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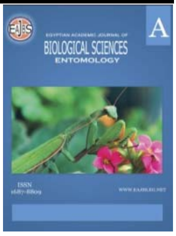

The Spatial Distribution of Honeybee *Apis mellifera* L. Drones in Their Colony

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ABSTRACT

This work was carried out in the apiary of Agric. Fac. Cairo Univ., Giza, Egypt during spring and summer seasons of 2015 to study the spatial distribution of young and old honeybee drones *Apis mellifera* L.. The obtained results showed that the spatial distribution of drones was differed according to their ages and seasons of the year. Generally the immature adult drones tend to concentrate on the brood combs, whereas the mature ones were showed on peripheral combs. On the other hand during the cold months the majority of young drones were showed on the central combs, whereas the stable temperature which was suitable for their sexual maturity.

INTRODUCTION

It is well known that the brood combs (combs contained eggs, larvae and pupae) are occupying the middle area of honeybee brood nest, while the stores, (pollen and honey), occupying the peripheral combs of it, (Free & Williams, 1975). Also, honeybee colonies have a distinct ability of social thermogulation, so, they are maintaining their brood areas in more consistent temperature (Budel, 1955; Simpson, 1961; Abd Al-Fattah, 1983; Seeley, 1985; Bujok *et al*., 2002 and Jones *et al*., 2005) than the outer non-brood areas, (Levin & Collison, 1990 and Dunham, 1933). So, many authors agreed that there is decreasing thermal gradient from the centre of the brood nest towards the periphery, (Budel, 1960; and Drescher, 1968).

Honeybee drones are responsible for producing semen and transmitting it to the virgin queens during the mating flight. Therefore, they appeared in numerous during swarming season, (spring and summer seasons) which varied according to climatic conditions in each region, (Free & Williams, 1975; Currie, 1987; Page & Peng, 2001 and El-Kazafy & Al-Kahtani, 2013). However, their number in a colony equivalent to about 20% of the workers number, (Abou-Elenin, 1992 and Sasaki *et al*., 2004), or doesn't exceed 10% of the total adult population, (Czekonska *et al*., 2015). There are a continuous changes in the ratio of drones to workers depends on the season, the colony population, the age and state of queen and the abundance of food stores, (Allen, 1963; El-Dakhakhni, 1980; Currie, 1987, Schmickl & Crailsheim, 2002 & 2004; Wharton *et al*., 2007 & 2008; Marzouk, 2009 ; Boes, 2010; Brodschneider & Crailsheim, 2010 and Faley *et al*., 2012).

In contrast with workers, the adult drones of honeybee are more numerous on the peripheral combs, (Free, 1957; Ohtani & Fukuda, 1977 and Kovac *et al.*, 2009). In the breeding programs, the capable of drones to coupling with virgin queens or to gather suitable amount of semen is mainly dependent on the maturity of these drones, (Mackensen, 1955; Woyke, 1955; Kepena, 1963 and Stürup *et al.*, 2013).

In this matter, Kurennoi, (1953) found that spermatozoa begin to move from the tests to the seminal vesicles when drone is about 3 days old and the age at which drones become mature varies from 6-12 days. He, also, mentioned that the percentage of drones everting the endophallus increased from 2% at age of 10 days to 53% at age of 38 days. However, because a regular short flight is an essential factor giving the drones the muscular reactions required for copulation, Kepena, (1963) and Rueppell *et al.*, (2006) found that 78.6% of drones started flying at the 9^{th} - 12^{th} day from emergence, while Reid, (1973) registered the 8^{th} day of drones age for this beginning.

The best drones age for sexual maturation varied from 10-14 days (Woyke, 1963), from 12-20 days, (Mackensen & Tuker, 1970) and 10-21 days, (Harbo, 1985), where the drones younger than 10 days are often not yet sexually mature.

