MATING FREQUENCY IS RELATED TO SURFACE AREA AND SURFACE-AREA-TO-VOLUME RATIOS IN *CENTROBOLUS* COOK, 1897

MARK I. COOPER
UNIVERSITY OF STELLENBOSCH, SOUTH AFRICA

Abstract **- I tested for relationships between male and female surface-area-to-volume ratios and mating frequency in red millipedes *Centrobolus*. Surface-area-to-volume ratios were related to mating frequency (r=-0.91, Z score=-5.61, n=16, p<0.01). Male surface-area-to-volume ratios appeared related to male mating frequencies (r=-0.93, Z score=-3.73, n=8, p<0.01). Female surface- area-to-volume ratios appeared related to female mating frequencies (r=-0.93, Z score=-3.63, n=8, p<0.01). There was a relationship between surface-area-to-volume ratios and mating frequencies when the sexes were pooled (r=-0.91, Z score=-5.61, n=16, p<0.01). There was no relationship between surface area-to-volume ratios and mating frequencies in *C. inscriptus* (r=0.21, Z score=0.48, n=8, p=0.32) or *C. anulatus* (r=-0.20, Z score=-0.45, n=8, p=0.33). Surface areas were not related to mating frequencies (r=0.12, Z score=0.44, n=16, p=0.33). Surface areas were related to mating frequencies in males (r=0.93, Z score=3.73, n=8, p<0.01). Surface areas were related to mating frequencies in females (r=-0.93, Z score=-3.63, n=8, p<0.01). There was no relationship between surface area-to-volume ratios and mating frequencies in *C. anulatus* (r=-0.20, Z score=-0.45, n=8, p=0.33) or *C. inscriptus* (r=-0.21, Z score=-0.48, n=8, p=0.32).**

I. INTRODUCTION

The forest genus of diplopods belonging to the Order Spirobolida found along the eastern coast of southern Africa was the subject of this study. 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 S. It occurs in all the forests of the coastal belt from the Cape Peninsula to Beira in Mocambique. While the coastal forests of the South-West and Eastern Cape are mist belt temperate forests, those of the Transkei, Natal, Zululand and Mocambique are somewhat different, being better described as East Coast Bush, they are developed almost entirely in a narrow strip of the litoral on a dune sand substratum, and are more tropical in aspect and composition than those to the west of them. There is a summer rainfall of 762-1016mm, a uniform temperature, and an absence of frost; the component trees of the coastal bush with their abundant creepers and lianes, while not usually reaching a height of more than 11 meters, provide a dense covering with abundant shade and humidity at ground level. As essentially shade-loving Diplopoda, the members of the genus are especially well represented in these littoral forests of the eastern half of the subcontinent. Members of the genus all have polygynandrous mating systems with sperm competition and cryptic female choice [1-87].

II. MATERIALS AND METHODS

Two morphometric parameters were used to obtain measurements, length and width, both of which were obtained from the published literature [18, 91, 92]. Surface areas were calculated based on the formula for the same cylinder SA = 2πr(r+h) in *C. anulatus* Attems, 1934, and *C. inscriptus* Attems, 1928 [18]. The data were collected during the rainy season because in southern Africa millipede surface activity is strongly seasonal and related to feeding and reproduction [88, 89] and this is also when population densities peak [90]. The two species of millipedes were sampled in their indigenous tropical coastal forest habitat at Twin Streams Farm, Mtunzini, South Africa (28°55'S; 31 °45'E). It is within this part of the typical coastal forest belt (Acocks, 1975) that *C. anulatus* and *C. inscriptus* are in geographical sympatry. An area of forest with continuous tree canopy cover was delimited and all sampling occurred within those bounds. In the first season, two temporally separate sampling efforts were made. In the following season a single sampling effort involved hand collecting all individual millipedes on the ground and in shrubs and trees separately, with the former measured on the ground and the latter as in the trees (>30cm but <3m above ground surface). The two species were morphologically separated based upon the presence of yellow flashes, red legs, and red heads (*C. inscriptus*) vs. discrete red-black annulations without yellow flashes, black legs, and blackheads (*C. anulatus*). Over a period of three full days, the total numbers of each species collected were used to calculate the relative abundance of each species

within the forest patch. The copulation frequencies were calculated as the number of copulating pairs divided by the population sample to get mating frequencies. Surface areas were relatedto volumes to get surface-area-to-volume ratios which were tested against mating frequencies for correlations at https://www.gigacalculator.com/calculators/correlation-coefficient-calculator.php.

