PROFITABILITY OF QUEEN BEE REARING AT APIARIES OF DIFFERENT CAPACITY[1]

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Abstract

In this paper authors presented the structure and amount of costs related to queen bee rearing, at apiaries with capacity of 50, 100 and 150 hives, where amortization period of equipment and material is 20 years. Authors presented realized production volume at apiaries of different quantity, production value of queen bees and economic estimation of investing into apiaries with main strategy in queen bee rearing. Besides economic indicators, authors also gave insight into process of commercial queen bee rearing at apiaries of different capacity, which was applied for all calculations in this paper. Main goal of this paper is to present possibility for obtaining a profit at family farm which poses 50, 100 and 150 hives and which is oriented toward comercial queen bee rearing.

Key words: *queen bee rearing, apiary, rearing expenses, profit*

Introduction

Honey bee is an insect which lives in perennial colonies whose founder is a mother - the queen bee. Queen bee is the only reproductive female in the colony and her biological quality largely determines the strength of the colony, work productivity and resistance to diseases. All members of the bee society inherit physical characteristics and performance traits from the queen bee.

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Thanks to queen bee pheromone, which is produced only by a queen bee, thousands of worker bees live together and are stimulated to work, which considers large number of various activities in and out of the hive. In conditions of moderate continental climate, queen bee starts to lay eggs in January, maxiumum is reached in June when a good quality queen bee can lay up to 2,000 eggs per day, and she stops to lay eggs in October. Although queen bee can live few years in one society, in modern commercial beekeeping, queen bees are "used" at most two years, because in time their capacity to lay eggs decrease. Mostly, after two years old queen bee is being replaced with young mated queen bee, to keep high productivity of the bee colony.

Beekeepers which want to enlarge their own apiary or want to rear queen bees for comercial sale must learn basic principles of queen bee rearing methods and to have certain conditions at their own apiary, which considers having enough number of strong colonies and equipment necessary for queen bee rearing. At apiaries oriented towards queen bee rearing, besides standard apiary equipment, additional equipment designed only for queen bee rearing must be present.

Benefits of mastering the skills of rearing queen bees are multiple and are reflected in:

- *Benefits for beekeeper* - reduction of expenses at ones apiary regarding queen bee purchase, controlled quality of queen bees, disappearance of stress regarding forehand queen bee purchase, providing of self-sufficiency (rearing of queen bees for the needs of own apiary) and increase of income at family farm from sales of queen bees (commercial queen bee rearing);
- *Benefits for the state* - stimulation of beekeeping development in Serbia, export of queen bees in surrounding countries, indirect impact of queen bee rearing on development of other agricultural branches though development of beekeeping and reduction of poverty (especialy in non-developed rural areas).

For successful queen bee rearing it is necessary to have knowledge and experience, which demands some time. When rearing queen bees it should not be forgotten that it is a living being and that by selecting colonies for grafting larvae beekeeper manipulate the genetic material.

Research method

In accordance with research topic in this paper the following methods are selected:

- Method of investment planning (Andrić et al., 2005)
- Method for estimation of investment projects (Subić, 2010)

For data analysis and presentation of queen bee rearing method, authors used data from agricultural production, findings of other authors published in books and thematic proceeding from scientific meetings as well as available electronic data bases.

Location of the apiary

Rearing of queen bees may be of interest to beekeepers who decide not to move their hives to a specific location with a rich pasture that is for beekeepers with stationary beekeeping. In stationary beekeeping total costs are lower because there there are no migration costs, depreciation costs of hives are lower and if the apiary is near beekeepers' home, there are no travel costs to the apiary (Relić, 2007). Beekeeper who does not move hives can have profitable apiary if his focus is on queen bee rearing. On mobile apiary, economically is justified only rearing queens for own needs (Relić, 2007). If in the vicinity of the apiary is rich pasture then the beekeeper can achieve benefit from the honey yield. When it comes to stationary beekeeping beekeeper can use any type of hive, although the most common type of hive in the world, and in our country, is Langstroth hive.

