

# IS COPULATION DURATION RELATED TO MOMENTS OF INERTIA 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. Copulation durations were recorded. Moments of inertia in three species were calculated. Copulation duration and moments of inertia were positively related ( $r=0.67$ ,  $Z$  score= $1.81$ ,  $n=8$ ,  $p=0.04$ ).

## 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  $-17^\circ$  latitude South (S) and southern limits at  $-35^\circ$  latitude S. It consists of taxonomically important species with 12 species considered threatened and includes nine vulnerable and three endangered species [24]. It occurs in all the forests of the coastal belt from the Cape Peninsula to Beira in Mocambique [23]. Spirobolida has two pairs of legs modified into gonopods on the eighth and ninth diplosegments [25]. 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 [26]) prevent lateral shifting (stabilizer) and stretch the vulva sac in a medial plane [3]. They facilitate insemination during prolonged copulation durations [2].

The copulation duration was recorded in three *Centrobolus* species [1]. These are worm-like

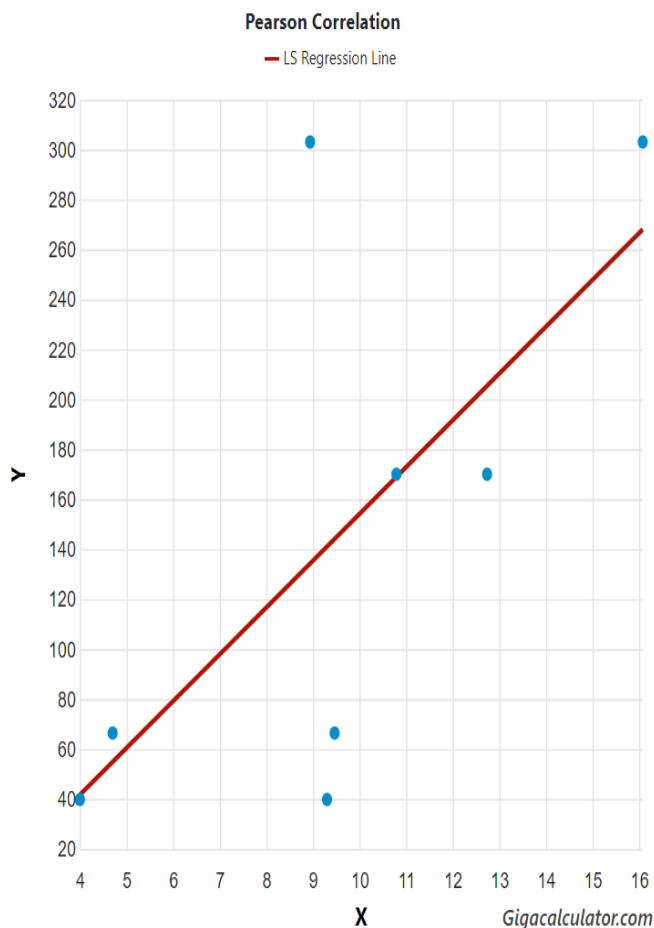
millipedes that have female-biased SSD [4-9, 12-18, 21]. From the results, correlations between copulation duration and moments of inertia were checked for correlations.

## 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 copulation durations were recorded. Dorsal tergite width was measured horizontally using Vernier calipers. Moments of inertia were calculated as half the mass multiplied by the square of the dorsal tergite width. Copulation duration and moments of inertia were correlated here using a Pearson Correlation Coefficient (<https://www.gigacalculator.com/calculators/correlation-coefficient-calculator.php>). Copulation duration was correlated with moments of inertia in three species (*C. fulgidus*, *C. inscriptus*, *C. ruber*) using a Pearson's Correlation Coefficient.

## III. RESULTS

Copulation duration and moments of inertia were positively related ( $r=0.66852064$ ,  $Z$  score= $1.80688507$ ,  $n=8$ ,  $p=0.03539005$ ). Least-Squares Regression Line  $y = 18.73838872 \cdot x + -33.25420271$ .



**Figure 1.** Relationship between copulation duration (y) and moments of inertia (x) across three species of *Centrobolus* (*C. fulgidus*, *C. inscriptus*, *C. ruber*).

#### IV. DISCUSSION

The copulation durations were recorded in three *Centrobolus* species [1]. A direct relationship between copulation duration and moments of inertia of the millipedes is shown which may support the function of the copulation duration in sperm competition [10, 27]. A relationship between this behavioral trait is present across three species suggesting adaptation to insemination. It can be difficult to understand the functionality and where there is no functional significance this could have been overlooked [22]. However, the copulation duration in *Centrobolus* millipedes predicts a functional significance in assuring paternity.

#### V. CONCLUSION

New relationships between copulation duration and moments of inertia of the *Centrobolus* millipedes supports the function of the prolonged copulation toward reducing sperm competition and assuring paternity. Prolonged copulation is related to higher moments of inertia.

#### APPENDIX

Female followed by male moments of inertia ( $\text{kg.m}^2$ ) and copulation duration in three species of *Centrobolus* with the first species (*C. inscriptus*) having two measurement sets.

- C. inscriptus* 12.7375375, 170
- C. inscriptus* 10.7911, 170
- C. inscriptus* 16.0777305, 303
- C. inscriptus* 8.9401, 303
- C. fulgidus* 9.46585, 66.4
- C. fulgidus* 4.70205, 66.4
- C. ruber* 9.3025, 39.8
- C. ruber* 4, 39.8

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