III. RESULTS

Male surface-area-to-volume ratios appeared related to male mating frequencies (Figure 1: r=-0.93139991, Z score=-3.73166936, n=8, p=0.00009514). Female surface- area-to-volume ratios appeared related to female mating frequencies (Figure 2: r=-0.92532821, Z score=-3.63333017, n=8, p=0.00013993). There was a relationship between surface-area-to-volume ratios and mating frequencies when the sexes were pooled (Figure 3: r=-0.91458556, Z score=-5.60616579, n=16, p=0.00000001). There was no relationship between surface area-to-volume ratios and mating frequencies in *C. inscriptus* (r=0.21166688, Z score=0.48056626, n=8, p=0.31541240) or *C. anulatus* (r=-0.19930448, Z score=-0.45170397, n=8, p=0.32574115). Surface areas were not related to mating frequencies (r=0.12195322, Z score=0.44190811, n=16, p=0.32927788). Surface areas were related to mating frequencies in males (Figure 4: r=0.93139991, Z score=3.73166936, n=8, p=0.00009514). Surface areas were related to mating frequencies in females (Figure 5: r=-0.92532821, Z score=-3.63333017, n=8, p=0.00013993). There was no relationship between surface area-to-volume ratios and mating frequencies in *C. anulatus* (r=-0.19930448, Z score=-0.45170397, n=8, p=0.32574115) or *C. inscriptus* (r=-0.21166688, Z score=-0.48056626, n=8, p=0.31541240).

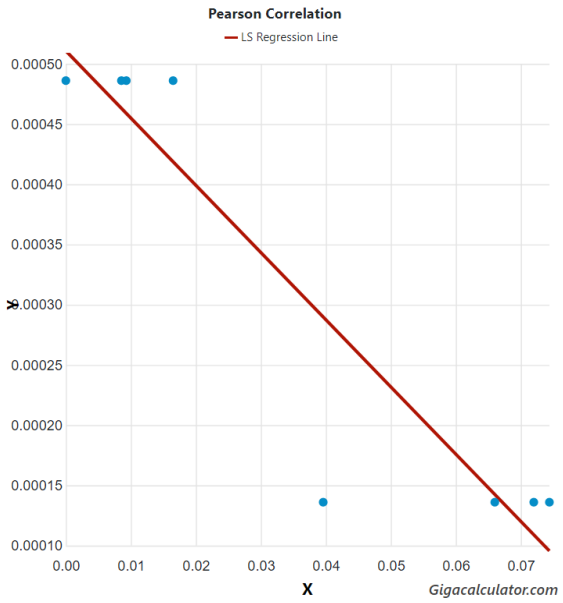

Figure 1. Relationship between male surface-area-to-volume ratios and male mating frequency in two species of *Centrobolus* Cook, 1897.

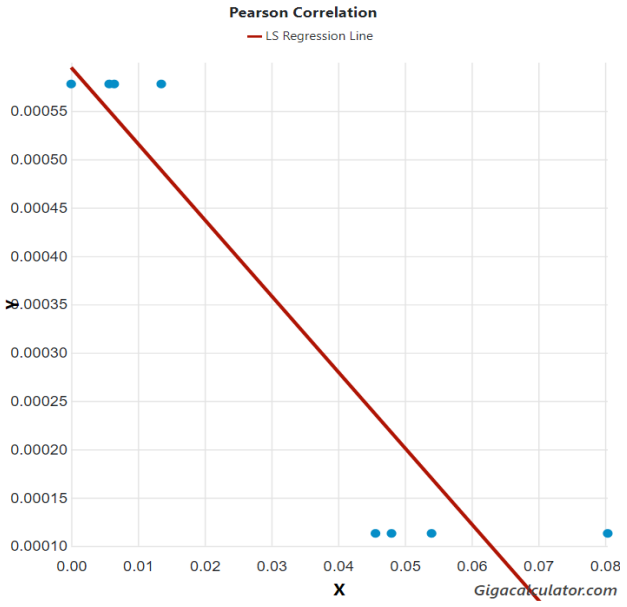

Figure 2. Relationship between female surface-area-to-volume ratios and female mating frequencies in two species of *Centrobolus* Cook, 1897.

