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EFFECT OF COLONY STRENGTH AND RACE ON SOME PRODUCTIVE CHARACTERS OF HONEYBEES, *Apis mellifera* L. COLONIES

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ABSTRACT: The present work was carried out in a private apiary located at El-Moullak region, Abu-Hammad District, Sharkia Governorate, to investigate the effect of colony strength and race of bee on the performance of honeybee colonies in brood rearing activity, drawing out wax foundation and honey production during citrus and clover flow period of 2014 and 2015 seasons. Summarized data are as follows: based on the two years mean strong Carniolan colonies reared the largest area of sealed worker brood during both citrus (1046.66 in^2/ colony) and clover (1310.65 in^2/colony) flows, followed by strong Italian colonies. On the other hand, the least sealed brood area was reared in median Italian colonies (502.66 in^2/colony) during citrus flow and for median Carniolan colonies (581.98 in^2/ colony) during clover flow. Strong colonies of both Italian and Carniolan hybrids drew out significantly higher area of wax foundation than median colonies of the two hybrids. However, the highest drawn out area was recorded for strong Italian colonies (270.16 in^2/ colony) during citrus flow and for strong Carniolan colonies (224.66 in^2/colony) during clover flow period. On the contrary, median Italian colonies drew out the least wax foundation area, that recorded 116.50 and 106.49 in^2/colony during citrus and clover flow period, respectively. Strong colonies of both hybrids proved to be more for citrus and clover honey producers than median ones. The highest citrus honey yield was gained from strong Italian (9.33 kg/colony) and strong Carniolan (11.66 kg/colony) in 2014 and 2015 seasons, respectively. On the other hand, median Carniolan colonies yielded the least citrus honey crop in both seasons. As to clover honey, both strong Italian and Carniolan hybrid colonies, produced 10 kg/ colony in 2014. The two hybrids showed similar trend in 2015. On the contrary, median Italian hybrid colonies produced significantly lower clover honey yield than strong ones of the two hybrids (7.43 and 6.91 kg / colony) in 2014 and 2015 seasons, respectively.

Key words: *Apis mellifera*, colony strength, hybrids, productive characters, citrus and clover flows.

INTRODUCTION

The productivity of a honeybee colony is multifactorial dependant. However, the number of workers (bee population) is considered one of the main factors in this respect, as the production of the colony of honey, for instance, equal the production of one worker multiplied by the number of workers (Zmarlicki, 1974; Szabo, 1977; Szabo and Lefkovitch, 1989; Racys, 2002; Bhusal *et al.*, 2011; Tahmasbi *et al*., 2014).

In addition, the race /or hybrid of honeybee plays an essential role, where there are some races of honeybee are more productive in some products than others under varied botanical and meteorological circumstances (Spivak *et al.*, 1989; Khater, 1998; Salem, 2009).

Therefore, the present work was conducted to assess the effect of two levels of colony strength (median and strong) as well as two honeybee hybrids, *i.e.*, Carniolan and Italian ones on the colony production of seaded brood, drawing out wax foundation and honey production during citrus and clover flows of 2014 and 2015 seasons.

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MATERIALS AND METHODS

The present investigation was carried out during the period extended from 2013 to 2015. Field experiments were performed in a private apiary located at El-Moullak region, Abu-Hammad District, Sharkia Governorate.

Experimental Honeybee Colonies

A total of twenty honeybee nuclei were initiated during late June 2013 and 2014, by division of strong colonies as follows: ten 3 – comb nuclei that were divided into two groups of 5 nuclei each (groups B, D); ten 5 – comb nuclei that were divided into two groups (groups A, C) and treated as mentioned above. Honeybee colonies arised from 3- comb nuclei (Carniolan and Italian) were considered later as median colonies, whereas those arised from 5-comb nuclei served as strong colonies (Carniolan and Italian). A mated young queen was introduced into each nucleus as follows: groups A and B nuclei (F_1 Carniolan). The introduced ten sister queens of the first hybrid Carniolan *(Apis mellifera carnica)*, resulted from open mated virgin queen reared from the progeny of localized Carniolan mother (brought from El-Manzalah District). Groups C and D nuclei (F_1 Italian): nuclei were provided with ten sister queens of first Italian (*A. m. ligustica*) hybrid, resulted from open mated virgins reared from the progeny of imported Italian mother obtained from Honeybee Department, Plant Protection Reseach Institue, Dokki, Giza. Open mating of virgin Italian and Carniolan queens was carried out at El-Moullak region, Abu-Hammad District using mated baby nuclei during late May 2013 and 2014. The introduction of mated queens into the experimental nuclei was taken place on the second day of division (nuclei initiation) to ensure rapid and safe queen's acceptance. A half ball netted cage was used for this purpose. All nuclei in each group were equalized as possible in strength, number of combs covered with bees, brood, stored honey and bee bread. The onset of experiments and records were started two months after the queen introduction, to be insure that the bees under experimentation are the offspring of the F_1 Italian or F_1 Carniolan introduced queens.

