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Antennal ultrastructure of three species of *Cyclocephala* Dejean, 1821 (Coleoptera: Scarabaeidae)

Sérgio Roberto Rodrigues & Andrezza Santos Cocco

Universidade Estadual de Mato Grosso do Sul, Cassilândia, MS, Brazil.

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Abstract. This study describes the antennal ultrastructure in *Cyclocephala forsteri* Endrodi, 1963, *Cyclocephala melanocephala* (Fabricius, 1775) and *Cyclocephala tucumana* Brethes, 1904 (Coleoptera: Scarabaeidae). Adult of *Cyclocephala* Dejean, 1821 specimens were collected using a light trap placed near a pasture area, segregated by gender, based on male-specific dilated pre-tarsomeres and preserved in 70% alcohol. Scanning electron microscopy (SEM) images of the antenna lamellae were obtained from ten specimens at Universidade Estadual Paulista (UNESP) in Ilha Solteira, SP, Brazil. We identified trichoid, chaetic, placoid, coeloconic, basiconic sensilla, and pores in antenna of all the species. Placoid sensilla were prevalent in the antennal lamellae. The antennae of *C. forsteri* females had 5,457 sensilla, of which 5,327 (97.62%) were placoid, 123 (2.25%) coeloconic, and seven (0.13%) basiconic, while the antennae of males showed 5,351 sensilla, with 5,238 (97.89%) being placoid, 100 (1.87%) coeloconic, and 13 (0.24%) basiconic. The antennae of *C. melanocephala* females presented 6,814 sensilla, with 6,581 (96.58%) being placoid, 231 (3.39%) coeloconic, and two (0.03%) basiconic; while those of males had 6,333 sensilla, with 6,023 (95.11%) being placoid and 310 (4.89%) coeloconic. Finally, the antennae of *C. tucumana* females had 1,981 sensilla, with 1,845 (93.13%) being placoid, 127 (6.42%) coeloconic, and nine (0.45%) basiconic; while the antennae of males had 3,756 sensilla, with 3,656 (97.34%) being placoid, 99 (2.64%) coeloconic, and one (0.02%) basiconic. Overall, adults of *C. melanocephala* and *C. tucumana* presented dimorphism in the antennal sensilla.

Keywords: Chemical communication; Chemoreceptors; Dynastinae; Scarabaeoidea.

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Corresponding author:

Sérgio Roberto Rodrigues
sergio@uems.br

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Cyclocephala Dejean, 1821 (Coleoptera: Scarabaeidae) is a genus of Dynastinae, plays a crucial ecological role by interacting with various plant species during its adult phase, often using flowers for feeding (Dieringer *et al*. 1998; Moore & Jameson 2013; Dias & Rodrigues 2018) and mating (Gottsberger 1989; Munin *et al*. 2008; Maia *et al*. 2013; Costa *et al*. 2017). These interactions between *Cyclocephala* adults and cultivated or native plants benefit both, as they act as important pollinating agents (Maia & Schlindwein 2006; Cavalcante *et al*. 2009; Maia *et al*. 2013).

Adults of *Cyclocephala* rely on chemical cues released by plants to locate flowers (Maia *et al*. 2013). Favaris *et al*. (2020) reported that flowers of *Lagenaria siceraria* (Mol.) Standl. (Cucurbitaceae) release (3S,6E)-nerolidol, which exerts an attractive effect on adults of *Cyclocephala paraguayensis* Arrow, 1903. Gottsberger *et al*. (2012) also noted that the methyl-2-methyl butyrate in flowers of *Magnolia ovata* (A.St.-Hil) Spreng. (Magnoliaceae) had great attractiveness for adults of *Cyclocephala literata* Burmeister, 1847. Moreover, other groups of Scarabaeidae have been recorded feeding on plant flowers or leaves, including *Leucothyreus femoratus* Burmeister, 1844 (Martínez *et al*. 2013); *Liogenys fusca* Blanchard, 1851 (Rodrigues *et al*. 2016); *Anomala testaceipennis* Blanchard, 1856 (Rodrigues *et al*. 2014); *Hoplopyga* Thomson, 1880 (Shaughney & Ratcliffe 2015); *Macrodactylus* Dejean,1821; *Hoplia* Illiger, 1803; *Phyllophaga* Harris, 1827; *Epectinaspis* Blanchard, 1850; *Strigoderma* Burmeister, 1844; *Anomala* Samouelle, 1819; and *Callistethus* Blanchard, 1850 (Morón 1996).

Sexual pheromones are another group of chemical compounds important for adults of Scarabaeidae, being identified in some species such as *Phyllophaga cuyabana* (Moser, 1918) (Zarbin *et al*. 2007); *Oryctes elegans* Prell, 1914 (Rochat *et al*. 2004); *Holotrichia reynaudi* Blanchard, 1850 (Ward *et al*. 2002); and *Phyllophaga georgiana* (Horn, 1885) (Robbins *et al*. 2009). As described, adults of Scarabaeidae, including adults of *Cyclocephala*, detect and actively use chemical compounds released by plant species.

Studies on the copulation behavior of adults of Scarabaeidae have demonstrated the active use of antennae to detect probably chemical information, as described for *Anomala orientalis* (Waterhouse, 1875) by Facundo *et al*. (1999); *Cyclocephala melanocephala* (Fabricius, 1775) by Rodrigues *et al*. (2018); and *Cyclocephala distincta* Burmeister, 1847, by Nóbrega *et al*. (2022). Several antennal sensilla were described by Meinecke (1975) and Keil (1999) in the antennae of adults of Scarabaeidae, which were associated with the detection of volatiles released by plants (Larsson *et al*. 2001) or detection of sexual pheromones (Leal & Mochizuki 1993; Kim & Leal 2000).