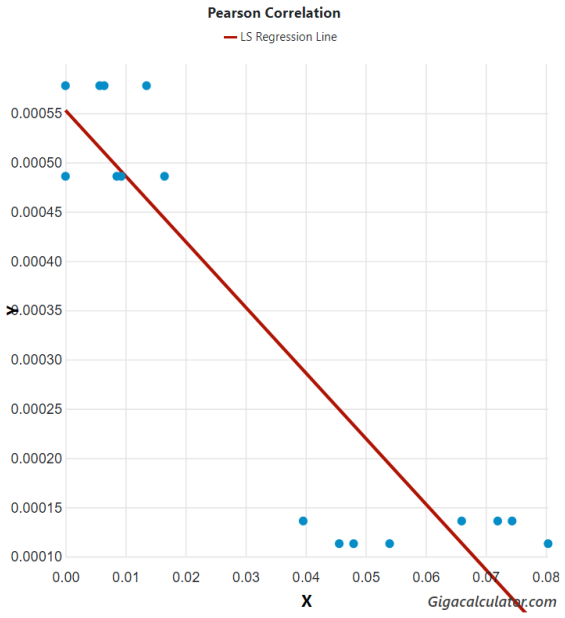

Figure 3. Relationship between male surface-area-to-volume ratio and mating frequencies in two species of *Centrobolus* Cook, 1897.

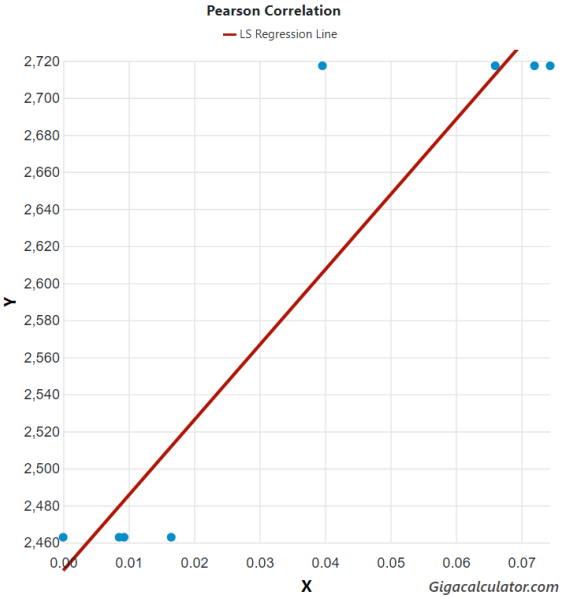

Figure 4. Relationship between male surface areas and male mating frequencies in two species of *Centrobolus* Cook, 1897.

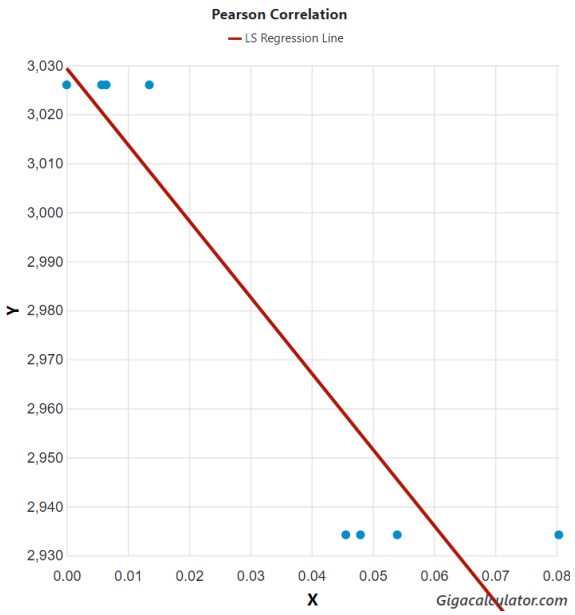

Figure 5. Relationship between female surface areas and male mating frequencies in two species of *Centrobolus* Cook, 1897.

