

# Queen Rearing Activity and Virgin Queen's Weight for Enhancing the Beekeeping Performance among the Carniolan, Buckfast, Italian and Cordovan Bees

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## ABSTRACT

Beekeepers around the world try their best to find the convenient geographical and economical races for pollinating and highly amount of honeybee products. However, from all known geographical races, Carniolan and Italian and other developed genotypes such as Buckfast and Cordovan bees are widely use by beekeepers in the most of countries. Nicot Cupkit apparatus system for queen rearing used in this study to compare and evaluate the Carniolan, Italian, Buckfast, and Cordovan bees' activity in the queen cells acceptance. In general, Cordovan genotype recorded the highest level of the percentage of queen cells acceptance followed by Buckfast, Italian, and Carniolan bees under the Egyptian environmental conditions. The highest queen cells acceptance percentage in general was in April, May, and July for all examined races and genotypes. In addition to, Buckfast bees recorded the highest rate of virgin queens' weight followed by Carniolan bees, whereas Cordovan bees recorded regular rate of the virgin queens' weight with no significant differences between the different study months. Furthermore, Carniolan and Buckfast bees had the best rate in virgin queens' weight during the period from February to July with preference of virgin queens emerged in May and June. This study provides a firm basis for future research to better understand the biological and genetic differences between the examined honeybee races and genotypes and their roles in adaptation to the environmental conditions in Egyptian apiaries of bee breeding in Egypt.

**Keywords:** Nicot Cupkit Apparatus, Evaluation, Acceptance Percentage, Queen Rearing, Beekeeping Practices.

## INTRODUCTION

Beekeeping is one of the most important industries all over the world (Reybroeck *et al.*, 2014). The main impact of beekeeping is to save honeybee as the most vital pollinator among the other pollinating insects (James and Pitts-Singer, 2008). Furthermore, honeybee provides many other important products with a highly nutritional and therapeutical value for the human beings (Mizrahi and Lensky, 2013). In this context, beekeepers around the world try their best to find the convenient

geographical and economical races for pollinating and highly amount of honeybee products producing.

Honeybee races (genotypes) are found all over the world, whereas these genotypes typically reduced gene flow with other such groups due to water, mountain or desert barriers and have been called "geographical races", to mirror their adaptation to specific geographic regions (Ruttner, 2013). Each of which was adapted according to its regional ecological and geographical dynamics. However, from all known geographical races, Craniolan bees (*Apis mellifera carnica*) and Italian bees (*Apis mellifera ligustica*) are known to be the most common races and have spread out in many countries (Ruttner, 2013). In this context, Carniolan bees is known with highly adaptation with different climatic conditions, as well, its orientation sense is arguably the best of any race, brood resistant to diseases and parasites, low food consumption over winter (Ruttner, 2013 and Mesbah *et al.*, 2017). On the other side, Italian bees, is known for its ability to adjust to various climatic circumstances, its docility, and high honey yield (KOÇ and Karacaoğlu, 2011). This race has been disseminated to a few nations in the beginning of the last hundred years but now many. In other words, the Carniolan queen can control the colony activity when pollen and nectar are scarce by reducing the brood production (Ruttner, 2013). On the other side, Italian bees, is known for its ability to adjust to various climatic circumstances, its docility, and high honey yield. This race has been disseminated to a few nations in the beginning of the last hundred years but now many beekeepers all over the world have recently preferred to use Italian queen bees (Caron and Connor, 2013).

