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## Architecture and disposition of orbicular webs of the spider *Verrucosa arenata* (Walckenaer 1841) on tropical rain forest edges in Southeastern, Brazil with notes on species Biology

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### Abstract

This work aimed to: (1) map the location of webs of the spider *Verrucosa arenata* (Walckenaer 1841) (Arachnida: Araneida) along transect (dirty road) in the edges of a rainforest in SE Brazil, (2) estimate the density of webs and their spatial orientation in relation to forest border, and (3) correlate the presence/density of webs with solar radiation intensity. The species were chosen because its relative abundance in the study area and total absence of studies in Brazil. In 2010-2011 we studied 48 individuals (46 females and 2 males) of *V. arenata*, with spider number having a strong increase in the beginning of autumn 2011, coincident with the peak of flowering and insect activity. Most webs of *V. arenata* were located mainly in the last three kilometers of the road where the measured solar radiation was lesser than that the six initial kilometers. Webs were oriented between 15° and 290°.

**Keywords:** Araneidae, Atlantic Forest, ruderal environment, foraging tactics.

### Resumo

Este trabalho objetivou: (1) mapear a localização de teias da aranha *Verrucosa arenata* (Walckenaer 1841) (Arachnida: Araneida) ao longo de um transecto (estrada de terra) na borda de uma floresta pluvial no sudeste do Brasil, (2) estimar a densidade das teias e sua distribuição espacial e orientação em relação à borda da floresta e (3) correlacionar a presença/densidade das teias com a intensidade de radiação solar. A espécie foi escolhida porque é relativamente abundante na área de estudo e por não ter sido estudada no Brasil. Em 2010 e 2011 estudamos 48 indivíduos (46 fêmeas e 2 machos) de *V. arenata*. O número de aranhas aumentou muito no início do outono de 2011, coincidindo com o pico da floração e da atividade de insetos. A maior parte das teias de *V. arenata* estava localizada nos três últimos quilômetros da estrada onde a radiação solar medida foi menor do que nos seis quilômetros iniciais. As teias estavam orientadas entre 15° e 290°.

**Palavras-chave:** Araneidae, Floresta Atlântica, ambiente ruderal, táticas de forrageamento.

### 1. Introduction

Spiders are mainly predatory animals that are present in almost all terrestrial biomes<sup>[1]</sup>. Orb web spiders are passive sit-and-wait predators, but the construction of a web is time consuming and the choice of a good place is crucial to optimize prey return.

Orbicular webs have by radial threads produced by ampullacea silk glands and spiral threads produced by flagelliforme and aggregated glands<sup>[2,3]</sup>.

The webs of the species *V. arenata* are common in forest edges and gardens where they build them every day in the morning when the weather conditions are favorable<sup>[4]</sup>.

The vegetation of edges of forests is structurally simpler than the forest interior and creates habitats for several flowering plant species, which are attractive to different insect species that are potential prey for spider species. But anthropogenic impacts can eliminate species whose individuals have a small dispersal ability. Indeed, this system is in constant modification and climax is rarely reached. Therefore, ruderal species were selected to survive in this changing environment<sup>[5]</sup>. The present study aimed to: (1) map the location of webs of the spider *Verrucosa arenata* (Walckenaer 1841) (Arachnida: Araneida) along a transect in the edges of a rainforest in SE Brazil, (2) estimate the density of webs and their spatial orientation in relation to forest border, and (3) correlate the presence/density of webs with solar radiation intensity.

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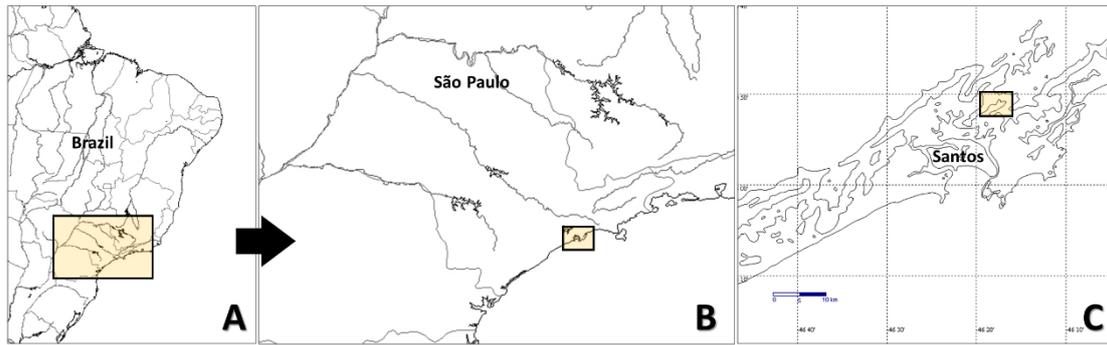
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## 2 Materials and Methods

### 2.1 Study area

Webs of *V. arenata* were relatively common along the edges of a dirty road in Quilombo river valley, Santos, SP, Brazil

(23°51'S, 46°21'W) (Figure 1). This road has 8,600 m length with ruderal edge vegetation in the open areas and secondary forest in shaded areas (see [6] for details).