IV. DISCUSSION

New relationships were discovered between male and female surface areas and surface-area-to-volume ratios and mating frequencies. The surface area relationships show opposite results across the sexes with a negative relationship in males and a positive relationship in females in surface areas but both surface-area-to-volume ratios and mating frequencies are all negative. The absence of species-specific relationships means the occurrences are purely sexually selected with the predators on these Mullerian mimicry pair of species possibly acting differently on each of the sexes.

REFERENCES

[1] M. I. Cooper, "Mating dynamics of South African forest millipedes *Centrobolus* (Diplopoda: Pachybolidae)," The University of Cape Town, pp. 1-141, 1998.

[2] M. I. Cooper, "Elaborate gonopods in the myriapod genus *Chersastus* (Diplopoda: Trigoniulidae)," Journal of Entomology and Zoology Studies, vol. 3, no. 4, pp. 235-238, 2015.

[3] M. Cooper, "Julid millipede and spirobolid millipede gonopod functional equivalents," Journal of Entomology and Zoology Studies, vol. 7, no. 4, pp. 333-335, 2019.

[4] M. I. Cooper, "Sexual size dimorphism and corroboration of Rensch's rule in *Chersastus* millipedes," Journal of

Entomology and Zoology Studies, vol. 2, no. 6, pp. 264-266, 2014.
[5] M. I. Cooper, "Copulation and sexual size dimorphism in worm-like millipedes," Journal of Entomology and Zoology Studies, vol. 5, no. 3, pp. 1264-1266, 2017.
[6] M. Cooper, "*Centrobolus anulatus* (Attems, 1934) reversed sexual size dimorphism," Journal of Entomology and Zoology Studies, vol. 6, no. 4, pp. 1569-1572, 2018.
[7] M. I. Cooper, "The relative sexual size dimorphism of *Centrobolus inscriptus* compared to 18 congenerics," Journal of Entomology and Zoology Studies, vol. 4, no. 6, pp. 504-505, 2016.
[8] M. I. Cooper, "Relative sexual size dimorphism in *Centrobolus fulgidus* (Lawrence) compared to 18 congenerics," Journal of Entomology and Zoology Studies, vol. 5, no. 3, pp. 77-79, 2017.
[9] M. I. Cooper, "Relative sexual size dimorphism *Centrobolus ruber* (Attems) compared to 18 congenerics," Journal of Entomology and Zoology Studies, vol. 5, no. 3, pp. 180-182, 2017.
[10] M. I. Cooper, "Competition affected by re-mating interval in a myriapod," Journal of Entomology and Zoology Studies, vol. 3, no. 4, pp. 77-78, 2015.
[11] M. Cooper M, Re-assessment of rensch's rule in *Centrobolus*," Journal of Entomology and Zoology Studies, vol. 5, no. 6, pp. 2408-1410. 2017.
[12] M. I. Cooper, "Sexual size dimorphism and the rejection of Rensch's rule in Diplopoda," Journal of Entomology and Zoology Studies, vol. 6, no. 1, pp. 1582-1587, 2018.
[13] M. I. Cooper, "Allometry for sexual dimorphism in millipedes," Journal of Entomology and Zoology Studies, vol. 6, no. 1, pp. 91-96, 2018.
[14] M. I. Cooper, "Trigoniulid size dimorphism breaks Rensch," Journal of Entomology and Zoology Studies, vol. 6, no. 3, pp. 1232-1234, 2018.
[15] M. Cooper, "A review of studies on the fire millipede genus centrobolus (diplopoda: trigoniulidae)," Journal of Entomology and Zoology Studies, vol. 6, no. 4, pp. 126-129, 2018.
[16] M. Cooper, "*Centrobolus sagatinus* sexual size dimorphism based on differences in horizontal tergite widths," Journal of Entomology and Zoology Studies, vol. 6, no. 6, pp. 275-277, 2018.
[17] M. Cooper, "*Centrobolus silvanus* dimorphism based on tergite width," Global Journal of Zoology, vol. 3, no. 1, pp. 003-005, 2018.
[18] M. Cooper, "Xylophagous millipede surface area to volume ratios are size dependent in forest," Arthropods, vol. 8, no. 4, pp. 127-136, 2019.
