Annals of Warsaw University of Life Sciences – SGGW
Animal Science No 53, 2014: 73–78
(Ann. Warsaw Univ. of Life Sci. – SGGW, Anim. Sci. 53, 2014)

The role of vestibulum in the nests of the red mason bee *Osmia bicornis* L.

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Abstract: *The role of vestibulum in the nests of the red mason bee Osmia bicornis L.* The function of vestibulum (the outermost empty brood cell, without provisioning mass and larvae) has not been precisely determined so far. It is most probably a behavioral relic, which currently has no adaptive value. However, red mason bees often build vestibulum. In this study, we examined the nest tubes of red mason bees in three sites (Kłoda, Kanie and Warsaw) in Mazovian Province and in one site (Sąpłaty) in Warmian-Masurian Province. About 70% of the nest tubes in Kłoda, Kanie and Warsaw had vestibulum, whereas only 29% of the tubes in Sąpłaty had vestibulum. It can be assumed that the vestibulum protects the brood against unstable atmospheric conditions, and the proximity of the lake Sąpłaty reduced the temperature amplitude. It was found, however, that the vestibulum did not protect the brood cell against nest parasitoides and cleptoparasites. More cells were infested by parasites and kleptoparasites in tubes with vestibulum.

Key words: Osmia bicornis L., red mason bees, vestibulum, parasitoides, cleptoparasites

INTRODUCTION

Nests of many Aculeata have empty cells in variable numbers and positions (Linsley 1958, Krombein 1967, Tepedino et al. 1979). Red mason bees *Osmia bicornis* L. build linear nests in horizontal holes in wood or reed tubes *Phragmites australis*. The bees leave the outermost cell of the nest (so-called vestibulum) empty, without provisioning mass and egg/larvae. Many authors have tried to explain the purpose of the vestibulum built by bees of the genus *Osmia*. In nests which are exposed to unstable weather conditions, the vestibulum protects the brood against temperature fluctuations (Seidelmann 1999). Another purpose of vestibular cell is to discourage parasites and predators from entering the nest (Krombein 1967). According to the probability models by Tepedino et al. (1979), empty, but closed cells can reduce the success of parasitoides of mud-nesting Hymenoptera. According to Krombein (1967), the vestibulum is a behavioral relic, which currently has no adaptive value. Accompanying fauna and parasitoides are major problems in mason bee keeping and may restrict the mason bee population, particularly in large bee aggregations (Wójtowski and Wilkaniec 1969,Wójtowski and Szymaś

1973, Szymaś 1991). Parasitoides and cleptoparasites usually enter open nest cells at the time the female is collecting pollen. The longer the female leaves the nest unattended, the more likely are parasites and cleptoparasites to lay their eggs inside. The risk of parasitism in open cells is correlated with the provisioning time (Seidelmann 2006). This is why in mason bee keeping it is important to provide bees with food base rich in flower pollen, which shortens the time of collecting pollen by the female and, additionally, results in obtaining larger and more effective pollinators (Giejdasz et al. 2005). The aim of this research was to determine the frequency at which bees build vestibulum and whether its presence limits the number of cells occupied by parasitoides and cleptoparasites.

MATERIAL AND METHODS

The material consisted of reed tubes nested by red mason bees *Osmia bicornis*, taken from four nesting sites: M1 – Kłoda, M2 – Sąpłaty, M3 – Kanie, M4 – SGGW. Artificial nest and cocoons placed first time in M1, M2 and M3, while in M4 red mason beehad been nesting every year for 10 years. All cocoons became from one populations breeded of Apicultural Division Warsaw Uvniversity of Life Science – SGGW. All the nesting sites had similar foraging conditions for the development of the solitary bee populations (mixed orchard apple and plum, home gardens, mixed forest). The M1, M3 and M4 sites were located in the Mazovian Province, while the M2 site was located in the Warmian-Masurian Province, in the vicinity of the lake Sąpłaty. Table 1 presents the mean daily temperatures in the period of bee flights. Four hundreds nest tubes were chosen randomly from each nesting site and analyzed. The nest contents were examined between October 2012 and February 2013 in the Bee Division of the Warsaw University of Life Sciences – SGGW. All the tubes were

TABLE 1. Daily temperature and nest exposure at annual and perennial nesting sites

	Mean daily temperature* (°C)			
Specification	M1 – Kłoda	M2 – Sąpłaty	M3 – Kanie	M4 – SGGW
April	9.4	5.6	10.0	9.6
May	15.1	14.2	14.0	15.5
June	17.6	16.3	17.6	17.1
July	22.3	19.7	20.6	20.8
August	19.2	17.9	19.1	19.4
Overall mean temperature	16.7	14.7	16.3	16.5
Nest exposure	south-east	south-east	south-east	south

