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Relative sexual size dimorphism *Centrobolus ruber* (Attems) compared to 18 congeners

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Abstract

The present research was aimed to study relative sexual size dimorphism of *Centrobolus ruber* (Attems) compared to 18 congeneric. Millipedes illustrate reversed sexual size dimorphism (SSD) where females are larger than males; and corroborate Rensch's rule as this dimorphism increases with body size. SSD was calculated in 18 species of the genus *Centrobolus* and illustrated as a regression. The approximate relative position of *C. ruber* was shown from measurements taken at Port Shepstone, South Africa (February 1996). The size of *C. ruber* was 57.8 X 5.0 mm: 62.3 X 6.1 mm (males: females; n=18) and logged (females/x = 3.267; males/y = 3.057) and plotted. The mean volume ratio for *C. ruber* was 1.621. The evidence suggests the proximate cause for SSD in *C. ruber* is sexual bimaturism while the ultimate cause in *Centrobolus* is intersexual competition.

Keywords: *Centrobolus*, dimorphism, millipede, *ruber*, SSD, size

1. Introduction

Sexual size dimorphism is prevalent in arthropods and females are usually larger than males *e.g.* beetle *Limnebius* [1]; sea spider *Ammothea hilgendorfi* [2]. Behavioural patterns such as provisioning *versus* non-provisioning relate to SSD [3]. Millipedes illustrate reversed sexual size dimorphism (SSD) and females are larger than males [4-9]. SSD in forest millipedes has successfully been understood as volumetric measurements using *Centrobolus* to corroborate Rensch's rule [4-7]. Based on the assumption of equal developmental rates in males and females, the proximate cause for Rensch's rule is sexual bimaturism [10-11, 14]. The general trend of SSD has been calculated for *Centrobolus* and bimaturism shown [7, 11]. The present study was aimed to illustrate the trend of SSD for the genus *Centrobolus* and pinpoint the position of *C. ruber* relative to 18 congeners in order to determine whether males and/or females follow the trend of Rensch's rule.

2. Materials and Methods

Three factors were measured from *Centrobolus ruber*: (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. ruber* (Attems) were collected Port Shepstone, South Africa (February 1996). Millipede SSD was also calculated in the genus *Centrobolus* [4, 7]. A regression of male volume on female volume was used to show the position of 18 species and the size of *C. ruber* was taken as a volumetric measurement and inserted into a Microsoft (MS) Excel spreadsheet and converted using the logarithmic (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. ruber* pinpointed.

2.1 Statistical Analysis

The basic descriptive figures were statistically compared using Statistica. 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 intersexual comparisons performed using Wilcoxon matched pairs tests. Size was perceived as body volume and calculated based on the formula for a cylinder ($l \cdot \pi \cdot r$) 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) ^{β} .

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3. Results

The quantitative resolution of Rensch's rule for 18 species of *Centrobolus* together with the relative estimated position of *C. ruber* is shown in Fig. 1. The size of *C. ruber* was: males

57.8 X 5 (l X 2r) mm and females 62.3 X 6.1 mm and logged (females/x = 3.267; males/y = 3.057) and plotted. The mean volume ratio (female volume/male volume) for *C. ruber* was 1.621. SSD was visible with the naked eye (Fig. 2).

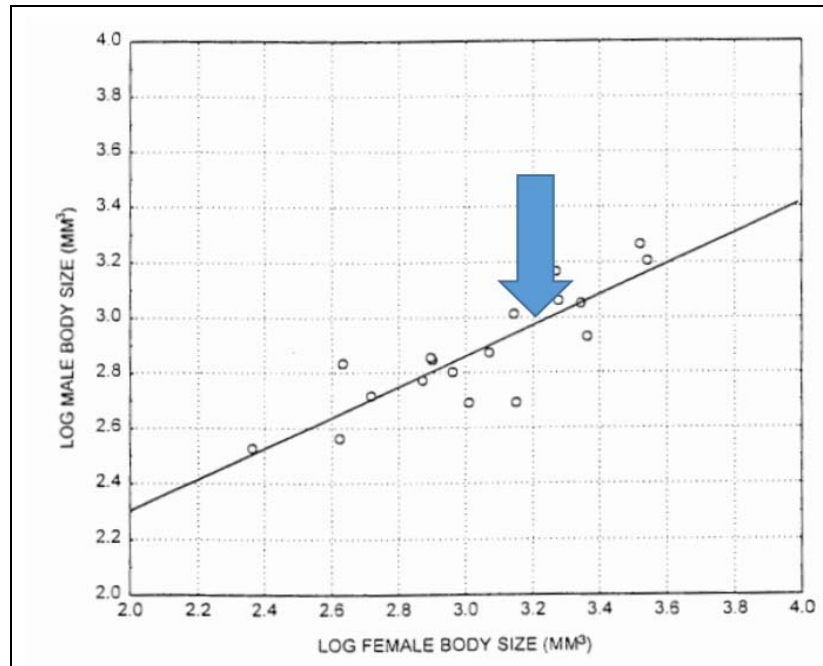


Fig 1: Quantitative resolution of Rensch's rule for 18 species of spirobolidan millipedes of the genus *Centrobolus*. Allometry for sexual size dimorphism (SSD) is based on the general allometric model [12-13], male size = α (female size) $^{\beta}$; correlation coefficient, $r = 0.85$. The regression of log (female size) on log (male size) would generate an identical relationship with $\beta < 1$. The estimated position of *C. ruber* is shown by the arrow.



Fig 2: *Centrobolus ruber* (Attems) SSD in copula.

4. Discussion

Unlike previous studies on SSD in invertebrates these results consistently corroborated Rensch's rule [18]. Figure 1 shows the 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; showing females get larger than males with an increase in body size [4, 7, 9]. The mean volume ratio of 1.621 was at the middle-upper end of the trend for the genus. Importantly, because the position of *C. ruber* was on the line corroborating Rensch's rule it indicated females/males obeyed the trend relative to 18 other members of the 39-species rich genus [4]. As a proximate cause for SSD in millipedes the evidence corroborated the sexual bimaturism hypothesis [11, 14]. As an ultimate cause for SSD this together with ecological evidence corroborated the intersexual competition hypothesis [15-17].

5. Conclusion

C. ruber males and females followed the trend for SSD and Rensch's rule in *Centrobolus*.

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