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Nesting Traps to Collect Solitary Cavity-Nesting Hymenoptera

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Abstract: The aim of this study to survey the bees species using nesting traps, determine the diameter and material of which the nests were made. This study was conducted at the Researches and experiments Station of the Faculty of Agriculture, University of Tripoli, using nesting traps. Traps were designed with diameters of 5,8,10 mm paper and 5 mm plastic drinking straws(tubes) with 20 cm long), the traps were mounted on trees that surrounding alfalfa field. The results showed that the percentage of occupied nests, were as follows: The paper nests strews 60% of 5 mm, 5% of 8 mm, (zero) of 10 mm, and only 5% of 5 mm plastic strews. Bees identification reveled one species as alfalfa leaf-cutter bee (*Megachile rotundata*, F: Megachilidae - Hymenoptera).The diameter of the straw was crucial in determining the sexual ratio, straws with 5 mm of diameter as the ratio of males to females was 1♀:1♂, whether paper or plastic strews, while 8 mm was 2♀:1♂.The research recommend reusing the nests made of paper tubes with 5 mm of diameter to collect the largest number of alfalfa leaf-cutter bees to get their benefits in pollinating the alfalfa crop.

مصائد الأعشاش لتجميع غشائيات الأجنحة (Hymenoptera) البرية المعششة في التجاويف

الكلمــات المفتاحيــة :
ليبيا،
مصائد أعشاش،
تعشيش عميق،
النحل قاطع الأوراق.

المستخلص : تهدف هذه الدراسة إلى إجراء مسح لأنواع النحل باستخدام مصائد التعشيش، وتحديد القطر، والمواد المناسبة التي صنعت منها الأعشاش. أجريت هذه الدراسة في محطة البحوث والتجارب بكلية الزراعة جامعة طرابلس باستخدام فخاخ التعشيش. تم تصميم الفخاخ بأقطار 5 ،10، 8 مم من قش الشراب (أنابيب) الورقي، و5مم البلاستيكي بطول 20 سم)، تم تركيب المصائد على الأشجار المحيطة بحقل البرسيم. أظهرت النتائج أن نسبة الأعشاش المشغولة كانت على النحو التالي: أعشاش الورق 60٪ من 5 مم، 5٪ 8 مم، (صفر) 10 مم، و5٪ فقط من 5 مم أعشاش بلاستيكية. كشف التعرف على النحل عن نوع واحد مثل: نحل البرسيم القاطع (*Megachile rotundata*، F: Megachilidae - Hymenoptera). كان قطر الشفاط حاسمًا في تحديد النسبة الجنسية، حيث كان قطر القش بقطر 5 مم حيث كانت نسبة الذكور إلى الإناث 1♀: 1♂، سواء كانت ورقية أو بلاستيكية، بينما كانت 8 مم 2♀:1♂. أوصى البحث بإعادة استخدام الأعشاش المصنوعة من أنابيب ورقية بقطر 5 مم لجمع أكبر عدد من نحل البرسيم القاطع لأوراق النحل للاستفادة من فوائده في تلقيح محصول البرسيم.

INTRODUCTION

Apoidea bees are the most important pollinators (Kevan, 1983), their release into farmland is the fastest and most effective way to provide sufficient numbers to meet the pollination requirements of many crops, and this is most often achieved with the use of honey bee hives (Apidae: Apini) (Free, 1993).

Recently with the management of bumblebee colonies (Apidae: Bombini), which are commercially available all year round, they have proven to be invaluable in pollinating plants in greenhouses (Kevan, 1991; Thorp, 2003). The study of the biology of nesting has enabled many researchers to explain its mechanisms and clarify its simplicity and its fullness for ease and the possibility of developing it. Alkali bees, (Halictidae: Nomiinae), which

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have been extensively studied, have been successfully developed and commercially produced for pollinating of some crops, especially alfalfa (Steffan-Dewenter et al., 2002; Steffan-Dewenter, 2003; Stephen & Osgood, 1965) reported a method of propagating Nomia bees by means of artificial beds, Where he built artificial beds, they all succeeded as nests for Nomia, but he found that the shallow beds needed frequent water treatments. (Stephen & Osgood, 1965) also demonstrated in another way that a 50 ft by 30 ft which occupied with a good population of Alkali bees could be responsible for producing from 50,000 to 80,000 pounds of alfalfa seeds. Finally, it should be noted that the industrial bed may serve the pollination of alfalfa for many years, but it may be lost quickly if the water overflows or insects are exposed to predators, diseases, pesticides, or agricultural operations. Cavity-using bees, particularly of the Megachilidae family, also showed the greatest potential for evolution as controllable pollinators, as they readily accepted artificial nesting materials, including nesting traps (Cane et al., 2007).

