mating cost of 23.04 EUR per mated queen and 45 % or almost half of the queen production costs. Croatia has the lowest mating cost of 5.16 EUR per queen or 22 % of total queen production costs, which is same percent for Slovenia. The lowest share in total costs has Spain with only 13 % and 5.84 EUR mating costs per mated queen (

Annex 3. Table 9 Average mating costs per 1 mated queen by country, in EUR).

Compared the cases based on mating method, it is evident that control mating with 20.54 EUR per mated queen is almost four times more expensive than the open mating approach. The highest difference is in the depreciation of assets which in case of control mating are almost ten times higher (10.62 EUR) and labour which are tree times higher (6.27 EUR).

Table 14. Average mating costs per 1 mated queen by mating method, in EUR

	Open	**Control**
Labour cost	2.20	6.27
Land concession (rent)	1.25	0.28
Electricity	-	0.91
Other costs	8.44	7.50
Transport costs	0.61	2.62
Variable cost mating	**4.44**	**9.92**
Mating depreciation costs	1.05	10.62
Total cost mating	**5.50**	**20.54**
Share of mating costs in total queen production costs	**19%**	**36%**

In Figure 52, the results for mating and cost of queen production are presented based on the country and mating method averages, compared with the average from all cases.[17]

[17] The mating cost does not include the cost for lost honey and performance testing, as it is hard to estimate their contribution to these loses. Anyhow, calculated this cost based on the share of mating costs in total costs, it means that additional 2 to 3 EUR should be allocated to the mating cost.

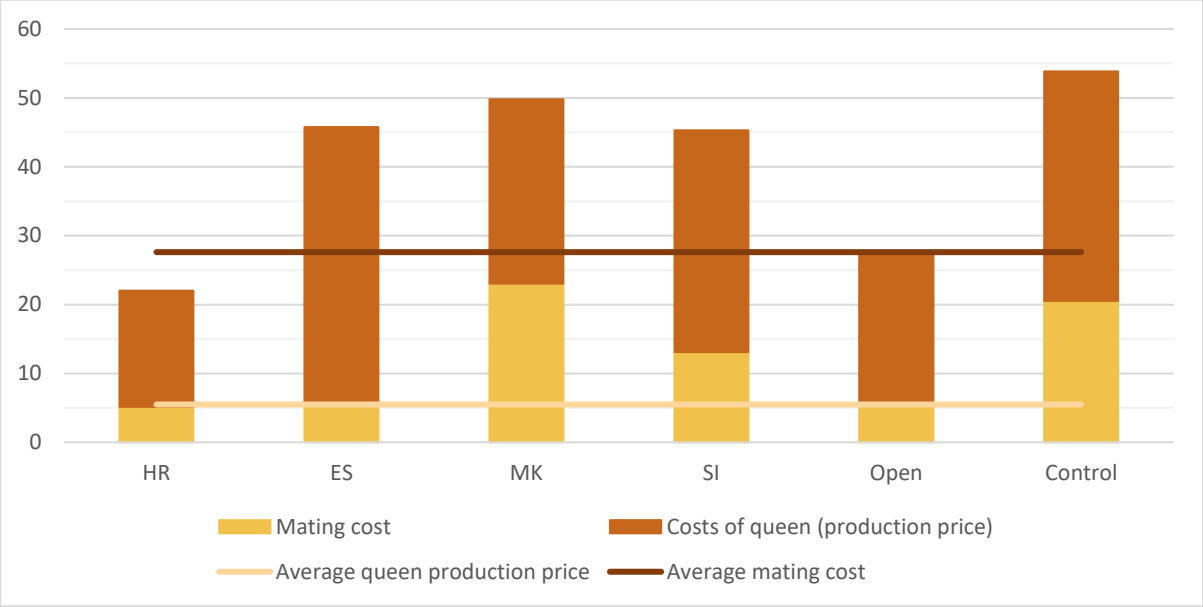


Figure 52. Queen production cost (price) and mating price per one mated queen, in EUR

Additional cost of queen production and mating service

Based on the mating costs and mating success ratio, the cost of controlled mating provided as services for other queen producers is on average 22.05 EUR per mated queen. The highest cost for mating services per one mated queen should be paid in Macedonia (37.40 EUR), while the lowest in Spain (6.96 EUR).

Additionally, in order to improve selection and mating, through saturation of the local/ surrounding producers in order to avoid the mixing and ensure the pure genetic potential, the additional costs of around 20.00 EUR per queen (21.71 EUR saturation with queen provided for free and 19.32 EUR saturation with DPC) should be made in order to service the colonies in radius of 5 km.

