Evaluation of Colony Parameters for Queen Rearing under Arid Ecosystem Conditions

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Abstract: Due to climate change, the study was conducted to give some recommendations for beekeepers and nucleus producers for best practices for queen rearing in Ismailia Governorate, Egypt. Several colony parameters were investigated such as number of accepted queen cups, mated queens, and royal jelly production under harsh arid ecosystem of Ismailia Governorate during two successive seasons of 2019 and 2020. In addition, choosing the appropriate location of the broad frame inside beehive that will be used for the grafting process was also tested. The results revealed that the months from March to August were the most suitable months for queen rearing and queen mating, while royal jelly could be produced throughout the year. With regard to the studied parameters, data recorded the largest inner size of queen cups in May, June, May, July and August. The same trend of results was recorded in weight and length of newly emerged queens. On the other hand, the best location for broad frame inside beehive was in the middle of hives and the middle area of brood frames was also the best location for transferring larvae for grafting in the queen rearing. These findings could help local beekeepers and producers for best beekeeping practices to obtain strong queens in good qualities.

Keywords: Honeybee, Beekeeping practices, Queen rearing, Royal jelly

INTRODUCTION

Honeybee is considered the most important insect all over the world due to their role in pollination, their different products, and their economic value. About 87% of blooming plants are dependent upon honeybee pollination (Klein *et al.,* 2007).

Queens are important to the survival of honeybee colonies, not only for their ability to put a large number of eggs but also due to the social coherence of their pheromones (Amiri *et al.,* 2017). Moreover, the queen is a depositary for all inherited characteristics of the species acquired through her progenitors and through the acquisition of sperm from drones at the time of mating. Incredibly, the queen stores sperm alive for the entire duration of her lifetime (Cobey, 2003).

Egypt is considered as the most important country for beekeeping among Arab nations, as well as throughout Africa (Al-Ghamdi *et al*., 2016). In Egypt, there are more than 1576542 beehives (FAO, 2016) and about one million and 250 thousand beehives are directly exported. The Egyptian Ministry of Agriculture has prevented the importation of bee queens since 1960 as a measure to control honeybee diseases. In Egypt, a lack of good characteristics of the productive queens is an important challenge for researchers and beekeepers (Soheir *et al*., 2018). Climate changes have a great impact on the decline of insects especially honeybees. The colony loss known as Colony Collapse Disorder (CCD) is a well-known phenomenon due to several environmental factors.

Royal jelly is one of the most valuable products of honeybee colonies and produces from hypopharyngeal and mandibular glands of 6-12 days old bee workers, which called nurse bees (Hassan and Khater, 2006).

Consequently, the aim of the current research is to address the best conditions for queen rearing and mating under arid conditions. Also, to recommend local beekeepers with the best beekeeping practices for producing strong colonies with good queen characters.

MATERIALS AND METHODS

The present study was carried out at the Bee Research Center (BRC) (30°37'11.9"N and 32°16'06.3"E), Faculty of Agriculture, Suez Canal University, Ismailia, Egypt. The experiments were performed during two successive seasons of 2019 and 2020.

Queen cups acceptance

Five colonies of hybrid Carniolan honeybees were used, and thirty grafted cups were represented each colony. The grafted frames were rapidly introduced to the queenless colony to initiate queen rearing. The colonies provided daily with sugar syrups during the period of queen rearing. This experiment was repeated three times each month over the seasons of 2019-2020. On the 10th day, the accepted queen cups were collected and recorded.

Collecting and caged the emerged queens

On the 10th day of grafting, queen cups were inserted inside the aluminum wire cages (2.5*2.5 cm). On the 15th day of grafting, the newly emerged queens were collected and recorded**.**

Queen mating

Five weighted and caged newly virgin queens were introduced into the mating nucleus. These nucleuses were consisted of one brood comb of different ages, one comb of honey and pollen, and enough population of workers covering all combs. After three days the virgin queens were released.

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The inspection was carried out for all mated nuclei to ensure that the virgin queens were mated or not yet. Numbers of mated and failed queens in all experimental times were recorded.

Studied parameters

Some parameters were recorded directly once the queens were emerged including the queen cups volume per (ml), length of virgin queens per (cm), and the weight of virgin queens per (mg).

Queen cup size

After emergence of queens, the inner size of ten queen cups were calculated by measuring the volume of water (mm) injected into and filled the empty queen cups using a milliliter syringe. The needed amount of water to fill these cups were represented the inner size of the queen cups.

Weight of newly emerged queens

The newly emerged queens were putted in plastic jar and left in the freezer at 0ºC for ten minutes. After being taking out, the virgin queens were weighted alive rapidly using a digital weighing scale.