**Fig 1:** Location of the study area in the Valley of river Quilombo in the Metropolitan Region of Baixada Santista (C), state of São Paulo (B), and Brazil (A)

The species was identified according to Levi [7]. Females of *V. arenata* are easily identified in field by their characteristic white or yellow triangular shaped mark on the abdomen. Voucher material will be deposited at Museu de Zoologia Adão José Cardoso of Instituto de Biologia da Universidade Estadual de Campinas (ZUEC).

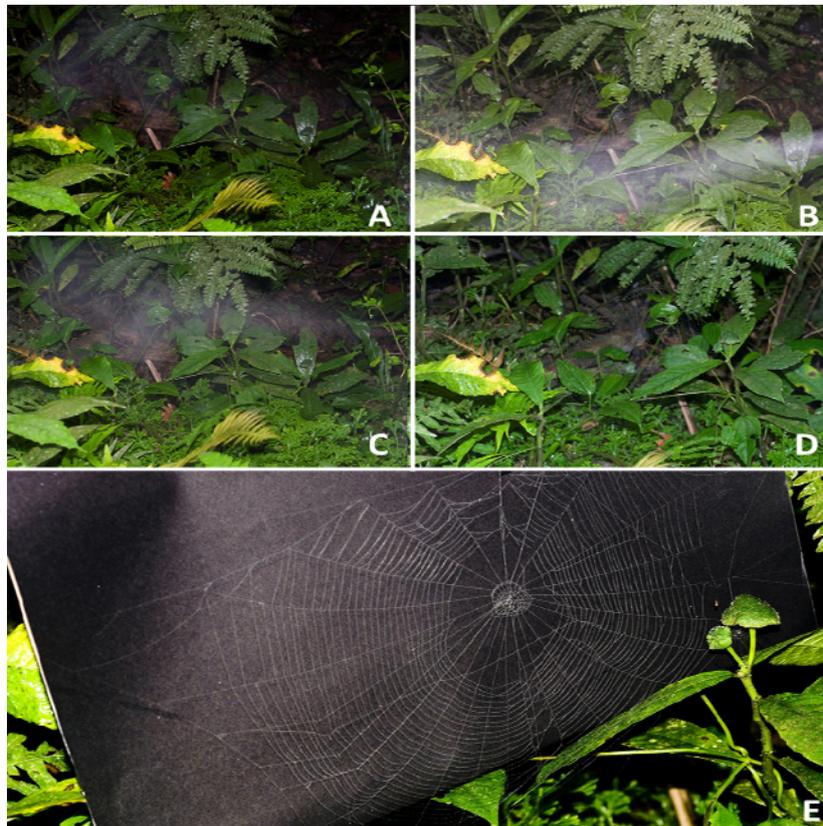
Road edges have width varying from a few centimeters to five meters being submitted to anthropogenic impacts by hand cleaning, or more infrequently, by use of fire.

### 2.2 Field work

We made the observations from August 2010 to January 2012 on 14 different sampling points along the road between 0800h and 1200h measuring the width and length of web (cm), its height above ground (in classes of 50 cm) and its orientation in relation to the road (azimuth in degrees). We made

photographs of the canopy openness at each 100 m along the road using a digital camera with a fisheye lens. Data of canopy openness were transformed in solar radiation units ( $W/m^2$ ) and used in the quantification of potential solar radiation at each segment of 500 m using software GLA (Gap Light Analyser; <http://www.ecostudies.org/gla/>).

We also made photos of all interesting aspects of the web and finally collected the spider, which was preserved in ethanol 90%. We began using water spraying to increase the visibility of the web but later we used a hair spray soon substituted by a black automotive acrylic resin paint (Xrow Colormax Premium®) aspersed on the web which were quickly glued to a rectangular white carton (Figure 2). Later, the mounting was photographed to produce a detailed drawing of the web transforming the color image into black and white through the threshold option.