To obtain mature drones with the maximum sexual activity, (either from queen-right or queen-less storage colonies that contain free living drones). Fresnaye, (1964); Reid (1973); Schlüns *et al.*, (2003) and Gencer & Kahya, (2011) could picked up these drones from outside combs, especially during bad weather conditions or early morning before drone flight time. But, there were a concentration of younger drones in the brood area and of older drones in the storage area as observed by Örösi-Pál, (1959), Ohtani & Fukuda, (1977) and Levin & Collison, (1990). In the recent study, Kovac *et al.*, (2009) found that the abundance of young drones on the brood nest was 3.5 times higher than that of the oldest drones (≥ 13 days). The younger drones are less often endothermic, though, they are preferred the brood area mainly to the normal migration of spermatozoa from the testes to the seminal vesicle at 35°C. and also to the higher attention from nursery workers, (Mindt, 1962; Haydak, 1970; Szolderits & Crailsheim, 1993 and Schmickl & Crailsheim, 2004).

Concerning the spatial distribution of drones, Ohtani & Fukuda, (1977) reported some results on this subject within ordinary and observation hive. After they discussed their results they concluded that age-specific temperature preference is the factor most consistent with all their obtained results. The target of this work is to investigate the spatial distribution of honeybee drones of different ages within normal drone preserving colonies to facilitate the selection of suitable and fit mature drones for breeding programs.

MATERIALS AND METHODS

This study was carried out in the apiary of Agric. Fac., Cairo Univ. Giza, Egypt during 2015; three colonies of the hybrid carniolan race were kept in Langstroth hives. These hives take a code of 15A, 25A and 35A. each colony inspected two times, one time during spring and the another ones during summer. These colonies were in similar strength either in brood comb numbers; food combs or worker population. The hive entrance was at the lowest base of the hive and directed toward the south.

To obtain numerous of newly emerged drones, combs of sealed drone brood were brought from several colonies to an incubator at 33±1°C. These combs were gathered continuously in the afternoon (at hour of 15.00 p.m.) of the day preceeded the drone adding to the experimental colony. The emerged drones during night were collected in the early morning (age ranged from 0 – 15h.), for marking with a color code for age identification using small paint dots (EDDING 751 paint marker) on the thorax, (Kovac *et al*., 2009). The marked drones were added gently under the lid of the hive at three days intervals and repeated five times for each experimental colony. The adding of adult drones was started in March or June in 2, 5,8,11 and 14 for hive 15A. Also, adding drones to the hive coded with 25A was in March, 28, 31, April, 3,6 and 9 and on June, 18,21,24,27 and 30. Hives 35A was received the emerged drones during spring on April, 22,25,28, May, 1 and 4 and during summer in July, 26,29, August, 1,4 and 7. Numbers of emerged drones ranged from 50-100 were introduced for each adding patch.

Each tested colony was inspected three times at 7 days intervals where the first inspection was justly started on the following day of last drones adding patch.

The inspection operation was done by one investigator in the morning, (between 8.00 -9.50 a.m. during spring and 7.50 - 9.00 a.m. during summer), before drone flying time, where the marked drones on each comb were counted.

The percentages of the recorded numbers of drones on each comb for each tested colony during spring and summer seasons were calculated and take in consideration in the presentation and discussion of the results.

RESULTS AND DISCUSSION

Spatial distribution of immature drones:

Data presented in Table (1) and illustrated in Figures (1, 2 and 3) showed the distribution percentages of young and old honeybee drones on the colony combs throughout March, April and May, 2015. Each percentage resulted from combination of three successive inspections due to the comb arrangements were the same and the distribution patterns similar within each month. The majority of young drones were concentrated on the brood combs in percentages of 82.4%, (total no. 433), 69.2% (total no. 438) and 56.5% (total no. 418) during March, April and May, respectively. So, in general, the mean distribution percentage of immature imago of drones during spring was in convex pattern where the brood combs contained an average of 69.5% (total no. 1294), of these drones.

Table 1: The spatial distribution percentages of immature and mature drones within honeybee colony during spring season (from March, 15 to May, 19 of year 2015).

Month of Inspection		Total no. of Counted drones/Month	Percentages of drones presented on comb no.								
			1	2	3	4	5	6	7	8	9
March	Immature	433	3.0	4.3	19.4	25.8	17.8	19.4	7.3	1.4	1.6
	Mature	370	0.3	5.4	18.6	24.6	28.1	13.5	6.5	3.0	0.0
April	Immature	438	7.5	10.1	13.2	19.2	21.7	15.1	11.6	1.4	0.2
	Mature	340	8.8	10.0	11.2	12.4	10.9	13.5	12.0	15.0	6.2
May	Immature	418	2.2	2.9	9.8	9.6	17.0	20.1	14.6	16.2	7.6
	Mature	506	4.2	13.6	9.7	6.7	6.5	11.3	16.2	15.8	16.0
Total	Immature	1294	4.3	5.8	14.2	18.3	18.9	18.1	11.1	6.2	3.1
	Mature	1216	4.3	10.1	12.8	13.7	14.3	12.6	12.1	11.7	8.4