During autumn and winter seasons the experimental colonies were fed on sucrose syrup (1:1 and 2:1) and pollen substitutes patties, when necessary to protect colonies from starvation and to maintain the colonies life. In addition, the rate of artificial sucrose feeding was increased, starting from December in both seasons to encourage the queen's egg laying capacity. Moreover, pollen substitute patties, weighing 3/4 kg each, were provided to each experimental colony in late autumn and winter to increase brood rearing activity. The patty consisted of a mixture of 3 parts of deffated soyabean flour and one part medical dry yeast in 4:1 sucrose solution, where the mixture of soyabean flour and yeast represented 10% of the total (*W:W*), the remained (90%) is old honey and sucrose .The patties were fortified with lemon juice (0.1%) as a source of vitamin C, and the fungicide Flagyl syrup (2 ml Flagyl/ 1 kg patty). The patties were offered in closed plastic saccules to prevent them from drying as long as possible. An open window (2 × 10 cm) was made along the saccule side to allow the bees to reach the patty inside.

Measuring brood rearing activity

Brood rearing activity of the experimental colonies of both F_1 Carniolan and F_1 Italian hybrids was followed, during citrus and clover flows of 2014 and 2015 seasons by measuring the areas of sealed worker cells present in each colony separately at twelve-day intervals, using a Hoffman frame divided into square inches by means of wire (El-Shakaa, 1985). The bees covering each brood comb were firstly shaken off to allow easier and safer measuring with lower bee damage (mortality), then sealed brood area in both sides of the comb was measured. The data were recorded and the total sealed brood area per colony during citrus and clover flows was then calculated.

Drawing out wax foundation

Each test colony of F_1 Carniolan and F_1 Italian hybrids was provided with one wax foundation that was inserted between brood combs during citrus and clover flows of 2014 and 2015 seasons. When the wax foundation was completely drawn out, a new foundation was inserted as described above. The drawn out area on both sides of wax foundation was measured by means of Hoffman frame divided into square inches.

Estimation of Honey Production

Citrus honey yield

To produce citrus honey, the test colonies belong to the two hybrids under study were moved to citrus orchards of the Egyptian Agricultural Company at El-Moullak region, Abu-Hammad District, Sharkia Governorate during the first week of March 2014 and 2015 seasons. The test colonies were fed twice on sucrose syrup (1:1) until the citrus flow has begun , during the third week of March , hence the artificial feeding was stopped and the test colonies were provided with wax foundation combs for drawing and drawn combs for honey storage. Citrus honey was harvested during the first week of April. The surplus honey combs were taken from their respective colonies and marked with paint colour after the bees covering were shaken off. Thereafter, honey yield was estimated for each colony separately (in kg/ colony) by calculating the differences between the weight of honey combs before and after extraction of honey. The extracted combs were then returned back to their respective colonies.

Clover honey yield

After citrus honey extraction, the experimental colonies were moved back to their original site and fed two times on sucrose syrup (1:1) in preparation for clover honey production. Clover flow started at the beginning of May and lasted to the first week of June when the honey yield was estimated for each experimental colonies of the two hybrids as described before.

Data obtained were statistically analysed according to Snedecor and Cochran (1967) methods, that calculated according to COSTAT Computer Program (2005).

RESULTS AND DISCUSSION

Brood Rearing Activity

Brood rearing activity was followed by measuring sealed brood area (in^2) on both sides of brood combs at 12 days interval during flow period of citrus and clover crops during 2014 and 2015 seasons. Data in detail are as follows:

Citrus flow period

Data presented in Table 1 and Fig. 1 clear the mean sealed brood area measured during flow period of 2014 and 2015 seasons. It is obvious that the measured sealed brood area attained 816.8, 402, 1114 and 842 in^2/colony in 2014, and 996, 603.32, 979.32 and 672 in^2/ colony of strong, median Italian, strong and median Carniolan hybrids during 2015 season, respectively.

