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ABUNDANCE IS RELATED TO SURFACE AREA AND SURFACE-AREA-TO-VOLUME RATIOS IN *CENTROBOLUS* COOK, 1897

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Abstract

I tested for relationships between male and female surface-area-to-volume ratios and abundance in red millipedes Centrobolus. Female surface areas appeared related to abundance (r=-0.63, Z score=-1.66, n=8, p<0.05). Male surface areas appeared related to abundance (r=0.63, Z score=1.66, n=8, p<0.05). There was no relationship between surface areas and abundance when the sexes were pooled (r=0.12, Z score=0.43, n=16, p=0.33). There was no relationship in species surface areas alone i. e. C. inscriptus (r=0, Z score=0, n=8, p=0.50) or C. anulatus (r=0, Z score=0, n=8, p=0.50).

Keywords: *Abundance, male, female*

INTRODUCTION

The forest genus of diplopods belonging to the Order Spirobolida found along the eastern coast of southern Africa was the subject of this study. The millipede genus Centrobolus is found in the temperate South African subregion, its northern limits on the east coast of southern Africa being about -17° latitude S. It occurs in all the forests of the coastal belt from the Cape Peninsula to Beira in Mocambique. While the coastal forests of the South-West and Eastern Cape are mist belt temperate forests, those of the Transkei, Natal, Zululand and Mocambique are somewhat different, being better described as East Coast Bush, they are developed almost entirely in a narrow strip of the litoral on a dune sand substratum, and are more tropical in aspect and composition than those to the west of them. There is a summer rainfall of 762-1016mm, a uniform temperature, and an absence of frost; the component trees of the coastal bush with their abundant creepers and lianes, while not usually reaching a height of more than 11 meters, provide a dense covering with abundant shade and humidity at ground level. As essentially shade-loving Diplopoda, the members of the genus are especially well represented in these littoral forests of the eastern half of the subcontinent (Lawrence, 1967). Members of the genus all have polygynandrous mating systems with sperm competition and cryptic female choice (Cooper, 2016; Cooper, 2017; Cooper, 2019).

MATERIALS AND METHODS

Two morphometric parameters were used to obtain measurements, length and width, both of which were obtained from the published literature (Cooper, 2018; Cooper, 2019; Lawrence, 1967; Schubart, 1966). Surface areas were calculated based on the formula for the same cylinder SA = 2πr(r+h) in *C. anulatus* Attems, 1934, and *C. inscriptus* Attems, 1928 (Cooper, 2019). The data were collected during the rainy season because in southern Africa millipede surface activity is strongly seasonal and related to feeding and reproduction (Dangerfield & Telford, 1991; Dangerfield et al. 1993) and this is also when population densities peak (Dangerfield, 1989). The two species of millipedes were sampled in their indigenous tropical coastal forest habitat at Twin Streams Farm, Mtunzini, South Africa (28°55'S; 31 °45'E). It is within this part of the typical coastal forest belt

(Acocks, 1975) that *C. anulatus* and *C. inscriptus* are in geographical sympatry. An area of forest with continuous tree canopy cover was delimited and all sampling occurred within those bounds. In the first season, two temporally separate sampling efforts were made. In the following season a single sampling effort involved hand collecting all individual millipedes on the ground and in shrubs and trees separately, with the former measured on the ground and the latter as in the trees (>30cm but <3m above ground surface). The two species were morphologically separated based upon the presence of yellow flashes, red legs, and red heads (*C. inscriptus*) vs. discrete red-black annulations without yellow flashes, black legs, and blackheads (*C. anulatus*). Over a period of three full days, the total numbers of each species collected were used to calculate the relative abundance of each species within the forest patch. Surface areas were relatedto volumes to get surface-area-to-volume ratios which were tested for correlations at https://www.gigacalculator.com/calculators/correlation-coefficient-calculator.php.

RESULTS

Female surface areas were related to abundance (Figure 1: r=-0.63046242, Z score=-1.65957221, n=8, p=0.04850025). Male surface areas were related to abundance (r=0.63046242, Z score=1.65957221, n=8, p=0.04850025). There was no relationship between surfaces and abundances when the sexes were pooled (r=0.11799121, Z score=0.42741424, n=16, p=0.33453885). There was no relationship between surface areas and abundance in *C. inscriptus* (r=0, Z score=0, n=8, p=0.50) or *C. anulatus* (r=0, Z score=0, n=8, p=0.50). Surface-area-to-volume ratios were related to abundance in males (Figure 3: r=-0.63046242, Z score=-1.65957221, n=8, p=0.04850025). Surface-area-to-volume ratios were related to abundance in males (Figure 4: r=-0.63046242, Z score=-1.65957221, n=8, p=0.04850025).