Suitable place for stationary apiary must meet several key requirements which are: to be protected from the wind, surrounding terrain must not be saturated with bees, the terrain must not be exposed to floods, apiary must not be near large water bodies and in the area of bees' flight must be enough pollen and melifferous plants (Relić, 2007).

In locations where there are a lot of other people's bees is greater potential for disease and robbery and large number of bees fight for the same pasture. Hives should be protected from strong winds, such as košava in Banat, because a strong wind interferes with the bee exit from hives and their flight.

Next to large water bodies there is usually rich melliferous vegetation so it is preferable to place stationary apiary at the optimum distance from such water bodies. Stationary beekeeping is not profitable if the apiary is in the area poor with melliferous and polen rich plants. The apiary will only make losses, because the bees have to be fed, because they can not get enough food (Relić, 2007).

Queen bee rearing process

There are many methods for queen bee rearing, and the choice of a method depends on the personal affinity of a beekeeper, level of his knowledge and equipment that he has or he can obtain. However, regardless on the chosen method, basic principles of queen bee rearing which consider respect of queen bee life cycle are the same. One of the most important principles of succssesful queen bee rearing is grafting of very young larvae after hatching i.e. larvae must not be older than 12 hours. So, for production of quality queen bees it is crucial to use the youngest possible larvae[4].

In this paper authors presented method which ensures continuous production in a longer period of time[5]. According to this method for queen bee rearing, it is necessary to prepare three groups of bee colonies:

1. *group of mothers* whose colonies are being monitored for few years and which are "donors" of young larvae for grafting,
2. *builder colonies* i.e. group of colonies necessary for raising of grafted queen bee larvae;
3. *mating colonies i.e.* group of colonies necessary for fertilization of queen bees.

Group of mothers that is colonies of which larvae are taken should be strong and healthy for a longer period of time; they must be able to give a lot of honey considering that the primary goal at the apiary is improvement of colonies performance. There are differences in characteristics between different races of bees so there are differences in characteristics between different colonies at one apiary, even though the starting material was of excellent quality. All colonies at one apiary do not have the same strenght. When choosing quality colonies as mother

[4]One of the main reasons for failure in queen bee rearing, often done by beginners, is grafting of older larvaes.
[5] http://www.glenn-apiaries.com/queenrear.html

colonies beekeeper must pay attention to: colonies strenght, bees diligence, resistance to diseases, expression of swarm instinct, bees aggressiveness, consumption of winter food stores, spring development, collection of pollen, honeycomb construction, arrangement of honey, hygiene and collecting of propolis. One of the certain indicators of good colony is large coverage of frames with capped brood.

Builder colonies are colonies for development of grafted larvae (queen bee cells)[6]. These colonies must be strong with large number of bees capable to nurture queen ceels well. Before they are put into builder colonies, beekeeper must limits activity of present queen bee by using queen excluder or he must remove the queen bee.

Builder colonies must fulfill the following conditions:
- to have 6 - 8 frames of brood;
- to be healthy;
- to have queen bee which is old 6 - 12 months (if one works with builder colonies with queen bee);
- to have lots of pollen and nectar;
- bees must cover all frames in the builder colony.

In builder colonies bees accept grafted larvae and their number can be seen by the number of constructed queen cells (cells with conical shape). When grafting, beekeeper must pay close attention to the number of grafted larvae which must not be to large. If the number of grafted larvae is to large produced queen bees will be of weaker quality or started queen cells will not developed completely. According to so far practical experience, one should not start more than 60 - 70 queen cells per colony (Mladenović and Stevanović, 2003).

Main steps in queen bee rearing, by order of activities, are the following:

1. *carefull selection of colonies* of which queen bee larvae are taken,
2. *grafting of queen bee larvae* from selected colonies into wax bases at frames using Chinese niddle,
3. *putting of frames* with grafted larvae into builder colonies,
4. *transfer of finished queen cells* from builder colonies to mating nucleuses.