Some other developed genotypes started to take place by beekeepers in some countries such as Buckfast and Cordovan bees. The Buckfast bee (*A. mellifera*), was developed by Brother Adam at Buckfast Abbey, South-West England from 1917 by crossing his 'Buckfast line' with a wide variety of bee races from across Europe, near Asia, and Africa (Adam, 1987). Thereafter, Buckfast Abbey and several bee breeders' groups across Europe have continued to maintain the

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Buckfast strain on islands and other isolated places (Holm, 2009). Adam's main traits favored for selection to develop his 'Buckfast line' was originally resistance towards the acarine mite, calmness on the comb, and excellent honey production, which the most properties beekeepers' value in *A. mellifera* (Olszewski, 2009). On the other hand, the Cordovan bees was introducing for the first time as a new phenotype by Mackensen (1951) and Laidlaw *et al.* (1953) which has been used in many genetic and behavior studies. Cordovan individuals express brown color cuticle in all areas that generally would be dark and there is significant variation in the amount of black cuticular color found in all subspecies of the western honeybee (Mackensen, 1951). Thus, Cordovan phenotype easily differentiated from their wild-type counter parts, letting them be informative in laboratory and field studies (Rinderer, 2013). Therefore, Cordovan marker has been utilized in various similar examinations among African-and European honeybees starting from the presentation of African bees, (*A. m. scutellata* L.), into the Americas (Schneider *et al.*, 2003 and Schneider *et al.*, 2004). Therefore, recently Cordovan phenotype be used as an indicator of European decent in the USA (Mortensen and Ellis, 2015).

As well known, the productivity of honeybee colonies during the different seasons in the year is affected by different factors such as queen's activity as the most impacted factor which in turn reflects on the performance of the honeybee colony (Châline *et al.*, 2003). Moreover, honeybee queen quality is hereditarily controlled by the source of larvae in addition to the conditions in which it grows which direct reflection of the queen genotype (Winston, 1991). From this end, it becomes clear that the honeybee races and genotypes significantly affected on the queen's quality and activity which in turn affected on the colony activity and the honeybee products quantity (Zaghloul *et al.*, 2017). Consequently, the aim of the present work is to study the effect of honeybee queen genotype source among two types of honeybee races and two genotypes "Carniolan, Buckfast, Italian and Cordovan bees" on the queen rearing acceptance and the virgin queen's weight.

## MATERIALS AND METHODS

The present study was carried out on honeybee colonies during the experimental period extended from January 2021 to September 2022 at the apiary of Honeybee Research Unit, Faculty of Agriculture, Tanta University, Egypt. The queens less nurse colonies were prepared to determine the acceptance rate of the grafted queen cups.

Four honeybee mated queens first hybrids were selected from the apiary and used for this study from each genotype (Carniolan, Buckfast, Italian, and cordovan) bees, which each queen (the source of the eggs) was in a good performance colony. Sixteen honeybee queen-less colonies were prepared for this study; they were divided into four different groups which each group prepared for evaluating one queen genotype source. Honeybee colonies were approximately equalized, each hive has eight combs covered with bees and have stored food before the beginning the study.

Nicot Cupkit apparatus system for queen rearing was used for collecting the eggs from the resources queens where the queen was confined inside the apparatus and the eggs laid by the queen were received in the cell cups of Cupkit apparatus. After three days of egg laying, cell cups containing less than 24 h-old larvae were collected and fitted to form complete cell cups as bottom in cell wall structures. The cell cups fitted into the blocks and fixed on three bars of queen rearing frame where each bar has 15 cell cups with in total 45 in the queen rearing frame which introduced to the queen-less colony and the acceptance of the cell cups was recorded (Dhaliwal *et al.*, 2017).

To evaluate the differences in virgin queens' weight between the examined races and genotypes, the emerged virgin queens were weighed by an analytical scale within 10-15 minutes after emergence to nearest 0.01 mg. The data were analyzed by one-way (ANOVA) for Completely Randomized Design (CRD) to determine the significance of differences among the mean values, least significant difference (L.S.D.) values were done at ( $P < 0.05$ ) level of significance (Steel and Torrie, 1981).

### Results and Discussion:

The evaluation of Carniolan and Italian bees and other developed honeybee genotypes, Buckfast and Cordovan bees, for queen cells acceptance and virgin queens weight cells conducted as follows:

#### 1. Different honeybee races and genotypes activity in queen cells acceptance.

In the efforts to evaluate certain honeybee geographical races and genotypes under the Egyptian environmental conditions, queen rearing activity was examined for four different honeybee races known between the Egyptian beekeepers using Nicot Cupkit apparatus system for queen rearing. In general, the highest level of queen cells acceptance was during May and July followed by April and August then March and June while the less acceptance rate was in January followed by February and September in all the examined races and genotypes (Table 1).