Antennal sensilla have crucial functions related to the various activities developed by adults of Scarabaeidae (Schneider 1964; Leal 1998). Few studies have been conducted on antennal sensilla for the genus *Cyclocephala*, such as the research with *C. literata* performed by Nagamine *et al*. (2022) and *C. putrida* Burmeister, 1847 developed by Saldanha *et al*. (2020). Given the richness of *Cyclocephala* species in the Neotropical region, associated with the scarcity of information about the antennal sensilla present in the antennae of adults, this study aimed to identify the antennal sensilla of the species *Cyclocephala forsteri* Endrodi, 1963, *Cyclocephala melanocephala* and *Cyclocephala tucumana* Brethes, 1904.

MATERIAL AND METHODS

The research was conducted at the University Unit of Cassilândia, Universidade Estadual de Mato Grosso do Sul (UEMS), in Cassilândia, Mato Grosso do Sul (MS), Brazil. Adult specimens of *C. forsteri*, *C. melanocephala* and *C. tucumana* were collected between September and December 2021 using a Luiz de Queiroz light trap positioned adjacent to a pasture area where *Urochloa decumbens* (Stapf) R.D. Webster grass was present. To identify the species, comparisons were made with preserved insects from the Scarabaeidae collection at the Laboratory of Entomology, Universidade Estadual de Mato Grosso do Sul (UEMS), Cassilândia, MS, Brazil.

Males and females were segregated based on the identification of adults, achieved by observing the presence of dilated pre-tarsomeres in the males. Following this, the adult specimens were preserved in 70% alcohol. The antennae were carefully extracted from ten specimens, and the lamellae (including the proximal, medial, and distal) were employed to acquire scanning electron microscopy (SEM) images. These SEM images were captured at the Department of Physics and Chemistry, Universidade Estadual Paulista (UNESP), located on the Ilha Solteira campus in SP, Brazil.

We followed the method outlined by Tanaka *et al*. (2006) to obtain the SEM images. Lamellae from ten male and ten female specimens were initially stored in 70% alcohol. Subsequently, they underwent a dehydration process, which involved immersing them in 80% and 90% ethanol solutions for 15 min. each, followed by complete dehydration in 100% ethanol for 20 min.. Afterward, they were subjected to drying using Leica™ CPD300 equipment at a critical CO_2 point.

To enhance the images, the specimens were metalized in a gold bath and then photographed using a Zeiss™ EVO LS15 SEM. The SEM images obtained underwent further refinement using image enhancement filters available in the Image-Pro Plus 6.0 software. The terminology used to categorize antennal sensilla was adopted from Keil (1999).

The quantification of sensilla was carried out by analyzing the SEM images from the lamellae of six males and six females. Statistical analysis, specifically Student's t-test, was employed to compare the distribution of sensilla.

RESULTS

The antennae of adult *Cyclocephala* individuals consist scape, pedicel and eight flagellomeres in *C. forsteri* and *C. melanocephala*, seven flagellomeres in *C. tucumana*; and the lamellae is formed by flagellomeres 6-8 in *C. forsteri* and *C. melanocephala*, and flagellomeres 5-7 in *C. tucumana* (here were designate the flagellomere of lamellae as proximal, medial and distal) (Figure 1).

Upon examining the inner and outer surfaces of these lamellae after their separation into proximal, medial, and distal flagellomeres, distinct types of sensillae were observed. The outer surface of the proximal flagellomere of the lamella exhibits trichoid and chaetic sensillae (Figure 2). Trichoid sensillae are characterized by their elongated and slender structure, primarily located at the lateral margins of the lamellae. Other hand, chaetic sensillae, which are wider and shorter, are predominantly found in the central region of the outer surface of the proximal flagellomere of lamella.

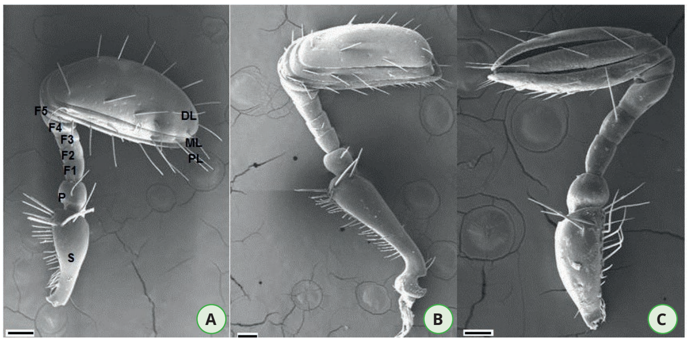

Figure 1. Antennae of *Cyclocephala* species: A) *Cyclocephala melanocephala* (Fabricius, 1775); B) *Cyclocephala forsteri* Endrodi, 1963; C) *Cyclocephala tucumana* Bretes, 1904. Legend: (S) scape, (P) pedicel, (F1-F5) funicle flagellomeres, (PL) proximal lamella, (ML) medial lamella, (DL) distal lamella. Scale = 200 µm.