[19] M. I. Cooper, "Allometry of copulation in worm-like millipedes," Journal of Entomology and Zoology Studies, vol. 5, no. 3, pp. 1720-1722, 2017.
[20] M. Cooper, "Does sexual size dimorphism vary with longitude in forest millipedes *Centrobolus* Cook, 1897?" International Journal of Recent Research in Thesis and Dissertation, vol. 3, no. 1, pp. 1-5, 2022.
[21] M. Cooper, "Does sexual size dimorphism vary with latitude in forest millipedes *Centrobolus* Cook,1897?" Int. J. Re. Res. Thesis Diss., vol. 3, no. 1, pp. 6-11, 2022. https://www.paperpublications.org/issue/IJRRTD/Issue-1-January-2022-June-2022.
[22] M. Cooper, "Does sexual size dimorphism vary with temperature in forest millipedes *Centrobolus* Cook, 1897?" Acta Entomol. Zool., vol 3, no. 1, pp. 08-11, 2022. https://doi.org/10.33545/27080013.2022.v3.i1a.51.
[23] M. Cooper, "DOES SEXUAL SIZE DIMORPHISM VARY WITH MONTH WITH THE HIGHEST NUMBER OF RAINY DAYS IN FOREST MILLIPEDES *CENTROBOLUS* COOK, 1897," Universe Int. J. Interdiscip. Res., vol. 2, no. 9, pp. 9-14, 2022. https://www.doi-ds.org/doilink/03.2022-63261534/UIJIR.
[24] M. Cooper, "PAIR-WISE COMPARISON OF SEXUAL SIZE DIMORPHISM AMONG NINE FACTORS IN FOREST MILLIPEDES *CENTROBOLUS* COOK, 1897," Universe Int. J. Interdiscip. Res., vol. 2, no. 9, pp. 31-33, 2022. https://www.doi-ds.org/doilink/03.2022-75935617/UIJIR.
[25] M. Cooper, "Does sexual size dimorphism vary with female size in forest millipedes *Centrobolus* Cook, 1897?" Acta Entomol. Zool., vol. 3, no. 1, pp. 15-18, 2022. https://doi.org/10.33545/27080013.2022.v3.i1a.57.
[26] M. Cooper, "Does sexual size dimorphism vary with hours of sunshine throughout the year in forest millipedes *Centrobolus* Cook, 1897?" Acta Entomol. Zool., vol. 3, no. 1, pp. 19-25, 2022. DOI: https://doi.org/10.33545/27080013.2022.v3.i1a.58.
[27] M. Cooper, "DOES SEXUAL SIZE DIMORPHISM VARY WITH SPECIES RICHNESS IN FOREST MILLIPEDES *CENTROBOLUS* COOK, 1897?" Universe Int. J. Interdiscip. Res., vol. 2, no. 10, pp. 25-29, 2022. https://www.doi-ds.org/doilink/04.2022-91496952/UIJIR.
[28] M. Cooper, "PAIR-WISE COMPARISON OF SEXUAL SHAPE DIMORPHISM AMONG FIFTEEN FACTORS IN FOREST MILLIPEDES *CENTROBOLUS* COOK, 1897," Universe Int. J.Interdiscip. Res., vol. 2, no. 10, pp. 9-14, 2022. https://www.doi-ds.org/doilink/04.2022-18727172/UIJIR.
[29] M. I. Cooper, "Five factors effecting copulation duration in the breeding season in forest millipedes *Centrobolus* Cook, 1897," Zoological and Entomological Letters, vol. 2, no. 1, pp. 17-22, 2022. https://www.zoologicaljournal.com/archives/2022.v2.i1.A.26.
[30] M. Cooper, "Does sexual size dimorphism vary with time in red millipedes *Centrobolus* Cook,1897?" Zool. Entomol. Lett., vol 2, no. 1, pp. 30-35, 2022. https://www.zoologicaljournal.com/archives/2022.v2.i1.A.29..
[31] M. Cooper, "Mating frequencies of sympatric red millipedes differ across substrate due to absolute abundances," Acta Entomol. Zool., vol. 3, no. 1, pp. 34-39, 2022. https://doi.org/10.33545/27080013.2022.v3.i1a.62.
[32] M. Cooper, "Does sexual size dimorphism vary with maximum and minimum temperatures in red millipedes *Centrobolus* Cook, 1897?" Zool. Entomol. Lett., vol. 2, no. 1, pp. 60-65, 2022. https://www.zoologicaljournal.com/archives/2022.v2.i1.B.34.
[33] M. Cooper, "Does sexual size dimorphism vary with sex ratio in red millipedes *Centrobolus* Cook, 1897?" Zool. Entomol. Lett., vol. 2, no. 1, pp. 66-68, 2022. https://www.zoologicaljournal.com/archives/2022.v2.i1.B.35.