**Table 1. Acceptance rate of queen cups for four honeybee races in queen rearing from January to September.**

Hybrids	F1 Carniolan		F1 Buckfast		F1 Italian		F1 Cordovan	
	Month	Total	Mean ± (S.D)	Total	Mean ± (S.D)	Total	Mean ± (S.D)	Total
Jan.	88	22 ± 2.58 d	90	22.5 ± 2.38 d	107	26.75 ± 3.59 d	120	30 ± 1.83 e
Feb.	139	34.75 ± 0.96 c	154	38.5 ± 1.29 b	155	38.75 ± 1.71 b	164	41 ± 1.83 bc
Mar.	150	37.5 ± 2.65 bc	155	38.75 ± 2.63 b	166	41.5 ± 2.08 ab	169	42.25 ± 0.96 ab
Apr.	157	39.25 ± 3.10 ab	168	42 ± 0.82 a	159	39.75 ± 0.96 ab	171	42.75 ± 0.96 ab
May	163	40.75 ± 1.26 a	171	42.75 ± 0.96 a	165	41.25 ± 0.96 ab	173	43.25 ± 0.96 a
Jun.	155	38.75 ± 2.63 ab	152	38 ± 4.24 bc	156	39 ± 0.82 b	161	40.25 ± 1.50 c
Jul.	164	41 ± 0.82 a	172	43 ± 0.82 a	169	42.25 ± 0.50 a	176	44 ± 0.82 a
Aug.	158	39.5 ± 1.29 ab	161	40.25 ± 0.96 ab	126	31.5 ± 2.65 c	130	32.5 ± 1.29 d
Sep.	139	34.75 ± 1.26 c	140	35 ± 2.16 c	116	29 ± 2.94 cd	123	30.75 ± 1.71 de
Total	1313	328.25	1363	340.75	1319	329.75	1387	346.75
Average	146	36.47	151.44	37.86	147	36.64	154.11	38.53
LSD: at								
0.05 %		2.925		3.062		3.004		1.989
level								

**For Acceptance Rate:**

"F" value = 7.335 (Significant at 1% level).

L.S.D between Hybrids = 0.895 at (5% level).

Hybrids	FI Cordovan (38.53)	FI Italian (36.64)	FI Buckfast (37.86)
FI Carniolan (36.47)	2.06*	0.17	1.39*
FI Buckfast (37.86)	0.67	1.22*	0
FI Italian (36.64)	1.89*	0	