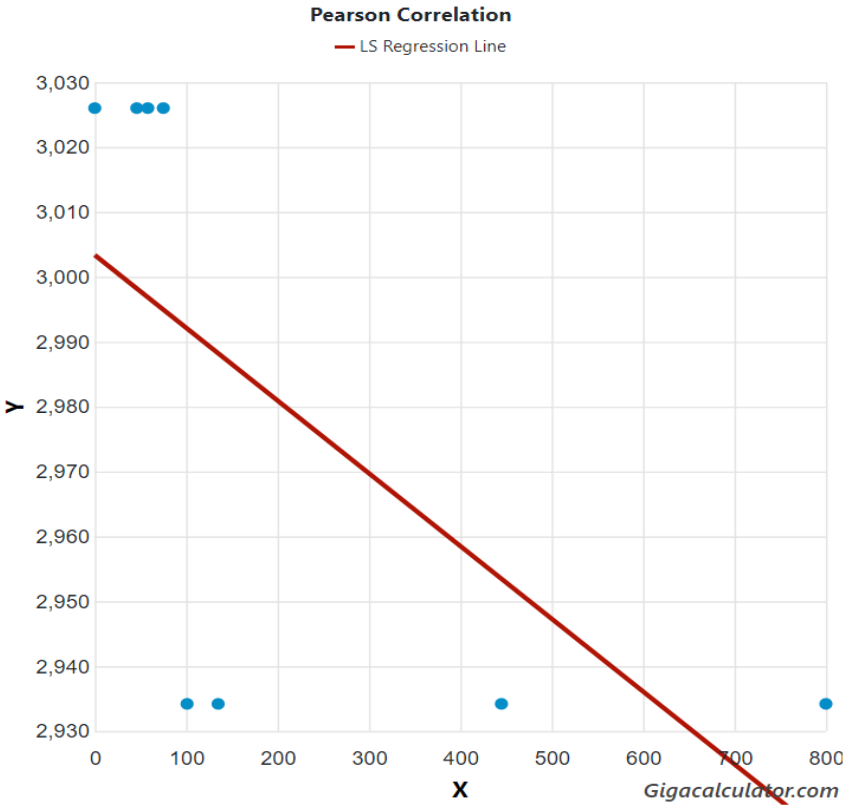

Figure 1. Relationship between female surface areas and abundance in two species of *Centrobolus* Cook, 1897.

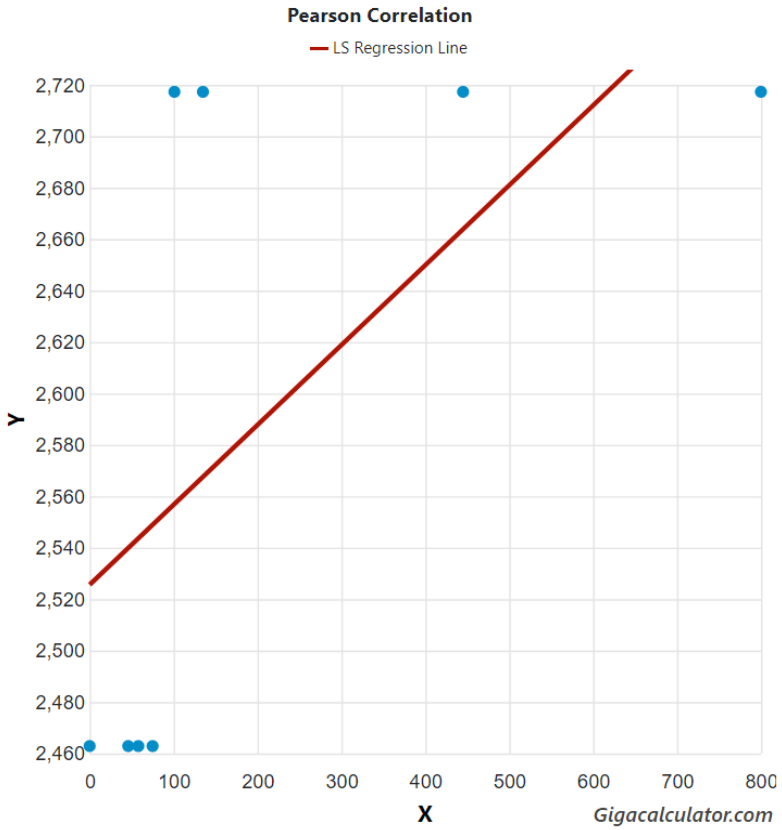

Figure 2. Relationship between male surface areas and abundance in two species of *Centrobolus* Cook, 1897.

