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SUMMARY

The present investigation was initiated to evaluate certain biometrics, defensive behaviour, physiological and biochemical characters of the most common races of honeybee. Egyptian race and local Carniolan race and their hybrid were tested in Assiut region, in different seasons during the period from June 2006 till May 2008. The obtained results can be summarized as follows:

Part I: Biometrical studies of the Egyptian and local Carniolan races and their hybrid:

1- Mean areas of workers sealed brood:

The highest mean area of workers sealed brood was recorded by the local Carniolan race with an average of 334.5 sq.inch/colony. While the lowest area was recorded by the Egyptian race, with an average of 263.8 sq.inch/colony. The Carniolan hybrid exhibited medium value between parents, with a mean of 301.9 sq.inch/colony. The highest seasonal values were recorded during Autumn by the Carniolan hybrid with a mean of 411.0 sq.inch/colony and during Summer by the local Carniolan race with an average of 437.8 sq.inch/colony. Variations between the monthly, seasonal and yearly mean areas of workers sealed brood were highly significant.

2- Mean areas of workers unsealed brood:

The workers unsealed brood (sq.inch) in tested colonies showed the same trend, as well as, the sealed brood. The descending order of the tested colonies was as follows: local Carniolan race followed by Carniolan hybrid, and Egyptian race. The highest seasonal values of workers unsealed brood were recorded during Autumn for the three tested colonies. Highly significant differences were recorded between all measurements during (2006-2008).

3 – Mean areas of drones sealed brood:

Similar results, as workers brood, were obtained during this work, whereas the tested colonies took the same ranking order. High variations were observed between the drones sealed brood areas from pure races, whereas the Carniolan race drones sealed brood was equal 2.73 more times, as compared with, Egyptian race. Spring contained the highest values of drones sealed brood areas with an average of 7.661 and 3.630 sq.inch/colony for the Carniolan and Egyptian races, respectively, while the Carniolan hybrid showed more value with a mean of 8.611 sq.inch/colony during Autumn. Seasonal values showed significant variations between the tested races and their hybrid.

4 – Adult population:

The highest adult population was recorded during Autumn with a mean of 17802, 16662, and 14085 adult/colony for local Carniolan race, Carniolan hybrid and Egyptian race, respectively. The lowest population was recorded during Spring with a mean of 12202, 11882 and 10057 adult/colony for the same tested races and their hybrid, respectively. Seasonal variations showed highly significant F value between the tested colonies. The same behaviour was recorded throughout the whole study period. Highly significant positive correlation was detected between adult population and sealed or unsealed workers brood.

5 – Mean numbers of queen cups:

For all of the tested colonies the highest mean numbers of queen cups was recorded during Spring, however, the lowest numbers were recorded during Summer with highly significant variations. The ranking order of the established queen cups throughout (2006-2008) was: 5.201, 3.636 and 3.297

queen cups/colony for the Carniolan race, Carniolan hybrid and Egyptian race, respectively, with non significant variations between the tested colonies. Highly significant and positive correlation was noticed between mean number of queen cups and mean sealed or unsealed workers brood.

6 – Mean numbers of unsealed queen cells:

Except for local Carniolan race which initiated a mean of one unsealed queen cell/colony during Spring, the other tested colonies established a mean of less than one unsealed queen cell/colony. The highest numbers of unsealed queen cells were recorded during Spring, however, the lowest numbers were recorded during Autumn with highly significant F value. During (2006-2008) the tested colonies took the same ranking order as the aforementioned measurements with an average of 0.394, 0.286 and 0.181 unsealed queen cells/colony for the local Carniolan race, Carniolan hybrid and Egyptian race, respectively.

7 – Mean numbers of sealed queen cells:

The highest mean numbers of the established sealed queen cells were recorded during Spring by the pure races (1.120 and 0.657 sealed queen cells/colony) for the Carniolan and Egyptian races, respectively. However, their hybrid established its highest seasonal sealed queen cells during Summer with an average of 0.398 sealed queen cells/colony. The tested colonies showed different ranking orders all over the study period. The Carniolan race established the highest number of sealed queen cells and followed by the Egyptian race, while the Carniolan hybrid established the lowest numbers with an average of 0.394, 0.206 and 0.195 sealed queen cells/colony for the abovementioned colonies, respectively.