It is clear that strong Carniolan colonies reared the highest significant area of sealed brood. On the other hand median Italian colonies reared the least significant brood area in 2014 season. In 2015 season the strong colonies of both hybrids reared significantly higher sealed brood area as compared to the median colonies of both hybrids. However, the median Italian colonies reared the least sealed brood area.

Based on the mean of two years strong Carniolan colonies showed superiority (1046.66 in^2/colony), followed by the strong Italian colonies (906.4 in^2/colony). On the contrary median Italian colonies manifested the least brood area (502.66 in^2 /colony).

Table 1. Mean sealed brood area (in^2) reared in strong and median colonies of F_1 Italian and F_1 Carniolan hybrids during citrus and clover flow of 2014 and 2015 seasons

Colony strength and race	Citrus flow		Mean of two years	Clover flow		Mean of two years
	2014	2015		2014	2015	
Strong Italian	816.8b	996a	906.4	870.64ab	994.64ab	932.64
Median Italian	402c	603.32b	502.66	502.64b	704b	603.32
Strong Carniolan	1114ab	979.32a	1046.66	1284a	1337.3a	1310.65
Median Carniolan	842b	672b	757	558.64b	605.32b	581.98
General mean	793.7	812.66	803.18	803.98	910.31	857.14
$LSD_{0.05}$	416.76	193.2		432.96	466.92	

* Values followed by the same letters in each column are insignificantly different.