[34] M. Cooper, "Millipede mass: Intersexual differences," Zool. Entomol. Lett., vol. 2, no. 1, pp. 69-70, 2022. https://www.zoologicaljournal.com/archives/2022.v2.i1.B.36.
[35] M. I. Cooper, "Do copulation duration and sexual size dimorphism vary with absolute abundance in red millipedes *Centrobolus* Cook, 1897?" Acta Entomol. Zool., vol. 3, no. 1, pp. 51-54, 2022. https://www.actajournal.com/archives/2022.v3.i1.A.64. https://doi.org/10.33545/27080013.2022.v3.i1a.64.
[36] M. Cooper, "DOES SEXUAL SIZE DIMORPHISM VARY WITH FEMALE LENGTH IN FOREST MILLIPEDES *CENTROBOLUS* COOK, 1897?" Universe Int. J. Interdiscip. Res., vol. 2, no. 12, pp. 1-7, 2022. https://www.doi-ds.org/doilink/05.2022-69939779/UIJIR.
[37] M. Cooper, "DOES SEXUAL SIZE DIMORPHISM VARY WITH PRECIPITATION IN FOREST MILLIPEDES *CENTROBOLUS* COOK, 1897?" Munis Entomology and Zoology, vol 17, no. 2, pp. 1185-1189, 2022. https://www.munisentzool.org/Issue/abstract/does-sexual-size-dimorphism-vary-with-precipitation-in-forest-millipedes-centrobolus-cook-189713813.
[38] M. I. Cooper, "Do copulation durations of sympatric red millipedes vary seasonally with mating frequencies?" Int. J. Re. Res. Thesis Diss., vol. 3, no. 1, pp. 85-90, 2022. https://doi.org/10.5281/zenodo.6613001.
[39] M. I. Cooper, "The inverse latitudinal gradients in species richness of Southern African millipedes," Int. J. Re. Res. Thesis Diss., vol. 3, no. 1, pp. 91-112, 2022. https://doi.org/10.5281/zenodo.6613064.
[40] M. I. Cooper, "DOES SEXUAL SIZE DIMORPHISM VARY WITH LOG SEXUAL SIZE DIMORPHISM IN RED MILLIPEDES *CENTROBOLUS* COOK, 1897?" Universe Int. J. Interdiscip. Res., vol. 2, no. 12, pp. 52-54,2022. https://www.doi-ds.org/doilink/06.2022-83544225/UIJIR.
[41] M. I. Cooper, "Do copulation duration and sexual size dimorphism vary with absolute abundance in red millipedes *Centrobolus* Cook, 1897?" Acta Entomol. Zool., vol. 3, no. 1, pp. 51-54, 2022. https://www.actajournal.com/archives/2022.v3.i1.A.64. https://doi.org/10.33545/27080013.2022.v3.i1a.64.46).
[42] M. Cooper, "DOES SEXUAL SIZE DIMORPHISM VARY WITH FEMALE LENGTH IN FOREST MILLIPEDES *CENTROBOLUS* COOK, 1897?" Universe Int. J. Interdiscip. Res., vol. 2, no. 12, pp. 1-7, 2022. https://www.doi-ds.org/doilink/05.2022-69939779/UIJIR.
[43] M. Cooper, "DOES SEXUAL SIZE DIMORPHISM VARY WITH PRECIPITATION IN FOREST MILLIPEDES *CENTROBOLUS* COOK, 1897?" Munis Entomology and Zoology, vol. 17, no. 2, pp. 1185-1189, 2022. https://www.munisentzool.org/Issue/abstract/does-sexual-size-dimorphism-vary-with-precipitation-in-forest-millipedes-centrobolus-cook-1897_13813.48.
[44] M. I. Cooper, "Do copulation durations of sympatric red millipedes vary seasonally with matingfrequencies?" Int. J. Re. Res. Thesis Diss., vol. 3, no. 1, pp. 85-90, 2022. https://doi.org/10.5281/zenodo.6613001.49).