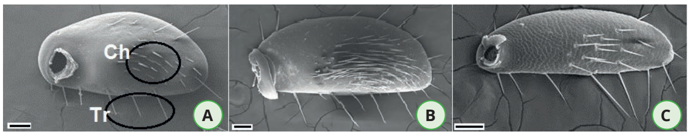

Figure 2. Outer proximal lamella of female *Cyclocephala* species: A) *Cyclocephala melanocephala* (Fabricius, 1775); B) *Cyclocephala forsteri* Endrodi, 1963; C) *Cyclocephala tucumana* Bretes, 1904. Legend: (Tr) Trichoid sensilla and (Ch) chaetic sensilla. Scale 100 µm.

The inner surfaces of the lamellae reveal the presence of placoid sensillae, which can be further classified into three types: type I, type II, and type III (Keil 1999). Type I placoid sensilla (Figures 3A-F), are circular or oval in shape and possess a smooth surface, occasionally displaying small holes or depressions. They occupy nearly the entire cavity within which they are situated and can vary in morphology. Type II placoid sensilla, are circular or oval and have a smooth surface without any notable surface irregularities (Figures 3G-H). Type III placoid sensilla, also possess a smooth surface and occupy the entire available space within the cavity where they are embedded (Figure 3I).

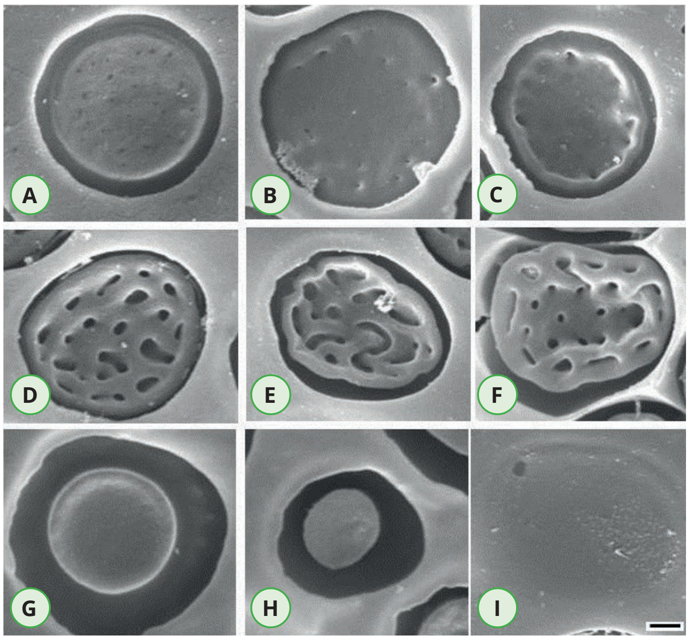

Figure 3. Sensillae in the lamellae of *Cyclocephala*. A-F) Type I; G-H) Type II; I) Type III placoid sensilla. Scale = 2 µm.

Furthermore, two types of coeloconic sensillae, type I and type II, were identified. These coeloconic sensillae are distributed on the inner surface of the proximal, medial, and distal flagellomeres of the lamellae in male and female specimens. Type I coeloconic sensillae, are characterized by their short length and acute apex (Figures 4A-B). In contrast, type II coeloconic sensillae, have a dilated apex (Figures 4C-D).

Basiconic sensillae were found in short quantities on lamellae (Figures 4E-F). Additionally, sensilla ampullacea (pores) was detected on the surfaces of the lamellae in *Cyclocephala* species (Figure 4G).