Nesting traps are a method of collecting sampling for bees that use cavities and tunnels to make their nests, and they have been used for many years to study the numbers of Hymenoptera used cavities, and to monitor their diversity and abundance (Buschini, 2006; Danks, 1971; Frankie et al., 1998; Godfrey & Hilton, 1983; Krombein, 1967; Steffan-Dewenter, 2003; Taki et al., 2008) and by providing them with artificial cavities, such as holes drilled in wood blocks or cardboard tubes (Potts et al., 2005).

The nests are gathered and incubated until the full bees come out, and they are classified according to the species. This type of bees has been propagated on a large scale in western countries by producers of alfalfa seeds, using artificial nests. (Bohart, 1962; Stephen, 1961) tested crumpled paper, brewed straw, and perforated wood as artificial insect nests they called Domiciles. The crumpled paper was prepared either by rolling it in the form of a cylinder with a diameter of 15 cm, which would be sufficient for 600 nests, or by cutting it into flat pieces that were placed on top of each other and separated each one, and when using paper tubes (drinking straws) they were dipping it in a thin layer of wax at the bottom of a tin can, then placed on the carton and protected from heat and rain with covers made of wood or glass straw, the diameter of the used tubes were 4,5,6 mm and a length of about 9 cm. (Bohart et al., 1964; Hobbs, 1956) produced semi-circular tunnels made of wood, these semi-circular grooves can be glued together to form a complete circular tunnel, where incomplete phases can be removed and stored.

(Hobbs, 1967) made improvements to these nesting material using Polysterene, instead of wood and reduced its weight to one-tenth. (Stephen & Every, 1970; Stephen & Osgood, 1965) mentioned that the media were prepared to provide nesting tunnels for females with inside diameters ranging from 4.0 to 6.0 mm and lengths ranging from 1.25 to 15.0 cm, and were made of paper soda straws, wood, blown poly-urethane, stacked Masonite, and acoustical tile. Because of commercial limitations of materials, no single medium was provided in which tunnels of all the diameters and lengths were represented.

(Nardone, 2013), used trap nest (144 trap nests in total) to study bees' diversity of Algonquin Provincial Park in Ontario, Canada. Traps consisted of a two-liter milk and 36 cardboard tubes, acting as cavities, placed through holes drilled into the polystyrene. The tubes were 15cm long, and there were nine each of four different diameters (3, 5, 7, and 9mm). Trap nests were covered in burlap for camouflage and tied to trees with clear fishing line at the edge of the plots, facing the center of the plot, at about 1-1.5m from the ground.

Several studies have been conducted in which nest traps have been used for many years to study the population of Hymenoptera, and to monitor their diversity and abundance (Steffan-Dewenter et al., 2002; Steffan- Dewenter, 2003). However, this study is considered the first of its kind in which nest traps were used in Libya by providing artificial cavities, including paper and plastic drinking straws.

This study aims at a general survey of bees species utilizing cavity nesting, and determine whether leaf-cutter bees are included in them, and study the effect of the diameter and material of which the tubes were made.

MATERIALS AND METHODS

This study was conducted at the Research and Experimental Stations at the Faculty of Agriculture - University of Tripoli, using nesting traps. These traps were designed according to the method developed by (Sheffield et al., 2008), and according to the method of (Taki et al., 2008) to collect Hymenoptera.

The traps consisted of a one litter milk carton (measurement 7cm x 7cm for the base and 22cm length) (Fig,1a), a piece of Styrofoam measuring $49cm^2$and 2.5cm thick (Fig, 1b), this piece fits with the open top end of the milk carton. The drinking straws (tubes) were 20 cm long, the diameter paper drinking straws (tubes) were (5, 8 and 10 mm) while the plastic drinking straws (tube) were(5mm) in diameter (Fig, 1c). For each milk carton, twelve paper and four plastic drinking straws (tubes), were placed through holes made in the piece of Styrofoam.