During summer season, the same distribution pattern (convex pattern) was observed for the young drones through June, July and August, 2015, (Table 2). The percentages of the recorded drones on brood combs were 70.8% (total no. 345), 67.6% (total no. 498) and 62.7% (total no. 545) during June, July and August, respectively (Figs 5, 6 and 7). In general, an average of 66.4% (1388 young drones) was presented on brood combs during summer season, (Fig. 8).

Table 2: The spatial distribution percentages of immature and mature drones within honeybee colony during summer season (from June, 15 to August, 22 of year 2015)

Month of Inspection		Total no. of counted drone /Month	Percentages of drones presented on comb no.								
			1	2	3	4	5	6	7	8	9
June	Immature	345	7.0	10.1	19.7	23.5	18.0	9.6	7.8	4.3	0.0
	Mature	470	24.1	13.8	9.2	7.2	2.1	1.7	8.3	9.8	23.8
July	Immature	498	4.8	8.8	12.7	19.3	19.3	16.3	10.8	7.0	1.0
	Mature	472	22.5	11.2	7.4	3.4	3.2	3.4	7.8	14.0	27.1
August	Immature	545	7.7	9.7	14.5	18.9	18.5	10.8	11.9	4.8	3.2
	Mature	687	20.7	17.2	10.5	3.2	1.7	6.1	11.1	12.2	17.3
Total	Immature	1388	6.5	9.5	15.1	20.2	18.7	12.4	10.5	5.5	1.6
	Mature	1629	22.2	14.5	9.2	11.5	2.3	4.0	9.3	12.0	22.0

The obtained results are in agreement with the findings of many researchers such as Örösi-Pál, (1959) and Ohtani & Fukuda, (1977). They noticed the concentration of less than 10 days old drones in the brood area. Kovac *et al*., (2009) recorded that the young drones were more abundant by 3.5 times in the brood combs than the oldest drones, (7 and 13 days). This may be attributed to its need to complete their maturity in area characterized with a consistent temperature at 35°C. for a long period. (Woyke, 1963; Haydak, 1970; Harbo, 1986 and Schmickl & Crailsheim, 2004). This temperature is very important to migrate the spermatozoa from the tests to the seminal vesicle, (Fresnaye, 1964; Szolderits & Crailsheim, 1993; Levin & Collison, 1990 and Kovac, *et al*., 2009).

Spatial distribution of mature drones

The distributed of mature drones on different colony combs through three successive inspections during each month were followed the similarity of distribution pattern and alteration the combs arrangement. In reverse with immature drones, the distribution of mature drones was varied between spring months. During March, they spread according to convex pattern, where a percentage of 84.8% of drones, (total no. 370), were found on the brood combs, (centre position). The lateral combs were approximately empty from drones, (Table 1 & Fig. 1). An intermediate distribution of mature drones was observed during April (Fig. 2), and then changed to a concave distribution pattern during May (Fig. 3). High percentages of drone were attained with the right outer combs which represented 16.2%, 15.8% and 16.0% for combs no. 7, 8 and 9, respectively. On the other hand, the highest distribution percentage on brood combs was recorded with the brood comb no. 6, (11.3%) of the total drones, (total no. 506). In general, during spring season, mature drones tend to congregate on the brood combs in rate, (53.4%) which had a higher food than the empty combs, (Fig. 4). So, the convex pattern of mature drones' distribution is the predominant pattern during spring season, (Fig. 4).

In contrast during spring season, the concave distribution pattern of mature drones during different months of summer season was very obvious as shown in Table (2) and Fig. (8). The lowest percentages of mature drones were represented on brood combs, (combs no. 3, 4, 5 and 6) during June, (20.2% of 470 drone), July, (17.4% of 472 drone), and August, (21.5% of 687 drone). The highest drone percentages were recorded on the lateral left and right combs, (combs no. 1 and 9).