Length of newly emerged queens

Length of virgin queens was measured using a millimetre-scaleruler, where the measurement was taken from the head to the end of the abdomen of the virgin queens.

The effect of brood frame location inside the hive

This experiment was conducted during April, May, and June of 2019 and 2020 seasons. Five colonies were used, each one consisting of 10 frames arranged as follows - two frames of honey and pollen, two brood frames near the entrance of the hive, two brood frames in the middle of beehive, two brood frames in the other side of the hive entrance, and finally two frames of honey and pollen. The grafting process was conducted by transferring one-day-old larvae from the brood frame with different their locations in the beehive. The number of accepted queen cups in each colony was recorded; this was done for determining the best brood frame location to be chosen as a source of young larvae for queen rearing.

The effect of the larval location on the brood frame on queen rearing

This experiment was conducted during April, May, and June of 2019 and 2020 seasons by selecting five colonies to test the best area of the brood frame which would used for grafting and queen rearing. Each brood frame in the selected hives was divided into three parts, the first part was the top of the brood frame, the second part was the middle of the brood frame, and the third part was the bottom of the brood frame.

The grafting was made by transferring one-day-old larvae from each part of the brood frame separately. Fifteen queen cups fixed in wooden bar were expressed to each part of the three parts of the brood frame. The succeeded queen cups for the three parts of brood frames of each colony were recorded.

Royal jelly production

At the 4th day of grafting, larvae were removed from each cup and the royal jelly was collected and weighted.

Statistical analysis

The obtained data were statically analyzed using one-way analysis of variance (ANOVA) procedure. CoStat program statistics version 6.311 was used to analyze the obtaining data. The significance level was set at the probability level of $P \leq 0.05$.

RESULTS AND DISCUSSION

Effect of months on the number of accepted queen cups and newly emerged queens

The number of accepted queen cells and emerged queens were differed significantly between months of the two seasons of the study Fig (1).

Effect of months on the inner size of queen cups, weight, and length of newly emerged queens

The average of inner size of queen cups, weight and length of newly emerged queens were significantly different between months of the two studying seasons Fig (3 and 4).

In 2019, data showed that the largest inner size of queen cups were recorded from May to September with the same trend of data was recorded in 2020. While the highest weight and length were obtained from May to August, and with the same trend of results were obtained in 2020.

Effect of different locations of the grafted frame inside beehive on the production of virgin queens

The production of virgin queens was significantly different as affected with the frame location inside beehive during the period from April to June of the two seasons of 2019 and 2020 Fig (5).

Data revealed that the best location to produce virgin queens inside the beehives was the middle of the hive followed by the side other of the entrance and then nearest side of the entrance.

