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# DOES SEXUAL SIZE DIMORPHISM VARY WITH LOG SEXUAL SIZE DIMORPHISM IN RED MILLIPEDES CENTROBOLUS COOK, 1897?

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***Abstract***

*This study aimed to determine what happened when Sexual Size Dimorphism (SSD) and log SSD were covaried. The log SSD was correlated with SSD in the forest millipede genus Centrobolus. There was a significant correlation between SSD and the log SSD (r=0.97, Z score=9.29, n=22, p=0). SSD was significantly different from log SSD (U=0, z score=-5.66864, n=22, 22, p<0.00001). Variance in the polygynandrous reproductive systems occurred when larger females and higher SSD covary with log SSD. There is no apparent reason to favor the log-transformed model over the non-transformed model.*

***Keywords:*** *Dimorphic; eco-geography; gradient; log; size; species*

## INTRODUCTION

A forest genus of diplopods belonging to the Order Spirobolida found along the eastern coast of southern Africa was the subject of this study [3]. 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 South (S) and its southern limits being -35° S (Lawrence, 1967). As essentially shade-loving Diplopoda, the members of the genus are represented by 39 species in the littoral forests of the eastern half of the subcontinent (Lawrence, 1967).

Sexual size dimorphism (SSD) is correlated with log SSD in the pachybolid millipede genus Centrobolus Cook, 1897 (Cook, 1897; Hamer, 1998; Lawrence, 1967). A null hypothesis is that there is no difference between SSD and log SSD.

## MATERIALS AND METHODS

39 valid species were identified as belonging to the genus Centrobolus Cook, 1897. Millipede-type localities were obtained from a checklist of southern African millipedes (Hamer, 1998). These were tabulated and known type localities also listed in Microsoft Word online (https://office.live.com/start/Word.aspx) (Table 1). Log SSD and body size were obtained by calculating the volumes (cylindrical) using the lengths and widths of species which were inputted into the formula for a cylinder's volume (https://byjus.com/volume-of-a-cylinder-calculator). SSD was calculated as the ratio of female volume to male volume. SSD and log SSD were checked for correlations using the Pearson Correlation Coefficient calculator(https://www.gigacalculator.com/calculators/correlation- coefficient- calculator.php).Data were tested for normality with a Kol mogorov-Smirnov calculator (https://www.socscistatistics.com/tests/kolmogorov/default.aspx). SSD was compared to log SSD using a Mann- Whitney U- test (https://www.socscistatistics.com/tests/mannwhitney/default2.aspx).

## RESULTS

There was a significant correlation between SSD and log SSD (Fig. 1: r=0.97226865, Z score=9.29399258, n=22, p=0). The least-squares regression line is y=0.27887766x-0.27332146. The 95% confidence interval is [0.9332, 0.9886]. The 95% right-sided interval is [0.9419, +1] and the 95% left sided interval is [-1, 0.9869]. SSD was normally distributed (D=0.15168, n=22, p=0.20477). Log SSD was normally distributed (D=0.09477 , n=22, p=0.97817). SSD was significantly different from log SSD (U=0, z score=-5.66864, n=22, 22, p<0.00001) (Table 1).