Table 15. Additional cost of queen production and mating per 1 mated queen, in EUR

	Min	Max	Average	StD
Mating service provided to other producer	1.13	109.57	22.05	26.23
Saturation - providing queens to beekeepers	0.01	200.29	21.71	10.66
Saturation – DPC	0.00	180.00	19.32	5.24

At the same time, the Slovenia has the highest average additional cost for saturation (44.09 EUR for saturation with queens and 51.26 EUR for saturation with DPC), primary as the result of cases high number of colonies in the radius of 5 km (

Annex 3. Table 10 Additional cost of queen production and mating per 1 mated queen by country, in EUR).

The control mating has higher price of mating services (33.32 EUR) compared with open mating (8.28 EUR). At the same time, the control mating has higher costs for saturation with DPC (31.13 EUR), but lower cost with saturation with queens (13.17 EUR) (

Annex 3. Table 11 Additional cost of queen production and mating per 1 mated queen by mating method, in EUR).

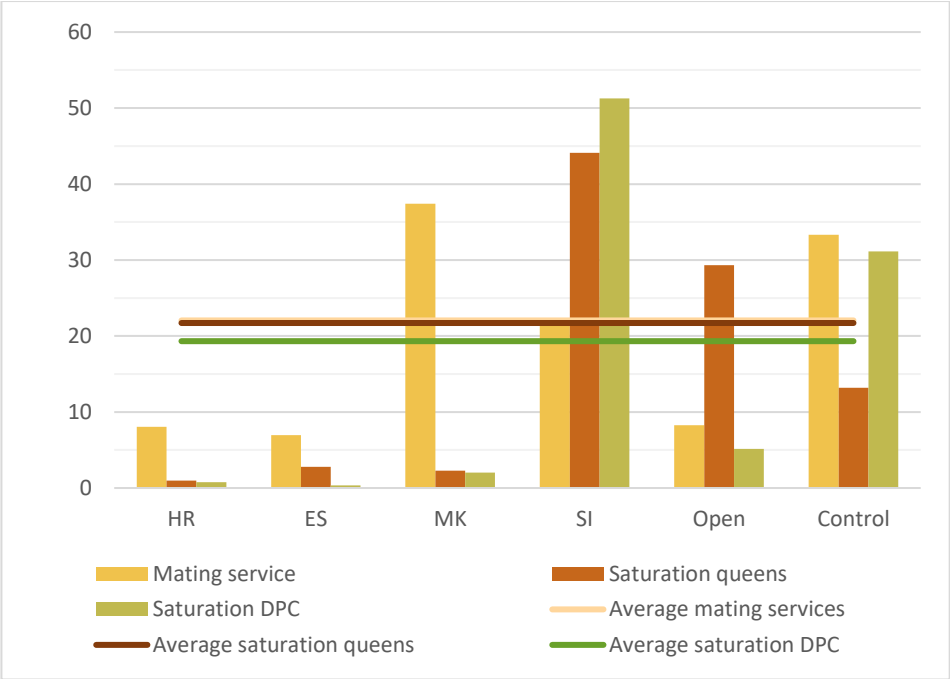


Figure 53. Additional cost of queen production and mating service per 1 mated queen, in EUR

Extra benefit of selection and mating

The calculation of extra benefit from selection and mating is based on the average annual increase of honey production for control mated and selected queens of 0.27 kg per hive or in total 6 kg in 11 generations (22 years) of continuous selection and 0.06 kg per hive or in total 1.4 kg in 22nd year for not selected. On average, it is expected to have increase honey yields of 0.36 kg or 3.88 EUR extra income per selected queen. In the last year of selection, in average it is expected to have average increase of 3.92 kg per colony or additional income of 42.66 EUR per queen, which is for 0.62 higher than the average queen's production price.

Table 16. Expected benefit from mating per 1 mated queen, in EUR

	Min	Max	Average	StD
Increased honey yields	0.13	0.54	0.36	0.13
Additional honey income (EUR)	**1.04**	**7.58**	**3.88**	**1.04**

Additional income in last year of selection	11.43	83.35	42.66	26.82
Difference Queen production price - Additional honey income	**-47.85**	**58.26**	**-0.62**	**27.08**

The effects of good selection and control mating can be clearly noticed through the extra yields and income from honey, which in control are almost four times larger (0.54 kg extra honey and 5.42 extra income per selected queen) compared with the open mating. The increased yields from control mating result with much highest extra income and in the last year of selection results with extra 9.40 EUR income on the queen production price. Contrary, the open mating production generates additional income, but this income in the last year of selection is 11.07 EUR lower and cannot cover the queen production price (

Annex 3. Table 13 Expected benefit from mating per 1 mated queen by mating method, in EUR).

Analysed by countries, the extra income in Croatia and Spain is larger than the queen production price, while in Slovenia it lower and cannot cover the production price. In Macedonia it is minor positive balance (

Annex 3. Table 12 Expected benefit from mating per 1 mated queen by country, in EUR).