The percentages of attended drones were 24.1% & 23.8%, 22.5% & 27.1% and 20.7% & 17.3% for the previous combs during June, July and August, respectively, (Figs. 5, 6 and 7). In general, the concave pattern is the only predominant distribution of mature drones within honeybee colonies during summer season, (Fig. 8).

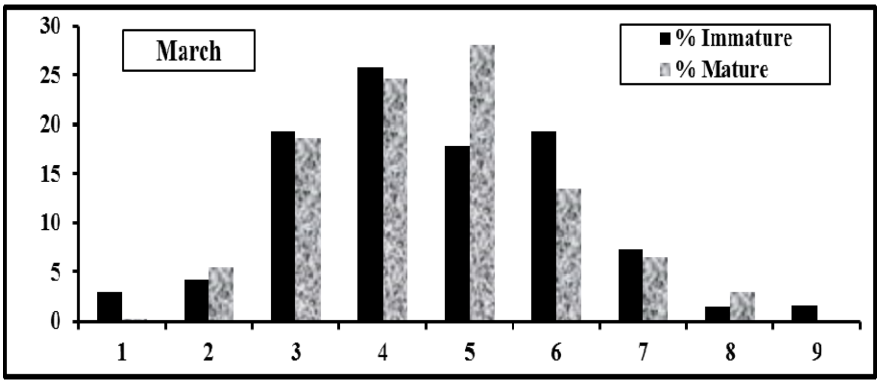

Fig. 1: The spatial distribution percentages of immature and mature drones within honeybee colony during March 2015.

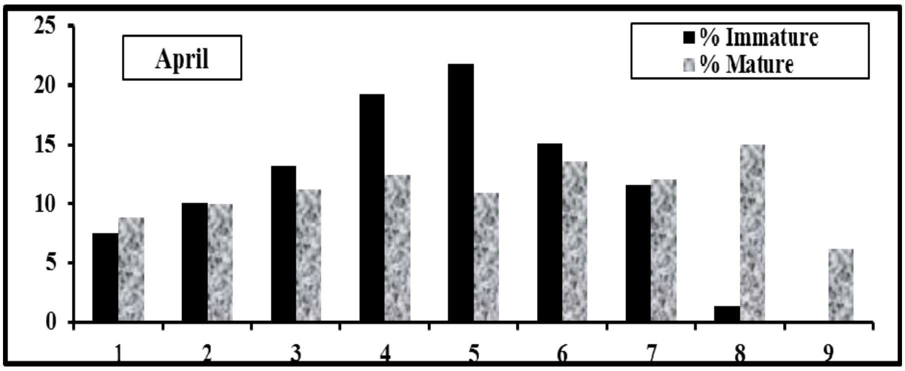

Fig. 2: The spatial distribution percentages of immature and mature drones within honeybee colony during April 2015.

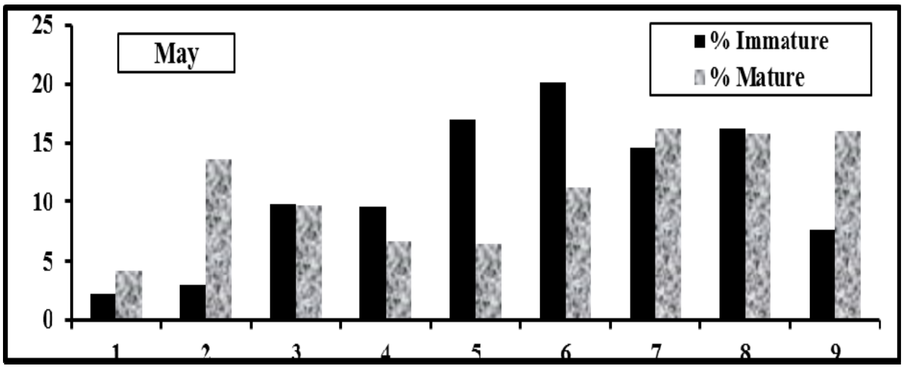

Fig. 3: The spatial distribution percentages of immature and mature drones within honeybee colony during May 2015.