Significant differences were detected between races, months, seasons and their interactions.

8 – Mean numbers of out-going foragers;

Seasonal and yearly general mean numbers of out-going foragers during (2006-2008) showed highly significant differences between the tested races and their hybrid, whereas the amount of the Carniolan hybrid out-going foragers was highly than it's parents. During the entire period of this work, Carniolan hybrid out-going foragers is equal 1.07 and 1.53 more times of the local Carniolan race and Egyptian race, respectively. Concerning the seasonal activity, Summer contained the highest numbers of out-going foragers with an average of 21.63, 18.18 and 13.80 out-going foragers/colony/min. day for the Carniolan hybrid, Carniolan and Egyptian races, respectively. However, Winter contained the lowest numbers for all of the tested colonies.

9 – Mean numbers of in-going foragers:

Similar behaviour was recorded between local Carniolan race and Carniolan hybrid, whereas similar numbers of in-going foragers were recorded during this work. On the other hand, the same differences between Carniolan bee and Egyptian bee is still recorded. General mean numbers of in-going foragers can be arranged in descending order as follows: Carniolan hybrid by 13.49, Carniolan race by 13.05 and Egyptian race by 9.08 in-going foragers/colony/min./day. Seasonal activities showed the same trend of out-going foragers, whereas, the highest in-going foragers were recorded during Summer, however, the lowest numbers were recorded during Winter for all of the tested colonies.

10- Mean numbers of in-going pollen collectors:

In-going pollen collectors showed the same behaviour of the in-going foragers, whereas the local Carniolan race and its hybrid showed high numbers than the Egyptian race with a mean of 2.87, 2.79 and 1.70 in-going

pollen collectors/colony/min/day for the tested races and hybrid, respectively all over the study period. Summer season contained the highest in-going pollen collectors while Winter contained the lowest ones. Highly significant F value was detected between colonies, either during seasons, or throughout the whole study period. Highly significant positive correlation was detected between pollen collectors and each of sealed or unsealed workers brood, in-going or out-going foragers.

11 – Mean areas of stored pollen:

The highest general mean areas of stored pollen sq.inch/colony was recorded by local Carniolan race (164.4) which was equal 1.04 and 1.22 more times of areas established initiated by Carniolan hybrid and Egyptian race, respectively. Seasonal differential behaviour was noticed between the measurements and the aforementioned ones, whereas the highest areas of stored pollen were recorded during Autumn with an average of 230.8, 222.5 and 179.3 stored pollen sq.inch/colony for the Carniolan race, Carniolan hybrid and Egyptian race, respectively. However, the lowest areas were recorded during Spring for all of the studied colonies with a mean of 122.7, 121.3 and 106.1 sq./inch/colony for the abovementioned colonies, respectively. Highly significant differences were detected between the tested colonies during seasons and throughout the period of study.

12- Mean areas of stored honey:

Approximately equal areas of stored honey were recorded during this work by the local Carniolan race and Carniolan hybrid with an average of 353.8 and 341.5 sq.inch/colony, respectively. However, low areas of the stored honey was detected by the Egyptian race with a mean of 284.2 sq.inch/colony. Highly significant differences were detected between stored honey established by Carniolan and Egyptian bees. The highest seasonal mean areas of stored honey were recorded during Autumn with an average of 537.4, 508.4 and 464.8 sq.inch/colony for the abovementioned colonies, respectively. However, the lowest areas were recorded during Spring for all of the tested colonies with a mean of 237.3, 213.8 and 152.2 sq.inch/colony for the same colonies, respectively. It is of important to notice that Summer and Winter seasons contained similar quantities of the stored honey. Variations between all of the tested measurements showed highly significant F values.