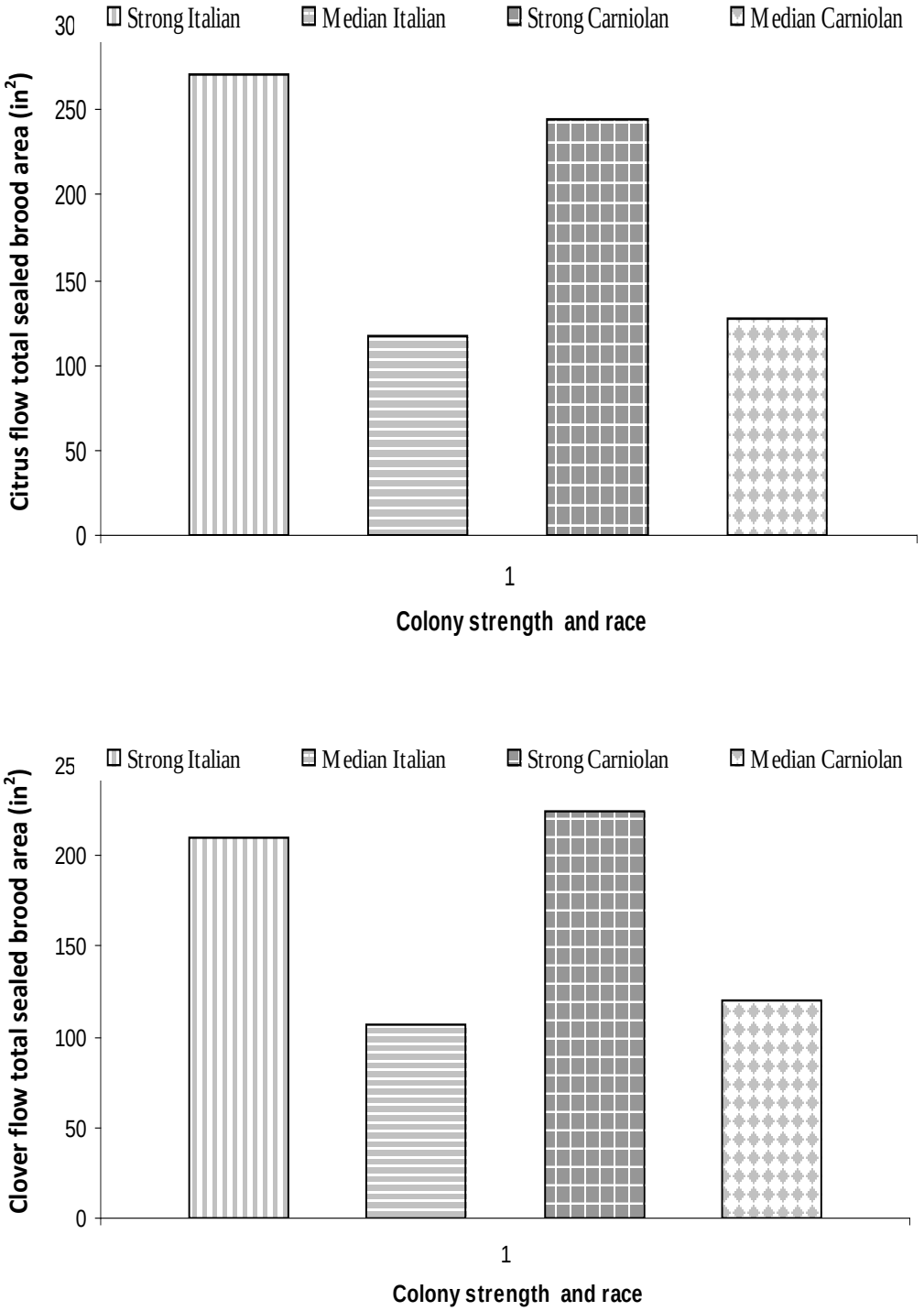

Fig. 1. The mean of two years of citrus and clover flow total sealed brood area (in^2) by strong, median Italian, and strong, median Carniolan hybrid colonies during 2014 and 2015 seasons

According to the general mean of sealed brood area reared in the test colonies, regardless of the race of bees and the strength of the colony it is clear that 2015 season was more suitable for brood rearing than 2014 season. This phenomenon was also revealed in case of honey production and drawing out wax foundation.

Clover flow period

Results presented in Table 1 and Fig. 1 clear that the mean sealed brood area measured during clover flow period reached 870.64, 502.64, 1284 and 558.64 in^2 sealed brood area per colony in 2014, and 994.64, 704, 1337.3 and 605.32 in^2 sealed brood/colony in 2015 for strong, median Italian, strong and median Carniolan hybrids, respectively.

Statistical analysis revealed that the strong colonies of both Italian and Carniolan hybrids reared higher significant sealed brood area during clover flow than median colonies of both hybrids. However, strong Carniolan colonies manifested superiority over the strong Italian colonies in this parameter. On the other hand, median Carniolan colonies reared the least sealed brood area.

In this respect, Bilash (1980) gave a logical interpretation to this phenomenon that in strong colonies, brood cells containing larvae at 3 days old had more food than corresponding cells in weak colonies and this in turn helps in initiating healthy and well built (bodies) workers.

In addition, Shawer *et al.* (1986) reported that queen heading strong colonies were more active in egg laying throughout the flow seasons of the year than those heading weak colonies. Moreover, Marcinkowski (1991) found that weakened colonies did not regain the strength of control colonies even after 40-50 days, having an unfavourable effects on wintering and spring development.

However, Mishra (1996) studied the effect of colony strength on the initiation of foraging activity in the morning and the number of trips and total foraging efforts indicating that the initiaton of foraging and the number of trips did not affect by colony population. Inversely, Bhusal *et al.* (2011) stated that brood rearing activity of bee colonies is significantly affected by bee population in the colony.

In addition, brood rearing activity in the test colonies was markedly higher in 2015 clover season as compared to that of 2014 one . This variation between the two seasons could be attributed to the botanical and meteorological factors that probably were more suitable for nectar secretion and foraging activity in 2015 (Nunez, 1982; Perez-Pineiro, 1986; Brandburgo and Goncalves, 1989; Nelson and Gary, 1993; Racys, 2002).

Drawing Out Wax Foundation

Data presented in Table 2 and Fig. 2 clear the drawn area of wax foundation by strong and median Italian and Carniolan honeybee hybrid colonies during citrus and clover flow period of 2014 and 2015 seasons.

Table 2. Mean drawn area (in^2) of wax foundation by strong and median colonies of F_1 Italian and F_1 Carniolan honeybee hybrids during citrus and clover flow of 2014 and 2015 seasons

Colony strength and race	Citrus flow		Mean of two years	Clover flow		Mean of two years
	2014	2015		2014	2015	
Strong Italian	273.66a	266.66a	270.16	206.33a	214a	210.16
Median Italian	113b	120b	116.50	96.33b	116.66b	106.49
Strong Carniolan	206b	283.33a	244.66	224a	225.33a	224.66
Median Carniolan	129.33b	125.66b	127.49	117b	124.33b	120.66
General mean	180.49	198.91	189.70	160.91	170.08	165.49
LSD 0.05	105	99.46		29.58	23.57	