**Fig 2:** (A-E) Steps of the spraying a web of *V. arenata* web for a better visualization

### 2.3 Data analysis

We tabulated data using Microsoft Office Excel 2007. An analysis was made using R software v. 3.02 win [8]. We used package circular v. 0.4-7 [9] for circular statistics with the Rayleigh Test of Uniformity to verify if webs were oriented according to a specific pattern. Two-sided T test was used to compare the averages of data from the first six kilometers with the averages from segments of last three kilometers where most webs were found.

The size of spiders were estimated measuring the area of the triangular shaped mark on their dorsum (height x width / 2).

### 3. Results and discussion

48 individuals of *V. arenata* were studied from winter 2010 to autumn 2011 totaling 46 females and 2 males. Size of female spiders (see methodology) ranged from 0.55 to 43.55 mm<sup>2</sup> (median = 9.37 mm<sup>2</sup>; n = 38; Figure 3).

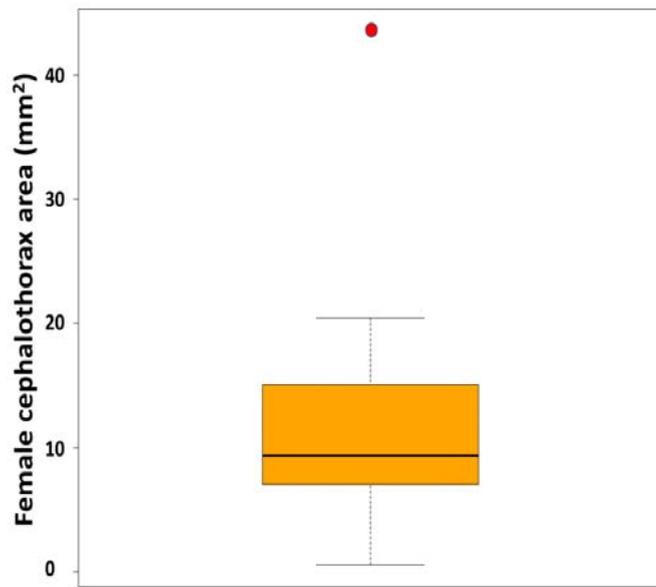


Fig 3: Female cephalothorax area (mm<sup>2</sup>) of *V. arenata* web

Spider population increased exponentially from March 2011 (Figure 4) coinciding with the peak of flowering and insect activity.

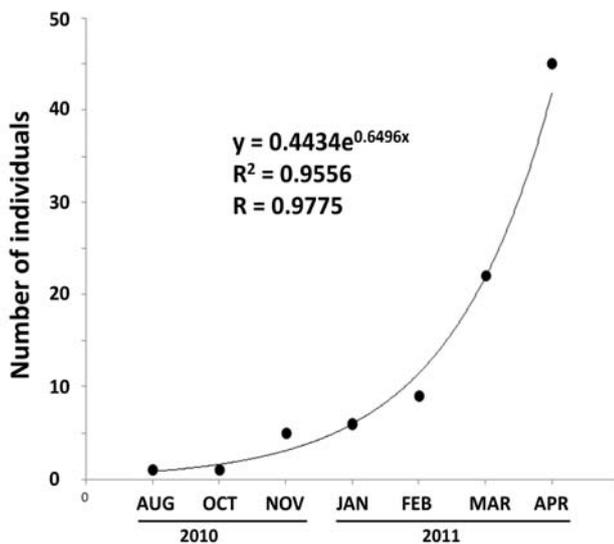


Fig 4: Increase in *V. arenata* population with the sampling effort

The webs of *V. arenata* were usually vertical, typically with an open hub slightly displaced toward the top frame (Figure 5). The sticky spiral was circular and covered an area limited to the length of the shortest radii in the web. Many webs had signs of damage and had been repaired (n = 13) and; others had large open holes, suggesting that the spider does not immediately replace a damaged web, but continues to use it through periodic renewal.