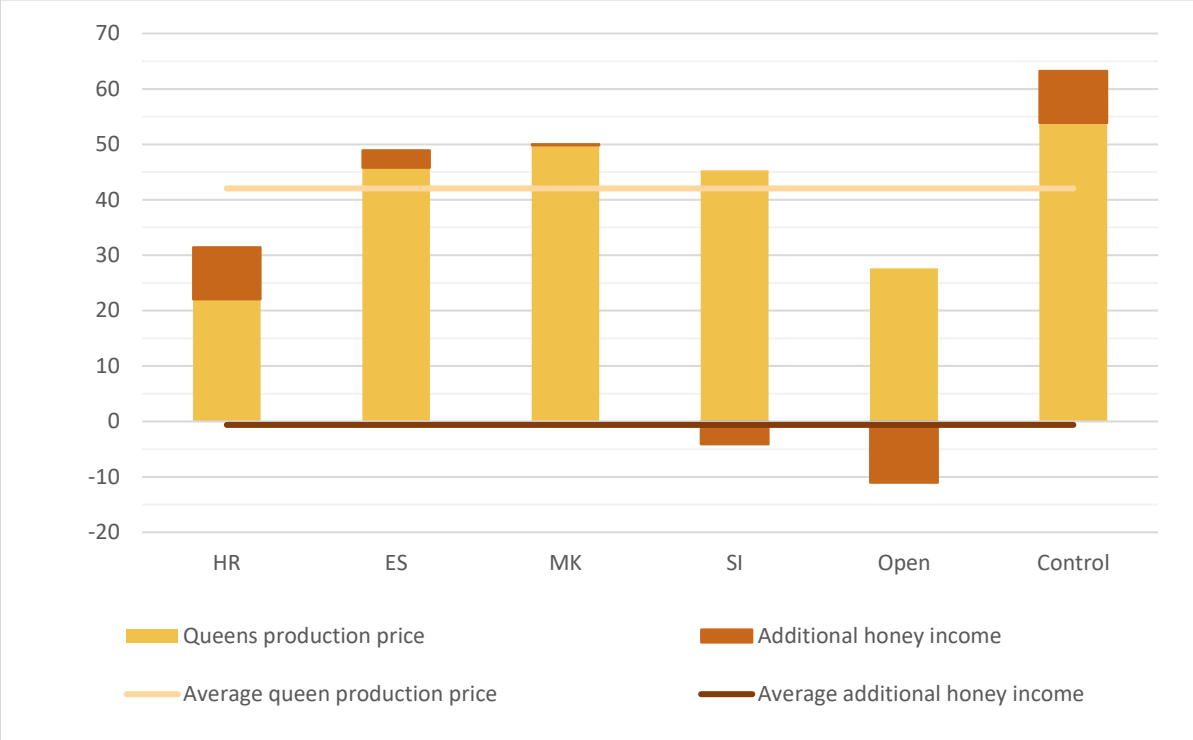


Figure 54. Extra benefit and income from mating per 1 mated queen, in EUR

Findings

Selective breeding of honey bees and producing of selected queens is expensive process, which in most cases impose high production cost, which cannot be compensated with the lower selling prices. The average cost of queen production is 42.05 EUR per one mated queen, which taking in consideration the average selling price of mated queen of 17.96 EUR which is much lower, on average results with negative difference between the selling price and the production price, which at variable costs is -2.50 EUR and -24.09 EUR full production price at total costs.

In cross-country comparison, Macedonia has on average the highest production costs and production price of mated queen of 49.81 EUR, while at the same time Croatia has the lowest production price of 22.04 EUR. Looking from the perspective of queen selling and production price, Spain on average has the highest selling price of 27.75 EUR per queen, while Croatia has the lowest with 9.66 EUR. The lowest negative difference is evidence in Croatia

with average -12.39 EUR lower selling price compared with the total production price and highest in case of Slovenia with -29.67 EUR lowest selling price.

The highest share of the queen production price are the costs for depreciation (34 %), labour (23 %), loss honey (14 %) and purchased queens and honey bee packages (13 %).

The high production costs and low selling price usually generates losses. The lower selling price in comparing with the full production price of mated queens, has impact on the queen production business profitability. On average, the income from queen production, including income from queens, but also the additional income from honey, colonies, nucleus and mating boxes is 40.39 EUR per one mated queen, which compared with the costs of 42.05 EUR, results with average losses of 1.65 EUR per mated queen. Anyhow, taking in consideration the income from subsidies, which is in average 7.24 EUR per mated queen from 10 cases which are receiving subsidies, on average the queen producers work with 1.97 EUR profit per mated queen.

The highest profit is noticed in case of Spain with average 48.43 EUR. Croatia has modest profit of 3.22 EUR per produced queen, while at the same time Slovenia has modest losses of -4.48 EUR per queen. Macedonia is country with the highest losses of -17.82 EUR per queen.

