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Mark Cooper
University of South Africa, Pretoria, South Africa

Correspondence
Mark Cooper
University of South Africa, Pretoria, South Africa

Re-assessment of rensch's rule in *Centrobolus*

Mark Cooper

Abstract
Sexual size dimorphism (SSD) was investigated in the helminthomorph genus *Centrobolus* (=Chersastus). Width, length and mass were used to compare the interspecific variation for 20 species. Interspecific variation in volume was calculated in these species and an allometric coefficient of 0.7 found. The allometric equation generated for the genus also the inverse of Rensch's rule as there was a positive correlation between SSD and body size (R=0.70485; P=0.00109; n=18 spp) in this diplopod genus. This SSD is thought to have evolved through intersexual competition driven by sexual selection.

Keywords: allometry, centrobolus, rensch's, spirobolida

1. Introduction
Diplopoda are underrepresented in allometric analyses of SSD, although sexual differences are known in body mass, length, width and leg dimensions of over half the taxa studied [1-3]. Size differences occur with factors such as color, sexes, species, urbanisation and water relations [4-8]. Diplopoda resemble the majority of invertebrates where SSD is reversed [9]. SSD has consequences for the outcome of sexual encounters in diplopod mating [10-14]. The detection of a relationship between body size and SSD is known by Rensch's rule [15-16]. Rensch's rule may be explained by sexual selection [17-21]. The macro-evolutionary pattern is unresolved in Diplopoda [22].

SSD has been studied in the Spirobolida genus *Centrobolus* and the relationship between the log of male and female volumes against each other used to Corroborate Rensch's rule [15-16]. In the present study, SSD in the genus *Centrobolus* is re-investigated and re-tested. The hypothesis was SSD is negatively correlated with mean body sizes [23].

2. Material and Methods
Three factors were measured from the sample of *Centrobolus*: (1) body length (mm) by placing individuals alongside a plastic rule (calibrated in mm); (2) width (mm) with Vernier calipers; and (3) mass (accurate to 0.01 g). *C. inscriptus* (Mtunzini), and *C. ruber* (Anerley, Port Shepstone) were collected in South Africa (1996) while more data was obtained from Attems [24]. Their helminthomorph size was calculated as shape volume based on the formula for a cylinder ($l.\ \pi.\ r^2$) where l was body length and r half of the width *i. e.* radius. SSD was estimated as mean female volume divided by mean male volume and converted into a SSD index by subtracting 1 [25]. SSD was plotted versus body size (http://www.socscistatistics.com). Allometry for SSD was based on a general allometric model where male size = α (female size) $^{\beta}$ [26]. A linear regression was calculated at http://www.socscistatistics.com/tests/regression/Default.aspx and Spearman's Rho coefficients calculated at http://www.socscistatistics.com/tests/spearman/Default2.aspx. Male and female width and volume have already been compared by Cooper [23].

3. Results
The allometric equation for *Centrobolus* was (1) $\hat{y} = 0.00051X - 0.01071$. SSD ranged from 0.63 – 2.89 (1.55 ± 0.63; n = 20) and was significantly positively correlated (R = 0.70485; P = 0.00109; n = 18 spp.) with volume ranging from 284 – 2683 mm^3 (1097.89 ± 638.06; 18) (Table 1).

Table 1: Body size, sexual size dimorphism (SSD) and SSD index for *Centrobolus* Cook, 1897.

Species	Body size (mm^3)	SSD	SSD-1	Sample size (n)
C. albitarsus	952	2.89	1.89	1
C. decoratus	557	0.63	-0.37	1
C. digrammus	522	1.01	0.01	6
C. dubius	1210	1.35	0.35	1
C. fulgidus	1518	1.65	0.65	11
C. fulgidus	1.65 g	1.25	0.25	22
C. immaculatus	1580	2.72	1.72	1
C. inscriptus	2.38 g	1.22	0.22	176
C. inyanganus	775	1.44	0.44	1
C. lawrencei	962	1.57	0.57	1
C. lugubris	2046	2.18	1.18	1
C. promontories	284	0.69	-0.31	1
C. pusillus	756	2.08	1.08	1
C. ruber	1.64 g	1.62	0.62	36
C. rugulosus	1666	1.97	0.97	1
C. sagatinus	1659	1.27	0.27	1
C. silvanus	749	1.13	0.13	1
C. titanophilus	393	1.15	0.15	1
C. transvaalicus	669	1.26	0.26	1
C. tricolor	781	1.10	0.10	1
C. vastus	2683	1.81	0.81	1

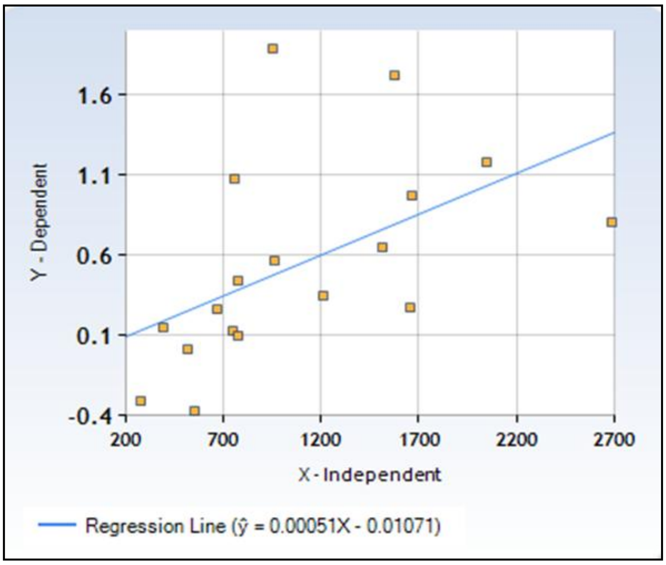

Fig 1: Regression showing the relationship between sexual size dimorphism and body mass for *Centrobolus* (N = 18)

4. Discussion

The significant differences between males and females have already been dealt with for this genus [23]. The regression of SSD on body size (Figure 1) of the data for SSD and body size (Table 1) indicates a positive regression to reject Rensch's rule in *Centrobolus*. Although the null hypothesis is accepted and the rule rejected the inverse relationship is true [26-32]. This was seen in the SSD increases with body size. The same result was obtained when the analysis was run with/without *C. fulgidus* suggesting there is little or no difference when mass and volume are used to calculate SSD. If Rensch's rule implies only hypo-allometric functions then it has been corroborated [23]. However, if Rensch's rule implies a negative relationship between SSD and body size then it must be rejected here. Both scenarios have been dealt with and the proximate cause of the relationship between SSD and body size may be suggested for *Centrobolus annulatus* and *C. inscriptus* in sympatry [33].

5. Conclusion

The inverse of Rensch's rule was found in *Centrobolus* based on the positive relationship between SSD and body size.

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