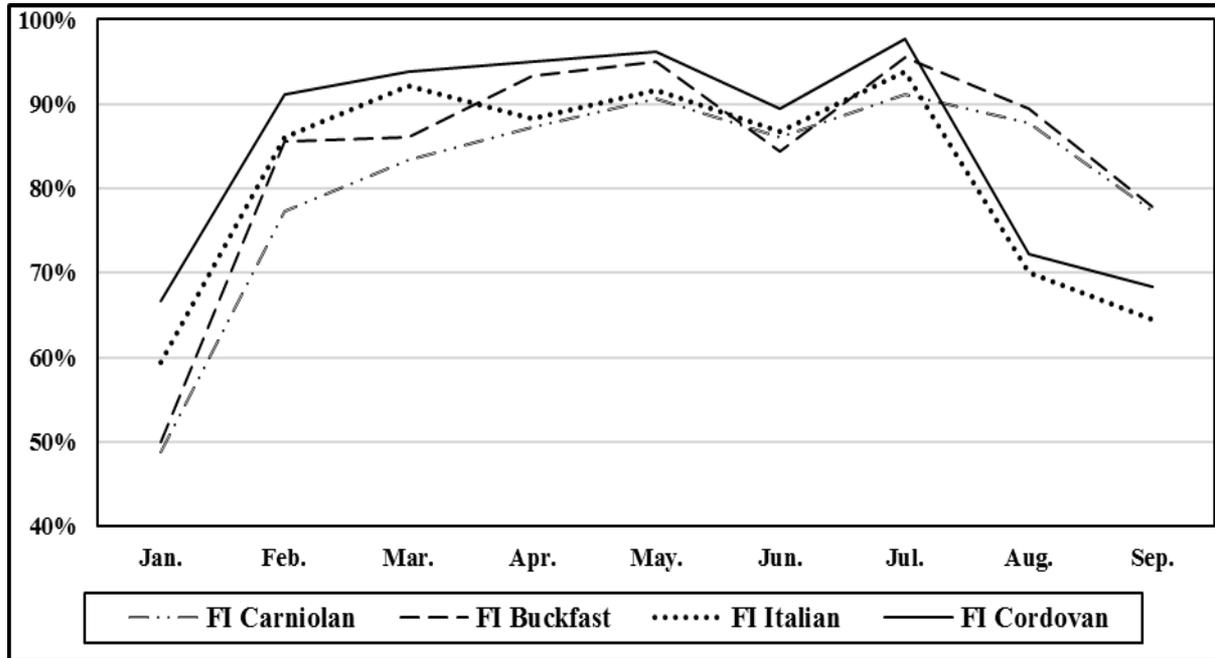
In the case of Carniolan bees there were no significant differences in the queen cells acceptance during April, May, June, July, and August while these months have significant differences with the other months during the study period. On the other side, for Buckfast bees there were no significant differences in the queen cells acceptance during April, May, July, and August with significant differences with the other months during the study period. While in Italian bees there were no significant differences in the queen cells acceptance during March, April, May, and July with significant differences with the other months during the study period with the same trend in the Cordovan bees.

On the other hand, Cordovan bees has the most acceptance number of the queen cells during the period from January to September with in total 1387 accepted queen cells followed by Buckfast bees with total 1363 accepted queen cells then Italian and Carniolan bees with in total accepted queen cells 1319 and 1313, respectively. In addition, the results showed that there were significant differences between Cordovan bees with Carniolan and Italian bees and no significant differences with Buckfast bees, while for the results of Buckfast bees with the other examined races it was the

same attitude as the cordovan bees with the others. It is clear from this end that the most effective in the queen cells acceptance under the Egyptian environmental conditions in this study were Cordovan and Buckfast bees' genotypes rather than Carniolan and Italian bees' races.

On the same trend, Cordovan genotype recorded the highest level of the percentage of queen cells acceptance from the 45 queen cells presented to the queen less colony whereas, the highest queen cells acceptance percentage was in July followed by May, April, March, and February with 96.11%, 95%, 93.89%, and 91.11% respectively (Fig. 1). In addition, the Buckfast genotype was in the second level for the queen cells acceptance percentage whereas, the acceptance percentages were 95.56% 95%, 93.33%, and 86.11%, during July, May, April, and February, respectively.

On the other hand, the highest queen cells acceptance percentage for Italian bees was in July followed by March then May with 93.89%, 92.22%, and 91.67% respectively. Whereas in Carniolan bees the highest percentage of queen cells acceptance was in July with 91.11% and May with 90.56%.