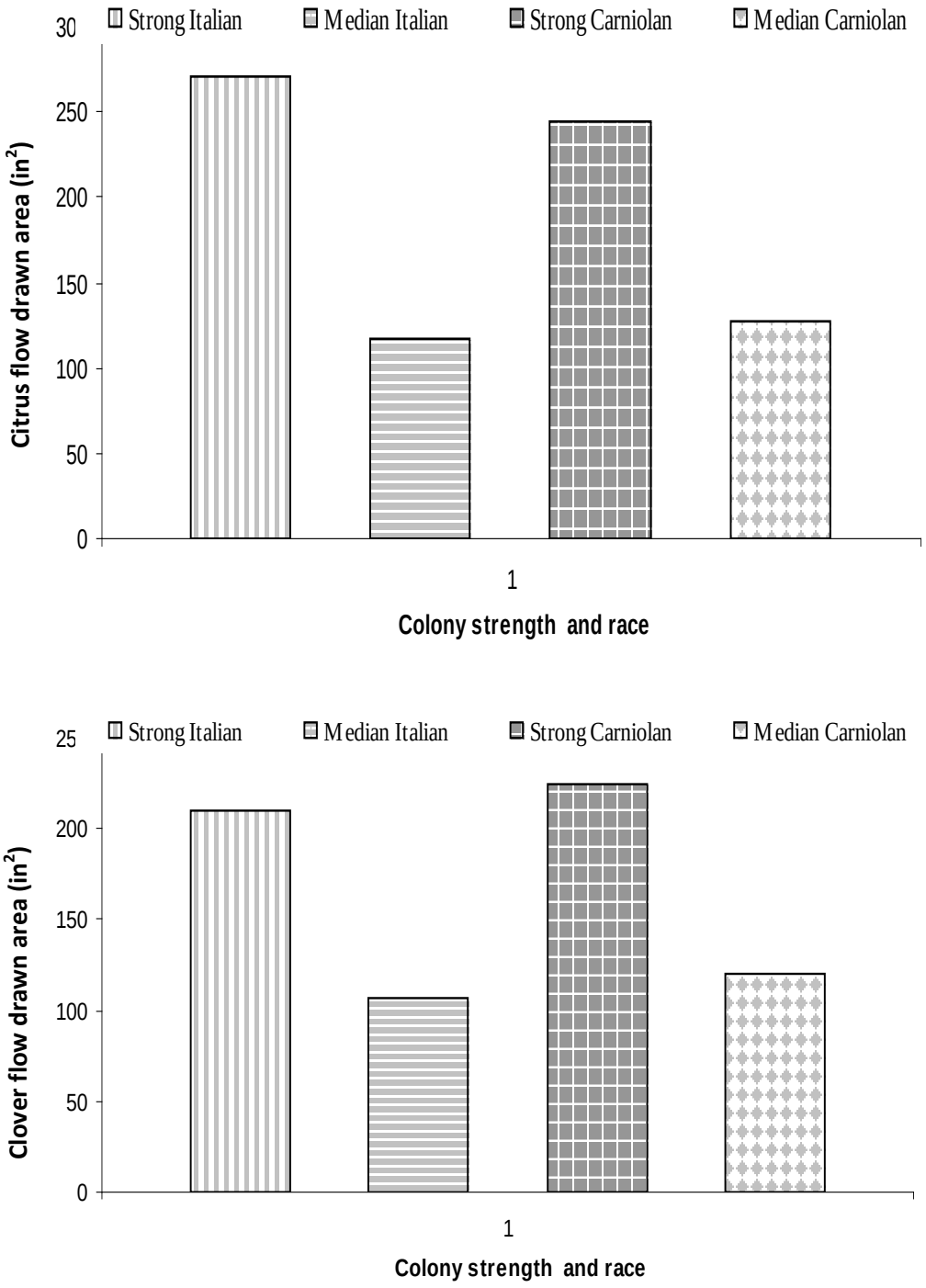

Fig. 2. The two years mean of citrus and clover drawn area (in^2) by strong, median Italian, and strong, median Carniolan hybrid colonies during 2014 and 2015 seasons

Citrus flow

It is obvious that strong colonies drew larger wax foundation area than the median ones. However, strong Italian colonies drawn out larger wax foundation area (270.16 square inch) than the strong Carniolan ones (244.66 in^2) during citrus flow, meanwhile median Carniolan colonies exceeded (127.49 in^2) the median Italian colonies (116.5 in^2) in this respect.

Generally, the differences between 2014 and 2015 seasons were very slight, except the strong Carniolan colonies in 2015 during citrus flow period that drew out the largest area (283.33 in^2) of wax foundation.

