IS A PROMINENT STERNITE RELATED TO WEATHER IN CENTROBOLUS COOK, 1897?

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***Abstract-* Three species of *Centrobolus* were identified (*C. fulgidus*, *C. inscriptus*, *C. ruber*) based on morphology and confirmed using Scanning Electron Microscopy (SEM) of gonopod structure. One set of linear measurements was made from the SEM micrographs: (1) prominence of the stemite. Weather gradients in three species were gaged. Sternite prominence and weather were positively related insofar as the lowest relative humidity (Kendall's τ=-1, Z score=-2.32, n=3, p=0.01), the month with the highest number of rainy days (Kendall's τ=1, Z score=2.32379001, n=3, p=0.01), and lowest and highest precipitation (Kendall's τ=1, Z score=2.32, n=3, p=0.01). *C. inscriptus* had the highest sternite prominence (0.5 or 50%) and *C. ruber* had the lowest sternite prominence (0.25 or 25%) which were at opposite weather gradients.**

I. INTRODUCTION

The red millipede genus *Centrobolus* is well known for studies on sexual size dimorphism (SSD) and displays prolonged copulation durations for pairs of individuals of the species [4-9]. *Centrobolus* is distributed in temperate southern Africa with northern limits on the east coast of southern Africa at -17° latitude South (S) and southern limits at -35° latitude S. It consists of taxonomically important species with 12 species considered threatened and includes nine vulnerable and three endangered species [27]. It occurs in all the forests of the coastal belt from the Cape Peninsula to Beira in Mocambique [26]. Spirobolida has two pairs of legs modified into gonopods on the eighth and ninth diplosegments [28]. In *Centrobolus* the coleopods are the anterior gonopods of leg-pair eight and can be classed as paragonopods or peltogonopods because they are fused into a single plate-like structure and play a subsidiary role as inseminating devices while leg-pair nine are sperm-transferring [1]. The sternites (or stigma-carrying plates [29]) prevent lateral shifting (stabilizer) and stretch the vulva sac in a medial plane [3].

The genital morphology and mechanics of copulation were figured in three *Centrobolus* species [1, 2]. These worm-like millipedes have female-biased SSD [4-9, 12-19, 24]. From the results, correlations between coleopod sternite prominence and weather gradients were checked for correlations.

II. MATERIALS AND METHODS

Three species of *Centrobolus* were identified based on morphology and confirmed using Scanning Electron Microscopy (SEM) of gonopod structure (*C. fulgidus*, *C. inscriptus*, *C. ruber*). The gonopods were dissected from males of these three species and prepared for SEM. Specimens were fixed, first in 2.5% glutaraldehyde (pH 7.4 phosphate-buffered saline) at 4 °C for 24 hours, then in osmium tetroxide (2%). Dehydration through a graded alcohol series (50%, 60%, 70%, 80%, 90% to 100% ethanol) and critical point drying followed. Specimens were mounted on stubs and sputter-coated with gold palladium. Gonopods were viewed under a Cambridge S200 SEM. SEM micrographs were examined and the individual components of the gonopods were identified according to the available species descriptions. One set of linear measurements was made from the SEM micrographs: (1) prominence of the stemite (%). This has been estimated before as a ratio of how far it extends from the basal region up to the top of the coleopod. The collection of SEM micrographs for each species is particularly informative when comparisons are made between congruent views. These results have been published [1]. Dorsal tergite width was measured horizontally using Vernier calipers. Weather gradients were obtained from https://en.climate-data.org/africa/south-africa. Sternite prominence and weather gradients were correlated here using a Kendall Correlation Coefficient (https://www.gigacalculator.com/calculators/correla tion-coefficient-calculator.php). Sternite prominence was correlated with weather gradients in three species (*C. fulgidus*, *C. inscriptus*, *C. ruber*) using Kendall's Correlation Coefficient.

III. RESULTS

Sternite prominence and weather gradients were positively related insofar as the following weather gradients are concerned:

Lowest relative humidity

Kendall's τ=-1, Z score=-2.32379001, n=3, p=0.01006835 (Figure 1).

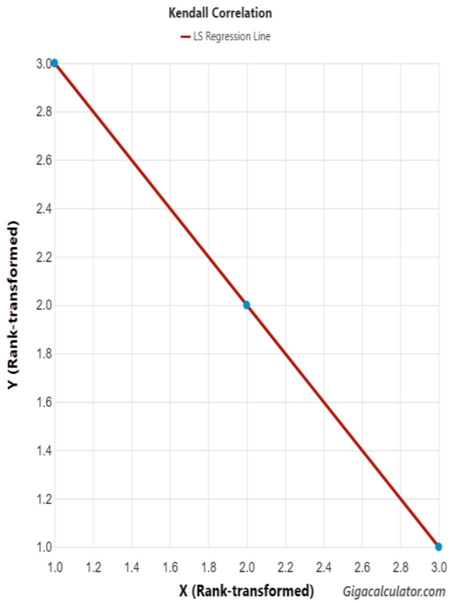

Figure 1. Relationship between sternite prominence and lowest relative humidity in *Centrobolus* Cook, 1897.

The month with the lowest number of rainy days

Kendall's τ=1, Z score=2.32379001, n=3, p=0.01006835 (Figure 2).