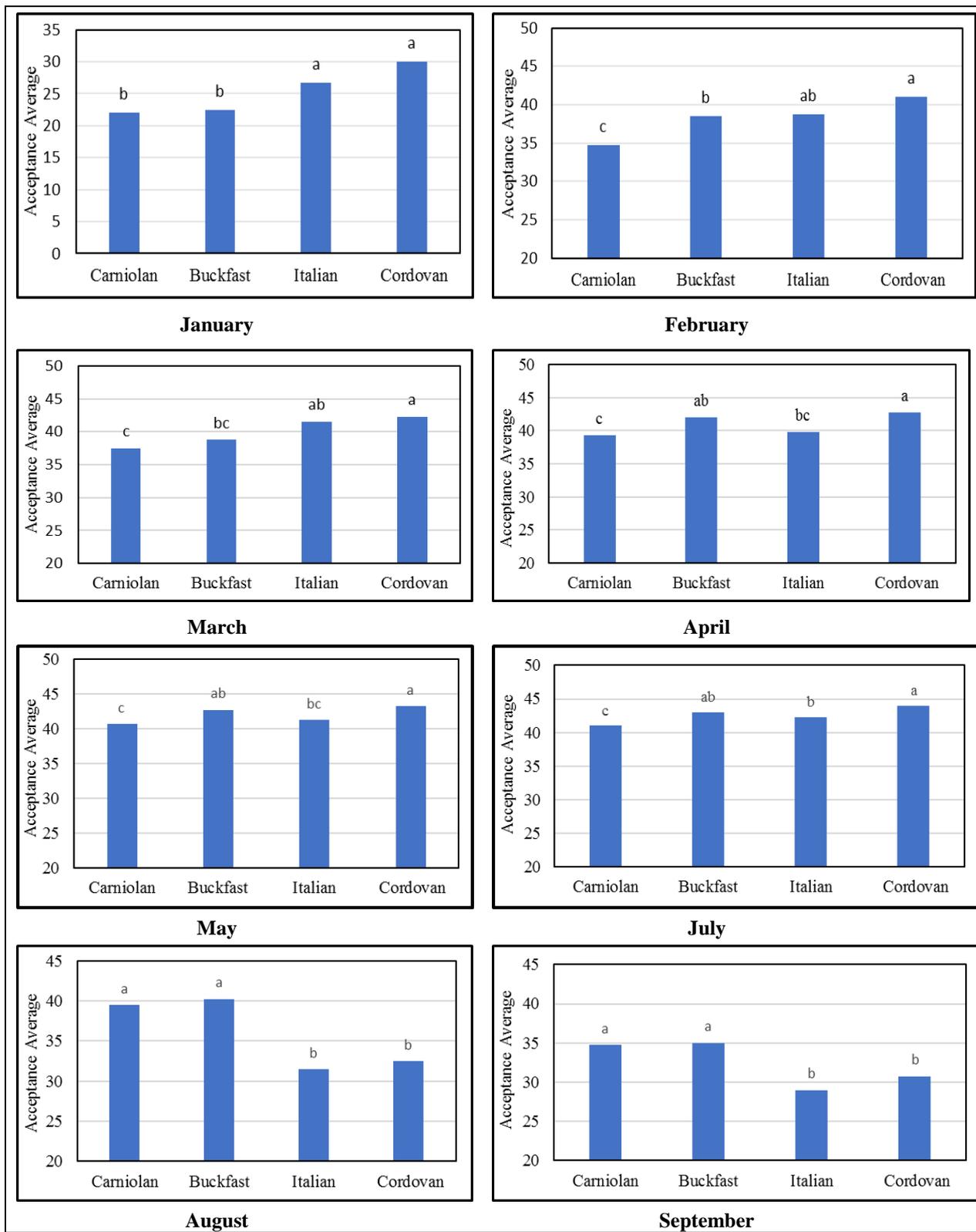


**Fig. 1. Acceptance Percent of four Honeybee Races and Genotypes Activity on Queen Rearing Cups from January to September.**

To better explore and navigate the best time for queen rearing activity in the apiaries according to queen cells acceptance activity data for the different races and genotypes in within months, diagramed data in (Fig. 2) showed that Cordovan and Italian bees had the best activity in queen cells acceptance during January, February, and March with significant differences with Carniolan and Buckfast bees. On the other side, Cordovan and Buckfast bees had the best activity in queen cells acceptance during April, May, and July with significant differences with Carniolan and Italian bees, while during August and September Carniolan and Buckfast bees had the best activity in queen cells acceptance with significant differences with Cordovan and Italian bees. Whereas there were no significant differences between the different races and genotypes during June.