Control mating is expensive and has significant contribution to total production costs. The effects of mating can be clearly noticed based on the production costs of queen produced with open mating and controlled mating. The production price of queen with control mating is 53.86 EUR, which is two times larger than production price of 27.61 EUR for queen produced with open mating. Based on the mating method, the average selling price of control mated queen is 19.71 EUR, which is insignificantly higher than the price of 15.82 EUR of queen with open mated, taking in consideration the high production costs for control mated queens and much higher production price, which results with high negative differences and production price higher for 34.15 EUR or almost two and half times compared with the average selling price of control mated queens. On contrary, in case of the queens with open mating, the negative difference between the selling and production price are lowest (-11.79 EUR). As result price difference, on average the control mated queens generate -17.58 EUR losses per produced mated queen, while the queens with open mating on average generate 17.82 EUR profit per mated queen.

The average mating cost for all cases is 13.77 EUR per mated queen, which represent share of 28 % of total cost of queen production. The highest share

of mating costs are the depreciation of assets (29 %) and labour (20 %). Compared the cases based on mating method, it is evident that control mating with 20.54 EUR per mated queen is almost four times more expensive than the open mating approach.

Improving of mating and mating condition will generate additional cost. Based on the mating costs and mating success ratio, the average costs of mating provided as services for other queen producers is in average 22.05 EUR per mated queen. The highest cost for mating services per one mated queen should be paid in Macedonia (37.40 EUR), while the lowest in Spain (6.96 EUR). Additionally, in order to improve selection and mating, through saturation of the local/ surrounding producers in order to avoid the mixing and ensure the pure genetic potential, the additional costs of around 20.00 EUR per queen (21.71 EUR saturation with queen provided for free and 19.32 EUR saturation with DPC) should be made in order to service the colonies in radius of 5 km. **It is important to notice that saturation has long-lasting effect on improving the genetical potential of surrounding bee yards (as queen provided will be used 2 years) and the costs which are calculated as one time event should be dispersed through years, which will significantly reduce the cost per produced mated queen.**

Selection and control mating can generate extra benefit and income. The effects of good selection and control mating can be clearly noticed through the extra yields and income from honey, which in control are almost four times larger (0.54 kg extra honey and 5.42 extra income per selected queen) compared with the open mating. The increased yields from control mating result with much highest extra income and in the last year of selection results with extra 9.40 EUR income on the queen production price. Contrary, the open mating generates additional income, but this income in the last year of selection is 11.07 EUR lower and cannot cover the queen production price. **The selection and control mating can significantly improve honey bee health and reduce colony losses, but also increase gentleness and reduce swarming tendency which, will increase queen production benefits and reduce the CoP (disease treatment, labour, lost of honey and colony), but unfortunate is hard to estimate and calculate at this moment.**

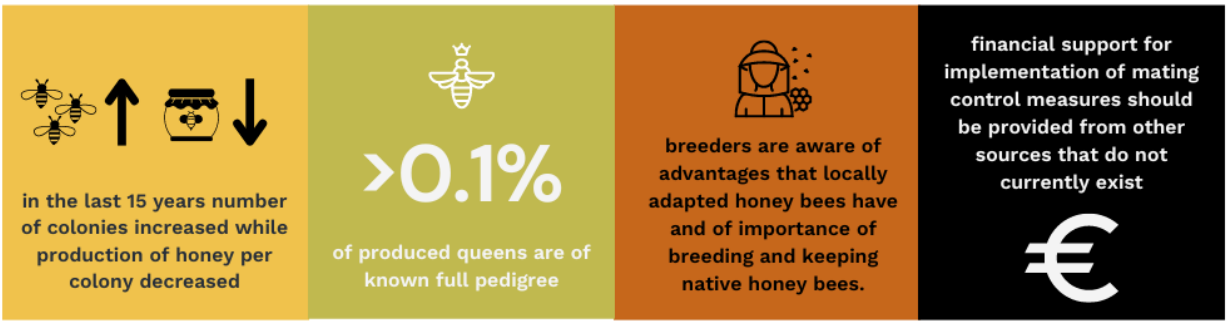
IV. CONCLUSIONS AND RECOMENDATIONS

The activities carried out as part of WP1 indicated the current state of beekeeping, bee breeding and controlled mating of queens in the three beneficiary countries: Croatia, Macedonia, and Slovenia. Analysing honey production for the last 15 years, we observed a negative correlation between the number of honey bee colonies and honey production per colony, meaning that number of colonies increased while production of honey per colony decreased. This certainly indicates the need for a deeper analysis of this problem and the joint action of all actors and measures (subsidies) in the beekeeping sector to find a satisfactory solution to this problem.

