MASS COVARIES WITH SURFACE AREA IN FOREST RED MILLIPEDES CENTROBOLUS COOK, 1897

MARK I. COOPER
UNIVERSITY OF JOHANNESBURG, SOUTH AFRICA.

***Abstract*- The size of Juliformia has two main components, body diameter and the number of rings. Other components include mass, volume, and surface area. Mean male and female mass (g) and surface area (mm^2) were recorded in four species of *Centrobolus* and tested for correlations with each other. *Centrobolus* range in surface area from female *C. promontorius* 628 mm^2 to female *C. lugubris* 3768 mm^2. Adult body surface areas were positively correlated with mass (r=0.90, Z score=3.89, n=10, p<0.01). Male body surface areas were positively correlated with male mass (r=0.93, Z score=2.37, n=5, p<0.01) (y= 0.00128240 · x + -1.19364241). Female body surface areas were marginally positively correlated with female mass (r=0.73, Z score=1.31, n=5, p=0.10). 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 mass correlates to the surface area. The particular sexual selection is thought to be a female preference for larger male size which operates when there are size-assortative mating behaviors. In the present study, mass in the genus *Centrobolus* was investigated in four available examples and mass-surface area correlation is analyzed. I wished to establish whether larger species had higher surfaces and are heavier. One null hypothesis states there is no correlation between millipede mass 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. Surface Area was calculated with the formula SA = $2\pi r.(r+h)$; where r is the radius and h the length. The length was measured by holding millipedes alongside a plastic rule calibrated in millimeters. Horizontal tergite width was measured with vernier calipers. Body mass and surface area were tested for normality using a Kolmogorov-Smirnov Test for Normality (https://www.socscistatistics.com/tests/kolmogorov/default.aspx). Covariation between mass 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 mass (Figure 1: r=0.89964042, Z score=3.89012802, n=10, p=0.00005012). Male body surface areas were positively correlated with male mass (Figure 2: r=0.93232763, Z score=2.37008235, n=5, p=0.00889205) (y=

0.00128240 · x + -1.19364241). Female body surface areas were marginally positively correlated with female mass (r=0.72736914, Z score=1.30548607, n=5, p=0.09586376). Surface area was normally distributed (D=0.16887, n=10, p=0.89435). The male surface area was normally distributed (D=26925, n=5, p=0.7804). The female surface area was normally distributed (D=0.33898, n=5, p=51115). Mass was normally distributed (D=0.23485, n=8, p=0.68701).

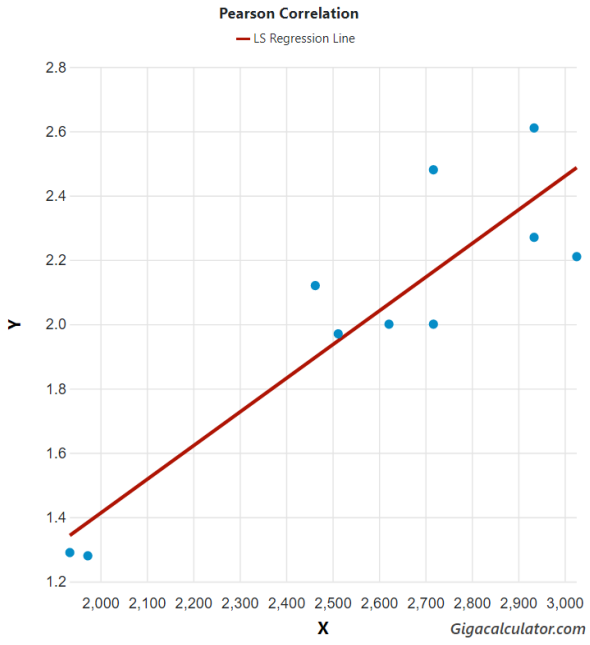
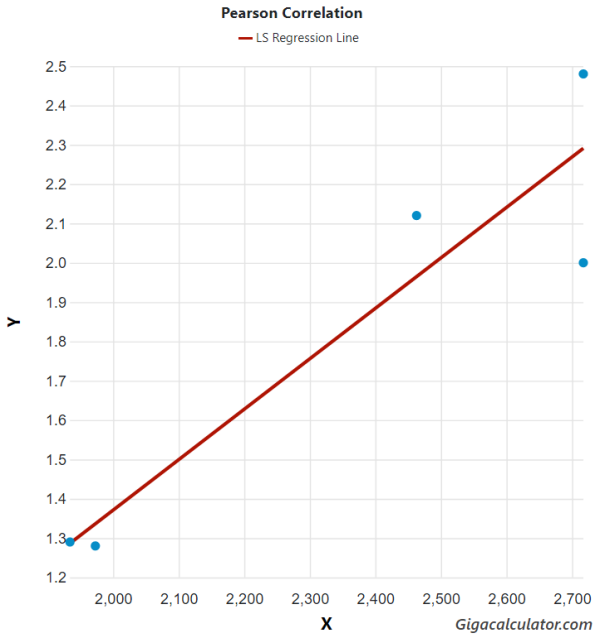


Figure 1. Relationship between mass (g) and surface area (mm^2) in four species of *Centrobolus* Cook, 1897.



IV. DISCUSSION

Mass is a useful size criterion for determining millipede volume and vice versa. With the correlation method available (Pearson's) I show a correlation between mass and surface area. This means variation in body mass sufficiently explains the variation in surface area and vice versa. The mass statistics of four species of *Centrobolus* were presented falsifying the null hypothesis i. e. showing mass 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 mass 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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