MOMENTS OF INERTIA COVARY WITH SURFACE AREA IN FOREST RED MILLIPEDES *CENTROBOLUS* COOK, 1897

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***Abstract*- The size of Juliformia has two main components, body diameter and the number of rings, and the cylindrical shape has two properties, volume and surface area. Other components include mass, volume, and surface area. Mean moments of inertia (kg.m^2) and surface area (mm^2) were recorded in four species of *Centrobolus* (*C. digrammus*, *C. fulgidus*, *C. inscriptus*, *C. ruber*) and tested for correlations with each other. *Centrobolus* range in surface area from female *C. promontorius* 628.256 mm^2 to female *C. lugubris* 3768.403 mm^2. Adult body surface areas were positively correlated with moments of inertia (r=0.97, Z score=5.68, n=10, p<0.01) (y = 6.31x -3.22). Male body surface areas were positively correlated with male moments of inertia (r=0.97, Z score=2.86, n=5, p<0.01) (y=5.87x-2.75). Female body surface areas were positively correlated with female moments of inertia (r=0.98, Z score=3.19, n=5, p<0.01) (y=6.61x-3.61). Other correlates of Juliform size include copulations duration, diet, the energetic cost of copulation, oxygen consumption, precipitation, sexual size dimorphism, temperature, and urbanization.**

I. INTRODUCTION

Diplopoda is an important environmental indicator and was previously under-represented in analyses of invertebrate size. Sexual size dimorphism (SSD) is the condition where the two sexes of the same species exhibit different characteristics beyond the differences in their sexual organs, although common sexual differences are thought to occur in body mass, length, width and leg dimensions of over half the taxa studied [5, 7-78]. Diplopods resemble the majority of invertebrates in SSD and are mostly reversed [6]. Heavier-shorter-wider females are under a type of fecundity selection [3]. Larger males have increased reproductive success through a female preference for the larger size when there is size-assortative mating behavior [76]. Mass is a useful standard in millipedes and mass measurements are known for at least 15 taxa [1, 2-4, 70-78].

Millipedes (*Centrobolus fulgidus*, *Centrobolus richardii*, and *Spinotarsus* sp.) influence selected soil elements but the results of these millipede studies have illustrated no major species and sex-specific differences [75]. Here it is hypothesized and appears in *Centrobolus* spp. the moments of inertia correlate to the surface area. No particular selection is thought to be operating and new relationships are simply documented for their predictive value. In the present study, moments of inertia in the genus *Centrobolus* were investigated in four available species and moments of inertia-surface area correlation is analyzed. I wished to establish whether species with higher surfaces are more inert. The null hypothesis states there is no correlation between millipede moments of inertia and surface area.

II. MATERIALS AND METHODS

Mean male and female mass (g) was recorded in males and females of four species of *Centrobolus* using a Mettler AC 100 Auto balance. Moments of inertia were calculated as half the mass multiplied by the square of the radius. Radius was obtained as half the dorsal tergite width which was measured with vernier callipers (mm). Surface Area was calculated with the formula SA = 2πr.(r+h); where r is the radius and h the length. The length was measured by holding millipedes alongside a plastic rule calibrated in millimeters. Body mass and surface area were previously tested for normality using a Kolmogorov-Smirnov Test for Normality (https://www.socscistatistics.com/tests/kolmogorov/default.aspx). Covariation between moments of inertia and surface area was calculated and plotted (https://www.gigacalculator.com/calculators/correlation-coefficient-calculator.php).

III. RESULTS

Adult body surface areas were positively correlated with moments of inertia (Figure 1: r=0.97299596, Z score=5.67688545, n=10, p=0.00000001) (y = 6.30759829 · x + -3.21884548). Male body surface areas were positively correlated with male moments of inertia (Figure 2: r=0.96573614, Z score=2.86345075, n=5, p=0.00209533) (y = 5.86982471 · x + -2.745899). Female body surface areas were positively correlated with female moments of inertia (Figure 3: r=0.97824213

score=3.18904339, n=5, p=0.00071379) (y= 6.60972554 · x + -3.61139321).