The high average success in technical aspects of queen production (success of mating, grafting, and hatching) clearly shows that breeders have overcome all technical difficulties that may arise in the production of queens. However, one of the main findings of the survey is that full mating control in project beneficiary countries is neglected and we could say that less than 0,1% of produced queens are of known full pedigree. This is a major problem for preserving native honey bee populations by continuous active genetic progress, ensuring the high natural and economic value of the local breeding stock. It is clear that full mating control is the main challenge for all breeders which are not able to cope with this by themself. Most of mating stations are not completely isolated because of a colony high density, lack of isolated places and proper infrastructure and finally, high costs. On the other hand, survey revealed that breeders are aware of advantages that locally adapted honey bees have and on importance of breeding and keeping native honey bees. Further, they are aware that controlled mating is crucial to improve desired traits in honey bees and given the fact that most of surveyed breeders plan to stay in business for more than 10 years, it is worthwhile to invest time and money to improve mating control.

Finally, one of the main obstacles to achieve increased mating control is of a financial nature. For the production of fully controlled mating queens, it is necessary to invest considerable financial resources. If breeder invests money, consequently the market price of queen will be higher, and beekeepers are mostly not ready to pay more money for the queen. Therefore, financial support for implementation of mating control measures should be provided from other sources that do not currently exist. This is certainly one of the reasons why breeders do not want to invest in it independently.

Activities and breeding strategies related to mating control should improve this situation, to present the path and provide simple tools and methods of controlled mating that could be used by the majority of breeders without significantly increased production costs. Our survey analysis clear indicates that the BeeConSel project addresses currently most important aspect of the honey bee breeding in HR, SI and MK.



Recommendations

It is evident that promotion and introduction of selection and controlled mating condition, on the long run can gain significant economic benefits for the queen producers, even higher than the production cost and enable to increase their income and profitability. At the same time, the selected and control mated queens will additionally increase positive benefits and effects on the beekeeping society.

Having in mind that market prices are much lower compared with the production price of selected queens, the policy-makers and scientists should make efforts in understanding the reasons for market disturbance and make efforts to reduce negative effects of this untypical disparity.

The collaboration among scientists and queen producers is essential for improvement of breeding programs, especially in line with increasing the

mating success ratio, but also in general increasing of productivity and reduction of production costs.

Last, but not least, perceiving the selection as long-lasting process, which imposes high production and investment costs, it needs higher understanding and support from policy makers and local authorities, as crucial basis for future business development of selection activities and greater institutional and financial support.

Annexes

Annex 1. Data explanation for Queen producers and Mating - Assets

Please provide information for the total value of all assets that you own/use in production.

If you keep accounting, you can use the purchase value of the asset from your official books.

In contrary, please try to estimate the purchase market value of the assets, if you will have to purchase/construct new one today (value of new asset at this moment in euro).

If the asset is use for your regular (daily) honey production, but also is used for queen production and mating, then please mark all fields with 1.

If asset is used only for specific production purpose, please mark with 1 for which purpose (mating box are used only mating and queen production, uncapping table/honey tanks/barrels/sieves are used only for regular honey production, etc).

NOTE: If asset is used for Mating, it means that at the same time it is used also for Queen production and when Mating is marked with 1, Queen production should be also marked with 1. If it is special case and the asset is used only for Mating purposes, please provide explanation in Comments.

Data are provided for NORMAL/TYPICAL/MOST COMMON YEAR of queen production or some average of production results in the last 5 years. For tested models of mating, fill the information should be enter based on the test results and some estimation of queen production and mating, if necessary.

The questionnaire has additional column for Comments which can be used only for internal use in order to better explain if some specific or untypical situation is evident.

Data questionnaire	Explanation of the data
Please select the mating model to enter assets, cost and income	The drop-down list is used to select of various mating models Geographical isolation (lowland, mountain, island or peninsula), Instrumental insemination, Temporal isolation 1 (with use of cooler) or Temporal isolation 2 (with use of labyrinth/maze), Drone saturation 1 (with drone producing colonies - DPC) or Drone saturation 2 (with providing queens), Open/controlled mating (traditional producing and mating of queens and option for Open mating (virgin queens).
Queen producer ID	The unique individual ID will be provided by the Regional Coordinator for easier identification of queen producer.
Buildings	
Solid and concrete buildings	All buildings (honey manipulation, storage, laboratory, meteorological station, etc.) with solid or concrete constructed.
Wood-frame, metal construction, etc.	All buildings (honey manipulation, storage, laboratory, meteorological station, etc.) with constructed from wood, metal or other less lasting materials.
Please specify:[1]	Option is available to define additional/other items which are relevant and are not predefined in the questionnaire.
Infrastructure	
Electricity, water supply, roads	If queen producer had invested in additional infrastructure in order to ensure access to bee yard, regular supply of electricity (electric power transformation substation, distribution lines, pipes, cable, etc.).
Colonies	
Colonies	All colonies (regular production, queen production and mating) on the bee yard.
Mini mating boxes	Mini type of boxes used for mating.
Nucleus mating boxes	Nucleus type of boxes used for mating.
Drone producing colonies (DPC)	Drone producing colonies (DPC) used for mating.
Equipment	
Beekeeping equipment	
Cell cups, bars and frames, grafting tools, queen rearing kits, queen cell protectors	All small equipment owned on the bee yard and used in the production.