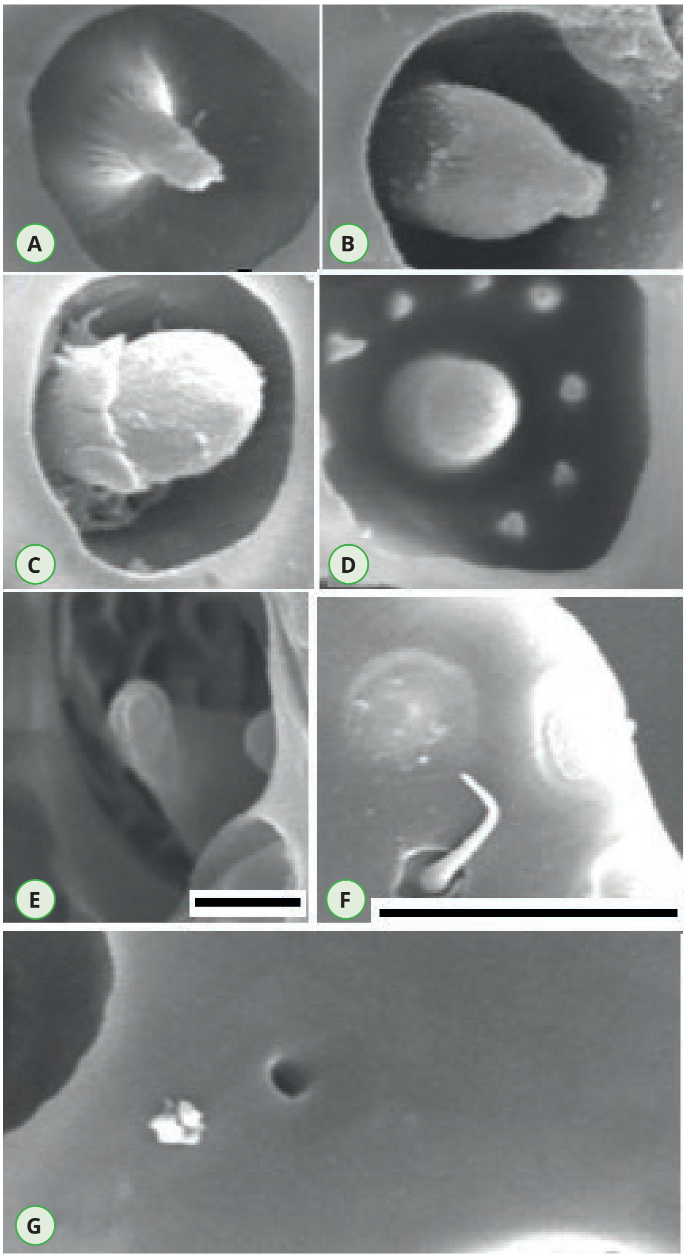

Figure 4. Sensillae in the lamellae of *Cyclocephala*. Coeloconic sensilla: A-B) Type I; C-D) and D) Type II; E-F) basiconic sensilla; G) ampullacea sensilla. Scale A-E, G = 2 µm, F = 20 µm.

Cyclocephala forsteri Endrodi, 1963

The comparison of female and male specimens revealed no statistically significant differences in terms of the length and width of the proximal, medial, and distal flagellomeres of the lamellae. Specifically, the following results were obtained: length of proximal flagellomere of the lamella (*t*=1.00; df=3; *P*<0.19) and width (*t*=1.06; df=2; *P*<0.20); length of medial flagellomere of the lamella (*t*=1.84; df=2; *P*<0.10) and width (*t*=0.22; df=2; P<0.42); length of distal flagellomere of the lamella (t=2.38; df=2; P<0.12) and width (*t*=0.39; df=2; *P*<0.38) (Table 1, Figure 5).

Regarding the dimensions of placoid sensillae, the average diameters were as follows for females and males: type I placoid sensilla: 7.70 ± 0.88 µm in females and 8.05 ± 1.36 µm in males; type II placoid sensilla: 5.19 ± 0.82 µm in females and 5.21 ± 0.76 µm in males; type III placoid sensilla: 9.62 ± 1.59 µm in females and 10.86 ± 1.42 µm in males.

In terms of the distribution of sensillae within the antennae, the following statistics were observed: female antennae contained a total of 5,457 sensillae, with the majority being type I placoid (97.62%), coeloconic (2.25%), and basiconic (0.13%); male antennae contained a total of 5,351 sensillae, with the majority being type I placoid (97.89%), coeloconic (1.87%), and basiconic (0.24%) (Table 2).

The inner surfaces of the lamellae displayed both homogeneous and heterogeneous areas. These areas were characterized by the presence of distinct types of sensillae, including type III placoid sensilla, types I and II placoid sensilla, and types I and II coeloconic sensilla (Figures 5 and 8).

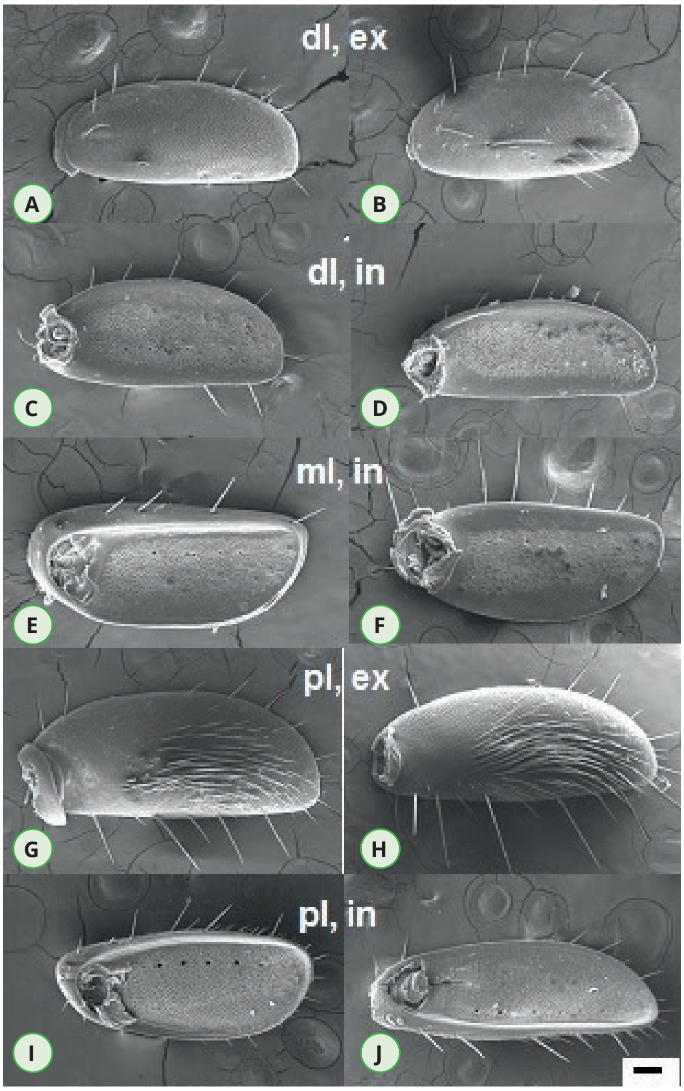

Figure 5. Antennal lamella of *Cyclocephala forsteri* Endrodi, 1963: A, C, E, G, I) left female lamellae; B, D, F, H, J) right male lamellae. Legend: (dl) distal flagellomere of lamella; (ex) outer surface; (in) inner surface; (ml) medial flagellomere of lamella; (pl) proximal flagellomere lamella. Scale = 100 µm.