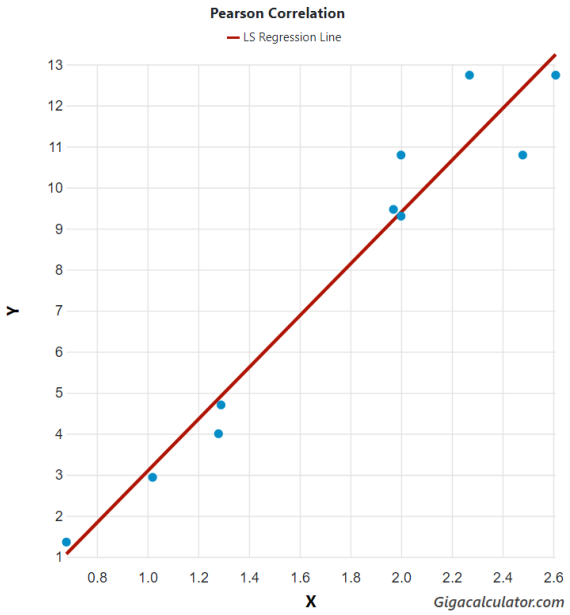

Figure 1. Relationship between moments of inertia (kg.m^2) and surface area (mm^2) in four species of *Centrobolus* Cook, 1897.

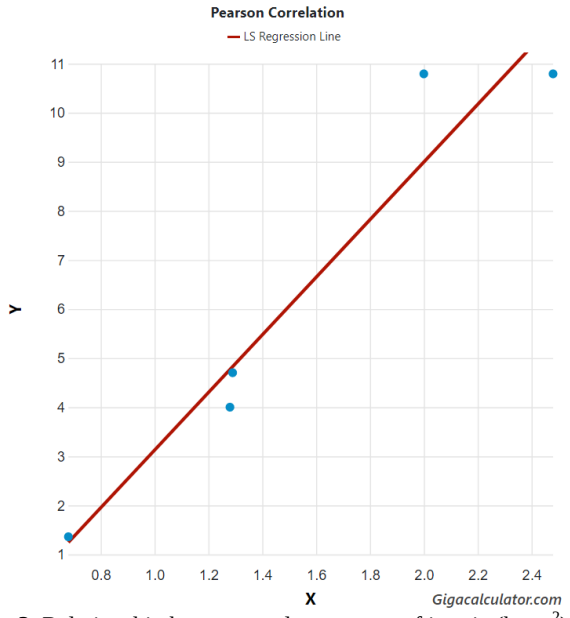

Figure 2. Relationship between male moments of inertia (kg.m^2) and male surface area (mm^2) in four species of *Centrobolus* Cook, 1897.

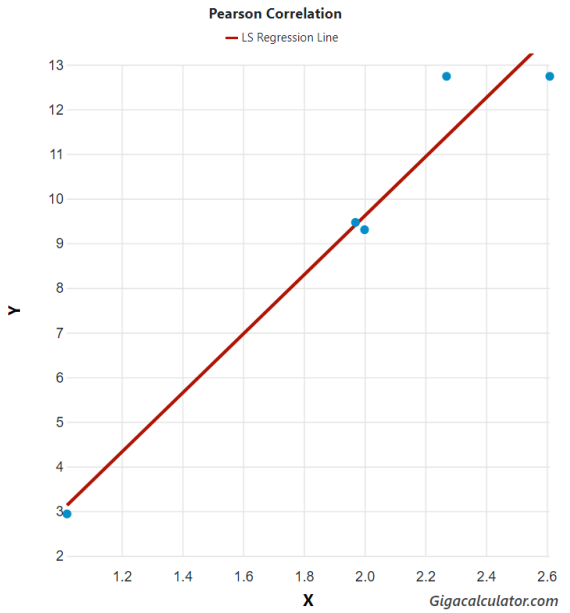

Figure 3. Relationship between female moments of inertia (kg.m^2) and female surface area (mm^2) in four species of *Centrobolus* Cook, 1897.

IV. DISCUSSION

Moments of inertia are an accurate measure related to the surface area. With the correlation method available (Pearson's) I show a correlation between moments of inertia and surface area. This means variation in moments of inertia sufficiently explains the variation in surface area and vice versa. The moments of inertia statistics of four species of *Centrobolus* were presented falsifying the null hypothesis i. e. showing moments of inertia correlated with surface area and finding species-specific standards. The finding extends upon studies that show the size of Juliformia has two main components, body diameter and the number of rings, and provides new information on millipede moments of inertia and surface area [69]

Correlates of Juliform size include copulations duration, diet, the energetic cost of copulation, oxygen consumption, precipitation, sexual size dimorphism, and temperature [1, 3-4, 67, 68, 75].

V. CONCLUSION

In *Centrobolus* spp. variation in body mass sufficiently explains the variation in surface area and vice versa.

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