Instrument for insemination	In case where instrumental insemination is used as mating model.
Other equipment	
Electronic equipment, mobile devices, computers, software	All electronic devices, including software used in the production.
Lab ware, furniture, other	Laboratory equipment, measurement instruments, tables, chairs, freezers, etc.
Machine and machinery	Honey extractor, beeswax foundation embossing, beeswax press machine, instrumental insemination, washing machines, bee hive lifter, etc. You can use each line to enter individual item or just use one line to state all items and provide total value for all, except for Bee hive mobile trailer.
Vehicles and transportation means	Cars, trucks, etc. You can use each line to enter individual item or just use one line to state all items and provide total value for all.
Intangible assets (studies, licenses, etc..)	Investment cost for promotion and marketing which are made for longer period as design of webpage, promotion materials and campaigns or other long-lasting investment in marketing. Trainings for human capacity development or development of special skills as skills for Instrumental insemination. Other investment cost can be for obtaining licenses, certificates, liaisons, studies, etc. You can use each line to enter individual item or just use one line to state all items and provide total value for all.
Other	Same as Please specify option is available to define additional/other items which are relevant and are not predefined in the questionnaire.

[1] The option to define additional/other items which are relevant and are not predefined in the questionnaire is available for most of the data.

Annex 2. Data explanation for Queen producers - Queen production Income, Costs and Mating

Same as the assets data, for the queen producer data for income, costs and mating are provided for **NORMAL/TYPICAL/MOST COMMON YEAR** of queen production or some average of production results in the last 5 years. For tested models of mating, the information should be enter based on the test results.

Data questionnaire	Explanation of the data
Queen producer ID	Same unique individual ID as used in Assets and provided by the Regional Coordinator for easier identification of queen producer.
Year of birth? (Year)	Year of birth of owner/lead queen producer.
How many years of work experience do you have in queen production? (Year)	Provide only years dealing with queen producing, not beekeeping.
Total number of colonies (number)	Number of all colonies (regular production, queen production and mating) used in production (entire business).
How many colonies are used only for queen production (number)	Number of colonies (from total) used only for the queen production.
Average production of honey per year (kg per colony)	If some of the colonies are used for production of honey. Divided total honey production of with number of colonies (survived) at the end of harvest season.
Price of produced honey (euro per kg)	Average price of your honey. If you are selling on different markets with different prices, the most exactly is to divided total income with total sold honey.

The data should refer **ONLY TO QUEEN PRODUCTION AND MATING**. For items that only total value is required, please fill income and costs value for **NORMAL/TYPICAL/MOST COMMON YEAR** of queen production year. For other items, please fill the information for number of units and value per unit. You can calculate or leave blank and the total value to be calculated by the Regional Coordinator.

NOTE: If you face challenges to allocate the costs only for queen production (especially for some common and general costs which are used at the same time for your regular (daily) honey production and at the same time for queen production as administration, telephone, accounting, etc.), then you can simply estimate percent of the costs allocated only on queen production

based on your experience or just based on the percent of colonies used for queen production from total colonies that you own (ex. If the total number of colonies is 100 and only 10 are used for queen production, then 10 : 100 = 10 % and only 10 % of the costs will be allocated for queen production. If in the same example, number of colonies used for queen production is 50, then 50 : 100 = 50 % is allocated to queen production).

Data questionnaire	Explanation of the data
Income	
Queens mated	Number of produced and sold mated queens and average selling price of 1 mated queen.
Queens virgin (the ones not used for producing mated queens)	Number of produced and sold virgin queens which are not used for producing mated queens and average selling price of 1 virgin queen.
Queens cells (the ones not used for producing virgin queens)	Number of produced and sold queens cells which are not used for producing virgin queens and average selling price of 1 queen sell.
Nucleus (returned in the regular production or sold)	Number of produced (which are sold or used to be returned in regular production or sold) and sold nucleus and average selling price of 1 nucleus.
Colonies (returned in the regular production or sold)	Number of produced (which are sold or used to be returned in regular production or sold) and sold colonies and average selling price of 1 colony.
Subsidies received for queen production	Total income (money) received from subsidies only for queen production.
Costs	
Purchased queens and honey bee packgaes	If you are buying genetic material for reproduction/multiplication in the process of queen production, please fill information for purchased queens.
Labour	
Permanent/Full time employed (paid on monthly salary)	Costs for salary of employed workers with regular monthly salary. If you employ 2 persons, number of units is equal to 24 months multiply by average monthly salary (value per unit) or if you employ 2 persons half year (6 months) it is equal on 12 months total.