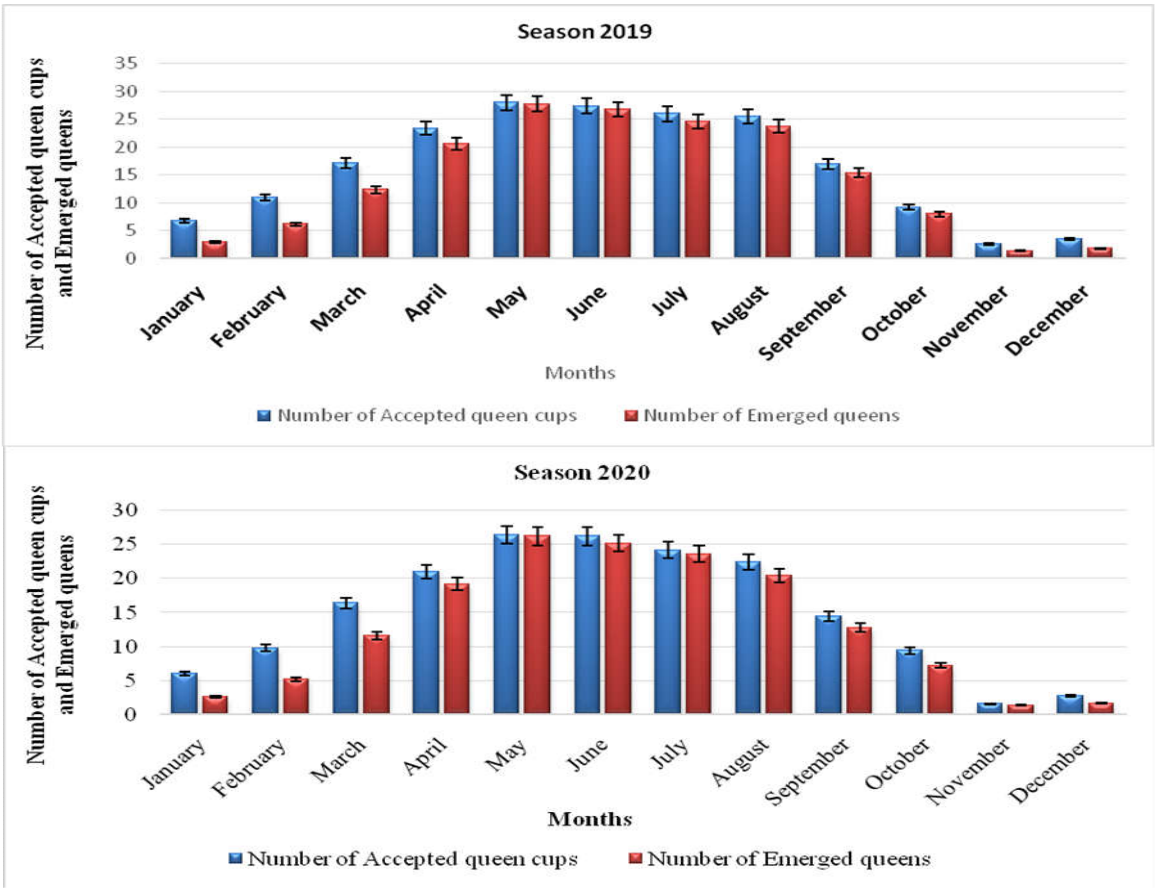


Fig (1). Effect of months on the acceptance of queen cups, and newly emerged queens at Ismailia region in seasons 2019 and 2020