[6]Grafted queen bee larvae can be placed into so called starters, for a first few days, and then they are tranffered into builder colonies. Starter colonies as well as builder colonies must be strong with enough quality food. Starter colony must be productive, without disease for a long period of time, diligent and calm.

Prior to queen bee hatching it is necessary to prepare so called mating nucleuses, that is small hives with small bee colony. Namely, if many younger virgin queens hatch at the same time they will attack one another and destroy non-hatched queen cells. To prevent this, it is necessary to transfer queen cells 1 - 2 day before hatching to colonies without queen bees i.e. mating nucleuses. Fortheen day old queen cells are placed in such mini-hives and, after two days, virgin queens will emerge. The simpliest mating nucleuses consist of 4 frames placed into mini-hive of which one frame is with honey, one frame is with pollen, two frames have open brood and there are additional bees from two more frames[7]. Considering that such mini - hives do not have queen bee, mini colony will starts to nurture placed queen ceels. After hatching, in the next two weeks, queen bees will fly to mating sites where they will be fertilized and after that they will start to lay eggs. After queen bee starts to lay eggs she will never fly to mate again.

If a builder colony is fomed quickly queen bee can die in the queen cells. Also, queen bee can die during careless grafting and manipulation with larvae material, if there is not enough food in builder colony and if grafting is done during unfavorable weather conditions.

When rearing queen bees, it is necessary to understand that the queen bee is a living being, with her own needs and instincts. Rearing of queens must be cooperation between beekeeper and bees where only large knowledge will ensure successful rearing and getting of high quality queen bees that will satisfy byers.

Equipment needed for queen bee rearing

Besides strong and healthy builder colonies and mating nucleuses it is also necessary to have certain specialized equipment necessary for rearing and later transport of queen bees:

- bottom of the queen cell cups;
- Chinese needle;
- frames with slats;
- pedestal for frames;

[7]Mating nucleuses can be individual or divided to several chambers. In this paper calculation is being done considering mating nucleuses with three chambers (3+3+3 LR frames).

- neon lamp;
- magnifier;
- cages for queen bee transport.

For grafting of larvae it is necessary to make artificial bottoms of the queen cell cups (of wax) or to purchase plastic artificial bottoms of the queen cell cups[8]. This procedure of grafting larvae into wax cups considers using of so called Chinese needle which serves for transfer of young larvae into cups.

At the bottom of each cell cup is a small quantity of Royal jelly, which is a food for larvae. Chinese niddle should be used carefully because larvae will not be accepted if it is hurt in any way, if it is dirty or wrongly turned. Frame with queen larvae must not be outside of builder hive more than 30 - 40 minutes.

Place where grafting is being done should be warm closed room with relative air moisture 60 - 70%, light source (neon lamp) and magnifier to see the smallest larvae. For adding royal jelly into queen cell cups one can use medicine pipette. Magnifier and neon lamp serve to see one day old larvae and pedestal for frames serves to hold the frames with queen larvae, because grafting is easier when frame is placed aslope instead of horizontal.

Frames with slats are serving for fixing of bottom of the queen cell cups. Transport cages are needed to transfer queen bees to a new place and can also be used for accepting of hatched virgin queen or for safe keeping of fertilized queen bees. Popular cage for transport of queen bees is so called Benton cage which can be used not only for transport but also for adding of queen bees to the colony.

Commercial queen bee rearing

Comercial rearing of queen bees considers rearing of large number of queen bees where main goal is successful emerging of large number of queen bees of good quality to satisfy the needs and wishes of byers. When rearing queen bees one must carefully plan and take care of time span because of timely delivery to a byer.

[8]For the calculation presented in this paper authors considered bottom of the queen cell cups made of wax.