Cyclocephala melanocephala (Fabricius, 1775)

No statistically significant differences were observed between females and males in terms of the length and width of the proximal, medial, and distal flagellomeres of the lamellae, as indicated by the following statistical results: length of proximal flagellomere of the lamella (*t*=0.40; df=11; *P*<0.34) and width (t=*1*.09; df=4; *P*<0.16); length of medial flagellomere of the lamella (*t*=0.06; df=7; *P*<0.47) and width (*t*=0.57; df=3; *P*<0.30); length of distal flagelommere of the lamella (*t*=0.46; df=5; *P*<0.33) and width (*t*=1.66; df=6; *P*<0.07) (Table 1, Figure 6).

Regarding the dimensions of the placoid sensillae, the following average diameters were observed in females and males: type I placoid sensilla: 7.91 ± 1.47 µm in females and 7.78 ± 1.30 µm in males; type II placoid sensilla: 8.54 ± 0.92 µm in females and 8.40 ± 1.16 µm in males; type III placoid

Table 1. Length and width of antennal lamellae in *Cyclocephala forsteri* Endrodi, 1963, *Cyclocephala melanocephala* (Fabricius, 1775) and *Cyclocephala tucumana* Bretes, 1904 (Coleoptera: Scarabaeidae).

	Length (µm)		**Width (µm)**	
C. forsteri	**Female**	**Male**	**Female**	**Male**
Proximal lamella	1,046.29±31.58a	1,069.44±19.64a	444.44±39.28a	388.88±62.85a
Medial lamella	990.74±36.98a	1055.55±39.28a	430.55±58.93a	416.66±62.85a
Distal lamella	896.29±6.4a	930.55±19.64a	397.22±3.93a	402.77±19.64a
C. melanocephala	**Female**	**Male**	**Female**	**Male**
Proximal lamella	791.15±63.20a	805.31±61.67a	378.25±12.80a	370.64±5.47a
Medial lamella	755.42±57.17a	752.61±70.70a	340.57±28.94a	323.18±43.55a
Distal lamella	772.16±9.52a	762.15±52.00a	347.82±19.11a	326.08±17.75a
C. tucumana	**Female**	**Male**	**Female**	**Male**
Proximal lamella	664.81±33.33b	910.86±15.36a	255.55±31.42a	200.95±38.24a
Medial lamella	602.46±47.62b	841.3±64.55a	212.96±2.61a	199.95±43.04a
Distal lamella	571.29±17.20b	740.74±12.38a	177.75±36.66a	190.73±7.85a

sensilla: 8.58 ± 1.03 µm in females and 8.78 ± 0.82 µm in males.

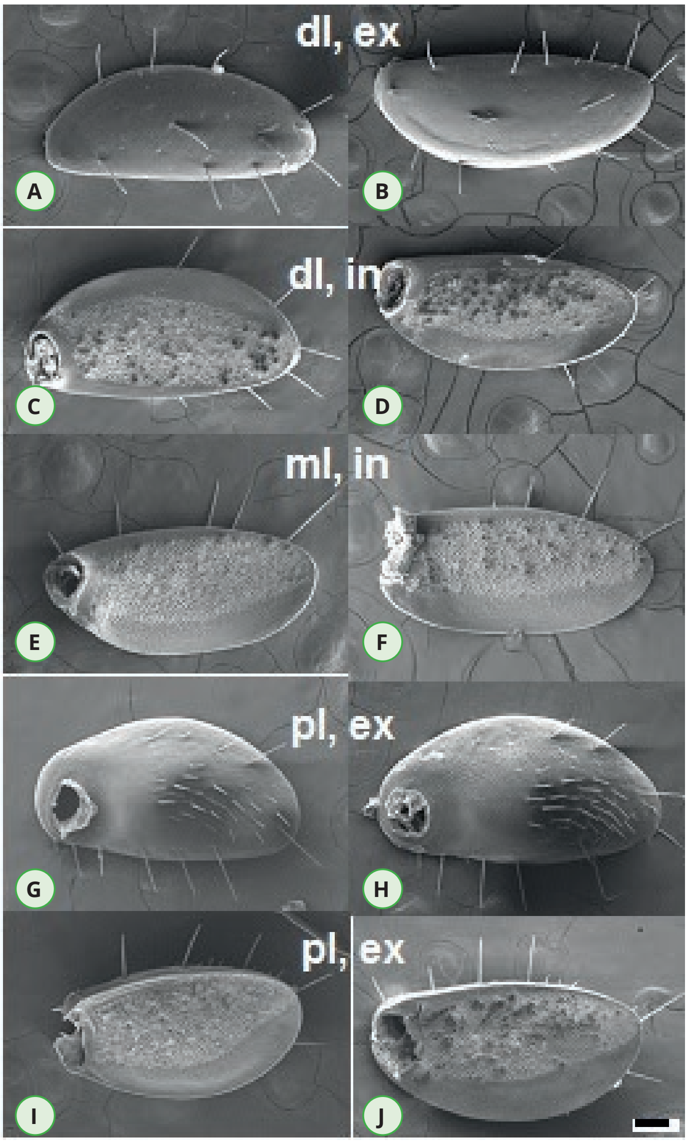

Figure 6. Antennal lamella of *Cyclocephala melanocephala* (Fabricius, 1775): A, C, E, G, I) left female lamellae; B, D, F, H, J) right male lamellae. Legend: (dl) Distal lamella; (ex) outer side; (in) inner side; (ml) medial lamella; (pl) proximal lamella. Scale = 100 µm.

