Sociality in the North African small carpenter bee, *Ceratina albosticta*

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Supplementary materials

Description of interesting nests:

There are described nests, which are interesting, but were not included to main analyses: Three-female and four female nests, two female nests collected in September and nests with males.

MA19-150 (Kelaat Mgouna, May 19, 2019). This social active brood nest contained three females. It was found in rose stem. Nest was 19.7 cm long; entrance burrow was 6.5 cm long. This nest contained 13 brood cells provisioned: 2 pupae, 8 larvae, 2 eggs and 1 partially provisioned pollen ball. All offspring was live at time of dissection. No empty cell was present; however, one brood cell was extensively longer than others.

Rank	Ovarian development	Head width	Wing wear
1	2.960	1.913	2.5
2	1.950	1.875	0.5
3	1.400	1.755	0.3

MA19-169 (Kelaat Mgouna, May 19, 2019). This active brood nest contained 4 females. Nest was in rose stem. Nest length was 17.5 cm, length of nest entrance was 10.5 cm. This nest contained 10 brood cells, 7 contained larvae, 2 eggs and 1 incompletely provisioned pollen ball. There were no cells with dead offspring or empty cells. In the bottom of nest, there was excrements – residue of previous nesting in same twig.

Rank	Ovarian development	Head width	Wing wear
1	2.107	1.925	1.5

2	1.917	1.600	0.3
3	1.633	1.700	1
4	0.983	1.750	1

MA19-66 (Kelaat Mgouna, May 19, 2019) This active brood nest contained three adult females. Nest was in rose stem. Nest length was 18.9 cm, length of nest entrance was 13 cm. Nest contained 8 brood cells - 6 larvae, one egg and one incompletely provisioned pollen ball. There was no empty cells or dead offspring. The nest was probably reused.

Rank	Ovarian development	Head width	Wing wear
1	3.725	1.850	4
2	2.900	1.775	4
3	0.500	1.813	1

MA19-36 (Kelaat Mgouna, May 18, 2019) This active brood nest contained four adult females. Nest was in rose stem. It was 16.4 cm long, length of nest entrance was 14.2 cm. There were four brood cells provisioned, three contained larvae and one incompletely provisioned pollen ball. There were no empty cells or dead offspring. Under the nest was 5.7cm long space containing fillings and excrements from previous nesting.

Rank	Ovarian development	Head width	Wing wear
1	2.517	1.938	0.0
2	2.217	1.950	0.3
3	2.033	1.775	0.5

4	1.633	1.913	0.5

MA19-438 (Kelaat Mgouna, September 27, 2019). This full brood nest contained one adult female and one adult male. Nest was in rose stem. Nest length and length of nest entrance was 2.5 cm. There was only one offspring – pupa in open brood cell. There was no residue of brood cell partitions.

MA19-498 (Ourzazatte, September 30, 2019) This full brood nest contained one adult female and one adult male. Nest was in *Foeniculum* stem. Nest was 8.7 cm long, length of nest entrance was 8.0 cm. Nest was surely reused, there were residua of previous nesting in the nest. There were two brood cells provisioned, bottom contained pollen provision – bottom offspring apparently died, upper brood cell was open and contained pupa. There were no empty cells.

MA19-121 (Kelaat Mgouna, May 19, 2019) This active brood nest contained one adult male and one adult female. Nest was in rose stem. It was 11.3 cm long. Contained only one brood cell with egg, which was still open. Under the nest there were residua of previous nesting (fillings and excrements).

MA19-493 (Zagora, September 29, 2019) This active brood nest contained two adult females. It was in *Lantana* stem. It was 7.4 cm long and nest entrance was 4.8 cm long. There were four brood cells provisioned, three contained larvae and one contained egg. There were not empty cells or dead offspring.

The first female had wing wear score 4.5, head width 1.950 and sum of three largest oocytes 1.717. The second female had lowered all three parameters – wing wear score 0, head width 1.875 mm and sum of three largest oocytes 0.417 mm.