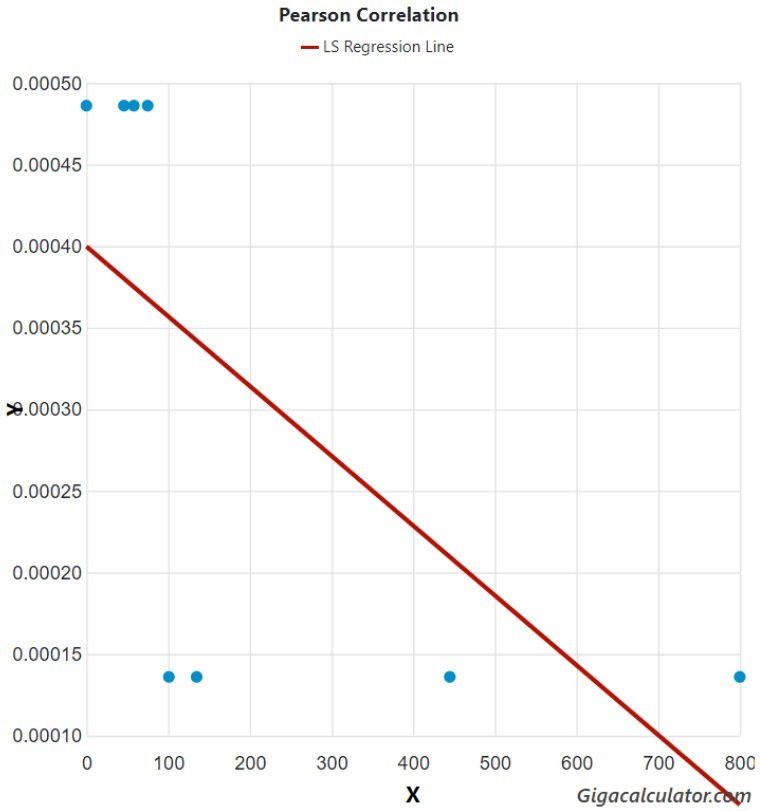

Figure 3. Relationship between male surface-area-to-volume ratio and abundance in two species of *Centrobolus* Cook, 1897.

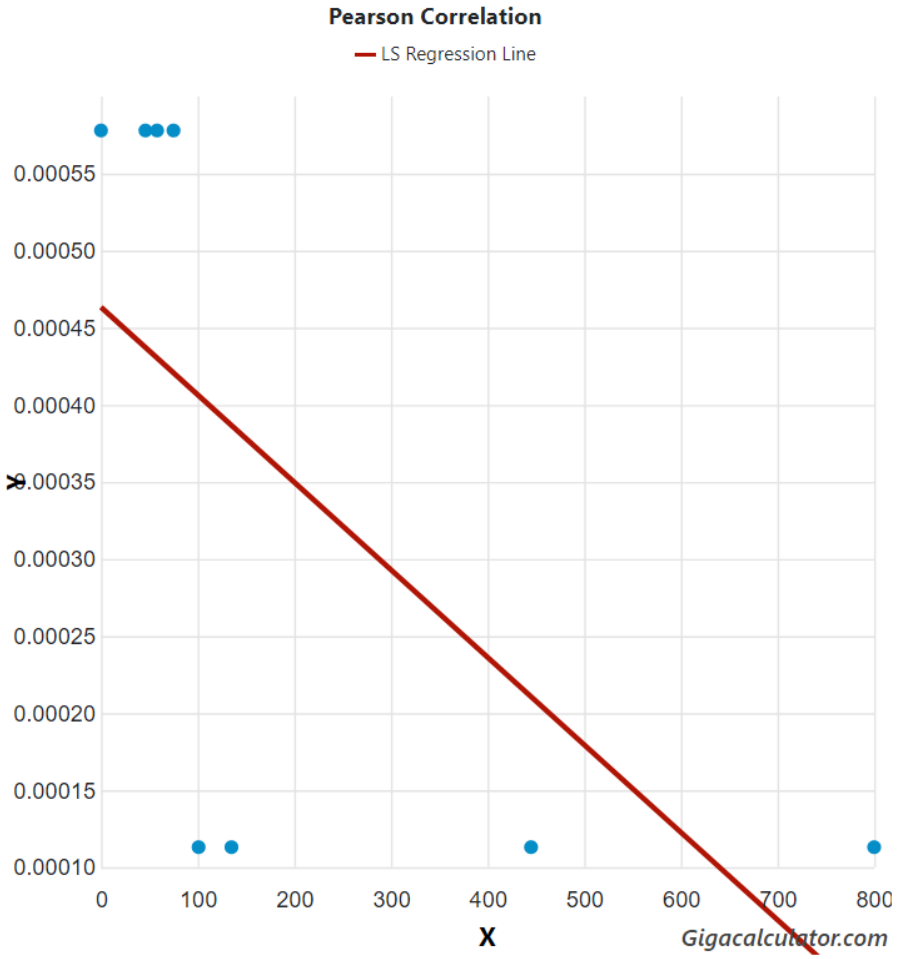

Figure 4. Relationship between female surface-area-to-volume ratio and abundance in two species of *Centrobolus* Cook, 1897.

DISCUSSION

New relationships were discovered between male and female surface areas and surface-area-to-volume ratios and abundance. The surface area relationships show opposite results across the sexes with a negative relationship in females and a positive relationship in males but both surface-area-to-volume ratios and abundances are negative. The absence of species-specific relationships means the occurrences are purely sexually selected and may have no survival value unless the Mullerian mimicry in this species pair acts differently on each of the sexes.

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