13- Honey sac weight and pollen content:

During the entire period of this work, the sacs of Carniolan hybrid bees contained the highest weight in mg./sac (22.08 mg./sac.). It followed by the Carniolan race with a mean of 19.91 mg./sac. The lowest amount was recorded by the Egyptian race with an average of 9.09 mg./sac. The pollen content showed the same trend whereas the tested colonies can be arranged in descending order as follows: Carniolan hybrid by 31.74 followed by local Carniolan race by 23.61 and Egyptian race by 20.44 pollen content/sac. The highest seasonal honey sac weights were recorded during Summer with an average of 43.53, 42.47 and 34.42 mg./sac for the Carniolan hybrid, the local Carniolan race and Egyptian race, respectively. However, the lowest weights were recorded during Spring with a mean of 12.05, 12.24 and 20.00 mg./sac

for the same colonies, respectively. The pollen content showed similar trend during seasons and throughout the whole period of study. Highly significant differences were detected between all of the tested measurements. Honey sac weight revealed highly significant positive correlation coefficient with out and in-going foragers and stored honey areas. Pollen contents revealed highly significant positive correlation coefficient with the mean numbers of out and in-going foragers and queen cups.

In general the tested colonies exhibited the same ranking orders in terms the brood rearing activities, whereas the local Carniolan race ranked the first

and followed by the Carniolan hybrid, while the Egyptian race ranked the least. The local Carniolan race ranked the first in respect to out and in-going foragers, and followed by Carniolan hybrid and Egyptian race, respectively. The local Carniolan race also ranked the first in terms the in-going pollen foragers, the stored pollen and the stored honey. It is of important to notice that the Egyptian race ranked the least except for the sealed queen cells. Honeybee activities showed variable differences between seasons.

Part II: Behavioural defensive assay:

Defensive assay was build up on the hygienic behaviour or the ability of bees to remove the killed workers brood cells. On the other hand, the amount of fallen varroa, and others debris constituents, could be express about the grooming behaviour of the tested colonies. So the behavioural defensive assay was measured by the following measurements:

A – Estimation of hygienic behaviour:

Hygienic behaviour of the tested colonies was evaluated by the liquid nitrogen method (freezing methodology). The pure races removed approximately 69% of the killed workers brood cells after 24 h of freezing,

however, their hybrid removed more than 86%. Similar quantities were removed by the parents after 48 h, however, more than 94% were removed by their progeny. After 72 h, the hygienic ability can be arranged in descending order as follows: Carniolan hybrid by 98%, Egyptian race by 97.43%, and local Carniolan race by 95.67%. Highly significant differences were recorded between hygienic values encountered by the tested races and their hybrid after freezing by 24 and 48 hours. However, non-significant F value was recorded after 72 hours.

B – Estimation of grooming behaviour and debris constituents:

The tested colonies showed differential ability in removing alive, dead and immature stages of varroa presented in honeybee hives. During this work the ability of the tested colonies in removing varroa can be arranged in descending order as follows: Carniolan race by 8.683, Carniolan hybrid by 7.853, and Egyptian race by 2.272 individuals/ colony. Therefore, grooming ability of Carniolan race is equal 1.12 and 3.82 more times as compared with the Carniolan hybrid and Egyptian race, respectively. Statistical analysis of the data revealed highly significant differences between races and their hybrid during months, seasons and all of their interactions.

Although, chalkbrood mummies were found in very small numbers, the local Carniolan race showed the highest ability in removing mummies and followed by Carniolan hybrid and Egyptian race with an average 1.075, 0.956 and 0.604 mummies/colony, respectively. Except for interactions between races, months and seasons which showed non significant F value, the remaining measurements showed highly significant differences.

Similar trend was recorded during the estimation of wax moth larvae presented in hive debris which showed highly significant differences between

months and seasons during this work. The ability of the tested colonies in removing dead workers during this work, showed that Carniolan race removed 3.629 individuals/colony. The Carniolan hybrid and Egyptian race followed the Carniolan race with approximately equal numbers. Interactions between races, months and seasons showed non-significant differences, while the remaining measurements showed highly significant differences.

Part III: Physiological and biochemical studies:

A – Estimation of fresh and dry weight, water content, fat, protein, carbohydrate and elements in workers developmental stages:

a- Monthly and seasonal fresh and dry weight and water content percentage during workers developmental stages of two races and their hybrid:

1- Three days old larvae:

The highest values of fresh weight content were recorded during Spring for all of the tested colonies. Mean values recorded all over the study period showed the same trend, whereas the tested colonies can be arranged in descending order as follows: Carniolan race by 11.7, Carniolan hybrid by 11.0 and Egyptian race by 9.6 (mg.) fresh weight/ larvae.