The purpose of the polystyrene is to provide spacing between the tubes, a lack of which could be a deterrent for some cavity-nesting bee species (Bosch & Kemp, 2001). Twenty five nests were used in this study. These traps were set up at the Crop Research Station near the field of alfalfa crop and were mounted on trees one meter above the ground with clear fishing line, and laid in April 2018, they were monitored twice a month and collected in March 2019. Tubes that were occupied by insects were collected and stored within a piece of clear piping (1.5 cm in diameter) for incubation, and the ends blocked off with fine aluminum mesh to allow air to enter in, these aluminum mesh prevent emerged insects from escaping,the incubated nests were checked every couple days for emerged insects.

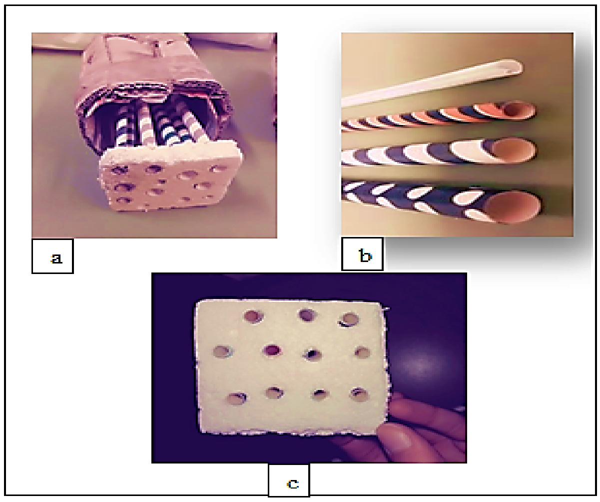

Figure (1). Traps designe,

a) The traps consisted of a one litter milk carton,
b) a piece of Styrofoam and
c) The drinking straws (tubes).

RESULTS

Nesting Diameter: The drinking straws (tubes) used in this study were 20 cm long, and (5, 8 and 10 mm) in diameter for paper drinking straws (tubes) and (5mm) in diameter for plastic drinking straws (tube). The results of this study showed that not all nests were exploited, the percentage of occupied nests (nests were occupied by insects), as follows: 60% of the nests made of paper strews of a diameter of 5 mm, and 5% with a diameter of 8 mm, while those with a diameter of 10 mm were not exploited (zero), however the nests made of plastic (5 mm), were only 5% were exploited (Fig, 2).

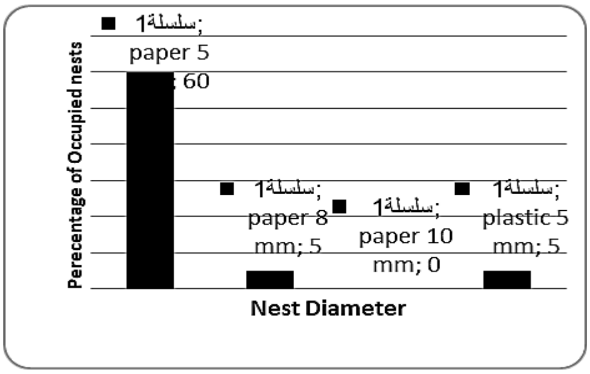

Figure (2). The percentage of occupied nests with different material and diameters, (5, 8 and 10 mm) in diameter for paper drinking straws (tubes) and (5mm) in diameter for plastic drinking straws (tube).

Bees' Identification: The rustles of this study revealed that these nests were exploited by one species of bee and identified as the alfalfa leaf-cutter bee which follows (Megachilerotundata, F: Megachilidae - Hymenoptera). These rustles agreed with previous studies, which showed that such nests are of limited diversity and usually only gather one or two species (Sheffield et al., 2011; Widhiono et al., 2017).

