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Seasonal Variation in Oxygen Consumption of Workers of Certain Races of Honeybees

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Abstract. The present study deals with the oxygen consumption of workers of different ages of the Sudanese and Carniolan honeybee races and their F1 hybrid. Comparison between the two races and their hybrid shows clearly that the Carniolan bees significantly consumed more oxygen during spring. This could be attributed to the early and intensive brood rearing activity in colonies of this race. The reverse was, however, true during summer where the Sudanese bees showed the highest oxygen uptake, followed by the F1 hybrid. The reason for that may partially be due to the continuous brood rearing activity in the Sudanese colonies and the F1 hybrid which extends till August, while it becomes much reduced in the Carniolan bees. The aggressive temperament of the Sudanese bees and the F1 hybrid during summer may be another reason. The relatively high oxygen consumption of bee races in winter could be regarded as an indication that fat bodies, protein reserves and the metabolic rate attain, at that time, higher levels than in other seasons.

Introduction

According to Rockstein [1], the nutritional conditions of insects influence the bioenergestics of sarcosomes, where mitochondrial changes may occur in association with feeding or starvation. These changes have manometric measurements of oxygen uptake [2]. The high oxygen consumption may be a reflection of the relative high growth rate and/or the release of neurosecretory materials related to food intake [3, 4, 5]. It may be also affected by the different stages of the insect as well as its age, enzymatic system and insect activities which are related to seasonal variations [6, 7].

The present study is an attempt to determine the variations in the oxygen uptake of workers of different ages of the Sudanese honeybee during different seasons, in comparison with the standard race, the carniolan as well as their F1 hybrid (Sudanese X Carniolan).

Materials and Methods

The experiments were conducted in the apiary of the College of Agriculture, Cairo University during three successive seasons: winter, spring and summer. The F1 hybrid bees were achieved by cross mating of virgin Sudanese queens with Carniolan drones in an isolated mating station at Matariah, Dakahliah Governorate. The newly emerged bees (24-36 hours) were obtained by maintaining combs of sealed brood about to hatch under wire cages. The nurse bees (less than 21-day old) were taken by gently shaking open brood combs on a swarm box. Foragers (more than 21-day old) were captured at the hive entrance of the same colony. The determination of oxygen uptake of workers was accomplished by means of Warburg apparatus following the procedure of Umbreit *et al.* [8].

Prior to measuring oxygen consumption, workers of the same age were starved for one hour in order to maintain standardized physiological conditions. Due to the light weight of the worker bees and in order to obtain more accurate results weights of groups of 5-10 workers were taken. Treatments were replicated four times. Each group was placed in a small muslin bag to minimize their movements in order to keep the inner volume of the respirometer flask in an accurate state [9]. The results were presented as microleters 02/gm./hr.

Results and Discussion

Table 1 shows the oxygen consumption of three ages of honeybee workers of the Carniolan and the Sudanese races and their F1 during three seasons; spring, summer and winter. A study of this data shows that oxygen consumption reached its maximum during winter and its minimum during summer. This was common among the compared races and the hybrid.

Comparison between the two races and the F1 irrespective of the season or the age indicates that the Sudanese race seems to consume more oxygen than the Carniolan, and the latter more than the F1. This was not always the case. In spring and winter, the races were arranged in this descending order according to their oxygen consumption; the Carniolan, the Sudanese and the F1. In summer, the Sudanese race came first and the Carniolan the last.

The nurse bees and the foragers consumed more oxygen than did the newly emerged bees. This was common among the Carniolan race and the F1 hybrid. During winter the Carniolan nurse bees' uptake of oxygen was more than 5 times that of the same age of the Sudanese bees. On the other hand, more oxygen was consumed by foragers and the newly emerged workers of the Sudanese race.

Table 1. Oxygen consumption (ul/gm/hr) of three ages of honeybee workers of the Carniolan and Sudanese races and their F1 hybrid during spring, summer and winter

[Means of 4 replicates]