The dry weight content of the three days old larvae showed their highest values during Winter, however, their lowest values were recorded during Autumn for all of the tested colonies. The pure races exhibited the same values throughout the entire period of study by 2.1 (mg.) dry weight/ larvae, while their hybrid exhibited similar value by 2 (mg.) dry weight/ larvae.

Although, the maximum water content (%) appeared in different seasons for each tested colony, the lowest values were recorded during Winter. Highly significant differences were recorded between all of the tested measurements

in respect to the fresh weight and water content percentages. However, non-significant F values were obtained in terms of dry weight in most of measurements.

2 – Six days old larvae:

The six days old larvae recorded their highest fresh weight values during Spring for all of the tested colonies, while the lowest values were recorded during Winter. All over the study period the Carniolan race recorded the highest value with an average of 127.5 (mg.) fresh weight/ larvae and followed by it's hybrid with an average of 125.7 (mg.) fresh weight/larvae. Quietly low value was recorded by the pure local race (Egyptian race) with an average of 105.2 (mg.) fresh weight/larvae.

Although, the highest dry weight content of the Carniolan race and Carniolan hybrid recorded during Spring, the highest dry weight content of the Egyptian race recorded during Autumn. On the other hand, similar values of dry weight content were recorded all over the study period by Carniolan race and Carniolan hybrid with an average of 30.30 and 29.90 (mg.) dry weight/larvae. The Egyptian race recorded the least value (25.90 mg.) dry weight/larvae.

The highest and lowest values of water content percentages were recorded during different months and/or seasons. The general mean values of workers water content percentage were recorded in descending order as follows: Carniolan race by 76.24%, Carniolan hybrid by 76.21%, and Egyptian race by 75.38%. For the three tested phenomena, the seasonal interactions between the tested colonies showed non-significant F values, while the remaining measurements showed highly significant variations.

3 – White eyes pupae:

The highest values of fresh weight content of the white eyes pupae were recorded during Summer. The lowest values of Carniolan race and Carniolan hybrid were recorded during Winter, however, the Egyptian race exhibited its lowest value during Spring. General mean of fresh weight content for all of the tested colonies can be arranged in descending order as follows: Carniolan race by 123.0, Carniolan hybrid by 122.3, and Egyptian race by 101.1 (mg.) fresh weight/pupae.

Also, seasonal mean values of dry weight content recorded their highest and lowest mean values during different months and/or seasons. In respect to the general mean, the Carniolan race and Carniolan hybrid exhibited similar values with an average of 26.40 and 26.10 (mg.) dry weight/pupae, respectively. However, the Egyptian race recorded 22.40 (mg.) dry weight/pupae.

Water content percentage showed their highest seasonal values with an average 79.12% and 79% for the Carniolan race and Carniolan hybrid, respectively, during Spring. However, the Egyptian race exhibited 78.51% during Autumn. Similar values of water content percentage were recorded during the whole study period with an average 78.66% for the Carniolan hybrid, 78.54% for the Carniolan race, and 77.84% for the Egyptian race. Highly significant differences were recorded during most of the tested periods.

4 – Red eyes pupae:

Summer season contained the highest fresh weight values for all of the tested colonies with a mean of 121.5, 120.0 and 99.60 (mg.) fresh weight/pupae for Carniolan race, Carniolan hybrid and Egyptian race, respectively. However, Winter contained the lowest values by 116.6, 114.6

and 95.90 mg. for the same colonies, respectively. General mean fresh weight values can be arranged in descending order as follows: Carniolan race with a mean of 117.9, Carniolan hybrid by 116.9 and Egyptian race by 97.10 (mg.) fresh weight/larvae.

The dry weigh content of the tested colonies exhibited their highest values during Summer for the Carniolan race and Carniolan hybrid, while the Egyptian race showed it's highest value during Winter. General mean dry weight values of the tested colonies can be arranged in descending order as follows: Egyptian race by 23.20 followed by Carniolan race by 22.80, and Carniolan hybrid by 21.80 (mg.) dry weight/pupae.

Water content percentage showed 81.19% and 80.76% for the Carniolan race and Carniolan hybrid respectively, during Autumn and 80.42% for the Egyptian race during Summer. The general mean values of water content percentages of the red eyes pupae can be arranged in descending order as follows: Carniolan hybrid by 80.50%, Carniolan race by 80.32%, and Egyptian race by 79.92%. Seasonal variations between the tested measurements showed non-significant F values. The remaining variables showed highly significance F values.