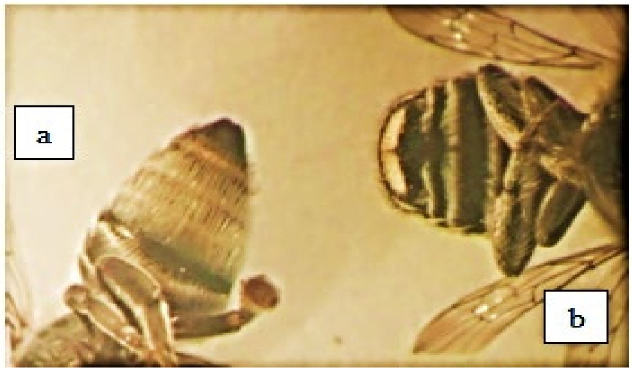

Figure (5). Ventral view of alfalfa leaf-cutting bees, a) female and b) male.

Life cycle: Under natural conditions, adult insects appear after 3:6 weeks after the alfalfa flower, usually from May to July, depending on the region. Females are fertilized while they are warmed by the sun, often near the mother's nest. The male can fertilize several times, but females fertilize only once. As for the fertilized female, she makes a series of cells in the tunnels or tubes that she chooses for the nest. This insect makes the walls and base of the cells from the leaves that the female cut, often from alfalfa leaves, where she sticks them together by salivary secretion.

The insect fills each cell from half to two-thirds with a mixture of honey and pollen. When the female returns from foraging, she enters her head into the tunnel first, then puts the nectar she collected, then goes to the entrance of the tunnel, wraps around it, and enters the tunnel with her back, where she puts the pollen load. When a sufficient amount of food is collected in the cell, she lays one egg on top of it and covers the cell after kneading it with 3:10 circular pieces of leaves. After rubbing it, it begins in another cell above it, and the chain of cells ends slightly below the entrance to the tunnel, as the end of the tunnel is closed with about 130 pieces of leaves. After that, it begins to build another series of cells in another tube, if the nectar and pollen grains are still available in the field. The bee that grows from the last egg placed in the tunnel is the first to exit, while the first egg that was placed at the base of the tunnel is the last to exit as a whole insect. This female produces approximately 35:30 eyes and lives for about two months, during which she lays 30-40 eggs. Approximately, two insects out of every three adults that emerge from the eyes are males, meaning that the sexual ratio is 2 males: 1 females.

The egg hatches within 2:3 days, where the caterpillar feeds on the lunch stored in the eye, and the growth of the caterpillar is completed after about two weeks. As some individuals continue to grow and develop and emerge as full insects, about 23:25 days after laying eggs. As for some other individuals, they remain without development, as they remain in the form of an incomplete phase until the following year, and then they complete their growth and development and emerge as a complete insect.

Males emerge about 5 days before females. And when the females come out, they are fertilized immediately. Leaf-cutter bees can be handled safely, as in the case of the alkaline bee, since although the female has a stinger, she rarely stings. Even when used as a stinger, it causes only slight pain (Hobbs, 1967; Rios-Velasco et al., 2014) showed that the adult Megachilid does not leave if the temperature is below 21°C. It was found that these insects can remain motionless inside their tunnels for 48 hours at a temperature of 2:4 degrees Celsius.

Gender Emergence: The study results found that the emergence of occupied nests started 15 days after brining the nest from the field to the laboratory, where the males began to emerge during the first two days, while the females came out after all males exited in one tube, i.e. over the next five days. Some nests were fully occupied by 12 cells and all cell were normal and all adults emerged alive, while other nests had some dead larvae or pupae stage, whereas, some nests were half occupied or three of forth occupied (Fig,5).

Nest Dimensions and Sex Ratio: The sex ratio, males to females, obtained from this study was 2♂:1♀in the paper drinking strew with 8 mm of diameter, while the sex ratio with diameters of 5 mm was 1♂:1♀whether the tube used was paper or plastic (Fig, 6).

pieces of cutting leaves were used to built each larva cell.

Although 5% of paper drinking strews with a diameter of 8 mm were exploited as the percentage of 5 mm of plastic drinking strews, however, there were difference found between the leaves cuts to make larvae cells, were females used paper drinking strews of 8 mm cut more leaves (32-36 piece) than the one used 5mm (24-26 piece) (Fig, 7). Despite the fact that females that cut more leaves to built their larvae cells visiting more plants, they don't invest their time and don't pollinate more flowers.