In terms of the sensillae distribution within the antennae, the following statistics were observed: female antennae had a total of 6,814 sensillae, with the majority being type I placoid (96.581%), coeloconic (3.39%) and basiconic (0.03%); male antennae had a total of 6,333 sensillae, with the majority being type I placoid (95.11%) and coeloconic (4.89%) (Table 2).

The inner surfaces of the lamellae displayed a combination of homogeneous and heterogeneous areas. These areas were characterized by the presence of distinct types of sensillae, including type III placoid sensilla, types I and II placoid sensilla, and types I and II coeloconic sensilla (Figures 6 and 8).

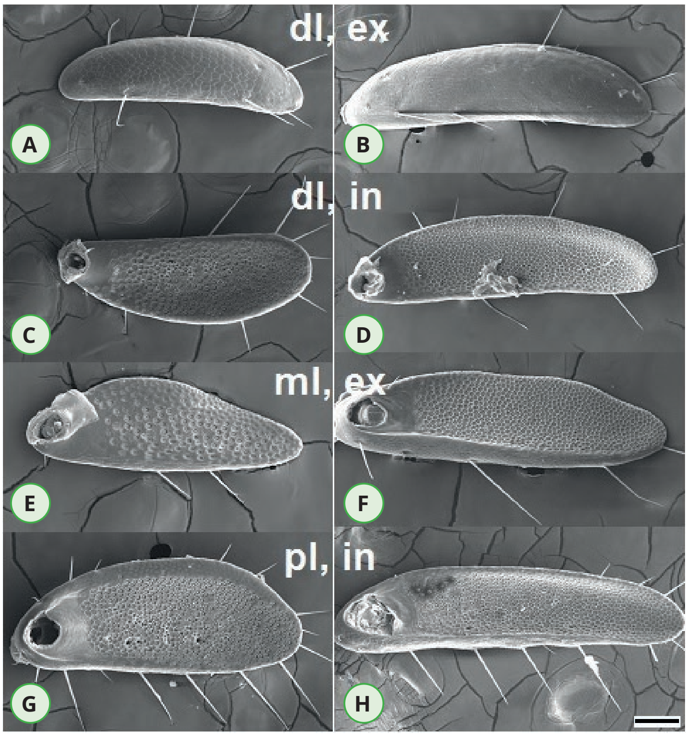

Figure 7. Antennal lamella of *Cyclocephala tucumana* Bretes, 1904: A, C, E, G) left female lamellae; B, D, F, H) right male lamellae. (dl) distal flagellomere of lamella; (ex) outer surface; (in) inner surface; (ml) medial flagellomere of lamella; (pl) proximal flagellomere of lamella. Scale = 100 µm.

Cyclocephala tucumana Brethes, 1904

Significant differences were observed between male and female specimens in terms of the length of the proximal, medial, and distal flagellomeres of the lamellae. Here are the specific statistical results: length of proximal flagellomere of the lamella (t=12.36; df=4; P<0.0001), but no significant differences were found for width (t=1.55; df=2; P<0.13); lenght of medial flagellomere of the lamella (t=4.48; df=2; P<0.02), but no significant differences were observed for width (t=0.42; df=2; P<0.37); length of distal flagellomere of the lamella (t=19.69; df=3; P<0.0001), but no significant differences were observed for width (t=0.49; df=2; P<0.36) (Table 1 and Figure 7).

Table 2. Number of sensillae in the lamellae of *Cyclocephala forsteri* Endrodi, 1963, *Cyclocephala melanocephala* (Fabricius, 1775) and *Cyclocephala tucumana* Bretes, 1904 (Coleoptera: Scarabaeidae) females and males.

Sensilla type Outer	Proximal lamella		Medial lamella		Distal lamella		Total
	Inner	Outer	Inner	Outer	Inner		
C. forsteri				**Female**			
Placoid	0	1,348	1,026	1,470	0	1,483	5,327
Coeloconic	0	52	8	38	0	25	123
Basiconic	0	0	0	2	0	5	7
Total	**0**	**1,400**	**1,034**	**1,510**	**0**	**1,513**	**5,457**
				Male			
Placoid	0	1,426	879	1,466	0	1,467	5,238
Coeloconic	0	42	14	26	0	18	100
Basiconic	0	7	2	0	0	4	13
Total	**0**	**1,475**	**895**	**1,492**	**0**	**1,489**	**5,351**
C. melanocephala				Female			
Placoid	0	1,513	1,805	1,697	0	1,566	6,581
Coeloconic	0	84	27	53	0	67	231
Basiconic	0	2	0	0	0	0	2
Total	**0**	**1,599**	**1,832**	**1,750**	**0**	**1,633**	**6,814**
				Male			
Placoid	0	1,403	1,686	1,531	0	1,403	6,023
Coeloconic	0	77	69	103	0	61	310
Basiconic	0	0	0	0	0	0	0
Total	**0**	**1,480**	**1,755**	**1,634**	**0**	**1,464**	**6,333**
C. tucumana				**Female**			
Placoid	0	851	330	226	0	438	1,845
Coeloconic	0	61	17	7	0	42	127
Basiconic	0	5	1	0	0	3	9
Total	**0**	**917**	**348**	**233**	**0**	**483**	**1,981**
				Male			
Placoid	0	747	815	1,096	0	998	3,656
Coeloconic	0	51	7	9	0	32	99
Basiconic	0	0	0	0	0	1	1
Total	**0**	**798**	**822**	**1,105**	**0**	**1,031**	**3,756**