	Annual work unit (AWU) is the full-time equivalent of annual work of 1800 hours is to be taken as the minimum figure or 225 working days of 8 hours each.
Hired labour (hired and paid per day of engagement)	Labour hired per day based on daily fee.
Unpaid/Family labour (if the production is done only with unpaid labour, please provide average daily hired labour payment in your region, 1 working day = 8 hours, 19 working days = 1 month)	Estimate the number of family and non-family members (not paid workers) engaged in production on the level of full-time engagement. Ex. If 2 family members are spending half time per month in production process, it will be equivalent of 1 engaged person per month. If the production is done only with unpaid labour and there is no permanent employed or hired labour (information about the labour price are not available), please provide average daily hired labour payment in your region
Feeding	Total costs for feeding all queen production colonies.
Labour and other transport to bee yard	Please estimate the total (yearly) costs for transport of family and non-family unpaid members to bee yards. If you pay additionally to permanent and hired labour for transport, please include the yearly costs in total value.
Protection (Disease treatment)	Total costs for protection (disease treatment) for all queen production colonies.
Equipment (1 - year use)	Total costs for equipment used only for one production season. Do not include equipment already stated in assets.
Veterinary services	Total costs for veterinary services for all queen production colonies.
Package, transport, labelling (in total only for the queens and queen production)	Estimate total costs for package, labelling and delivery of produced queens to your clients. Please estimate the costs only for queens, not for entire production.
Water, electricity, heating	Total costs for water, electricity, heating for all queen production colonies.
Promotion and marketing	If you have some promotional or marketing activities, please provide us with the total costs for these activities for queen production.
Insurance	Total yearly costs for insurance of the different items for entire business.
Income tax	Total value of paid income (corporate) taxes. Tax paid on gross income or also know profit before taxes.

Other general costs (administration, telephone, accounting, etc.)	Total general yearly costs for queen production (costs rising from activities common for entire business) as administration, post, internet, telephone, accounting, etc.
Please specify	Other costs not mention (expert, technical or other services) for queen production.

Data questionnaire	**Explanation of the data**
Mating (if you perform mating, please in detail specify mating part):	
Colonies used only for mating process	Number of colonies used only for the mating process.
Mating boxes (number)	Number of mini mating boxes. If open mating is practiced leave blank.
Nucleus (number)	Number of nucleus mating boxes. If open mating is practiced leave blank.
Drone production colonies (DPC) used only for mating process (number)	Number of drone production colonies (DPC) used only for mating process.
Number of queens produced with open mating (number)	Please provide the total number of queens produced with open mating per this production year.
Number of queens produced with controlled mating (number)	Please provide the total number of queens produced with controlled mating per this production year.
Total potential number (capacity) of mating queens per season (number)	Estimate and provide the total number of queens that can be produced per season with existing assets and capacity.
Total number of working (labour) man days for the whole mating process (if you cannot provide information, please answer next 2 questions) (number)	Total number of working days for the whole mating process. Have in mind that if 2 persons are working 1 day, it is 2 working man days. If you cannot provide information about working man days, please answer next 2 questions for the number of persons involved and average time spent per one day visit/activity.
1. Average number of persons involved in mating process per one working day (number)	Please estimate how many people in average perform mating process per one working day (one visit and mating activity).
2. Average time spent during the mating process per one working day (number)	Please estimate how much time is needed in average to perform required mating activities one working day (one visit and mating activity).

Land concession (rent) (euro)	If you are paying for the land, please provide the amount of yearly amount paid for the use of land, concession or rent.
Electricity (euro)	Costs for used electricity in mating process.
Please specify (euro)	In case you had some additional costs for mating (other costs for mating except labour and transport as insurance, feeding, protection, transport of mating boxes, etc.), please estimate the total value for these costs.
Number of loss queens (number)	Number of loss queens during the mating process.
Average mating success ratio (in percent %)	If mating is successful at 9 out of 10 colonies, it means 90% success.
Number of times you visit the mating station per entire mating process (number)	Please, provide us with the number of visits to the mating station only with the purpose to perform mating.
Distance from home to mating station (km)	Average distance in one direction in kilometres.
Fuel price (euro)	Average yearly price of fuel used for transport (diesel, unleaded, gas).
Total number of other colonies in radius of 5 km from the mating station	Number of colonies of other beekeepers in the radius of 5 km.
Data questionnaire	**Explanation of the data**
Performance testing (if the performance testing is performed by other beekeepers, can you specify):	
Total number of queens provided for performance testing per year	Total number of queens produced per one production season for testing purpose.
If you pay for performance testing, what is the average price that you paid per one tested queen?	If you paid for testing, then please provide the value you paid per one queen. Divide total amount paid with number of queens tested.
Data questionnaire	**Explanation of the data**
Distance from other queen producers to your mating station (km)	Please provide the distance in kilometres from your mating station to at least 3 queen producers in your region.