Statistical analysis revealed significant difference in favour of strong Italian colonies in 2014. Strong colonies of both hybrids drew out larger significant area of wax foundation as compared to the median colonies of the two hybrids.

Clover flow

Results obtained clear that the drawn out area of wax foundation attained 206.33 and 214 in^2 ($\overline{X}$ = 210.16 in^2) for strong Italian colonies; 96.33 and 116.66 in^2 ($\overline{X}$ = 106.49 in^2) for median Italian colonies; 224 and 225.33 in^2 ($\overline{X}$ = 224.66 in^2) for strong Carniolan colonies; 117 and 124.33 in^2 ($\overline{X}$ = 120.66 in^2) for median Carniolan colonies. Analysis of data manifested significant difference in the drawn out area of wax foundation in favour of strong colonies of both hybrids.

In general, the test hybrid colonies of both levels of strength drew out larger area of wax foundation during citrus flow as compared to this activity during clover flow in both seasons. In connection, Muller (1992) reported seasonal variation in the amount of wax secreted by bee colonies. In addition, Starostenko (1971), Skowronek (1976), Cherevko and Gaidar (1979) and Jay and Jay (1983) reported racial variation in wax production. Morever, Rashad *et al.* (1980) stated that the highest wax secretion was taken place during high nectar flows. However, Jay and Jay (1983) and Whiffler and Hepburn (1991) found that queen status is greatly effective. Szabo (1977) added that the number of combs built greatly determined by the weight of bees in the colony and air temperature.

Honey Production

Citrus and clover honey yields were estimated during 2014 and 2015 seasons for strong and median colonies of both Italian, *Apis mellifera ligustica* and Carniolan hybrids, *A. mellifera carnica*. Results obtained are presented in Table 3 and Fig. 3.

Table 3. Mean citrus and clover honey yield (kg) produced by strong and median colonies of F_1 Italian and F_1 Carniolan hybrids during 2014 and 2015 seasons

Colony strength and race	Citrus honey yield (kg)		Mean of two years	Clover honey yield (kg)		Mean of two years
	2014	2015		2014	2015	
Strong Italian	9.33a	9.75a	9.54	10a	9.58a	9.79
Median Italian	6.33b	5.75b	6.04	7.43b	6.91b	7.17
Strong Carniolan	8.88a	11.66a	10.27	10a	9.16a	9.58
Median Carniolan	6.10b	5.16b	5.63	7.83b	7.37b	7.6
General mean	7.66	8.08	7.87	8.81	8.25	8.53
LSD 0.05	2.55	3.21		1.23	1.20	