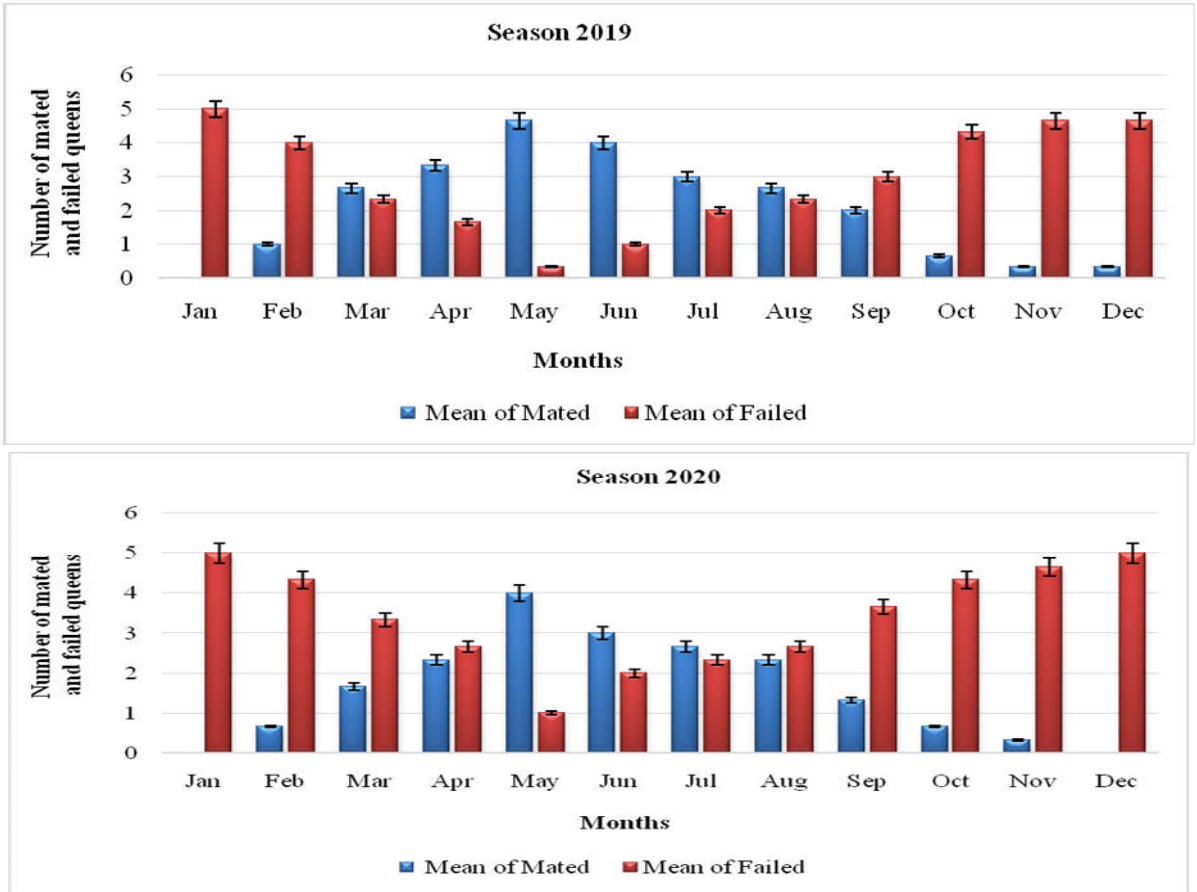
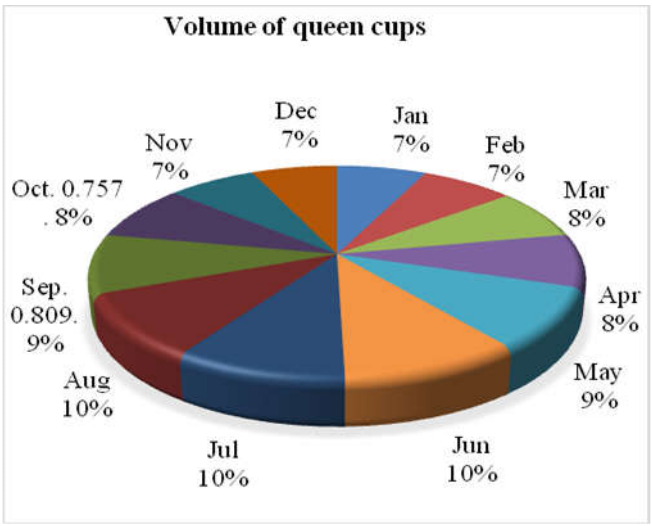
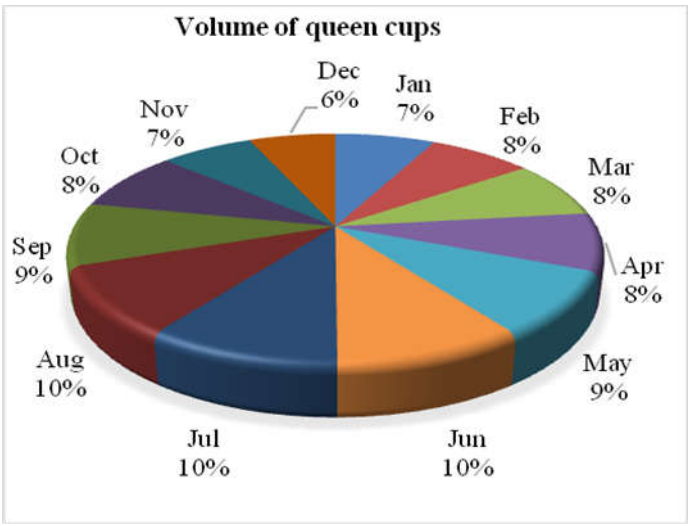
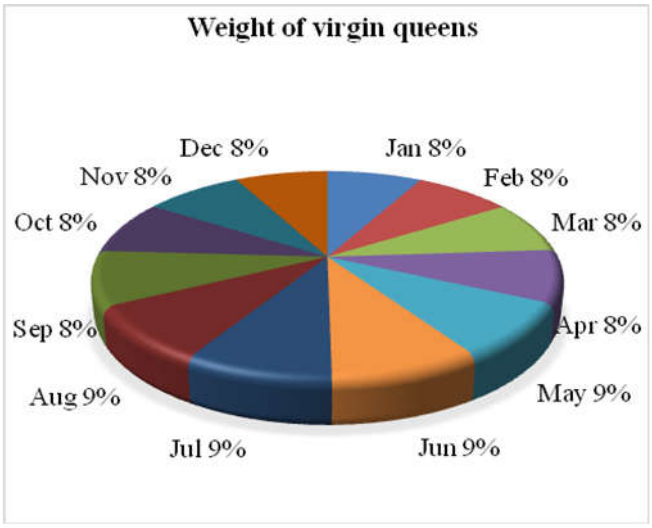
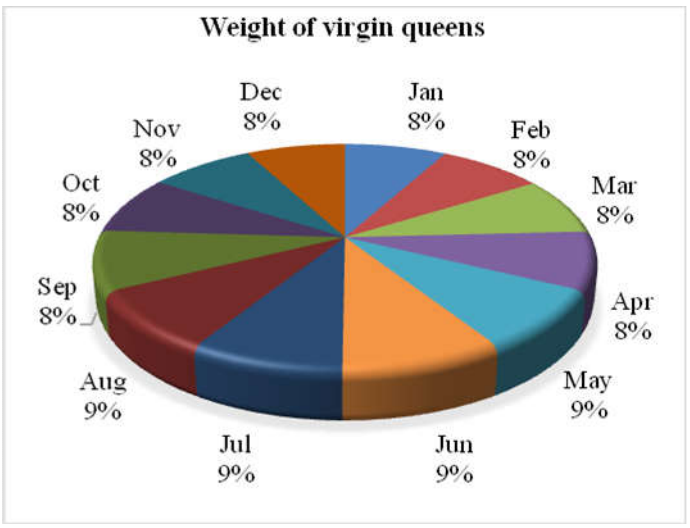