Figure (7). Leaves pieces of leaf-cutter bees'cells.

DISCUSSION

Nesting Diameter: The results of this study showed that the percentage of occupied nests (nests were nested inside), as follows: 60% of the nests made of cardboard were with a diameter of 5 mm, and 5% with a diameter of 8 mm, while those with a diameter of 10 mm were not exploited (zero), as for the nests made of plastic (5 mm), only 5% were exploited. It was also found that the old tunnels are more attractive to bees than the new tunnels, as the old ones still have the smell of the insects that used to occupy them.

The death of larvae that occurs in tunnels with a diameter of 4 mm were four times more than what occurred in tunnels with a diameter of 5.5 mm,in addition, the number of males that emerge from the tunnels with a diameter of 4 mm are three times as the number of females,but in tunnels with a diameter of that larger(5.5mm), the proportion of males is equal to that of females (Hobbs, 1967).

Bee samples collected from nests are of low diversity because they only collect cavities-nesting bees, although they usually collect species that have not been captured using other sampling methods (Westphal et al., 2008) and thus these traps can give a good estimate of diversity (Tscharntke et al., 1998).

(Nardone, 2013) mentioned that only 20 of 144 nests contained bees, with most of the remaining nests containing wasps. These bees from 5 different species in 3 genera were found within these nests. One possible reason for the low capture of the trap nests is that there may have been an excess of natural cavities in the study sites that bees could use for nesting. Natural cavity use has been suggested in a few other studies as a possible explanation for lower bee abundance and richness collected in trap nests in certain study sites (Giles & Ascher, 2006; Sheffield et al., 2008) and in forested habitats (Buschini, 2006). There were large amounts of deadwood in some sites that could serve this purpose.

(Nardone, 2013) claimed that bees seemed to select different tube diameters for their nests based on genera; all Hylaeus bees were found collected in the smallest tube diameter (3mm), all Osmia bees in the second smallest (5mm), and both Megachilid nests were in second largest (7mm). All of these species were also collected using other trapping methods, though trap nests collected over 50% of the total individuals of each of these species except for O. *proxima*. In the case of the most abundant species collected, *O. tersula*, trap nests collected over 80% of all individuals.

Gender Emergence: Studies reveal that identifying male and female offspring in the nest is strategic and that cell size plays a large role in the size of the offspring, regardless of the size of the mother (Krombein, 1967).The innermost cells of each series usually contain females and the outermost contain males. Females, which may construct several cell series during their lifetime, repeat this pattern consistently and are therefore believed capable of controlling the sex of each egg deposited. It was observed that mothers lay female eggs in the inner cells and male eggs in the outer cells (Bohart et al., 1960; Hobbs, 1956; Hobbs & Richards, 1976), this is consistent with what was found in the nests that were used in this study, where the males began to emerge during the first two days, followed by females over the next five days.

Exceptions to the general pattern of sex location in each series of cells are not uncommon. It is suggested that consecutive occupation of 1 tunnel by several females or the construction of the series by a single female may account for these deviations (Stephen & Osgood, 1965).

Although great variability in the position of sexes in the cell series has been observed, the innermost cells of each series usually contained females and those nearest the entrance, males. Cell series have ranged from all males to all females; have had females located in the outer cells and males in the inner; or had an intermixture of sexes within the series. The usual pattern, however, suggests that females are capable of controlling the sex of each egg deposited. This conclusion was confirmed by a study in which several females were tagged and the tunnels that each filled were removed for rearing (Stephen & Undurraga, 1976).

(Stephen & Every, 1970; Stephen & Osgood, 1965) during their work for 4 years found that several nests have been reared containing all females, while other nests represent uncommon occurrences in the location of sexes within each series, some have females in the last-formed or top cell while other nests illustrate an admixture.

Nesting Diameter and Sex Ratio.: With regard to sex ratios, larger cell provisions correlate with increased female offspring production. There are two explanations for these behaviours in terms of nutritional maternal behaviours: 1) the mother brings more food to the inner cells because she expects to produce female offspring there and 2) the mother chooses to fertilize the egg, thus enhancing production (Stephen & Osgood, 1965).