Supplementary tables:

Table S1: Results of models testing influence of nest stage (active brood nests vs full brood nests) and sociality (solitary vs two-female nests). Only two-female nests collected in Kelaat Mgouna in May are included.

	Number of brood cells, Poisson GLM, N=132			
	df	deviance	residual deviance	p
Nest stage	1	2.62	261.65	0.1058
Sociality	1	136.25	125.40	2.00E-16
Interaction	1	2.22	123.18	0.1364

	Proportion of empty cells, binomal GLM, N=126			
	df	deviance	residual deviance	p
Nest stage	1	0.08	188.79	0.7731
Sociality	1	40.28	148.51	2.21E-10
Interaction	1	0.18	148.33	0.67

	Length of nest, linear model, N=132		
	df	F	p
Nest stage	1	0.41	0.52
Sociality	1	9.32	0.0028
Interaction	1	3.25	0.074

Table S2: Proportion of nest sages collected in different part of season

Stage	% Of nests in May (N=213)	% of nests in September + October (N=146)
Burrows	28.16	30.82
Active brood nests	46.48	0.68
Full brood nests	19.72	8.21
Full-Mature brood nests	0.00	3.42
Mature brood nests	0.00	47.94
Destroyed nests	5.63	8.90

Table S3: Proportion of different nest types regarding adults present.

Nest type	Active brood nests (N=100)	Full brood nests (N=54)	All nests (N=154)
Solitary	79.00%	81.48%	79.22%
Multifemale	19.00%	11.11%	16.23%
Bisex	1.00%	3.70%	1.95%
Orphaned	2.00%	3.70%	2.60%

Supplementary figures:

Fig. S. 1: Rose plantations in Kelaat Mgouna with dry cut or broken end of rose twigs, suitable habitat for nesting of *C. albosticta*

Fig S2: Solitary full brood nest of *C. albosticta*. This nest contains two brood cells. Outermost brood cell is open; therefore, mother is in contact with offspring there. There are empty cells between these two brood cells.