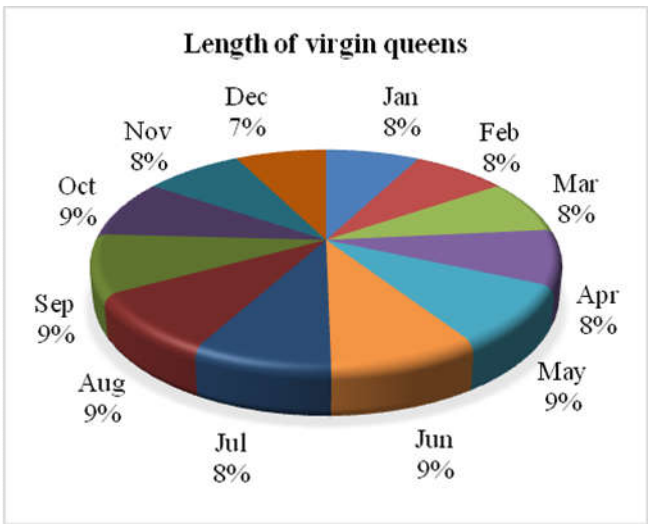
Fig (2). Effect of months on the number of mated and failed queens at Ismailia region in seasons 2019 and 2020











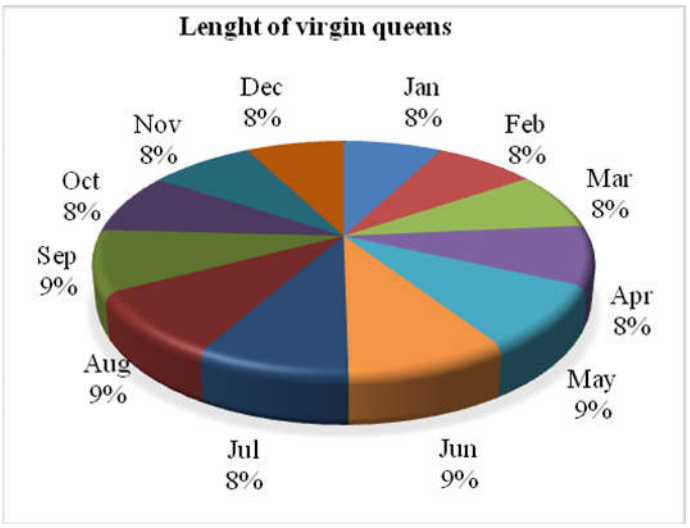


Fig (3). Effect of months on some parameter studies (Volume of queen cups - Weight of virgin queens - Length of virgin queens) in season 2019

Fig (4). Effect of months on some parameter studies (Volume of queen cups - Weight of virgin queens - Length of virgin queens) in season 2020