Comerical rearing of queen bees considers grafting of large number of larvae, more times during one season, into bottoms of the queen cell cups made of wax. Chinese niddle is used for grafting of larvae.

Beekeeper must choose the right moment for grafting larvae because every attempt to graft larvae in the wrong time of the year will result in poor quality of queen bees. Ideal period for grafting is when there is good uptake of nectar and pollen. Queen bees can be reared only during period of drone's activity and in moderate - continental climate that is from May to August (Umeljić, 2010)[9].

The beginning of activity related to queen bee rearing starts with preparing of mating nucleuses which is being done in time of rich bee pasture. In one season there can be totally six rotations i.e. larvae are being grafted six times. Activity calendar regarding queen bee rearing, is given in the following table (Table 1.).

Table 1. *Activities calendar*

Days	Activity
1	Queen bee lays eggs
2	
3	Larvae hatching from eggs
4	Grafting of one day old larvae (afternoon)
	Placement of grafted larvae in builder colonies
5	
6	
7	
8	Queen cells are sealed
9	
10	
11	
12	
13	
14	Removal of queen ceels from builder colonies and,
	their placement into mating nucleuses

[9] In mountain climatic conditions the period of queen bee rearing is shorter and instead of three months lasts two months (June - July).

15	
16	Emerging of queen bees
17	
18	
19	
20	
21	
22	Mating of virgin queen bees
23	
24	
25	
26	
27	Fertilized queen bees begins to lay eggs
28	
29	
30	

Source: *http://www.glenn-apiaries.com/queenrear.html*

The most optimal time cycle for starting of rotation is 14 days. In this case queen bees are sold on 28th day, starting from the beginning of the cycle (Umeljić, 2010).

So, on 28th day young mated queen are removed from mating nucleuses and the same day in the after noon new 14 day old queen ceels are placed into mating nucleuses. To ensure successfulnes of rearing, queen bees must be fed with optimal amount of syrup, and pollen storage in hives must also be optimal.

After emerging of queen bees from queen cells, excellent queen bee will start to lay eggs in 8 days, very good queen bee will start to lay egss in 9 days, good queen bee in 10 days and poor quality queen bee will start to lay eggs after 10 days (Boža Petrović, Slavomir Popović, 1995).

All important activities at apiary must be recorded so that beekeeper does not lose sight of the timeline of events. All those activities can consider the following: date of larvae grafting, number of accepted cells, colony which was donor of the larvae material, date of queen bee emerging, date of distribution etc.

Economics of queen bees rearing

In Serbia, beekeeping can activate and normalize the life of an impoverished population, especially in marginalized rural areas. In many rural areas in Serbia, due to long trend of population emigration to urban centers, the number of inhabitants in rural areas decreased but the quality of the environment is preserved. Development of beekeeping in these areas would stimulate development of the manufacturing industry, trade and other economic sectors.

Investments are the main material factor of economic and social development. Investments play a decisive role in the realization of goals and priorities of the agricultural and rural development, especially as a driving instrument of quantitative and qualitative growth of total agricultural and production factors and production, and they also create better living conditions in the countryside (Subić, 2010).

According to the definition, investments are sacrifice, abandonement of the current secure satisfaction, by a physical or legal person, in order to achieve the products and/or services in the future on account of certain invested financial assets (Subić, 2010). For the smooth functioning of the production process, it is necessary to invest in fixed as well as working assets, where the proportion of these investments depends on the specificity of the production.

Investment decisions in agriculture should be based on rigorous quantitative and qualitative provisions that will ensure accurate direction of money assets, and invest in the best (most effective) project variants. Investments should be carried out in a form that will ensure maximum effectiveness of exploitation that is greater level of achieved effects per unit of investment (Subić, 2010).

Key assumptions for calculating the profitability of queen bee rearing consider initial investment in the establishment of the apiary with the basic strategy directed towards queen bee rearing. Financing of investment is done with own funds and the investment does not include investments in land and auxiliary facilities.