Annex 3. Detail tables

Table 1. Average loss/profit per 1 mated queen including subsidies, in EUR

	Min	Max	Average	StD
Total income of queen production	**11.23**	**108.67**	**40.39**	**22.97**
Subsidies	1.00	20.83	7.24	6.23
Total income of queen production	**15.23**	**108.67**	**44.02**	**22.75**
Total cost of queen production	**11.61**	**123.44**	**42.05**	**25.52**
Average loss/profit per 1 mated queen	**-103.20**	**64.31**	**1.97**	**24.33**

Table 2. Difference between average selling and production price per 1 mated queen by mating method, in EUR

	Open	Control
Selling price queens	15.82	19.71
Difference selling and production price at variable cost	**0.99**	**-5.36**
Difference selling and production price at total cost	**-11.79**	**-34.15**

Table 3. Difference between average selling and production price per 1 mated queen by country, in EUR

	HR	ES	MK	SI
Selling price queens	9.66	27.75	23.33	15.63
Difference selling and production price at variable cost	**-1.98**	**-8.85**	**-1.75**	**-1.74**
Difference selling and production price at total cost	**-12.39**	**-18.00**	**-26.48**	**-29.67**

Table 4 Average loss/profit per 1 mated queen, open vs. control mating, in EUR

	Open	Control
Total income of queen production	45.43	36.27
Total cost of queen production	27.61	53.86
Average loss/profit per 1 mated queen	**17.82**	**-17.58**

Table 5 Average loss/profit per 1 mated queen by country, in EUR

	HR	ES	MK	SI
Total income of queen production	25.26	94.17	31.99	40.82
Total cost of queen production	22.04	45.75	49.81	45.30
Average loss/profit per 1 mated queen	**3.22**	**48.43**	**-17.82**	**-4.48**

Table 6 Mating capacity and results

	Min	Max	Average	StD
Used mating capacity	7%	100%	52%	21%
Number of loss queens per 1 mated queen	0.18	1.00	0.49	0.23
Average mating success ration	50%	85%	69%	10%
Average number colonies in radius of 5 km per 1 mated queen	0.00	13.13	1.40	0.67

Table 7 Mating capacity and results by mating method

	Open	Control
Used mating capacity	57%	47%
Number of loss queens per 1 mated queen	0.43	0.53
Average mating success ration	71%	67%
Average number colonies in radius of 5 km per 1 mated queen	1.90	0.84

Table 8 Mating capacity and results by country

	HR	ES	MK	SI
Used mating capacity	56%	78%	34%	56%
Number of loss queens per 1 mated queen	0.48	0.21	0.50	0.54
Average mating success ration	69%	83%	68%	66%
Average number colonies in radius of 5 km per 1 mated queen	0.10	0.10	0.14	2.85

Table 9 Average mating costs per 1 mated queen by country, in EUR

	HR	ES	MK	SI
Labour cost	3.13	3.72	6.98	3.38
Land concession (rent)	0.20	0.63	0.14	1.25
Electricity	0.11	-	2.50	-
Other costs	-	-	-	7.97
Transport costs	0.46	0.11	0.86	3.38
Variable cost mating	**3.70**	**4.15**	**8.30**	**9.53**
Mating depreciation costs	1.46	1.68	14.74	3.58
Total cost mating	**5.16**	**5.84**	**23.04**	**13.11**
Share of mating costs in total queen production costs	**22%**	**13%**	**45%**	**22%**

Table 10 Additional cost of queen production and mating per 1 mated queen by country, in EUR

	HR	ES	MK	SI
Mating service provided to other producer	8.03	6.96	37.40	21.32
Saturation - providing queens to beekeepers	0.99	2.80	2.28	44.09
Saturation - DPC	0.78	0.36	2.03	51.26

Table 11 Additional cost of queen production and mating per 1 mated queen by mating method, in EUR

	Open	Control
Mating service provided to other producer	8.28	33.32
Saturation - providing queens to beekeepers	29.30	13.17
Saturation - DPC	5.15	31.13

Table 12 Expected benefit from mating per 1 mated queen by country, in EUR

	HR	ES	MK	SI
Increased honey yields	**0.34**	**0.34**	**0.47**	**0.28**
Additional honey income (EUR)	**2.86**	**4.45**	**4.55**	**3.74**
Additional income in last year of selection	**31.45**	**48.94**	**50.01**	**41.19**
Difference Queen production price - Additional honey income	**-9.41**	**-3.19**	**-0.20**	**4.11**

Table 13 Expected benefit from mating per 1 mated queen by mating method, in EUR

	Open	Control
Increased honey yields	**0.13**	**0.54**
Additional honey income (EUR)	**1.50**	**5.42**
Additional income in last year of selection	**16.55**	**59.65**
Difference Queen production price - Additional honey income	**11.07**	**-9.40**