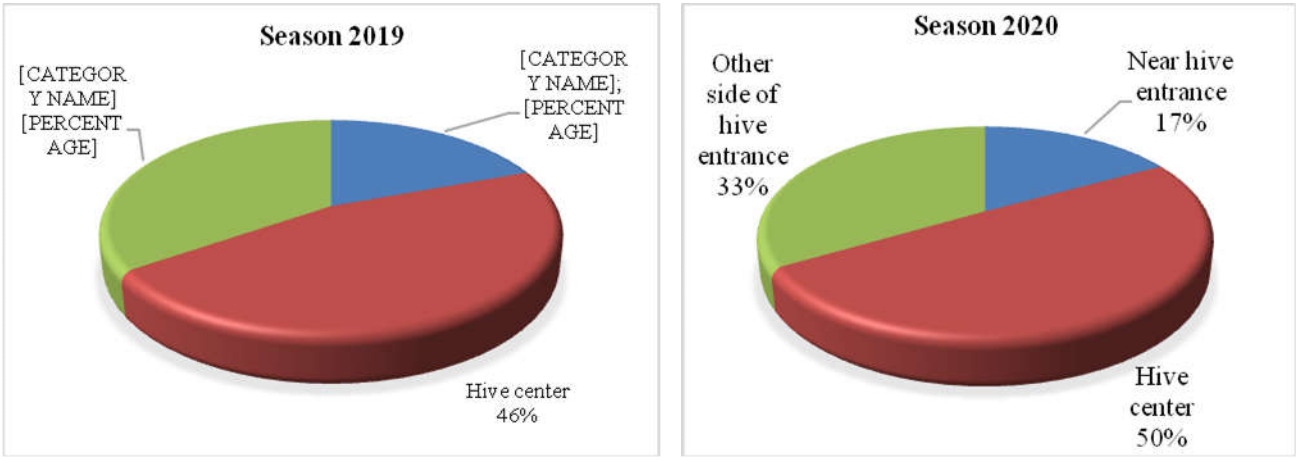


Fig (5). Effect of different locations of grafted frame on the production of virgin queens in two seasons 2019 and 2020

Effect of different locations of the grafted larvae on the brood frame on the production of virgin queens

The production of virgin queens was significantly different as affected with the location of grafted larvae on the brood frame during the period from April to June of the two seasons of 2019 and 2020 Fig (6).

The obtained data in the two seasons recommend beekeepers to take the grafted larvae taken from the middle and the bottom parts of the brood frame, while they must avoid the grafted larvae taken from the top of the brood frame.

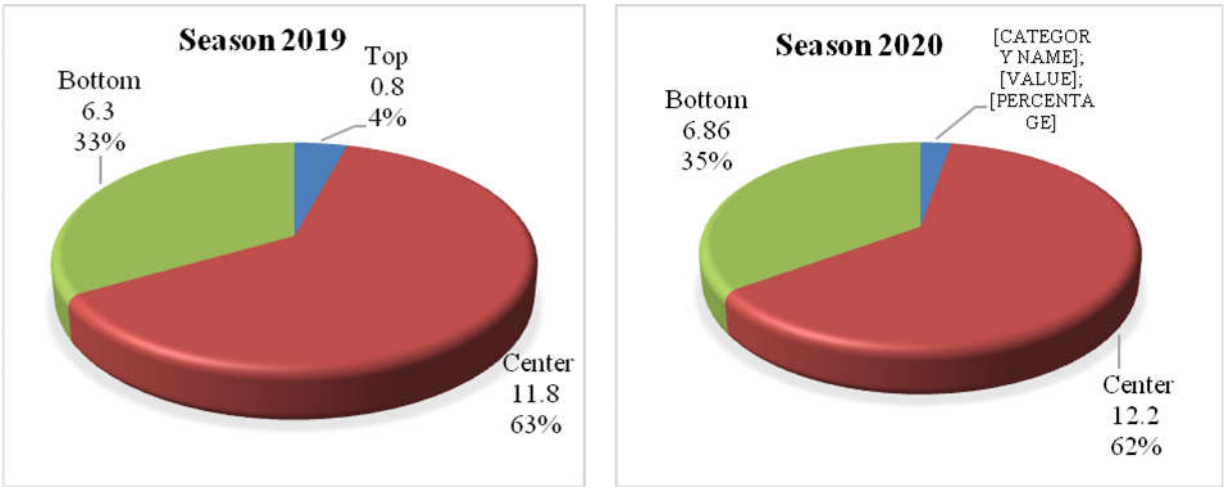


Fig (6). Effect of different locations of grafted larvae on the production of virgin queens in seasons 2019 and 2020

Effect of months on the production of royal jelly

The results clearly showed that there were significant differences between months in their impact on the production of royal jelly Fig (7).

Data showed that the most suitable months for producing royal jelly were from March to August during the two study seasons of 2019 and 2020.