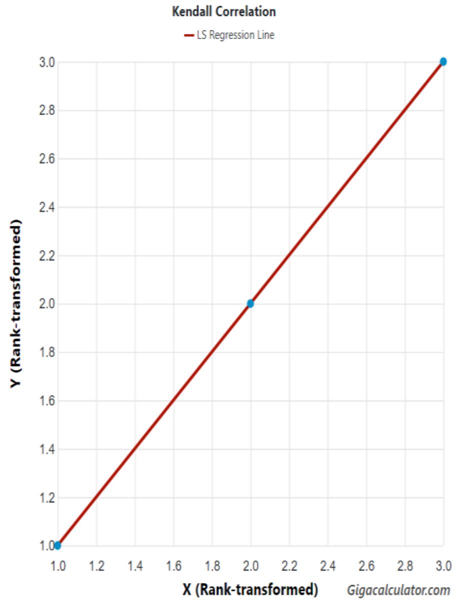

Figure 2. Relationship between sternite prominence and month with the lowest number of rainy days in *Centrobolus* Cook, 1897**.**

Lowest precipitation

Kendall's τ=1, Z score=2.32379001, n=3, p=0.01006835 (Figure 3).

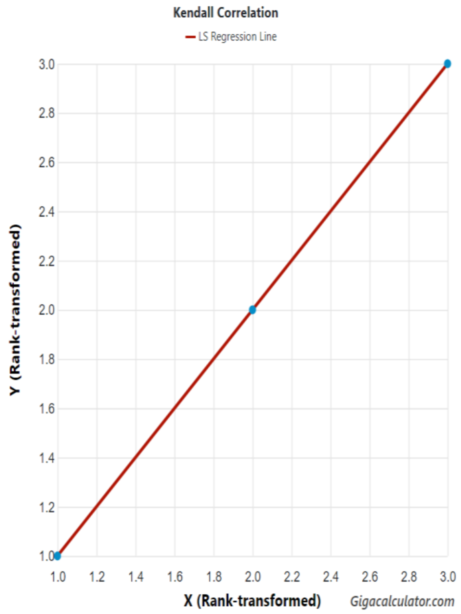

Figure 3. Relationship between sternite prominence and lowest precipitation in *Centtrobolus* Cook, 1897.

Highest precipitation

Kendall's τ=1, Z score=2.32379001, n=3, p=0.01006835 (Figure 4).

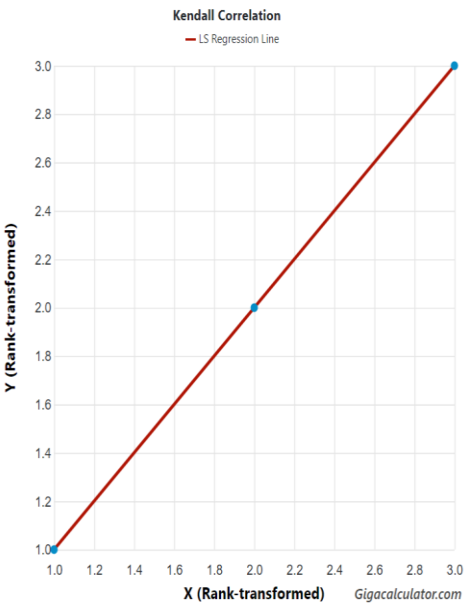

Figure 4. Relationship between sternite prominence and highest precipitation in *Centtrobolus* Cook, 1897.

IV. DISCUSSION

The genital morphology and mechanics of copulation were figured in three *Centrobolus* species [1, 2]. A direct relationship between an ultrastructural feature (sternite prominence) and weather gradients in the millipedes is compared which certainly supports the function of the sternite as a device adapted to environmental conditions [10, 30]. A relationship between this structural feature is present across three species suggesting adaptation to insemination in different environments. *C. inscriptus* had the highest sternite prominence (0.5 or 50%) and varied negatively with the lowest relative humidity and positively with the month with the highest number of rainy days and precipitation while *C. ruber* males had the lowest sternite prominence (0.25 or 25%) and were at the opposite extreme. It can be difficult to understand the functionality and where there is no functional significance this could have been misjudged [25]. However, the sternites in *Centrobolus* millipedes predict a functional significance in assuring paternity in four differing weather gradients. This was explained with a mechanical fit and stimulatory one-size-fits-all arguments under static and dynamic (above four) weather gradients [22, 23].

V. CONCLUSION

New relationships between ultrastructural features of the morphology (sternite prominence) and weather gradients among the *Centrobolus* millipedes support the function of the sternite as a hypoallometric device adapted toward reducing sperm competition and assuring paternity among various weather gradients. A prominent sternite is adapted to function in dynamic weather conditions.

APPENDIX

Male and female mass (g) and sternite prominence (%) in three species of *Centrobolus* with the first species (*C. inscriptus*) having two measurement sets.

C. inscriptus 2.48, *50* (male)
C. inscriptus 2.27, *50* (female)
C. inscriptus 2.00, *50* (male)
C. inscriptus 2.61, *50* (female)
C. fulgidus 1.29, *35* (male)
C. fulgidus 1.97, *35* (female)
C. ruber 1.28, *25* (male)
C. ruber 2.00, *25* (female)

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