5 – Newly emerged workers:

The highest mean values of the newly emerged workers fresh weight content were recorded during Autumn for the Carniolan race and it's hybrid with an average of 115.4 and 112.1 (mg.) fresh weight/worker, respectively. The Egyptian race recorded the least high value during Winter with an average of 96.30 (mg.) fresh weight/worker. The general fresh weight mean values of the newly emerged workers can be arranged in descending order as follows: Carniolan race by 111.9, Carniolan hybrid by 108.6, and Egyptian race by 90.80 (mg.) fresh weight/worker.

The highest value of the Carniolan race and Carniolan hybrid dry weight content were recorded during Autumn with an average of 50.00 and 42.70 (mg.) dry weight/worker for the abovementioned colonies, respectively. However, the Egyptian race recorded 34.00 (mg.) dry weight/worker only during Spring. The general mean recorded 40.50, 38.80 and 31.90 (mg.) dry weight/worker for the Carniolan race, Carniolan hybrid and Egyptian race, respectively.

The highest values of water content percentage were recorded during Winter for all of the tested colonies with an average of 69.26% for the Egyptian race, 68.84% for the Carniolan race, and 67.32% for the Carniolan hybrid. The lowest values appeared during Autumn for the Carniolan race and its hybrid, and during Summer for the Egyptian race. The general mean values of water content percentage of the newly emerged workers can be arranged in descending order as follows: 64.87%, 64.27% and 63.81% for the Egyptian race, Carniolan hybrid and Carniolan race, respectively. Except for yearly differences between races in terms of water content percentages which showed non-significant F values, the remaining measurements and interactions showed highly significant F values.

In a general comparison between the tested developmental stages, the obtained results indicated that six days old larvae exhibited the highest fresh weight values for all of the tested colonies. However, the three days old larvae exhibited the lowest fresh weight values. Also, the fresh weight values were increased as the larvae aged, however, it decreased as the pupae aged.

Dry weight contents of the six days old larvae is equal 13.63, 14.43 and 14.24 times of dry weight content of the three days old larvae for the Egyptian race, Carniolan race and Carniolan hybrid, respectively. However, dry weight content of the red eyes pupae was equal 0.87 times as compared with white

eyes pupae dry weight for all of the tested colonies. On the other hand, the highest values of dry weight content were recorded by the newly emerged workers for all of the tested colonies.

The highest water content percentages was recorded by the three days old larvae, while the lowest percentages were recorded by the newly emerged workers. Water content percentages showed slightly increase as the larvae

underwent from six days old larvae to white and red eyes pupae. Highly decrease was recorded when the pupae transformed into the newly emerged workers.

b- Evaluation of fats, protein and carbohydrate content:

Gradually decrease of fat content was observed during the developmental stages of all of the tested colonies. Quietly stability of fat content was observed during the six days old larvae and the white eyes pupae stages. Fat content of the three days old larvae is equal 1.92, 1.71 and 1.83 times of their newly emerged workers in the Egyptian, Carniolan races and their hybrid, respectively.

In contrast, gradually increase of protein content was recorded as the developmental stages aged. Suddenly decrease was recorded when the pupal stage transformed into the newly emerged workers. The highest quantities of protein were recorded during the red eyes pupae stage with an average of 43.58%, 42.67% and 32.48% of the food reserves of the Carniolan race, Carniolan hybrid and Egyptian race, respectively. The lowest percentages were recorded during the three days old larvae stage with an average of 27.39%, 27.14% and 20.04% for the abovementioned colonies, respectively.

Except for the white eyes pupae, the Egyptian race recorded the highest carbohydrate percentages and followed by the Carniolan race and their hybrid, throughout all of the tested developmental stages. Gradually decrease of carbohydrate content was observed as the three days old larvae underwent to the red eyes pupae. Suddenly increase was observed as the newly emerged workers was transformed. Highly significant differences were recorded between all of the tested measurements except for interactions between seasons and races which showed non-significant differences. The aforementioned food reserve contents presented in the newly emerged worker were correlated with the pollen counts/honey sac. During the entire period of study, fat content showed positive and highly positive correlation coefficient ($r= 0.547^*$ and 0.728^{**}) with pollen counts during Summer and Spring, respectively. Positive (r) was recorded between protein content and pollen counts recorded during Autumn. Also, positive correlation coefficient ($r= 0.382^*$) was recorded between carbohydrate content and pollen counts during the entire period of study. However, highly positive (r) was recorded between carbohydrate and adult population of each of Carniolan race and its hybrid.