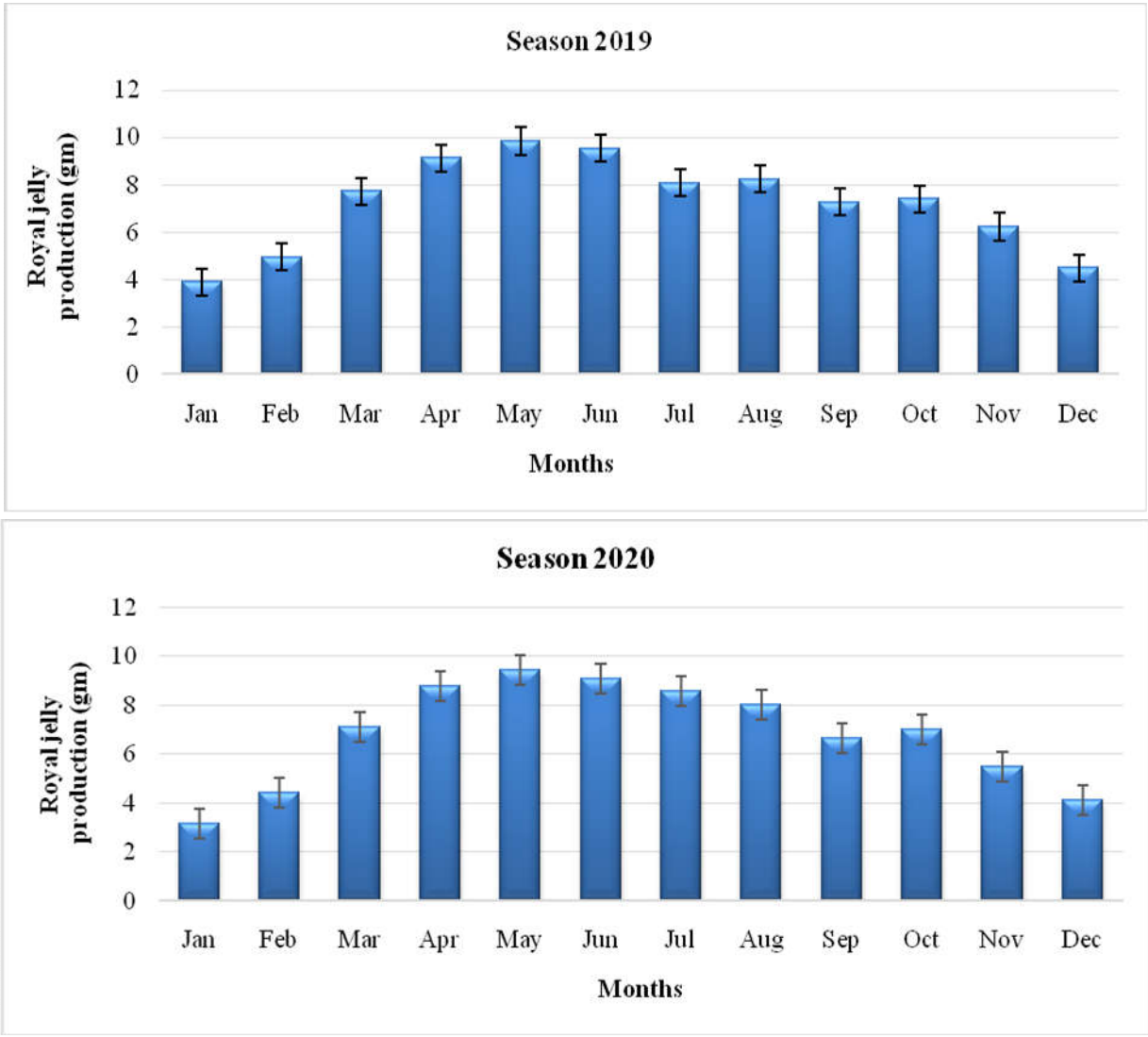


Fig (7). Effect of months on the production of royal jelly during the two seasons of 2019 and 2020

Accepted queen cell cups

Data indicated that the number of accepted queen cells differed significantly between months of the two seasons, this was due to the difference in weather conditions between months. The lowest and the highest temperature had a negative effect on the acceptance rate of larvae and queen cell acceptance rate (Guler and Alpay, 2005; Khan *et al.,* 2021).

Moreover, results demonstrated that the highest number of accepted queen cell cups was recorded in May and June, whereas the lowest number of accepted queen cell cups was in November and December. The larvae acceptance rate was found as 95% and 78.33% in June, respectively, which were higher than that of other months (Cengiz *et al.,* 2009; Ahmad and Dar, 2013).

On the other hand, data showed that the best months to produce queen cell cups were from March to August and the lowest months were from November to February. The spring season was favorable for accepted cells, followed by autumn and summer, while winter season came the latest one (El-Metwally and Tagour, 2010).

Newly emerged queens

Data indicated that the number of accepted queen cups differed significantly during the months of the two seasons and the best months to produce newly emerged queens were from March to September. In spring, mean number of emerged queens was 37.66 and 47.07 emerged queens (El-Metwally and Tagour, 2010). Moreover, the spring season was favorable for accepted cells and emerged queens, followed by autumn and summer, while the winter season came the latest one.

On the other hand, the highest number of newly emerged queens was recorded during May and June. The maximum mean number of newly emerged queens was noticed in colonies with higher worker population in May (Fathy *et al.*, 2019).