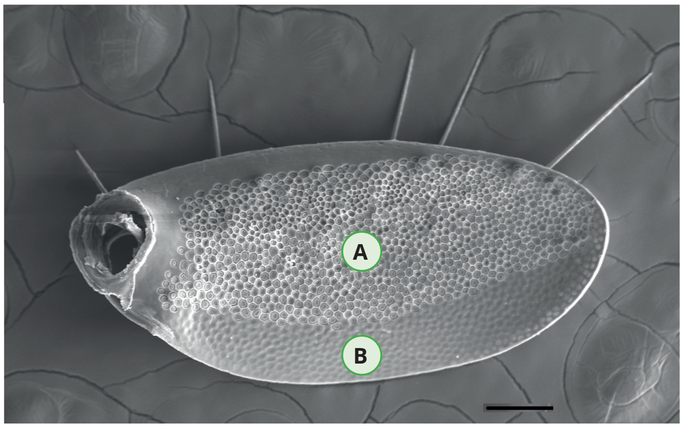

Figure 8. Medial flagellomere of lamella of *Cyclocephala melanocephala* (Fabricius, 1775): A) heterogeneous areas; B) homogeneous areas. Scale = 100 µm.

Regarding the dimensions of placoid sensillae, the average diameters in females and males were as follows: type I placoid sensilla: 7.68 ± 1.39 µm in females and 6.52 ± 1.14 µm in males; type II placoid sensilla: 6.0 ± 1.95 µm in females and 5.34 ± 0.57 µm in males; type III placoid sensilla: 10.07 ± 1.38 µm in females and 9.40 ± 1.98 µm in males.

In terms of the distribution of sensillae within the antennae, the following statistics were observed: female antennae contained a total of 1,981 sensillae, with the majority being type I placoid (93.13%), coeloconic (6.42%) and basiconic (0.45%); male antennae contained a total of 3,756 sensillae, with the majority being type I, II and III placoid (97.34%), coeloconic (2.64%) and basiconic (0.02%) (Table 2).

Interestingly, the inner surface of medial and proximal flagellomeres of the lamellae of females exhibited both homogeneous and heterogeneous areas, while the inner surface of medial and proximal flagellomeres of the lamellae of males showed predominantly a heterogeneous area (Figure 7).

DISCUSSION

Studies conducted in Midwest Brazil have allowed the description of *C. melanocephala* population dynamics by observing adults swarming from September to October and in February, while *C. tucumana* swarms from September to November (Nogueira *et al*. 2013) and *C. forsteri* swarms from October to January (Santos & Ávila 2007). The swarming period of adults must coincide with that most suitable for their survival, which is mainly linked to favorable environmental conditions (Nogueira *et al*. 2013). Shao *et al*. (2019) described that the coeloconic sensillae on the antennae pedicels of *Maladera orientalis* (Motschulsky, 1857) (Coleoptera: Scarabaeidae) have hygroreceptor and thermoreceptor functions for perception of environmental changes of humidity and temperature, respectively. However, Kim & Leal (2000) and Ochieng *et al*. (2002) reported that coeloconic sensillae would be related to detection of plant volatiles.

Our findings showed that coeloconic sensillae are present in small quantities in the lamellae of *C. forsteri* females (123; 2.25%) and males (100; 1.87%); *C. melanocephala* females (231; 3.39%) and males (310; 4.89%); *C. tucumana* females (127; 6.42%) and males (99; 2.64%). Overall, the main function of these sensillae is detecting information related to adult survival (Romero-López *et al*. 2004; Shao *et al*. 2019).

The swarming of *C. forsteri*, *C. melanocephala*, and *C. tucumana* adults occurs during their active foraging for food sources, such as flowers of plant species. Adults of *C. forsteri* are mainly associated with *Acrocomia aculeata* (Jacq.) Lodd. ex Mart. (Arecaceae) (Oliveira & Ávila 2011); while adults of *C. melanocephala* are associated with sunflower (*Helianthus annuus* L., Asteraceae) (Camargo & Amabile 2001), passion fruit (Dias & Rodrigues 2018), and *Cereus peruvianus* (L.) Mill. (Cactaceae) (Silva & Sazima 1995); however, the adults of *C. tucumana* are related to passion fruit (Dias & Rodrigues 2018). Therefore, plant species may release chemical compounds that are attractive and can be detected by Scarabaeidae adults, as described by Stensmyr *et al*. (2001), Ruther (2004), and Ruther & Mayer (2005).

Numerous factors were investigated concerning the foraging behavior of adult *Cyclocephala* beetles when they locate plant species for feeding, including copulation behavior, which takes place on these plants. In this sense, formation of mating pairs and copulation events have been observed on plant species that are attractive to adult *Cyclocephala* beetles (Gottsberger *et al*. 2012; Maia *et al*. 2013; Favaris *et al*. 2020). The steps associated with the copulation behavior of adult *Cyclocephala* beetles encompass multiple sequences, one of which involves active identification between adults, mediated by the potential compounds released by them. In this context, Saldanha *et al*. (2020) revealed that mating pairs of *C. putrida* can form following acceptance by females, but some females may reject males for copulation, suggesting a chemical identification process. Fávila (1988) investigated the copulation behavior of *Canthon cyanellus cyanellus* Le Conte, 1859 (Coleoptera: Scarabaeidae) and observed active mate selection among adults, underscoring their chemical identification mechanisms.