*The weather data from the nearest meteorological stations were provided from http://pogoda.ekologia.pl/.

opened with a scalpel and the cells with well developed cocoons, dead larvae and nest parasitoides and cleptoparasites were counted. The frequency of building a vestibulum by bees was determined. Whether the presence of vestibulum in a reed tube affected the numbers of well-developed cocoons, dead larvae and the number of brood cells infested by three species of the most commonly found parasitoides and cleptoparasites (*Cacoxenus indagator*, *Monodontomerus obscurus*, *Chaetodactylus osmiae*) was examined by analyzing the data on the nest contents of red mason bees. The statistical analyses were performed by the SPSS 17 software. The normality of data distributions was verified using Kolmogorov-Smirnov test and Shapiro-Wilk test. Non-parametric Chi-square, Kruskal-Wallis and Mann-Whitney U tests were used for comparing the groups.

RESULTS

Distributions of the analyzed data

The distributions of all analyzed features differed significantly from the normal distribution (Kolmogorov-Smirnov test and Shapiro-Wilk test, $P \leq 0.001$). The distribution of the number of vestibular cells was slightly to moderately skewed – between –1; 1, the number of fully formed cocoons, dead larvae, parasitoides and cleptoparasites was slightly to highly skewed – between –1; 9.

Frequency of constructing vestibulum by the red mason bee

Almost 70% of tubes in the M1, M3 and M4 sites had a vestibulum. Bees nesting in the M2 site left the outermost brood cell empty significantly less (in every third tube) than in sites M1 ($\chi^2 = 44.63$, df = 1, $P < 0.001$), M3 ($\chi^2 = 42.98$, df = = 1, $P < 0.001$) and M4 ($\chi^2 = 48.38$, df = 1, $P < 0.001$) – Table 2.

TABLE 2. Frequency of a vestibular cell in nest traps for solitary bees *O. bicornis* L. in new and perennial nesting sites

Nesting site	Number of tubes	Tubes with vestibulum			
		No	%	Median	Skewness
M1 Kłoda	400	276	69.0	1 a*	0.97
M2 Sąpłaty	400	116	29.0	0 b	0.93
M3 Kanie	400	272	68.5	1 a	–0.77
M4 SGGW	400	287	71.8	1 a	0.12

*Different letters in columns indicate significant differences in mean ranks of the groups (Kruskal-Wallis test: $\chi^2 = 799.00$, df = 3, $P < 0.001$; pairwise comparisons: Chi-square test, $P < 0.01$).

Impact of vestibular cells on the number of fully formed cocoons, dead larvae and parasitism

The results demonstrated that significantly more healthy cocoons were obtained from nest tubes lacking vestibulum than from tubes without vestibulum in M1, M3 and M4 sites (Mann-Whitney U test, $P < 0.00$). The numbers of parasitized cells and cells with dead larvae were similar in tubes with and without vestibulum (Tables 3 and 4).

DISCUSSION

In all the nests (M1, M2, M3 and M4) bees built vestibulum. The vestibulum protects the brood from unstable environmental conditions (Seidelmann 1999). In nests exposed to sun and high temperature bees built vestibulum more frequently (Seidelmann 1999). The M2 site, Sąpłaty, is located next to the lake Sąpłaty in the Warmian-Masurian Province, which has a cooler climate (Table 1), but also smaller temperature amplitudes. This is probably why bees from the M2 site built fewer vestibulum – only in ca. 30% of the tubes, while at the other sites (M1, M3 and M4) vestibuli were found in ca. 70% of the tubes (Table 2). It can be concluded that the frequency of building vestibulum by mason bees is mainly influenced by environmental conditions (e.g. temperature amplitudes, lower diurnal temperatures).

TABLE 3. Fully formed cocoons and dead larvae in nest tubes with and without vestibulum in M1 (Kłoda), M2 (Sąpłaty), M3 (Kanie) and M4 (SGGW)

Specification	Mean	Median	Skewness	Mean	Median	Skewness
M1 – Kłoda	With vestibulum (71.3%*)			Without vestibulum (28.7 %)		
No of cocoons	6.77 a**	7	0.2	7.23 b	7	–0.15
No of dead larvae	0.74 a	0	2.13	0.71 a	0	2.54
M2 – Sąpłaty	With vestibulum (29%)			Without vestibulum (71%)		
No of cocoons	7.08 a	7	0.06	6.91 a	7	0.01
No of dead larvae	0.85 a	0	1.28	0.84 a	0	1.71
M3 – Kanie	With vestibulum (69%)			Without vestibulum (31%)		
No of cocoons	6.94 a	7	–0.04	6.01 b	6	–0.15
No of dead larvae	0.28 a	0	2.25	0.33 a	0	1.14
M4 – SGGW	With vestibulum (68%)			Without vestibulum (32%)		
No of cocoons	5.93 a	6	–0.11	5.37 b	6	–0.7
No of dead larvae	0.66 a	0	2.57	1.13 a	1	1.74

*Percentage of tubes with/without vestibulum in all analyzed tubes.
**Different letters in the same lines indicate significant differences in mean ranks of the groups (Kruskal-Wallis test, $P < 0.01$ and Mann-Whitney U test, $P < 0.01$).

