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ORIGINAL RESEARCH ARTICLE

Rate of Emergence and Mortality of *Sceliphron caementarium* (Hymenoptera: sphecidae) as a Result of Parasitoids to Endogenous Factors in Ahmadu Bello University Zaria, Kaduna, Nigeria.

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ABSTRACT
The nests of *Sceliphron caementarium* were studied to ascertain the rate of emergence and mortality causes of *S. caementarium* before emergence. Ten (10) nests of *S. caementarium* were taken from the various Faculties of Ahmadu Bello University's main campus, located in Zaria, Kaduna, Nigeria and analyzed. The greatest width of the head (GWH) was employed to estimate the size and sex ratio of emerged adult wasps. The nests of *S. caementarium* collected and examined from the study consist of 1-23 vertically arranged cylindrical allantoid-shaped cells. The average length and width of the male and female wasp cells were (l = 24.8 mm, w = 7.0 mm) and (l = 25.5 mm, w = 7.8 mm) respectively. The mean fecundity of the female *S. caementarium* from the study was calculated at 15.1 eggs per female. The sex ratio of the emerged adult *S. caementarium* obtained from the nests was 1 male : 1.28 female. With respect to size, the females black-and-yellow mud dauber wasps were observed to be significantly bigger than the males ($p < 0.05$). The highest rate of Mortality that was observed in the nest of *S. caementarium* in the study area was due to an endogenous factor 64.15% (which may be a developmental failure, pathogenic or fungal infection) followed by parasitoids accounting for about 24.52% deaths in the cells and accidental cell damage (11.32%) was the least cause of mortality in the cells.

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Sceliphron, Nest cell, Emergence, Mortality, Fecundity, Parasitoids.

INTRODUCTION
Sceliphron caementarium also known as the black-and-yellow mud dauber wasp is a species of wasp family specidae. It is found in all world's temperate and tropical continental areas and on many islands. The genus Sceliphron consists of about Thirty species. Quite a number of these species have been introduced to various new localities anthropogenically (Bohart and Menke 1976).

Sceliphron caementarium is well-known to be non-aggressive and will hardly sting except it is forced. These species of wasps are characteristically solitary using their stingersa only to hunt down their prey, spiders and other insects they might encounter by paralyzing them with their venom (Eulberg, 2003).

Wasps hunt down and kill pest insects, but the significant role they played in holding the pest number down in our environment has gone unnoticed by the populace. We are indebted to these little insects. Because if it weren't for them and other natural enemies, we would be knee-deep in pest insects (Waren, 2010).

These Wasp are like "smart bombs" that seek out and kill only specific kinds of insects (Waren, 2010). Therefore, if we can harness their full potential, they would be vastly preferable to chemical pesticides, which broadly kill or poison many organisms in the environment, including us.

The study of *Sceliphron caementarium*, commonly known as the mud dauber wasp, is important, in that the *Sceliphron caementarium* exhibit fascinating nesting behaviors such as constructing intricate mud nest and preying on spiders providing the paralyzed spiders as food for their young. By studying their behavior we gain insights into the natural pest control mechanism in the ecosystem and can provide a valuable insights into animal cognition, learning and parental care strategies. Also, studying *S. caementarium* is essential for its conservation. Learning about their habitat requirements, threats, and population dynamics can inform conservation efforts to protect these pest controllers.

Recents and past researches on *S. caementarium* have focuses more on study of its distribution (Bogusch and

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Macek, 2005; Ravoet *et. al.,* 2017; Cassar and Mifsud, 2020; Ceccolini, 2023), behaviour (Ferguson and Hunt, 1989) and venom (Rosenbrook Jr and O'connor, 1964). Hence, the present research was conducted to assess the rate of emergence of the adult *S. caementarium* and the causes of its mortality before emergence.

MATERIALS AND METHOD

Study Area

The study was conducted in Ahmadu Bello University, situated in Samaru, Zaria in the Sabon Gari Local Government area of Kaduna State. It is located on latitude 11° 15'N to 11°3'N of the equator and longitude 7° 30'E to 7°45'E of Greenwich Meridian. (Abbas and Arigbede, 2012). The study area falls in the northern Guinea Savannah region. It has a tropical climate and two distinct seasons. The wet season (May to October) with an average annual rainfall of about 1047.08 mm, and a dry season (November to April). The relative humidity varies between 70-90% in June-August and fall to less than 20% in December. The highest average air temperature occurs in March/April (28.9 °C) and the lowest in December/January (21.9 °C), with a mean annual temperature of about 26 °C (Hazo *et al.,* 2020).