Season	Age of bees	Races of honeybees			
		Carniolan	Sudanese	F1 hybrid	Average
Spring	Newly emerged	4492.16± 37.10	4644.83± 34.84	4229.06± 26.19	
	Nurse	5433.42± 103.06	4984.44± 76.49	4968.72± 55.59	
	Foragers	5357.53± 42.81	4226.71± 28.57	2598.63± 19.30	
	Average	5094.37± 462.55	4618.66± 336.69	3932.14±1036.31	4548.39
Summer	Newly emerged	4038.68± 33.89	3855.84± 92.21	3484.78± 54.23	
	Nurse	2079.54± 41.09	2687.50± 29.20	3297.51± 31.48	
	Foragers	1785.45± 20.60	6030.75± 68.40	4439.14± 24.11	
	Average	2634.56±1046.27	4191.36±1452.23	3740.48± 526.83	3522.13
Winter	Newly emerged	1213.94± 26.09	6667.52± 132.63	3788.13± 89.03	
	Nurse	12050.89± 82.37	2313.61± 45.01	6767.36± 40.41	
	Foragers	5184.83± 52.77	8922.62± 62.06	4836.79± 88.47	
	Average	6149.89±4676.73	5967.92±2869.53	5130.76±1296.11	5749.52
All season	Newly emerged	3248.26±1515.99	5056.06±1248.76	3833.99± 338.33	4046.1±1143.64
	Nurse	6521.28±4329.44	3328.51±1237.18	5011.19±1481.98	4953.7±2134.52
	Foragers	4109.27±1719.43	6392.36±2022.69	3958.18±1023.01	4820.3±1034.72
	Average	4626.3	4926.0	4267.8	

L.S.D. = 56.734

The statistical analysis of data showed highly significant differences (at 0.01% level) between races, ages and seasons as well as between the interactions of these sources of variations.

The fluctuating oxygen consumption of bee race in the different seasons may be due to the nature of the activity of the honeybee workers. According to Butler [10] an adequate separation in the division of labor among honeybee workers may exist particularly in the nursing and foraging activities.

The relatively high oxygen uptake of bees in winter may be regarded as an indication that fat bodies, protein reserves and the metabolic rate attain, at that time, higher levels than in other seasons. Lotmar [11] found a close relationship in individual bees between the development of the pharyngeal glands and the winter fat bodies. This relationship ceased to hold when brood rearing commenced. He also observed significant differences between the bees on the boundary of the winter cluster and those at its center. The glands and fat bodies of the former group were much less developed. The reverse was true when brood rearing started.

The highest oxygen uptake of the Carniolan bees during spring could be attributed to the early and intensive brood rearing activity of this race [12].

During summer, the oxygen consumption of the Sudanese bees and the F1 hybrid colonies remained almost unchanged. A sudden drop was, however, observed with the Carniolan bees in which oxygen uptake was reduced by almost 50%. This difference may be explained by the fact that brood rearing activity starts at the beginning of spring, and a peak is reached late May or June. In the Carniolan bees brood rearing declines fairly rapidly after this peak. But in the Sudanese bees and those of the F1 hybrid, brood rearing continues till August forming a major peak [12]. The aggressive behavior of the Sudanese bees and the F1 hybrid reported by El-Sarrag [12], may add to the explanation of the high oxygen uptake of certain races of bees during summer and the reduced uptake of same in others.

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الاختلافات الموسمية لاستهلاك الأكسجين في عاملات بعض سلالات نحل العسل

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ملخص البحث. تم دراسة التغيرات الموسمية لاستهلاك الأكسجين في أعمار مختلفة من عاملات نحل العسل الكرنيولي والسوداني وهجينهما الأول وذلك بواسطة جهاز فاربرج.

أظهرت النتائج أنه خلال فصل الشتاء استهلكت عاملات سلالة النحل الكرنيولي ٦١٤٩,٨٩ ميكرولتر/جم/ساعة من الأكسجين مقابل ٥٩٦٧,٩٢ ميكرولتر/جم/ساعة للسلالة السودانية و٥١٣٠,٧٦ ميكرولتر/جم/ساعة لهجينهما الأول. واستمر استهلاك الأكسجين على نفس النمط استهلاك الأكسجين خلال فصل الشتاء إلى أن الأجسام الدهنية والبروتينات المخزونة ومعدلات التمثيل الأيضي تكون أعلى في هذا الفصل عن مثيلاتها في فصول السنة الأخرى. أما خلال فصل الصيف فقد أظهرت عاملات سلالة النحل السودانية تفوقًا في استهلاك الأكسجين حيث بلغت ٤١٩١,٣٨ مقابلة بـ ٣٧٤٠,٤٨ و ٢٦٣٤,٥٦ ميكرولتر/جم/ساعة في الهجين الأول والسلالة الكرنيولي على التوالي. وقد يرجع ذلك إلى طبيعة سلوك السلالة السودانية وشراستها النسبية في الدفاع عن طوائفها ومهاجمة غيرها خلال هذا الفصل.

وتشير النتائج المتحصل عليها إلى أن معدلات استهلاك الأكسجين في طوائف النحل تتأثر بالحالة الفسيولوجية والسلوكية للعاملات. كما يبدو أن سلالة النحل الكرنيولي أكثر تأقلمًا للتغيرات البيئية الموسمية يليها الهجين الأول فالسلالة السودانية.