The high male to female ratio has been attributed to the diameter of the nesting tunnel, length of the tunnel, and the type of medium in which the nest is formed. It has been assumed that a 1:1♀sex ratio is dominant among solitary bees, but apart from the few records about completed nesting tunnels in Megachile, there is no published information available on this subject (Stephen & Osgood, 1965).

In the leaf-cutter bee *Megachile rotundata* (F), sex ratios of 3♂:l♀ and 2♂:l♀ can be consistently obtained from media with nesting-tunnel diameters of 5.5 and 6.0 mm, respectively. Smaller tunnels with inside diameters of 4.0 mm yielded bees with sex ratios of 5-11♂:l♀. The type of medium of which the tunnels are composed appears to exert little effect on the sex ratio. However, the data suggest that sex ratios of 3♂:1♀ and 2:1♀can be obtained consistently from soda straws, wood, or polyurethane with nesting tunnels of 5.5 and 6.0 mm in diameter, respectively (Stephen & Osgood, 1965).

(Bohart, 1972) stated that the sex ratio varies depending on the nest size, height, and nesting material, this ratio is controlled by the mother. These observations were made of females who nest in tunnels, for example, a tunnel diameter of 5.5 mm correlates with a 1♂:1♀ratio and a tunnel diameter of 6.0 mm correlates with a 2♂:1♀ ratio of male to female, shorter tunnels, those less than 5.0 cm in length, are less convenient.

(Stephen & Osgood, 1965) concluded from their data that the lowest number of females were consistently obtained from the tunnels at their smallest diameters. The sex ratios of the 4.0 mm diameter tunnels ranged from 11♂:l ♀in a 7.5 cm straw to 5 ♂:1 ♀in a 15.0 cm straw. The sex ratios of 6♂: 1♀ were recorded of 4 mm tunnels in wood, 7♂:1♀from acoustical tile, and 9♂:1 in polyurethane.

This study indicated that the ratio of males to females in the paper drinking straws with 8mm ofdiameter was 2♂:1♀, while the ratio of males to females in pipes with diameters of 5 mm was 1♂:1♀whether the tube used was paper or plastic drinking straws, these results partially agreed with (Stephen & Osgood, 1965) astheirdata suggested that sex ratios of 3♂:1♀ and 2♂:1♀can be obtained consistently from soda straws, wood, or polyurethane with nesting tunnels of 5.5 and 6.0 mm. These results also consistent with the statement of (Bohart, 1972), as these statements agreed with you that the sex ratio is 1♂:1♀when using a 5 mm diameter tunnel, while when utilizing a 6 mm diameter tunnel the sex ratio was 2♂:1♀.

(Rahimi et al., 2021) reviewed previous studies and mentioned that some of them have dealt with the effects of the length of the tubes used for bee nest (RebouÇas et al., 2018),while others have discussed the effects of tube diameter in the efficiency of bee nest in attracting bees. (Westerfelt et al., 2015) claimed that nest diameter was the most important factor explaining the occupation of a certain aculeate species. Some studies found that *Megachilezaptlana*occupy tubes with a 6-mm diameter (dos Santos et al., 2020), while *Megachileconcinna*prefere 6 mm and 5 mm diameter with 88.2 % compared with only 11.8% for 4 mm (Alvarez et al., 2012).

Nesting Material: The material of the tubes also affects the efficiency of bee nests in attracting bees, where different materials were used to provide nests for bees, (Bohart, 1962; Stephen, 1961) However, they found that the bees prefer wooden nests over nests made of paper tubes or wrinkled paper, as the latter does not have the ability to resist the weather, there is also great difficulty in dealing with and storing these artificial nests. (Bohart et al., 1964; Hobbs, 1956) produced semi-circular tunnels made of wood, these semi-circular grooves can be glued together to form a complete circular tunnel, where incomplete phases can be removed and stored. Although in an area where moisture condensation in the holes is a serious problem, (Hobbs, 1964), maintained them and claimed that he could minimize mold in grooved polystyrene by using wide diameter holes, by preventing the bees from nesting in "clusters," and by sterilizing the polystyrene after removing the cells. He controlled mold in cold storage by letting the leaf cells dry out before storing them in tight containers.