Sample Collection

The nests were collected from the Faculty of Sciences (FS), Faculty of Education (FE), Faculty Veterinary Medicine (FVM), Faculty of Medicine (FM) and Divisions of Agricultural Colleges (DAC) in Ahmadu Bello University main campus located in zaria, Kaduna state, Nigeria.

The black-and-yellow mud dauber wasp nest was collected according to Camilo (2002) . Collection of nests was carried out between the months of February to June of 2013. The nest, is collected by pushing the blade of a putty knife between the nest and the surface it is built upon and carried in a plastic container to the laboratory for further analysis.

In the laboratory the length and diameter of the cells were measured by mean of a caliper. The size and sex ratio of emerged adult wasps was estimated using the Greatest Width of the Head (GWH) as described by Camilo (2002). At the point of emergence each *S. caementarium* cut its own exit hole proportional to its head size, with the female having a larger head than the male.

Tables were constructed showing the rate of emergences, mortality, various causes of mortality at various phases of the life cycle and relative immature individuals dying from each known-causes.

RESULTS AND DISCUSSION

Ten (10) nest of *Sceliphron caementarium* were collected from different locations of Ahmadu bello university Zaria, and taken to the laboratory for analysis.

The Nests of *Sceliphron caementarium*

The structural design of the nests of *Sceliphron caementarium* is shown in Fig. 1. The nest was constructed out of mud. It consists of vertically arranged cylindrical cells that are stockpiled by the female wasp with paralyzed spiders as brood feed. The female *S. caementarium* lays a single egg in each of the cell and seals it with mud plug. On emergence the adult *S. caementarium* cuts its own exit hole on the nest equivalent to the size of its head. The surface of the assembled build cells was also covered with an extra layers of mud, as it was witnessed in nest of *S. fistullarium* and *S.servillei* (Camilo, 2002; Ighere *et al.*, 2014).

Fig. 1. Nests of *Sceliphron caementarium* showing the arrangement of Allantoid-shaped cells (A, B); cells of emerged Males (A.1) and Females (A.2); Accidentally damaged cell (B.1); Cells of nonemergent *S. caementarium* (B.2)

The nests of *Sceliphron caementarium* collected from Ahmadu bello university Zaria consisted of cells ranging from 1-23 allantoid shape (x = 15.1 ± 1.8, n =10) which were mostly build under a shade away from rain, sunlight and other environmental factors. The siting of the *S. caementarium* nest was no different from the siting and architecture of the nest of *S. fistullarium* as reported by Camilo (2002). Also, *S. laetum* and *S. formosum* nests were

reported to be predominantly located in sheltered area, shielded from uninterrupted sunlight and water by Smith (1979). A small amount of water droplets on the nest can go a long way to impede the emerging processes of the larvae and pupae: depending at which stage of development the nest was wetted (Ighere *et al.,* 2014).

With regard to length and width of the cells. The mean length and width of the male and female *S. caementarium* nest was measured to be(l = 24.8 mm, w = 7.0 mm) for males and (l = 25.5 mm, w = 7.8 mm) for females. A Mann-Whitney test indicates that there is no significant difference between the male and female cells in terms of its length and width (Mann-Whitney: Z = 0.0335 for length, Z = 0.0494 for width, $p < 0.05$).

Emergence Rate of *Sceliphron caementarium*

The number of emerged and non-emergent or dead individuals in each of the collected analysed nests. The sex ratio of the emerged adult *S. caementarium* obtained from the nests was 1 male : 1.28 females. The *S. caementarium* were observed to vary in sizes between sexes with the female (GWH = 5.41 mm, n = 8) being larger than the male (GWH = 4.62 mm, n = 10). A Mann-Whitney U-test conducted to determine the statistical significance of the size distribution indicate that the female is significantly bigger than the male (Z = 0.0143, p < 0.05) (Table 1).

Fecundity: The mean fecundity calculated as successful emergences per cell for all the nest (assuming no multiple nesting by the the *Sceliphron spp*) can be synonymous to the number of cells per nest, since the wasp laid a single egg in every cell it built and its expected that under normal condition an adult wasp will emerged from every cell . Therefore, the mean fecundity of *Sceliphron caementarium* obtained from this study is 15.1 eggs per female. This is lower than the 25 eggs per female reported for *S. fistullarium* (Camilo, 2002) in south-eastern Brazil. And higher than the 8.1 eggs per female recorded for *S. laetum* in Southern-Australia (Smith, 1979).