c- Determination of the major element content:

Percentages of potassium content don't reach 2% in all of the developmental stages and the newly emerged workers. The Carniolan race recorded the highest percentages during the three days old larvae, with an average 1.228% and during the newly emerged workers with an average 1.092%, however, it's hybrid recorded the highest percentage during the six days old larvae. The Egyptian race recorded the highest percentage during the white and red eyes pupae. Highly significant variations were recorded between seasons of each stage except for the 3 days old larvae which showed non-significant variations.

Calcium content were mostly less than 1% during all of the development stages of the tested colonies. The highest percentages was recorded during the Egyptian race newly emerged workers stage with an average 0.398%. However, the lowest percentages were recorded during the Carniolan hybrid

white eyes pupae with an average 0.125%. Highly significant variations were recorded between seasons/ each stage.

Sodium content did not reach 0.8% absolutely and it ranged between 0.463% during adult stage to 0.50-0.60% in the remaining developmental stages of the Egyptian race. Little increase in sodium content was observed in the developmental stages of the Carniolan race and hybrid, wherever, the newly emerged workers recorded similar quantities as their post embryonic stages. Highly significant differences were recorded between all of the tested measurements except for interaction between races and seasons of the newly emerged workers, which showed non-significant differences.

Magnesium content was recorded in very low percentages as compared with the other elements. The highest quantities was recorded during the white eyes pupae of the pure races with an average of 0.104% and 0.162% for the Egyptian race and Carniolan race, respectively. This element recorded it's highest percentage in the Carniolan hybrid during the six days old larvae with an average of 0.133%. The remaining quantities recorded less than 0.09%. Highly significant differences were detected between the tested parameters except for variations between races during the 3 days old larvae which showed non-significant differences.

Potassium content had a highly positive correlation coefficient ($r=0.806^{**}$ and 0.544^{**}) with pollen counts recorded during Summer and Winter, respectively. However, calcium content showed positive (r) with the total

pollen count encountered during the entire period of study. Also, it showed highly positive (r) values with pollen counts collected by the Egyptian race and the Carniolan hybrid. Sodium content showed highly positive significant (r) with the amount of pollen counts presented in honey sacs of the Egyptian race and as a general during Winter. Magnesium content showed only positive (r) with the amount of pollen encountered in the Egyptian race honey sacs.

B- Haematological studies:

a- Determination of total soluble solids (T.S.S.%) in larval haemolymph:

The highest values of (T.S.S.) estimated in the Egyptian race and Carniolan hybrid six days old larvae were recorded during Summer with an average 15.94 and 15.68 (T.S.S.%). The Carniolan race recorded it's highest values during Autumn with an average 15.72 (T.S.S.%). The remaining values were quietly similar. Also, mean percentages of (T.S.S.%) during different seasons were similar, with very few variations. The tested colonies have non significant differences in (T.S.S.%) values all over the study period.

b- Determination of total haemocytes counts/mm³ haemolymph (T.H.C.):

The pure races showed their highest (T.H.C.) values during Spring with an average of 5005.3 and 5933.3 T.H.C./mm³ for the Egyptian race and Carniolan race, respectively. However, their hybrid showed it's highest T.H.C. values during Summer with an average 5361.3 T.H.C./mm³ haemolymph. The lowest values of the three tested colonies were recorded during Winter. The general mean during the study period showed that Carniolan race ranked first and followed by the Carniolan hybrid and Egyptian race, respectively. Highly significant differences were recorded between the tested colonies during seasons and the entire period of study.

c- Estimation of differential haemocytes counts % (D.H.C.):

During the entire study period Prohaemocytes (Pr.) constituted nearly 50% of the haemolymph haemocytes. In all of the tested races and their hybrid the encountered haemocytes can be arranged in descending order as follows: Prohaemocytes by 51.42% > Plasmohaemocytes by 16.50% > Spindle cells by 12.80% > Granular cells by 10.19% > Oenocytes by 9.09%.