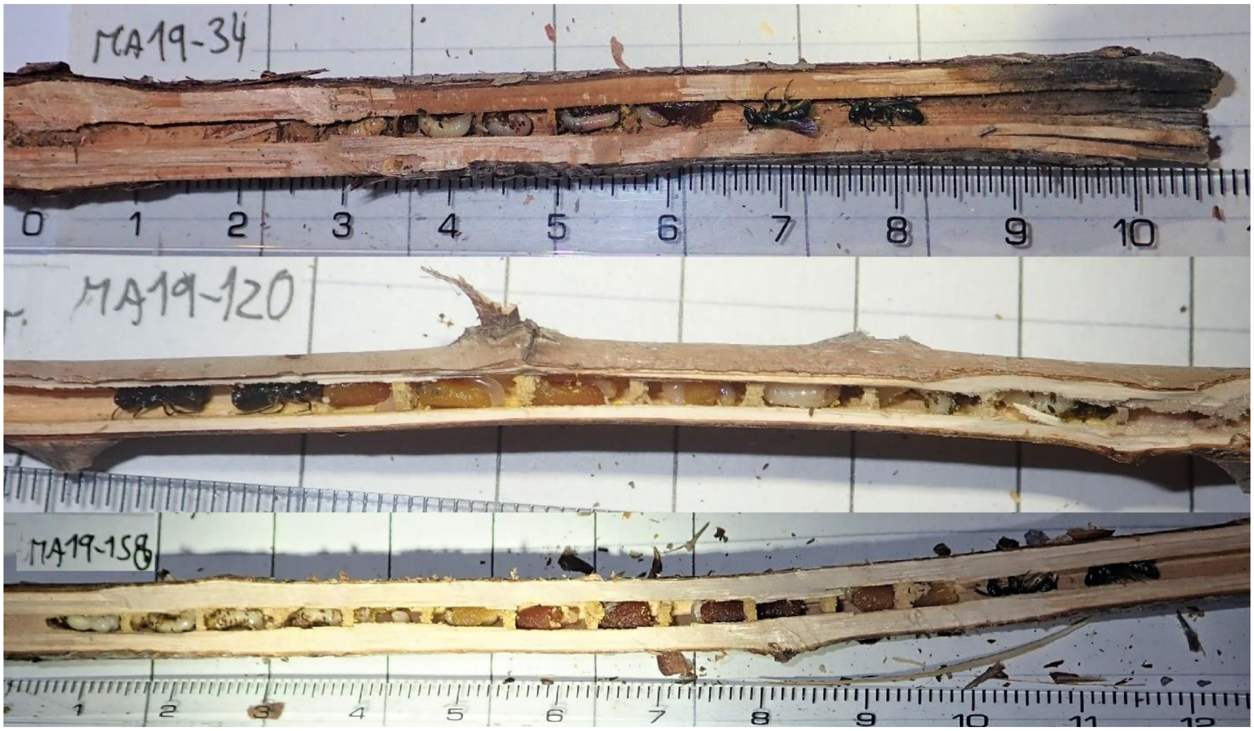

Fig S3: Social nests of *C. albosticta*. Brood cells are linearly arranged, the oldest offspring is in the bottom of nest, the youngest is in the top of nest. There are two females in entrance burrow. In upper picture is full brood nest with open last outermost cell. In middle and bottom picture are active brood cell, where outermost brood cell is currently provisioned.

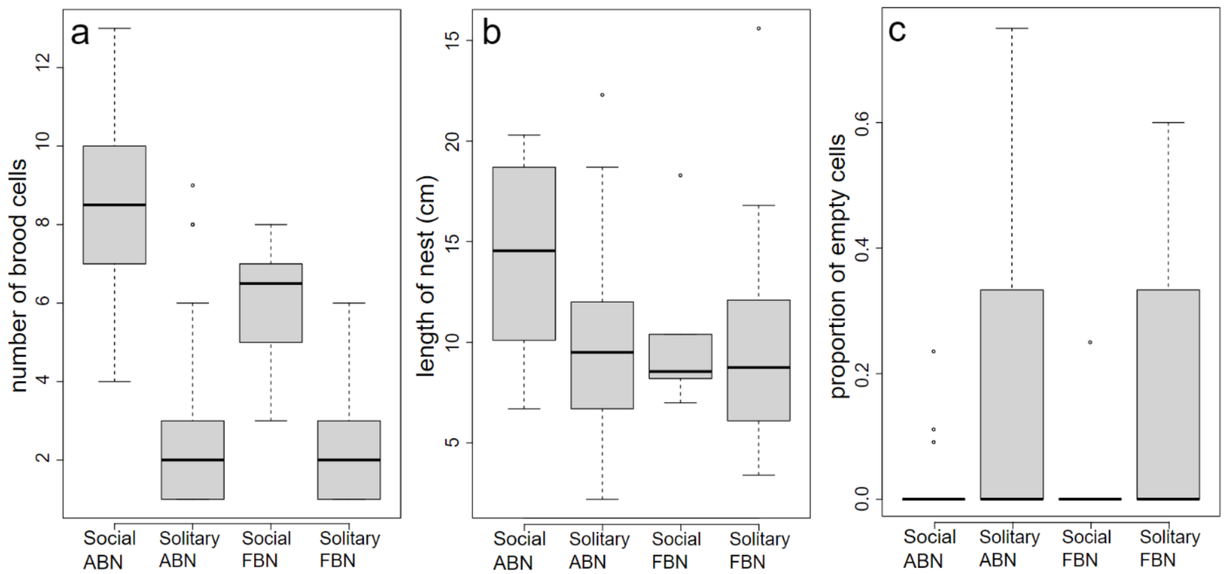

Fig S4: Comparison between solitary and two-female active brood and full brood nests. There is a significant difference in a) number of brood cells provisioned between solitary and social nests, b) length of nest, and c) proportion of empty cells in total number of cells in nest. Nests collected in Kelaat Mgouna in May are included. ABN=Active brood nest, FBN=Full brood nest