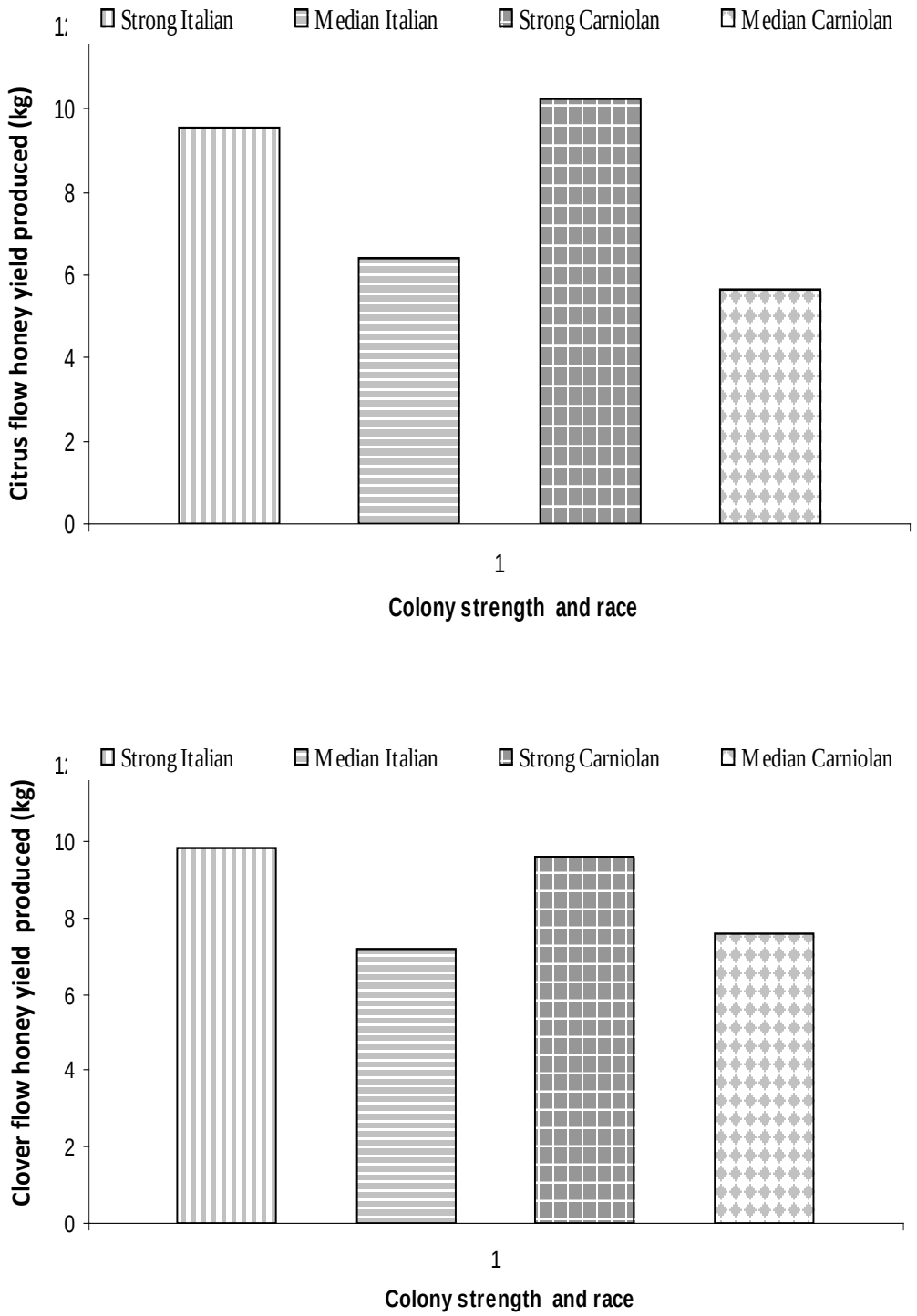

Fig. 3. The two years mean of citrus and clover honey yield (kg) produced by strong, median Italian, and strong, median Carniolan hybrid colonies during 2014 and 2015 seasons

Citrus honey yield

Results presented in Table 3 and Fig. 3 clear that the citrus honey yield harvested from strong and median Italian and Carniolan hybrid colonies weighed 9.33, 6.33, 8.88 and 6.10 kg/ colony in 2014 and 9.75, 5.75, 11.66 and 5.16 kg/ colony in 2015 season for strong, median Italian, strong and median Carniolan hybrid colonies, respectively. It is obvious that strong colonies of both hybrids yielded significantly more honey than those of the median colonies of both hybrids. Generally, the highest citrus honey yield was produced from strong Italian colonies (9.33 kg) in 2014 season, while in 2015 season, strong Carniolan colonies were the most honey producers (11.66 kg/colony). In general, 2015 season was more suitable for citrus honey production, recording (8.08 kg/colony) regardless of bee race and the strength of the colony.

Clover honey yield

Results given in Table 3 and Fig. 3 clear that clover honey yield of strong and median colonies of Italian and Carniolan hybrids attained 10, 7.43, 10 and 7.83 kg/colony in 2014 and 9.58, 6.91, 9.16 and 7.37 kg/ colony in 2015 season for strong, median Italian, strong and median Carniolan colonies, respectively.

As to clover honey yielded from strong and median Italian and Carniolan hybrids, it is obvious that 2014 season was more suitable than 2015 one. For instance, the general mean clover honey yield produced during 2014 attained 8.81 kg/colony compared to 8.25 kg/colony in the next season, regardless of colony strength and bee race.

It seemed that the meteorological factors were more suitable for both bee foraging and nectar secretion. This statement is in agreement with that of Lazar (1980), Nunez (1982) and Tahmasbi *et al.* (2014). Moreover, strong colonies of both hybrids showed superiority in clover honey production over median ones. The differences between the colonies of the two levels of strength were significant in both seasons. However, the difference between the colonies of each level was insignificant.