TABLE 4. Parasitoids and cleptoparasites in nest tubes with and without vestibulum in M1 (Kłoda), M2 (Sąpłaty), M3 (Kanie) and M4 (SGGW)

Specification	Mean	Median	Skewness	Mean	Median	Skewness
M1 – Kłoda	With vestibulum (71.3%*)			Without vestibulum (28.7%)		
C. indagator	0.27 a**	0	2.18	0.29 a	0	4.05
M. obscurus	0.05 a	0	5.07	0.02 a	0	7.77
Ch. osmiae	0.11 a	0	5.04	0.16 a	0	4.48
M2 – Sąpłaty	With vestibulum (29%)			Without vestibulum (71%)		
C. indagator	0.36 a	0	3.79	0.24 a	0	2.91
M. obscurus	0.13 a	0	3.60	0.02 a	0	8.82
Ch. osmiae	0.11 a	0	3.30	0.09 a	0	4.81
M3 – Kanie	With vestibulum (69%)			Without vestibulum (31%)		
C. indagator	0.47 a	0	3.29	0.54 a	0	3.06
M. obscurus	0.13 a	0	2.77	0.18 a	0	2.60
Ch. osmiae	0.03 a	0	7.23	0.05 a	0	4.34
M4 – SGGW	With vestibulum (68%)			Without vestibulum (32%)		
C. indagator	0.91 a	0	1.56	1.2 a	1	1.65
M. obscurus	0.13 a	0	3.60	0.20 a	0	2.95
Ch. osmiae	0.32 a	0	3.30	0.35 a	0	2.01

*Percentage of tubes with/without vestibulum in all analyzed tubes.
**Different letters in the same lines indicate significant differences in mean ranks of the groups (Kruskal-Wallis test: $P < 0.01$ and Mann-Whitney U test: $P < 0.01$).

It has been hypothesized that these vestibular cells function to discourage penetration of parasitoides and predators to the stored cells (Krombein 1967). Nevertheless, our observations during the present study demonstrated that the occurrence of vestibulum did not decrease the number of cells in the tubes occupied by parasitoides/cleptoparasites (Table 4). Unexpectedly, more cocoons were obtained from the nesting tubes which had no vestibular cell in M1, M3 and M4 sites (Table 3).

It may be concluded, therefore, that the main function of vestibular cells built by mason bees is most probably to protect the nest against harmful atmospheric conditions (e.g. overheating) rather than against parasites and accompanying fauna.

CONCLUSIONS

1. The frequency of building vestibular cells by red mason bees is probably influenced by unstable environmental conditions. In Sąpłaty where the temperatures during bee flights were lower and the temperature amplitudes were smaller, only 29% of the nest tubes had a vestibulum.
2. The vestibulum does not protect mason bee nests against nest parasitoides and cleptoparasites.

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Streszczenie: *Funkcja vestibulum w gnieździe murarki ogrodowej Osmia bicornis L.* Funkcja vestibulum (najbardziej zewnętrznej komory gniazdowej) nie została dotychczas dokładnie określona. Prawdopodobnie jest to behawioralny relikt obecnie bez żadnej wartości adaptacyjnej. Jednak pszczoły chętnie budują vestibulum. W trzech miejscach badań: Kłoda, Kanie, Warszawa (woj. mazowieckie), w 70% rurek gniazdowych znajdował się przedsionek. Stwierdzono, że murarki gniazdujące w Sąpłatach (woj. warmińsko-mazurskie) vestibulum wybudowały jedynie w 29% rurek. Można przypuszczać, że przedsionek chroni czerw przed zmiennymi warunkami atmosferycznymi, a bliskość jeziora łagodziła amplitudy temperatury. Stwierdzono natomiast, że vestibulum nie zabezpieczało komórki z czerwiem przed pasożytami i kleptopasożytami gniazdowymi. W rurkach, które miały vestibulum, stwierdzono więcej komórek porażonych przez pasożyty i kleptapasożyty.

MS. received in November 2014

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