Self - financing is the safest, most stable and readily available source of financing for investment, considering that it is ensured from the positive business results and the collected funds from amortization of fixed assets

(Andrić et al., 2005). Needed funds for establishing apiaries of different capacities are shown in the following table (Table 2.):

Table 2. *Investments into apiaries with 50, 100 and 150 hives, in €*

INVESTMENTS, €	Apiary capacity - 50 hives	Apiary capacity - 100 hives	Apiary capacity - 150 hives
Hive LR, standard	2,093.00	4,186.00	6,279.00
Swarm at 5 LR frames	1,500.00	3,000.00	4,500.00
Selected queen bee	375.00	750.00	1,125.00
Main equipment and production material	2,190.00	4,215.00	6,167.00
Equipment for queen bee rearing	2,361.00	4,721.00	7,036.00
TOTAL	8,519.00	16,872.00	25,107.00

Source: *Authors' calculation*

In the investment structure the largest percent of finantial assests, in compare to total investment assets, is related to purchase of hives and swarms, while in the case of the equipment for queen bee rearing, the largest part of expenses is related to purchase of mating nucleuses[10].

Equipment for queen bee rearing included purchase of: mating nucleuses, Chinese niddles, cages for queen bee transport, LR frames with slats for production of queen cells and additional small equipment. Incomes and expenses of queen bee rearing at apiaries of different capacity, during one year, are presented in the following table (Table 3.):

[10] For apiary with capacity of 50 hives is calculated purchase of 10 mating nucleuses, for apiary with 100 hives is calculated purchase of 20 mating nucleuses and for apiary with 150 hives is calculated purchase of 30 mating nucleuses (purchase price of mating nucleuses = 29.00 €)

Table 3. *Income and expenses at the apiary during one year*

Income, €	**Apiary capacity - 50 hives**	**Apiary capacity - 100 hives**	**Apiary capacity - 150 hives**
Queen bee[11]	10,350.00	20,700.00	31,050.00
Expenses, €			
Sugar[12]	173.00	300.00	450.00
Medicine (complet)	110.00	200.00	300.00
Workers[13]	1,200.00	2,400.00	2,400.00
Total	1,483.00	2,900.00	3,150.00
PROFIT	8,867.00	17,800.00	27,900.00
Net profit (-15%)	7,537.00	15,130.00	23,715.00

Source: *Authors' calculation*

In the structure of expenses the largest part of expenses is related to labour force, which has seasonal character, in accordance with demands of queen bee rearing. With the increase of apiary capacity, increases the income derived from the sale of queen bees. The following table shows the profit from the sale of queen bees for the period of 20 years, as well as associated costs related to the queen bee rearing (Table 4.):

Table 4. *Income and expenses at apiary during 20 years*

Income/expenses, €	**Apiary capacity - 50 hives**	**Apiary capacity - 100 hives**	**Apiary capacity - 150 hives**
Total income	207,000.00	414,000.00	621,000.00
Total expenses without amortization	29,650.00	58,000.00	63,000.00
amortization (5% annualy)	8,144.00	16,123.00	23,982.00
Profit	169,206.00	339,877.00	534,019.00
Net profit (-15%)	143,825.00	288,896.00	453,915.00

Source: *Authors' calculation*

[11] Calculated selling price of queen bee is 7.5 €.

[12] Calculated amount of sugar per colony is 5 kg by price 0.69 €. In apiaries with 100 and 150 hives calculated sugar price is 0.60 €/kg.

[13] For apiary with 50 hives number of workers is 1; for apiary with 100 and 15 hives number of workers is 2. All workers work in period of three months for monthly payment of 300.00 €.

For the period of 20 years, all equipment used in the production is completely amortized. The largest economic effect in queen bee rearing is achieved in beekeepers with the largest number of hives, 150 hives.