(Hobbs, 1967) made improvements to these nesting materialusing Polystyrene, instead of wood and reduced its weight to one-tenth. The advantage of this, bees paper cells can be removed more easily than in the case of wooden tunnels, however, they can be spoil easily, and bees can chew them.

(Stephen & Osgood, 1965) compared the effect of paper soda straws, polyurethane, and wood of the same diameter and length on sex ratios of the bees and found that there is no correlation between the nesting medium and sex ratio, while (Johansen et al., 1969), stated that weathered wood was more attractive than fresh and that Douglas fir was usually more attractive than pine, and mentioned that the problem of poor ventilation, common to all plastic materials.

Moreover, (Bohart, 1972) indicated that each material has its advantages and disadvantages, however, drilled boards are used most commonly, Plastic blocks with holes, items are adapted for cell removal (drilled boards with removable backs, grooved wood, grooved polystyrene), paper and plastic straws and corrugated paper. Of the many kinds of nesting materials tried, those listed above are still used to some extent.

(Johansen et al., 1969; Stephen & Every, 1970) emphasized the advantage of wider diameter holes in laminated boards and grooved units for removal of cells without crushing the larvae. The latter authors also stated that the larger bees that emerge from wider holes are superior, but they did not present data to support this contention. (Bohart, 1972) claimed that when bees re-nest in these wider holes, the offspring are smaller than average because the bees fail to clean out much of the old leaf material. Consequently, the larger holes would yield larger bees only when the cells are removed each year.

A study revelledthat*Osmia rufa* occupied all tubes made of straw and printer sheeting but in plastic straws, the occupation rate was 80% (Wilkaniec & Giejdasz, 2003), in addition, cardboard tubes could reduce the infestation rate of mites (Fernandes et al., 2020). Moreover, (McCallum et al., 2018) found that nest occupation was significantly affected by nest design, with more bees nesting in tubes of milk cartons (71%) than wooden nests, while (Gaston et al., 2005; Guimaraes-Brasil et al., 2020) claimed that there was a nesting preference for bamboo as nest materials.

Time Investment: The flight of the ferrets takes a relatively short time, as it takes from

20:10 seconds to collect the cut leaves and 150:90 seconds to collect the pollen load, while we find that the female pollinates every flower she visits in the flight, the males do not leave constantly, but collect nectar only and often Without pollinating the flower you visit. During warm periods in the spring, pre-pupae turn into pupae.

(Stephen & Osgood, 1965) claimed that bees reared in large-diameter straws are 2 to 4 times the size of those reared from small tunnels, collect more pollen per foraging trip, and provide each cell with a greater quantity of provisions. These statements disagree with the results of this study, where these results found no difference between bees size emerged from straws of 5 or 8mm. However the difference where found between the leaves cuts to make larvae cells, where the female used straws of 8 mm cut more leaves (32-36 piece) than the one used 5mm (24-26 piece), while it correspond with M. *rotundata,* like M. *relativa,* which provide more leaf layers to a cell cup when the cell is constructed in larger-diameter tunnels (Kim, 1992).

It can be calculated from the number of flowers per acre benefiting from pollination because bees visit alfalfa flowers at rates ranging from 11 to 15 per minute. 10,000 female nests would be required, according to (Bohart, 1962; Stephen, 1962) calculation, to pollinate a 5-acre (2 ha) crop of alfalfa. According to (Klostermeyer, 1964), 500 pounds of clean alfalfa beds require at least 2,000 females per acre. While (Hobbs, 1967) demonstrated that 40,000 females would be needed to complete the pollination process on one acre of alfalfa in just three weeks. Regarding the researchers' other findings, they fall between the two limits (2000: 40000 females / acre). Theoretically, the number of generations can multiply ten times if tunnels are available for nesting. (Bohart, 1962) mentioned that the number of bees increased by five times from year to year if good conditions were available.

CONCLUSION

Through this research, we recommend reusing the nests made of paper tubes with a diameter of 5 mm to collect the largest number of alfalfa leaf-cutter bees and try to manage and benefit from them to pollinate the alfalfa crop to increase seed productivity.

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