Mated queens

Data indicated that the number of mated queens and failed queens differed significantly during the months of the two seasons. There were large seasonal variations in the acceptance, and this was due to a genetic influence of the mother queen on the

introduced queen acceptance rate (Moretto *et al.,* 2004).

Results showed that the highest number of mated queens was recorded during May and June. The greatest mating success was achieved in May and the smallest was recorded during July and August (Al□Ghzawi and Zaitoun, 2008).

Studied parameters

The results showed that the largest inner size of queen cups after emergence was observed in July, June, and August. In contrary, the highest average values were obtained in March than in other months and values in November were nearly as high as those in April (Brar *et al.,* 2005).

The greatest weight of newly emerged queens was recorded in June and July and the same data was found in June and July (Hegazy, 1974; Taha, 2005).

On the other side, results showed that the best months of newly emerged queens weight were May, June, July, and August and the same trend of weight was also found in May, June, and July (Zohairy, 2007).

The results indicated that the maximum length of newly emerged queens was recorded in August, May, and June and the same was found for the maximum mean length of newly emerged queens during late summer (Mustafa *et al*., 2002).

The brood frame location inside the hive

Data showed that the best location to produce virgin queens inside the hives was the middle of the hive followed by the side other of the entrance then near the entrance. The queen cells in the center of the hive's brood nest were correlated with higher temperature and had a greater chance for emergence (El-Metwally and Tagour, 2010).

The larvae location on the brood frame

Data showed that the grafted larvae from the center and the bottom of the brood frame were the highest comparing to the top. The Eggs in cells near the center were reared more frequently than those on the edges, and those near the top of the frame were more frequently than those lower down (Visscher 1986; Hoffman *et al.,* 1993).

Royal jelly production

Results showed that royal jelly could be produced all year round, but the most suitable months were from Mar to Aug. In addition, Data represented that the highest production of royal jelly was recorded in May, Jun, Apr and July. The acceptance rate and royal jelly production were highest in April and lowest in September. This was due to the shortage of fresh pollen during summer and weakness of the queenless cell builders due to ageing (Şahinler and Kaftanoğlu, 2005).

CONCLUSION

Data revealed that the highest number of accepted queen cell cups was recorded in May and June, whereas the lowest one was in November and December. Moreover, the best months to produce newly emerged queens were from March to September. Therefore, the highest number of mated queens was recorded during May and June. As for the studied parameter, data showed that the inner size of queen cups was high in May, June, May, July, and August. The same trend of results was obtained in weight and length of newly emerged queens. On the other hand, the best location inside beehives for broad frame was the middle of the hives and the middle area of the brood frames was also the best location for transferring larvae for queen rearing. Meanwhile, data represented that the highest production of royal jelly was recorded in May, Jun, April, and July.

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تقييم معاملات الطائفة لتربية الملكات تحت ظروف النظام البيئي الجاف

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نتيجة التغيرات المناخية التي يعاني منها العالم أجريت هذه الدراسة لإعطاء بعض التوصيات للنحالين ومنتجي الطوائف وذلك للوصل إلي أفضل الممارسات لتربية الملكات في محافظة الإسماعيلية. حيث تم دراسة بعض الصفات مثل عدد الكؤوس الملكية الناتجة، وعدد الملكات المتزاوجة، وكمية الغذاء الملكي المنتجة في ظل النظام البيئي الجاف لمحافظة الإسماعيلية وذلك خلال موسمين ٢٠١٩ و ٢٠٢٠. بالإضافة إلى ذلك، تم أيضًا اختبار اختيار موقع الإطار داخل الطائفة أثناء عملية التطعيم. وكشفت النتائج أن الأشهر من مارس إلى أغسطس كانت أكثر الشهور ملاءمة لتربية الملكات وتزاوجها، بينما يمكن إنتاج غذاء ملكات النحل على مدار السنة. في الصفات المدروسة، أظهرت النتائج أن أعلى حجم للكؤوس الملكية كان في مايو ويونيو ومايو ويوليو وأغسطس وأيضا ظهرت نتائج مماثله في وزن وطول الملكات الناتجة حديثًا. من ناحية أخرى، كان أفضل موقع للإطار هو منتصف خلية نحل العسل وكان منتصف إطارات الحضنة أفضل مكان لاختيار اليرقات لتربية الملكات. يمكن أن تساعد هذه النتائج مربي النحل والمنتجين المحليين للحصول على أفضل ممارسات تربية النحل للحصول على ملكات جيدة وقوية.

الكلمات الدالة: نحل العسل - تربية الملكات- الممارسات النحلية - غذاء ملكات النحل.