Copulations among adult individuals are likely facilitated by the release of sexual pheromones, a phenomenon documented in certain Scarabaeidae species, such as *Oryctes elegans* (Prell, 1914) (Rochat *et al*. 2004), *Phyllophaga cuyabana* (Moser, 1918) (Zarbin *et al*. 2007), and *Dasylepida ishigakiensis* (Niijima & Kinoshita, 1927) (Wakamura *et al*. 2009).

Studies have provided evidence that placoid sensillae located in the antennal lamellae are associated with the detection of sexual pheromones, as observed in *Anomala cuprea* (Hope, 1839) (Leal & Mochizuki 1993); *Phyllopertha diversa* Waterhouse, 1875 (Nikonov *et al*. 2001); and *Popillia japonica* Newman, 1841 (Kim & Leal 2000). Nevertheless, it is noteworthy that placoid sensillae in adults of *A. cuprea* are believed to serve a dual function in detecting both sexual pheromones and plant volatiles (Larsson *et al*. 2001).

The examination of placoid sensillae in various species, including *C. forsteri* females (5,327; 97.62%) and males (5,238; 97.89%); *C. melanocephala* females (6,581 sensilla; 96.58%) and males (6,023; 95.11%); and *C. tucumana* females (1,845; 93.13%) and males (3,656; 97.34%), suggests that these sensilla likely play crucial roles in chemical detection and identification among adults, particularly in mediating the steps associated with copulation behavior.

Another vital function attributed to antennal sensillae is detection of suitable oviposition sites by females, which is crucial for the development of immature stages. The choice of an appropriate oviposition site is intricately linked to the successful development of these immature stages. In some *Cyclocephala* species, immature stages have been found feeding and developing within roots of economically significant cultivated plant species (Santos & Ávila 2007; Coutinho *et al*. 2011).

Coutinho *et al*. (2011) documented instances of *C. forsteri* and *C. verticalis* developing and causing damage in commercial sugarcane areas. Santos & Ávila (2007) reported damage inflicted by *C. forsteri* in commercial areas dedicated to soybean cultivation. Aragón-García & Morón (2000) noted the presence of *Cyclocephala lunulata* Burmeister, 1847, associated with sugarcane cultivation in Mexico, while Gordon & Anderson (1981) recorded the occurrence of *Cyclocephala parallela* Casey, 1915, in sugarcane crops in Florida, USA.

Whit respect the basiconic sensillae, even in smaller quantities sampled in the lamellae, may also be related to the detection of plant volatiles present in the environment (Romero-López *et al*. 2004).

As demonstrated, the sensillae found in adults of Scarabaeidae serve essential functions that contribute to the successful development and persistence of these species. Herein, we identified ampullacea, chaetic, coeloconic, placoid and trichoid sensillae. These findings align with previous research conducted by Renou *et al*. (1998), Bohacz *et al*. (2020), Saldanha *et al*. (2020), and Nagamine *et al*. (2022), which have described ampullacea, basiconic, chaetic, coeloconic, placoid and trichoid antennal sensillae in species belonging to the subfamily Dynastinae, including *Adoryphorus coulonii* (Burmeister, 1847); *C. literata*; *Cyclocephala putrida* Burmeister, 1847; *Oryctes nasicornis* (L., 1758); *Oryctes rhinoceros* (L., 1758); *Phyllognathus excavatus* (Forster, 1771); and *Temnorhynchus coronatus* (Fabricius, 1781). Our results contribute to understanding of antennal sensillae in Dynastinae species.

In the case of *C. melanocephala*, females exhibited a higher number of antennal sensillae compared to males, whereas in *C. tucumana*, males had a greater quantity of antennal sensillae compared to females. This finding confirms the presence of sexual dimorphism in antennal sensillae in these two species. However, *C. forsteri* did not show any differences in the number of antennal sensillae between males and females. Notably, adults of *Hoplopyga liturata* (Olivier, 1789) and *Hoplopyga albiventris* (Gory & Percheron, 1833) had higher quantities of sensilla in males, as reported by Costa *et al*. (2021). Similarly, males of *D. ishigakiensis* exhibited higher quantities of sensilla, indicating sexual dimorphism in their antennae, as documented by Tanaka *et al*. (2006). In line with this, Kim & Leal (2000) proposed that sexual dimorphism in antennae may be associated with the detection of sexual pheromones. It is plausible that the sensilla of males play a crucial role in detecting sexual pheromones, typically emitted by females of the species.

According to the results presented, our findings significantly contribute to the understanding of antennal sensillae in *Cyclocephala* species and shed light on their functions in the adults of the studied species.

AUTHORS CONTRIBUTION

All authors contributed to the study conception and design, ASC: obtaining scanning electron microscopy images, ASC: initial writing and statistical analysis, SRR: Final writing and analysis of metadata, SRR: Revision and final writing of the article.

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CONFLICT OF INTEREST STATEMENT

The authors of this article declare that there is no conflict of interest.

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