In general, the results of evaluating the different honeybee races and genotypes activity in queen cells acceptance indicated that the highest rate of queen cells acceptance was during May and July followed by April and August then March and June while the less acceptance rate was in January followed by February and September in all the examined races and genotypes. In addition, Cordovan genotype recorded the highest level of the percentage of queen cells acceptance followed by Buckfast, Italian, and Carniolan bees whereas, the highest queen cells acceptance percentage in general was in July, May, and April for all examined

races and genotypes. Furthermore, Cordovan and Buckfast bees had the best activity in queen cells acceptance during the nectar and pollen flow seasons in April, May, and July with significant differences with Carniolan and Italian bees and there were no significant differences between the different races and genotypes during June. These results somewhat agreed with Kruk and Skowronek (2002). They indicated that the highest queen rearing rate occurred in the second decade of May (55.8%) and then declined to (25.8%) until the second decade of July then raised again (44.6%) in August. Likewise, Eissa *et al.* (2012) reported that the best period for acceptance of queen cells was early summer season followed by spring then late summer. To this end, it was clear that the acceptance of honeybee queen cells in the queen rearing activity clearly affected by the flow of nectar and pollen during the months of flowers availability in spring and summer, whereas in April there are abundance of flowers in the beginning of spring and abundance of clover flowers in May, furthermore the maize pollens during the period from July to August which in turn enhance the queen rearing activities during these months.



**Fig. 2.** Acceptance averages of four honeybee races on queen cups rearing during the period from January to September.

## 2. Evaluating the differences in virgin queens' weight between examined races and genotypes.

The differences in virgin queens' weight for the examined races and genotypes were evaluated, whereas in general, the highest level of virgin queens' weight was during the period from February to June while the less virgin queens' weight average was in August and September in all the examined races and genotypes (Table 2).

In the case of Carniolan bees, the highest rate of virgin queens' weight was in May and June with no significant differences between these months, while these months had significant differences with the other months during the study period from February to September. On the other side, for Buckfast bees the highest rate of virgin queens' weight was in April, May, and June with no significant differences between these months, while these months have significant differences with the other months during the study period. While in Italian bees the less rate of virgin queens' weight was September with no significant differences between the virgin queens rate in the other months. The Cordovan bees recorded regular rate of the virgin queens' weight during the study with no significant differences between the virgin queens' weight during the different study months.

To better explore and navigate the determine the right time to get the best weight for the virgin queens, data for the different races and genotypes virgin queens' weight within months, diagramed data in (Fig. 3). The obtained data showed that Carniolan and Buckfast bees had the best rate in virgin queens' weight during the period from February to July with significant differences with Cordovan and Italian bees. On the other side, Cordovan and Buckfast bees had the best rate in virgin queens' weight during August and September with significant differences with Carniolan and Italian bees.

In general, the results of evaluating the different honeybee races and genotypes according to virgin queens' weight indicated that Buckfast bees recorded the highest rate of virgin queens' weight followed by Carniolan, with significant differences between all examined races and genotypes. Whereas Cordovan bees recorded regular rate of the virgin queens' weight with no significant differences between the different study months. Furthermore, Carniolan and Buckfast bees had the best rate in virgin queens' weight during the period from February to July, while, during August and September Cordovan and Buckfast bees had the best rate in virgin queens' weight.

**Table 2. The Honeybee Different Races and Genotypes Virgin queens' Weight (mg) from February to September.**

Hybrids	FI Carniolan		FI Buckfast		FI Italian		FI Cordovan	
	Mean weight [mg]	[SD]						
Feb.	155.78 bc	4.07	157.78 c	2.05	138.03 a	2.85	139.70 a	2.00
Mar.	157.98 b	3.05	163.05 b	5.70	138.05 a	1.58	140.13 a	2.00
Apr.	152.01 c	2.37	164.78 ab	2.40	134.78 ab	2.40	136.83 a	2.54
May	158.96 ab	2.54	169.25 a	2.54	136.25 a	1.69	139.70 a	2.05
Jun.	162.28 a	2.01	168.73 a	2.32	138.23 a	1.76	139.25 a	2.37
Jul.	145.69 d	2.82	157.38 c	3.25	136.38 a	2.70	139.75 a	2.98
Aug.	131.43 e	2.72	142.98 d	3.33	134.98 ab	3.97	138.40 a	3.07
Sep.	125.50 f	1.76	140.20 d	1.95	132.20 b	1.24	137.78 a	1.36
Average	148.70		158.02		136.11		138.94	
LSD: at 0.05 % level	4.009		4.609		3.535		3.438	

### For Weight Difference:

"F" value = 24.831 (Significant at 1% level).

