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The relative sexual size dimorphism of *Centrobolus inscriptus* compared to 18 congenerics

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Abstract
Millipedes illustrate reversed sexual size dimorphism (SSD) as females are larger than males. SSD was calculated in 18 species of the genus *Centrobolus* and illustrated as a regression. The approximate relative position of *C. inscriptus* is shown. The size of *C. inscriptus* was 2245mm^3: 1841 mm^3: (females: males; n=88) and logged (x = 3.351216; y = 3.265054) and plotted. The mean volume ratio for *C. inscriptus* was 1.219446. Sexual size dimorphism was visible with the naked eye.

Keywords: Millipedes, sexual size dimorphism, *Centrobolus*

1. Introduction
Millipedes illustrate reversed sexual size dimorphism (SSD) and females are larger than males [1-3]. SSD in forest millipedes has successfully been understood as volumetric measurements using *Centrobolus* to corrobrate Rensch's rule [1]. Although the general trend has been calculated for *Centrobolus* it has not been illustrated. Here I aim to illustrate the trend of SSD for the genus *Centrobolus* and calculate and position the well-studied species *C. inscriptus* relative to 18 congenerics.

2. Materials and methods
Three factors were measured from 19 *Centrobolus* species: (1) body length (mm) by placing individuals collected in South Africa (1996-1998) alongside a plastic rule (calibrated in mm); (2) width (mm) with Vernier calipers; and (3) mass (accurate to 0.01 g) was measured with a Mettler balance. *C. inscriptus* (Mtunzini) were collected in South Africa. These basic descriptive figures were statistically compared using Statistica (Mann-Whitney tests). Body length: width ratios were compared on arcsine transformed data. The mean values of length, width and number of segments was extracted from published data for 18 species [4-5] and intersexual comparisons performed using Wilcoxon matched pairs tests. Size was perceived as body volume and calculated based on the formula for a cylinder ($l.\pi.r$) where l is body length and r half of the width. SSD was estimated as the mean female volume divided by mean male volume and converted into a SSD index by subtracting 1 Allometry for SSD was based on a general allometric model where male size = α (female)$^{\beta}$ [6].
Millipede SSD was thus calculated in the genus *Centrobolus* [1]. A regression of male volume on female volume was used to show the position of 18 species and the size of *C. inscriptus* was taken as a volumetric measurement and inserted into a Microsoft (MS) Excel spreadsheet and converted using the logorithmic (mathematical) equation. The chart for SSD in 18 species was captured, copied and exported using the snapshot function in the programme Soda Portable Document File (PDF) 8. It was pasted into a MS Word file and the position of *C. inscriptus* estimated using a 12 cm metal rule held against the screen of a Samsung laptop (R580).

3. Results
The quantitative resolution of Rensch's rule for 18 species of *Centrobolus* together with the relative estimated position of *C. inscriptus* is shown in Figure 1. The size of *C. inscriptus* was obtained from Cooper (2014): males 1841mm^3 and females 2245mm^3 and logged (females/x = 3.351216; males/y = 3.265054) and plotted. The mean volume ratio for *C. inscriptus* was 1.219446. Sexual size dimorphism is visible with the naked eye (Figures 2 & 3).

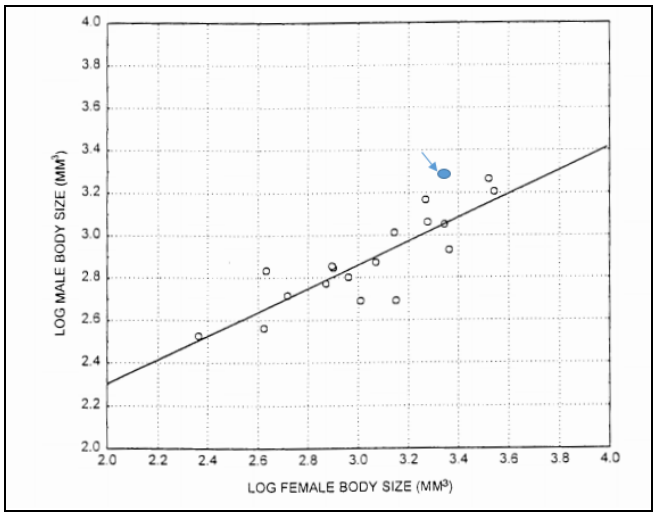

Fig 1: Quantitative resolution of Rensch's rule for 18 species of spirobolidan millipedes of the genus *Centrobolus*. Allometry for sexual size dimorphism (SSD) is based on the general allometric model, male size = α (female size) $^{\beta}$ [6-7]. Allometric coefficient, $\beta < 1$ (hypoallometric); correlation coefficient, r = 0.85. The regression of log (female size) on log (male size) would generate an identical relationship with $\beta < 1$. The estimated position of *C. inscriptus* is shown by the solid circle and arrow.

Fig 2: Sexual dimorphism in trigoniulid millipedes: A. *Centrobolus fulgidus*, both sexes are conglobated (coiled up) showing the larger female; B. *C. ruber*, the male is the brighter with longer legs; C. *C. digrammus* male, displaying the legs with the elaborate tarsal pads; D. *C. digrammus* female, legs are smaller and cannot be seen from the dorsal aspect.

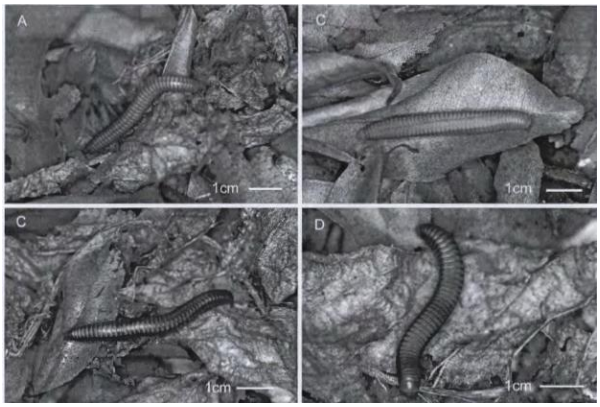

Fig 3: Sexual dimorphism in trigoniulid millipedes: A. *Centrobolus striolatus*, surface active male displaying how the legs equipped with tarsal pads extend beyond the cylindrical body; B. *C. striolatus*, female with the short squat cylindrical bauplan; C. *C. strigosus*, surface active male; D. *C. strigosus* female feeding amongst leaf litter.

4. Discussion

Figure 1 shows the previous finding for *Centrobolus* where mean volume ratios ranged from 0.63-2.72 with the regression of log male volume on log female volume was highly significant with a positive slope less than 1[1]. Here the estimated relative position of *C. inscriptus* is given as females: males (2245mm$^{3:}$ 1841mm^{3}; n = 88) showing it at the upper end of the trend for the genus. *C. inscriptus* falls at the upper end of the trend for SSD in the genus. Importantly, because the position of *C. inscriptus* is above the line corroborating Rensch's rule it indicates females are smaller compared to males relative to 18 other members of the 39-species genus.

5. Conclusion

C. inscriptus is a large member of the genus with relatively large males and small females compared to the other 18 *Centrobolus* species for which data is available.

6. Acknowledgements

Robin Crewe reviewed the thesis wherein these results were presented.

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