It could be concluded that Carniolan hybrid is more citrus honey producers than Italian one. This statement is greatly supported by that of Khater (1998), El-Sayed (2006) and Ali (2011). The reported superiority of Carniolan bees could be attributed to the rapid build-up of their colonies early in spring that resulted in producing higher population of workers responsible for honey production. This trend was also reported by Tarakanov (1974) and Zmarlicki (1974). Moreover, Zmarlicki (1974) and Vesely (1976) found that spring development was 80% better in Carniolan and in hybrid colonies than in Caucasian. During average early nectar flow bees produce 60% more honey than Caucasian bees. The same conclusion was also reported by Szabo and Lefkovitch (1989) who reported that honey production was significantly correlated with the number of worker brood cells.

Results of the present work clear also that 2015 season was more suitable for honey production than 2014, especially during citrus flow period perhaps due to the more suitable weather conditions, in addition to the effect of weather factors on the flowering and nectar production (Brandburgo and Goncalves, 1989). These findings are in accordance with those of Lazar (1980), Nunez (1982), Ledgard and Simes (1983), Perez-Pineiro (1986), Abd Allah (1999) and Racys (2002).

It is also important to report that the test colonies manifest early and intense foraging during spring that led to higher production of honey where the onset of foraging was very early and in higher populations at 7 a.m. This conclusion was also reported by Tahmasbi *et al.* (2014).

In conclusion and in order to gain higher yields of colony products, it is important to rear (invest) healthy and well built colonies with higher population of worker, not to rear higher numbers of weak unprepared colonies to harvest the highest possible production of hive products.

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تأثير قوة الطائفة وسلالة النحل على بعض الصفات الإنتاجية لنحل العسل

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تم إجراء هذا البحث في منحل خاص بمنطقة الملاك - أبو حماد - محافظة الشرقية لدراسة تأثير قوة الطائفة وسلالة النحل على أداء طوائف نحل العسل فى نشاط تربية الحضنة ومط الأساسات الشمعية وإنتاج عسل الموالح والبرسيم في عامي ٢٠١٤ و٢٠١٥، ويمكن تلخيص النتائج كما يلي: إستنادا لمتوسط العامين لوحظ أن طوائف الكرنيولى القوية قد أظهرت أعلى نشاط في تربية الحضنة أثناء فيض الموالح والبرسيم حيث بلغت مساحة الحضنة ١٠٤٦.٦6 و١٣١٠.٦٥ بوصة مربعة حضنة مقفلة / طائفة خلال فترتي الفيض على الترتيب تلتها طوائف النحل الايطالي القوية، من ناحية أخرى سُجلتّ أقل مساحة حضنه مقفلة في الطوائف الإيطالي متوسطة القوة (٥٠٢.٦٦ بوصة مربعة / طائفة) أثناء موسم الموالح ولطوائف النحل الكرنيولى متوسطة القوة (٥٨١.٩٨ بوصة مربعة/طائفة) أثناء موسم البرسيم، مطت الطوائف القوية من كلا الهجينين مساحة أكبر معنويا من الشمع الأساس مقارنة بالطوائف متوسطة القوة ومع هذا سُجلت أعلى مساحة شمع ممطوط للطوائف الإيطالي القوية (٢٧٠.١٦ بوصة مربعة/طائفة) أثناء موسم الموالح وللطوائف الكرنيولى القوية (٢٢٤.٦٦ بوصة مربعة/ طائفة) أثناء موسم تزهير البرسيم، على النقيض قد مطت طوائف الإيطالي متوسطة القوة أقل مساحة حضنة مسجلة ١١٦.٥٠ و١٠٦.٤٩ بوصة مربعة/طائفة أثناء تزهير الموالح والبرسيم على الترتيب، كانت الطوائف القوية من كلا الهجينيين الأكثر إنتاجا للعسل من الطوائف متوسطة القوة، هذا وقد جمع أكبر محصول من العسل (٩.٣٣ كجم / طائفة) للطوائف الإيطالي القوية أثناء موسم الموالح وللطوائف الكرنيولى القوية (١١.٦٦ كجم/طائفة) في موسمي ٢٠١٤ و٢٠١٥ على الترتيب، ومن ناحية أخرى سجلت أقل كمية عسل موالح للطوائف الكرنيولى متوسطة القوة خلال موسمي الدراسة، وبخصوص عسل البرسيم قد تم حصد ١٠ كجم للطوائف القوية من كلا الهجينيين وقد لوحظ نفس الإتجاة فى ٢٠١٥، على النقيض أنتجت طوائف النحل الإيطالي متوسطة القوة إنتاجا أقل معنويا من العسل، مسجلة ٧.٤٣ و ٦.٩١ كجم / طائفة في موسمي ٢٠١٤ و ٢٠١٥ على الترتيب.

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