For the assessment of the investment project in this paper is used static evaluation of the economic efficiency of investments: cost of production, accumulation of production and period of investment return. Static evaluation of economic efficiency of investments is based on simple statistic methods which are being calculated using parameters from only one average year of project exploitation (Subić, 2010).

Economics of production is presented by *efficiency coefficient*, which represents ratio between total income and total expenses and it is being calculated using the following formula:

$$K_E=Up/Ur$$

Where: K_E - efficiency coefficient, Up - total income, Ur - total expenses.

Investment project is economically efficient i.e. investment is profitable when total income is larger than total expenditure that is when $\kappa_E>1$.

Accumulativity (rentability) of production represents the ratio between profit (net effect) and total income. It is expressed trough the *rate of accumulation* and calculated using the following formula:

$$S_A=D/Up \times 100$$

Where: S_A - rate of accumulation, D - profit (net), Up - total income

Investment is accumulative when $C_A>p_k$.

Period of investment return is calculated using the following formula:

$$T=I_{pv}/D$$

Where: T - period of investment return, Ipv - estimated value of investment, D - profit (net)

In the following table is presented economic evaluation of investing into queen bee rearing at apiaries of different capacity (Table 5.).

Table 5. *Economic estimation of investing in queen bee rearing*

Economic estimation of investing	Apiary capacity - 50 hives	Apiary capacity - 100 hives	Apiary capacity - 150 hives
Efficiency coefficient	6.98	7.14	9.86
Rate of accumulation, %	88.48	89.67	94.46
Period of investment return, in years	1.13	1.12	1.06

Source: *Authors' calculation*

From the table it can be seen that production in all three cases is economical, because the efficiency coefficinet is > 1, i.e. the investment is economical because the total income excess total expenses. The investment project is profitable and the most profitable is at the apiary with 150 hives. Period of investment return is the fastest in the case of the apiary with the highest capacity and it is one year and 0.72 months.

Conclusion

From the presented economic analysis can be seen that in the production of queen bees positive financial effects can be achieved. Commercial queen bee rearing is a very profitable activity where the major effect is achieved at the apiaries of the highest capacity. Period of investment return is the fastest in the case of the apiary with the highest capacity even though the time difference in terms of return of investment between apiaries of different capacity is very low.

This analysis showed that although the initial investment is high, the invested funds are returned very quickly so that beekeeper is placed, upon return of investments, in a very favorable position for the next production cycle (Mladenović et al., 2011).

The overall conclusions of the analysis presented in this paper are as follows:

- In the commercial production of queen bees, with the aforementioned material costs, prices and yields, positive financial effects are generated,
- Production is economical and the most economical it is at the apiary with the highest capacity,
- Production is accumulative and the most acumulative is the one with the highest capacity,
- Time of investment return ranges from one year and 1.56 months, in the case of 50 beehives, up to one year and 0.72 months in the case of 150 hives.

Rearing of quality queen bees considers cooperation of beekepers with appropriate scientific and professional institutions with experience in this business. Scientific and technical institutions should, together with the beekepeer, monitore the health of bees at the apiary where production takes place. Queen bee rearing would improve the development of beekeeping in Serbia and would improve the financial situation of not only beekeepers but also producers of agricultural products, processing industry and trade. In Serbia, beekeeping can activate and normalize the life of an impoverished population, especially families who have been left without a safe source of existence (Mladenović et al., 2011).

Also, given that the comercial queen bee rearing is technically a bit more demanding work, in relation to the production of honey, beekeepers should receive trainings in this kind of production which would contribute to the development of family farms focused on beekeeping in Serbia.

To achieve better results in the production, it is necessary to expand the production capacity of the farm. In Serbia, there is a tradition of beekeeping so we can say with certainty that any improvement of this production will have a positive impact on the overall development of family farms in our country and therefore on the foreign trade balance of the Republic (Mladenović et al., 2011).

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