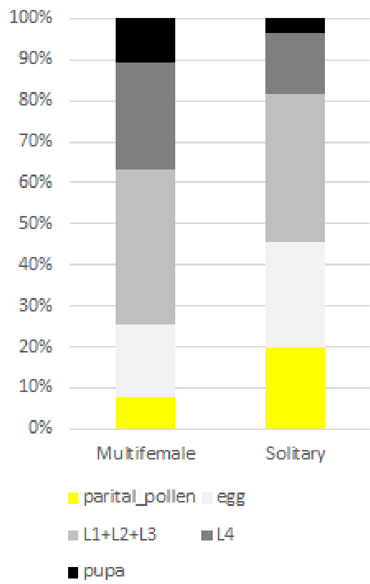

Fig S5: Comparison in proportion of different developmental stages between solitary and two-female nests. Active brood nests and full brood nests collected in Kelaat Mgouna in May are included.

Script for testing non-random ovarian development in two-female nests:

Script for R software which test non-random differences in ovarian development in two-female nest. Author of Script: Jiří Hadrava (Department of Zoology, Faculty of Science, Charles University, Prague, Czech Republic and Institute of Entomology, České Budějovice, Czech Republic)

Existence of non-random differentiation of ovarian development was tested using randomization test. Primarily, there was calculated average ovarian difference in ovarian development between females from 11 two-female active brood nests. Later was randomly selected pairs 11 pairs of females from 52 solitary active brood nests and compared difference in ovarian development between females in social nests and randomly selected pairs of solitary females. We repeated this procedure 10000 times. Difference in ovarian development in two-female active brood nests was greater than simulated difference from pool of solitary females in all of 10000 cases.

```
## difference in ovarian development in social nests

# data:
female1<-c(2.333,1.417,2.933,2.483,3.617,1.417,2.350,2.960,3.617,1.183,2.775)
female2<-c(1.050,0.000,1.200,0.533,1.783,0.633,1.100,0.583,1.050,0.333,0.000)

# difference in ovarian development:
difference<-female1-female2
difference<-abs(difference)
mean_difference_social<-mean(difference)
mean_difference_social

# average difference was 1.710909


## difference in ovarian development between solitary females:

# data:
ovary_size<-
c(3.029,1.850,2.067,1.500,1.417,3.000,2.283,0.000,1.713,2.217,2.126,3.117,1.925,1.667,0.867,1.983,1.2
```

```
75,1.750,3.345,0.775,1.696,3.554,2.483,2.029,0.238,1.792,1.979,1.000,1.938,3.350,1.950,3.150,1.239,1.
893,1.063,1.804,2.388,1.733,2.567,1.750,1.838,3.750,0.000,1.688,1.313,1.250,1.438,1.738,1.425,1.400,
1.163,2.567)

# distribution of differences:
distribution<-rep(0,10000)
for(i in 1:length(distribution)){
  pairs_data<-sample(ovary_size,22,replace=FALSE)
  pairs_differences<-rep(0,length(pairs_data)/2)
  for(j in 1:length(pairs_differences)){
    pairs_differences[j]<-abs(pairs_data[j*2-1]-pairs_data[j*2])
  }
  distribution[i]<-mean(pairs_differences)
}

mean(distribution)
# 0.9139285

sd (distribution)
# 0.1920405

range (distribution)
# 0.3278182 1.6753636

length(distribution[distribution>mean_difference_social])
# 0
length(distribution[distribution==mean_difference_social])
# 0
length(distribution[distribution<mean_difference_social])
# 10000

# Average simulated distribution is 0.9139285. In any case was simulated distribution larger than
observed distribution.
```