**Table 1. Species in the millipede genus Centrobolus Cook, 1897, with SSD, type or collected localities and log SSD.**

| Species | SSD | Location | Log SSD |
|---|---|---|---|
| C. albitarsis | 2.89 | Lochiel | 0.460897843 |
| C. angelicus | | Makhanda | |
| C. anulatus | 1.19 | Umhlanga Rocks | 0.0755469614 |
| C. atrophus | | Signal Hill | |
| C. bifidus | | Nkhandla | |
| C. coriaceus | | Caffraria | |
| C. decoratus | 0.63 | Ngome Forest | -0.200659451 |
| C. digrammus | 1.01 | Hout bay | 0.00432137378 |
| C. dubius | 1.35 | Gans bay | 0.130333768 |
| C. formosus | | Caffraria | |
| C. fulgidus | 1.65 | Richards Bay | 0.217483944 |
| C. immaculuatus | 2.72 | Gorongosa | 0.434568904 |
| C. inscriptus | 1.21 | Scottburgh | 0.0827853703 |
| C. inyanganus | 1.44 | Inyanga village | 0.158362492 |
| C. lawrencei | 1.57 | Pietermaritzburg | 0.195899652 |
| C. litoralis | | Algoa Bay | |
| C. luctuosus | | Inhambambane | |
| C. lugubris | 2.18 | Glenconnor | 0.338456494 |
| C. miniatomaculatus | | Tsitsikamma | |
| C. pococki | | Cape Peninsula | |
| C. promontorius | 0.69 | Little Lions Head | -0.161150909 |
| C. pusillus | 2.08 | Qolora River mouth | 0.318063335 |
| C. richardii | 0.95 | Richards Bay | -0.0222763947 |
| C. ruber | 1.62 | Port Shepstone | 0.209515015 |
| C. rubricollis | | Karkloof waterfall | |
| C. rugulosus | 1.97 | Hluhluwe | 0.294466226 |
| C. sagatinus | 1.27 | Between Uitenhage and Addo | 0.103803721 |
| C. sanguineomarginatus | | Bain's Kloof | |
| C. sanguinipes | | Qolora River mouth | |
| C. saussurii | | Caffraria | |
| C. silvanus | 1.13 | Kentani | 0.0530784435 |
| C. splendidus | | Masiene near Chai Chai | |
| C. strigosus | | Caffraria | |
| C. striolatus | | Port St Johns | |
| C. titanophilus | 1.15 | DeHoop vlei | 0.0606978404 |
| C. transvaalicus | 1.26 | Mariepskop | 0.100370545 |
| C. tricolor | 1.10 | Champaigne Castle | 0.0413926852 |
| C. validus | | Haroni River | |
| C. vastus | 1.81 | Port St Johns | 0.257678575 |

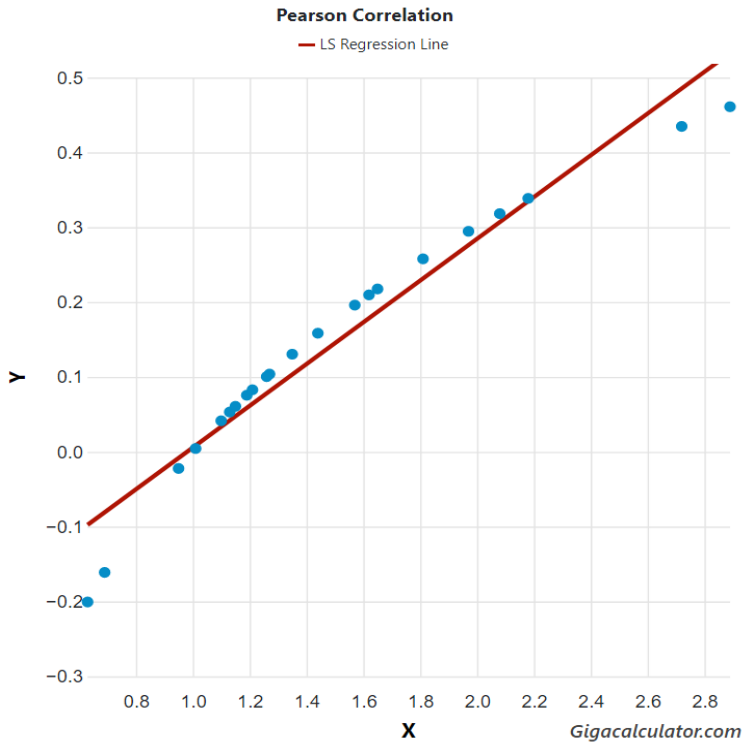


**Figure 1. Correlation between log SSD (y) and SSD (x) in Centrobolus Cook, 1897.**

## DISCUSSION

A positive relationship was found between log SSD and SSD. C. albitarsus has the highest SSD (2.89) and the highest log SSD (0.460897843). SSD was lowest in C. decoratus (0.63) which had the lowest log SSD (-0.200659451). This study supports the log SSD as a predictor of SSD and supports the converse in Centrobolus. Although the null hypothesis is not corroborated there is no reason to favor the log-transformed model over the non-transformed model due to their close correlation (Ranta et al. 1994). The classical statistical method provides equal inferences to log-transformed models (Feng et al. 2014).

## CONCLUSION

SSD increased systematically with log SSD in Centrobolus. SSD increased hypo-allometrically with body size in this genus.

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