Mortality Rate and the Causes of Mortality In *Sceliphron Caementarium* Nest before Emergence

The actual cause of death in the different stages of life of the Black and Yellow Mud Dauber Wasp (*Sceliphron caementarium*) before emergence was recorded in 53 of 151 cells (35.10% of the studied cells). The use of death spanned from accidental cell damage, parasitoids to endogenous factors. The endogenous cause may be due to developmental failure, pathogenic or fungal infection.

The highest mortality observed in the study was due to endogenous factors resulting in 34 of the 53 deaths recorded (64.15%).) and it occurs across all the four developmental phases. Parasitoids are the second cause of mortality mostly observed at the pupae stage of life of the wasp, it accounts for 24.53% (13 of 53) death observed in the study. Damaging of cells by accident (11.32%) was the least cause of mortality in the nest of the *S. caementarium*.

Parasitism observed in the cell of *S. caementarium* in Ahmadu Bello University Zaria was majorly due to *Milittobia spp.* and *Hedyhridium jebbanum.* These prasitoids were identified by their remains or pupal exuviae in the cells and the tiny exit hole they cut on the cell wall through which the adult parasitoids emerged. They were also sighted flying around the vicinities. *Milittobia spp* the major parasite of *S. caementarium* nest in this research was also reported to cause the highest rate of parasitism in the cells of *Sceliphron jamaicense* (Starr *et al.*, 2018) *Sceliphron spirifex* (Polidori *et al.*, 2005), *S. assimile* (Freeman and Parnell 1973; Genaro 1994), and Camilo (2002) in cells of *S. fistullarium* (Table 2).

Table 1. The Emergence and Mortality of the *Sceliphron caementarium* In ten Faculties within Ahmadu Bello University Zaria, Kaduna, Nigeria.

Nest number	Number of cells	Emergence		Parasitoids and dead immatures	Damaged and empty cells	Dead Adults in cells
		Male	female			
FS1	10	2	3	2	3	-
FS2	7	1	2	3	1	-
FS3	12	5	7	-	-	-
FS4	20	5	8	5	-	2
FE5	8	3	1	-	1	3
FVM6	23	6	7	5	5	-
FVM7	21	8	6	5	-	2
FM8	14	4	7	-	2	1
DAC9	17	5	8	-	-	4
DAC10	19	4	6	8	1	-
Total	151	43	55	28	13	12

Key: FS = Faulty of Sciences, FE = Faculty of Education, FVM = Faculty of Veterinary Medicine, FM = Faculty of Medicine, DAC = Division of Agricultural Colleges.

Table 2: The Causes of Death in the Different Stages of Life of the Black and Yellow Mud Dauber Wasp (*Sceliphron caementarium*) Before Emergence.

Stage of Development	Number of Cells	Mortality Factor	Number of Dying Cells	Percentage of Dead (%)
Egg	151	Endogenous	11	7.28
		Accident	4	2.65
		Total	15	9.93
Larvae	136	Endogenous	8	5.88
		Accident	2	1.47
		Total	10	7.35
Pupae	126	Parasitoids	13	10.32
		Endogenous	8	6.35
		Total	21	16.67
Adults in Cells	105	Endogenous	7	6.67
Emerged Adults	98			

The presence of these parasitic wasps in the nest of *Sceliphron caementarium* has make it bioreservoirs of parasitic insect. Further study into this parasitic relationship may shed light on complex behaviors, such as host manipulation and reproduction strategies, which are fascinating from a behavioural ecology standpoint.

CONCLUSION

Base on the findings of the study, the nest of the *Sceliphron caementarium* consist of cells ranging from 1-23. The female black-and-yellow mud dauber were significantly larger than the males. And the sex ratio of the male to female emerged adult *S. caementarium* was 1.28 females: 1 male. The mean fecundity of the female *S. caementarium* in the study area was estimated to be 15.1 eggs per female.

The number of emerged cells (64%) was higher than nonemergent cells (36%). Death due to endogenous factor 64.15% (which may be a developmental failure, pathogenic or fungal infection) was the major cause of mortality, followed by prasitoids accounting for about 24% deaths in the cells.

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