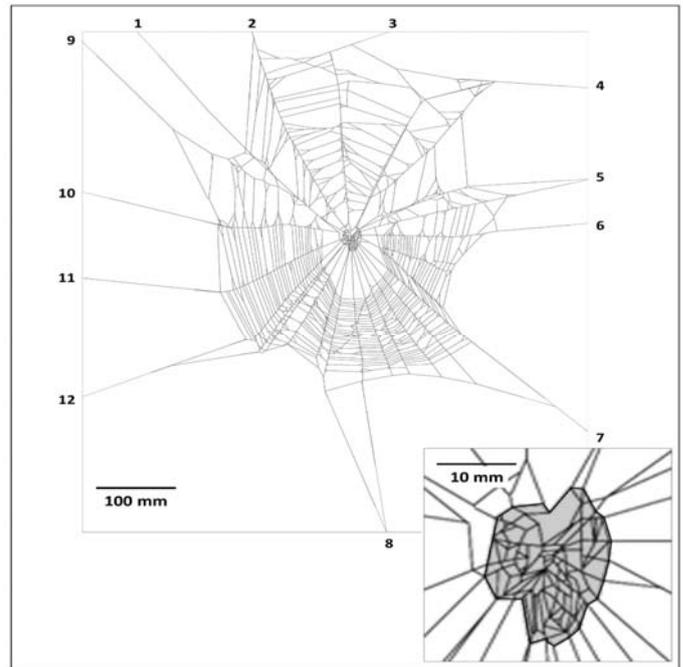
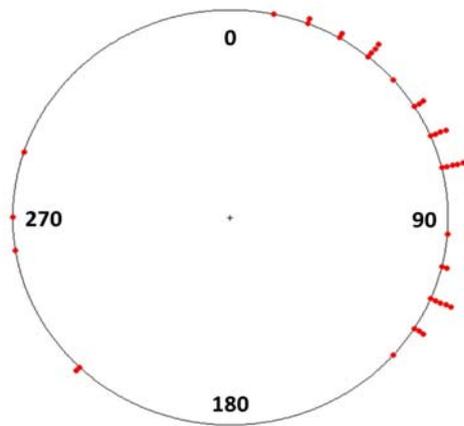


Fig 5: Shape of a web of *V. arenata* showing 12 radial mooring threads (see description in the text). Central hub detailed on bottom right.

Most webs (n = 30) presented an stabilimentum situated under the hub, with their width being smaller than three to four times the spider body, and their length equal or bigger than the spider body. Several threads, forming a compact conspicuous area (Figure 5), composed stabilimentum structure. However, stabilimenta function is unknown, as noted by some workers [10, 11, 12]. The amount of prey available in the environment for each species may determinate the number of web spirals [3]. Webs of *V. arenata* have an architecture distinct of other web spiders due the presence of central hub without radial threads. The free zone is larger under the hub than above it and the sticky spiral zone had a bigger density of adhesive threads (Figure 5).

Web traits which were measured (Table 1) showed strong variation probably due to the age and/or physiological condition of the spider.

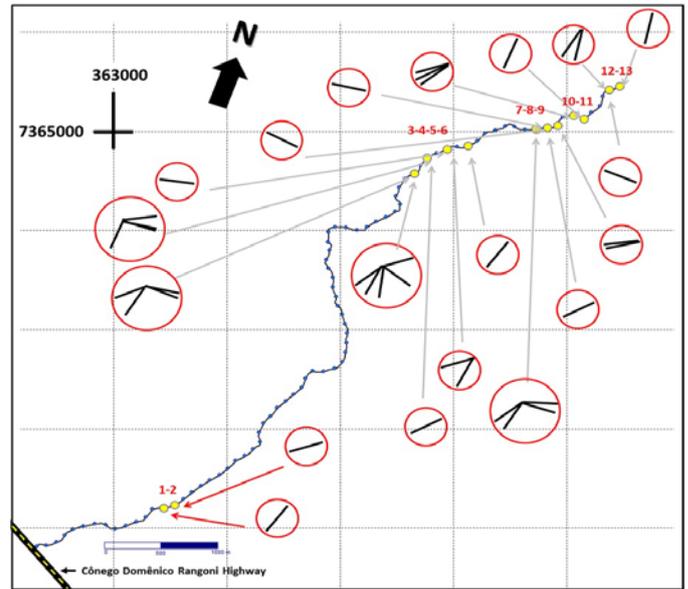
Web orientation varied between 15° and 290° (Mean = 74.21°; variance = 0.7796°; Median = 69°; Rayleigh test r = 0.6102; p = 0.00001) with most webs oriented to NE and SE directions (Figure 6).



**Fig 6:** Circular diagram of the orientation of webs of *V. arenata* showing the clustering of data between 40° and 130°

Circular correlation coefficient between web orientation and road orientation was low ( $r = 0.3049$ ;  $t = 1.9477$ ;  $p = 0.0590$ ). The difference of orientation of web in relation to road varied between 0 and 65° ( $n = 39$ ). Only 11 webs (28.0%) were positioned near parallel to the road ( $\pm 10^\circ$ ) indicating that webs were positioned to catch preys that were flying perpendicular to road. There was no preference for the positioning of the webs in the road edges, with 20 positioned at left side and 19 at right side ( $X^2 = 0.0256$ ;  $p > 0.05$ ). In addition, there was no correlation of the web area with the size of the spiders ( $R = 0.006$ ;  $p > 0.05$ ;  $n = 38$ ).