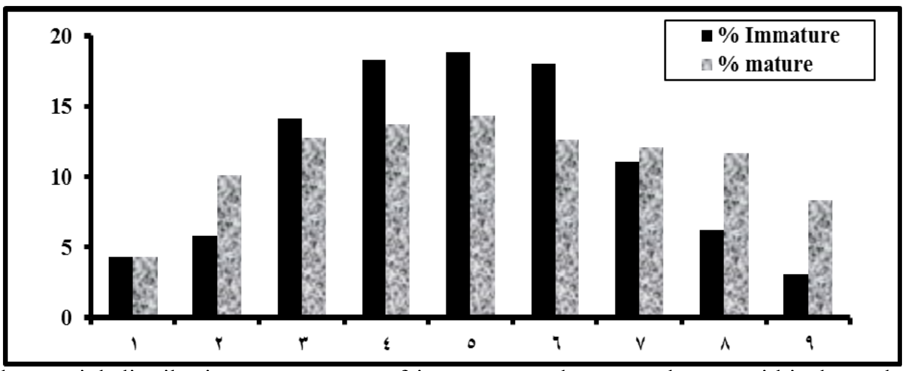

Fig. 4: The spatial distribution percentages of immature and mature drones within honeybee colony during spring season (from Mar., 15 to May, 19 / 2015)

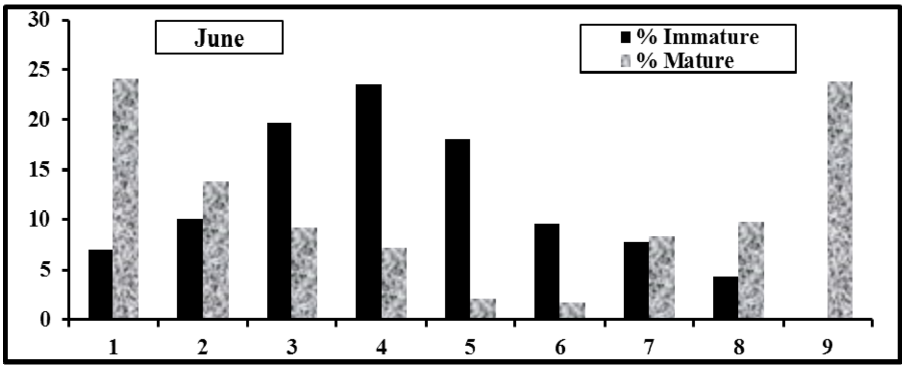

Fig. 5: The spatial distribution percentages of immature and mature drones within honeybee colony during June 2015.

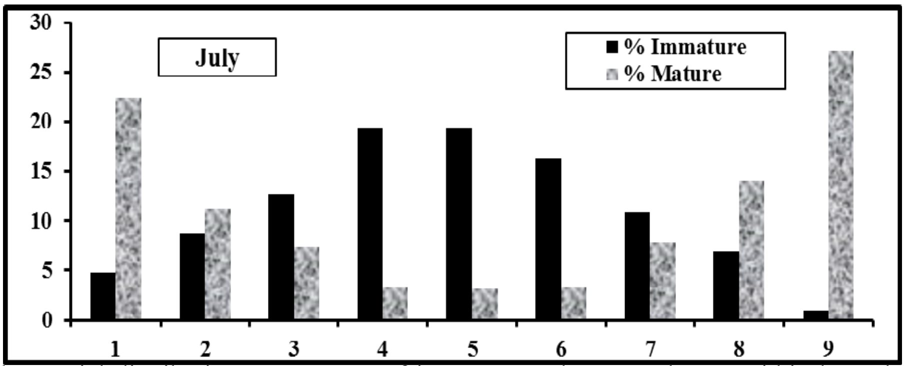

Fig. 6: The spatial distribution percentages of immature and mature drones within honeybee colony during July 2015.

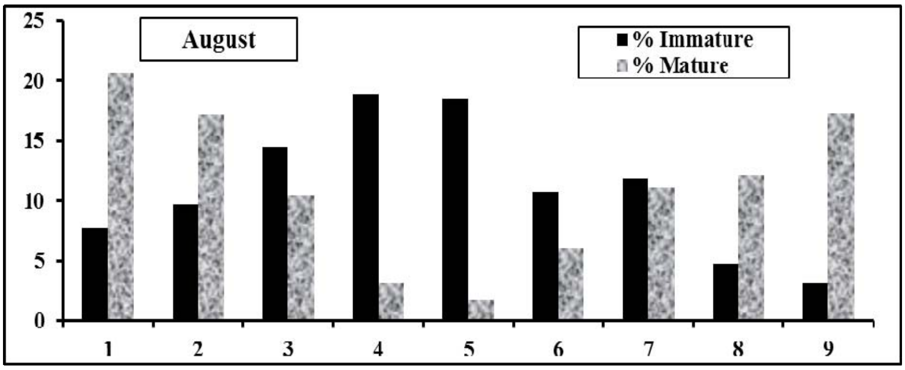

Fig. 7: The spatial distribution percentages of immature and mature drones within honeybee colony during August 2015.