L.S.D between Hybrids = 1.335 at (5% level).

Hybrids	FI Cordovan (138.94)	FI Italian (136.11)	FI Buckfast (158.02)
FI Carniolan (148.70)	9.76*	12.59*	9.32*
FI Buckfast (158.02)	19.08*	21.91*	0
FI Italian (136.11)	2.83*	0	

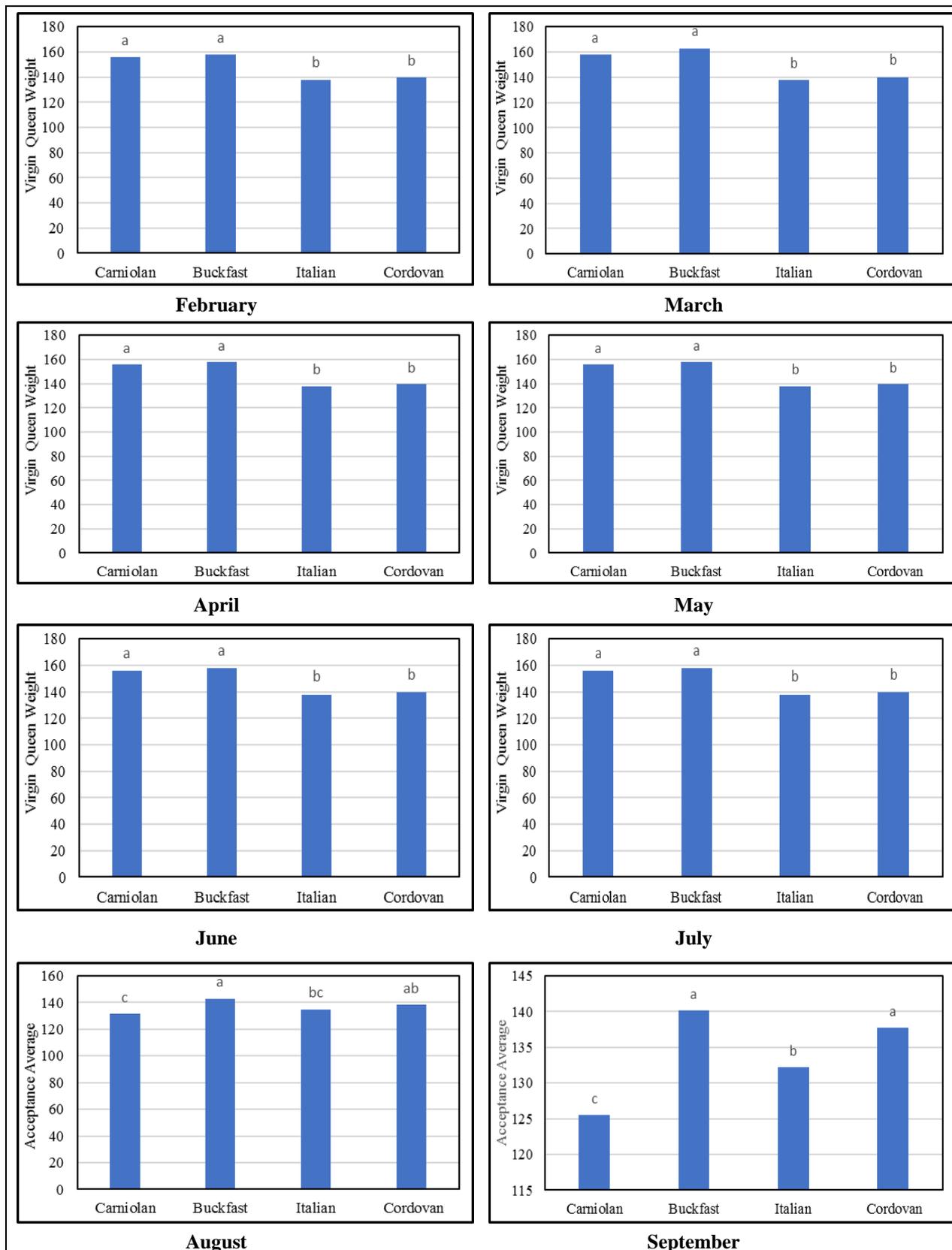


Fig. 3. Evaluation of The Honeybee Different Hybrids Virgin Queen Weight within Months.

To this end, the right time to get the best weight for the virgin queens was from February to July with preference of May and June. Furthermore, the best for the virgin queen weight was Buckfast genotype followed by Carniolan bees. From these results, it was clear that the weight of honeybee virgin queens directly affected by the flow of nectar and pollen, whereas started lightly in February the increased gradually in April until June.

### CONCLUSION

In conclusion, for beekeepers who are interested with queen rearing, Cordovan bees according to our study was the best in queen cells acceptance activity among the other examined races and genotypes followed by Buckfast, Italian, and Carniolan bees. Furthermore, the best time for the queen rearing activity was in July, May, and April for all examined races and genotypes according to the data of the highest queen cells acceptance percentage during the study. In addition, Buckfast bees recorded the highest rate of virgin queens' weight followed by Carniolan bees and the right time to get the best weight for the virgin queens was from February to July with preference of May and June.