Most webs of *V. arenata* (95%) were located mainly in the last three kilometers of the road (Figure 7) where the measured solar radiation was lower (mean = 180.9 W/m<sup>2</sup>; sd = 76.79;  $n = 5$ ) than that the six initial kilometers (mean = 288.8 W/m<sup>2</sup>; sd = 40.91;  $n = 12$ ) ( $t = 3.8304$ ;  $p < 0.0016$ ). Although not quantified, the moisture in this environment was higher due to the presence of a more closed canopy.

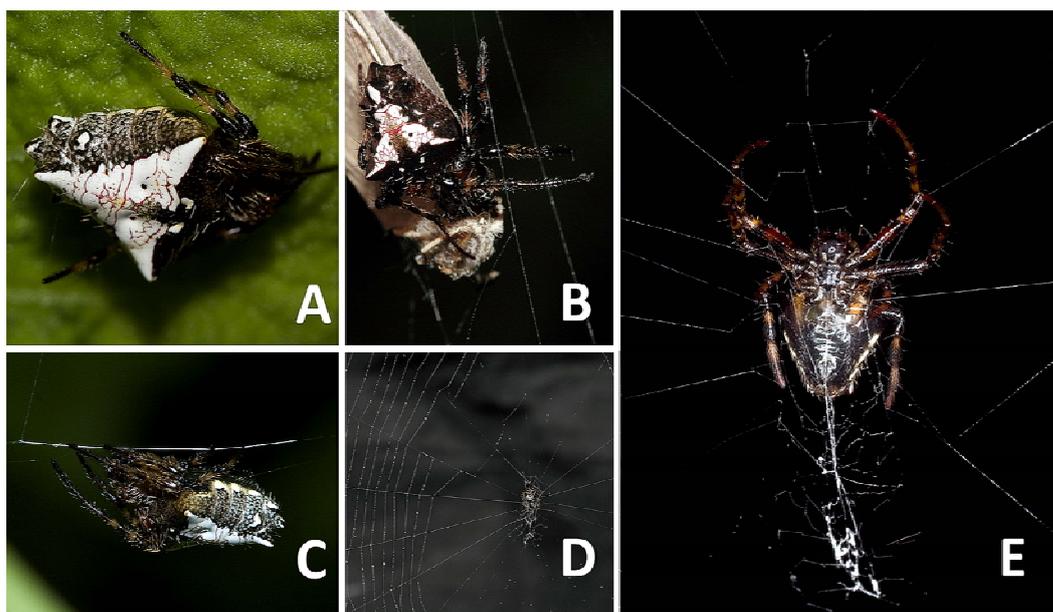


**Fig 7:** Dirty road along we made the study.

Each small blue circles were 100 m distant from each other. Yellow circles indicate the 13 points where we sampled webs. Points 3, 4, and 7 are more open or have corners. The black lines inside red circumferences show the orientation of the webs of *V. arenata* along both sides of the road. Coordinates shown at upper left are in UTM units

All females were ever observed in the center of web head up unlike those of other Araneidae<sup>[13]</sup> with the apex of the white or yellow triangular shaped mark pointing to the ground (Figure 8 A, B) and head up as yet observed by Zschokke and Nakata<sup>[14]</sup>. The position of spider in the center of web (Figure 8 D) optimizes the search for preys maximizing their catch.

When disturbed by mechanical movements the spider displaced itself from the hub for its shelter, which made with leaves and silk in one of the web superior extremities of the mooring threads (Figure 8 C). The spider preys insects, which can reach two times its size (Figure 8 B). It rolls the prey with a silk thread and, if it is out the center, the spider carries on to this position.



**Fig 8:** *Verrucosa arenata* females (A) showing the characteristic triangular drawing in the abdomen. (B) Eating a moth. (C) Displacing along horizontal thread to reach the refuge area. (D) Detail of the web visualized by water spraying against a black background. (E) Positioned on the hub showing the conspicuous stabilimentum below her body

#### 4. Conclusion

Our study increased the knowledge of *V. arenata* ecology because Levi <sup>[13]</sup> worked only with material from Mexico and east of United States.

#### 5. Acknowledgements

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