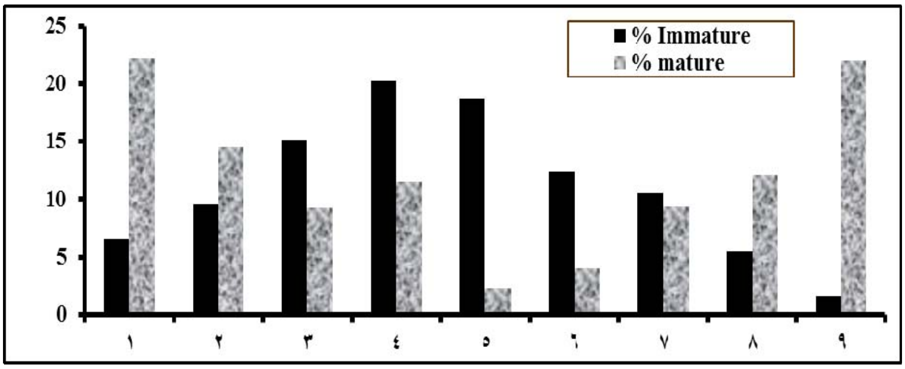

Fig. 8: The spatial distribution percentages of immature and mature drones within honeybee colony during summer season (from Jun., 15 to Aug., 22 / 2015).

These results agreed with the findings of many researchers. Free, (1967) and Örösi-Pál, (1959) from their investigations in observation hives found that the young drones were concentrated in the brood area and the old ones in the storage area. Ohtani & Fukuda, (1977) reported that, during summer, the older drones in a normal frame hive were more on the peripheral combs, but, with decreasing air temperatures during autumn, they moved to the central area. They, also, concluded, from their study in a single-comb observation hive, that the age specific temperature preference is the most and main factor governing the spatial distribution of adult drones in a bee colony. So, due to a great fluctuation in spring temperature, different distribution patterns were induced. However, with the consistent summer temperature and to decrease the temperature load within brood area a concave pattern of the old drones was observed. This conclusion could be enhanced by the results of Harrison, (1987) and Kovac, *et al*., (2009). Harrison, (1987) found that adult drones take part in colony heat production under extreme thermal stress conditions. Kovac, *et al*., (2009), reported that the relative abundance of old drones, (≥13 days) on brood versus whereas on non-brood areas was (1:11.8). Further critical studies must be take inconsideration for the synchronous measurements of drone distribution and temperature gradients in the hive. This factor is recently under investigation.

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ARABIC SUMMERY

التوزيع المكاني لذكور نحل العسل *Apis mellifera* L. داخل طائفتها

محمد عبد الوهاب عبد الفتاح، أحمد عبد الحليم الشيمي، محمد صلاح المعصراوي
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أجريت هذه الدراسة بمنحل كلية الزراعة – جامعة القاهرة – الجيزة - مصر خلال فصلي الربيع والصيف لعام 2015، وذلك لدراسة التوزيع المكاني لذكور نحل العسل داخل الطائفه لكلاً من الحشرات الكامله الناضجه وغير الناضجه، وقد أظهرت النتائج المتحصل عليها إختلافات في التوزيع المكاني داخل الطائفه تبعاً لعمر الذكور وايضاً الفصول المختلفه للسنه.

وبصفة عامه فإن الذكور غير الناضجه جنسياً تميل إلى التجمع على أقراص الحضنه في وسط الخليه، وعلى العكس من ذلك شوهدت معظم الذكور الناضجه على الأقراص الجانبيه. ويمكن القول أن إنخفاض درجة حرارة الطقس يؤدي إلى تجمع معظم الذكور الصغيره على الأقراص الوسطيه حيث درجة الحراره الثابته والملائمه لإكتمال النضج الجنسي لها.