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## الملخص العربي

### نشاط تربية الملكات ووزن الملكات العذارى لتحسين أداء تربية سلالات النحل الكرنولي، الإيطالي، الباكفاست، ونحل الكوردوفان

هيثم محمود رمضان

بشكل عام في أبريل ومايو ويوليو لجميع السلالات والأنماط الجينية المختبرة. بالإضافة إلى ذلك، سجل نحل الباكفاست أعلى معدل لوزن الملكات العذارى يليه النحل الكرنولي، بينما سجل نحل الكوردوفان معدل منتظم لوزن الملكات العذارى مع عدم وجود فروق معنوية بين شهور الدراسة المختلفة. بالإضافة إلى ذلك، حقق كلا من النحل الكرنولي ونحل الباكفاست أفضل معدل في وزن الملكات العذارى خلال الفترة من فبراير إلى يوليو مع الأفضلية للملكات العذارى في شهري مايو ويونيو. توفر هذه الدراسة أساسًا ثابتًا للبحوث المستقبلية لفهم الاختلافات البيولوجية والجينية بشكل أفضل بين سلالات نحل العسل التي تم دراستها والأنماط الجينية ودورها في تكيف سلالات النحل مع الظروف البيئية في المناحل بجمهورية مصر العربية.

يبدل النحالون حول العالم قصاري جهدهم للعثور على السلالات الجغرافية والاقتصادية الملائمة للتلقيح وإنتاج كميات كبيرة من منتجات نحل العسل. ومع ذلك، من بين جميع السلالات الجغرافية المعروفة، يستخدم مربي النحل سلالات النحل الكرنولي والنحل الإيطالي وأنماط وراثية أخرى مطورة مثل نحل الباكفاست ونحل الكوردوفان على نطاق واسع في معظم البلدان. تم استخدام نظام جهاز Nicot Cupkit لتربية الملكات في هذه الدراسة لمقارنة وتقييم نشاط نحل الكرنولي والنحل الإيطالي ونحل الباكفاست ونحل الكوردوفان لتقييم قبولها لبيوت تربية الملكات. بشكل عام، سجل نحل الكوردوفان أعلى نسبة قبول لبيوت الملكات يليها نحل الباكفاست والإيطالي ثم الكرنولي في ظل الظروف البيئية المصرية، بينما كانت أعلى نسبة قبول لبيوت الملكات