[45] M. I. Cooper, "The inverse latitudinal gradients in species richness of Southern African millipedes," Int. J. Re. Res. Thesis Diss., vol. 3, no. 1, pp. 91-112, 2022. https://doi.org/10.5281/zenodo.6613064.
[46] M. I. Cooper, "DOES SEXUAL SIZE DIMORPHISM VARY WITH LOG SEXUAL SIZE DIMORPHISM IN RED MILLIPEDES *CENTROBOLUS* COOK, 1897?" Universe Int. J. Interdiscip. Res., vol. 2, no. 12, pp. 52-54, 2022. https://www.doi-ds.org/doilink/06.2022-83544225/UIJIR.
[47] M. I. Cooper, "FEMALE VOLUME, LOWEST HOURS OF SUNSHINE, MONTH WITH THE HIGHEST NUMBER OF RAINY DAYS, RAINFALL, AND TEMPERATURES IN THE COOLEST AND WARMEST MONTHS OF THE YEAR ARE RELATED TO LATITUDE (AND LONGITUDE) ACROSS THE DISTRIBUTION OF PILL MILLIPEDES *SPHAEROTHERIUM* BRANDT, 1833," Universe Int. J. Interdiscip. Res., vol. 3, no. 1, pp. 11-22, 2022. https://www.doi-ds.org/doilink/06.2022-51527898/UIJIR. URL: http://hdl.handle.net/10019.1/125464.58).
[48] M. Cooper, "THE TIE-IN OF MALE BODY WIDTH ON COPULATION DURATION IN *CENTROBOLUS* COOK, 1897," Universe Int. J. Interdiscip. Res., vol. 3, no. 1, pp. 45-47, 2022. https://www.doi-ds.org/doilink/06.2022-88932399/UIJIR.59).
[49] M. I. Cooper, "IS A PROMINENT STERNITE RELATED TO MOMENTS OF INERTIA IN *CENTROBOLUS* COOK, 1897?" International Journal of Engineering Science Invention Research & Development, vol. 8, no. 12, pp. 26-28, 2022. http://www.ijesird.com/1_june_22.PDF.
[50] M. I. Cooper, "IS COPULATION DURATION RELATED TO MOMENTS OF INERTIA IN *CENTROBOLUS* COOK, 1897?" International Journal of Engineering Science Invention Research & Development, vol. 8, no. 12, pp. 29-31, 2022. http://www.ijesird.com/2_june_22.PDF.
[51] M. I. Cooper, "COPULATION DURATION IS RELATED TO EJACULATING VOLUME IN *CENTROBOLUS INSCRIPTUS* (ATTEMS, 1928)," International Journal of Engineering ScienceInvention Research & Development, vol. 8, no. 12, pp. 32-40, 2022. http://www.ijesird.com/3_june_22.PDF.
[52] M. I. Cooper, "Is a prominent sternite related to mass in *Centrobolus* Cook, 1897?" International Journal of Engineering Science Invention Research & Development, vol. 9, no. 1, pp. 1-4, 2022. http://www.ijesird.com/1_jul_22.PDF.
[53] M. I. Cooper, "Does sex ratio vary with absolute abundance in red millipedes *Centrobolus* Cook,1897?" International Journal of Engineering Science Invention Research & Development, vol. 9, no. 1, pp. 5-8, 2022. http://www.ijesird.com/2_jul_22.PDF.
[54] M. I. Cooper, "Does copulation duration vary with absolute abundance in red millipedes *Centrobolus* Cook, 1897?" International Journal of Engineering Science Invention Research & Development, vol. 9, no. 1, pp. 9-11, 2022. http://www.ijesird.com/3_jul_22.PDF.
[55] M. I. Cooper, "Are a prominent sternite, coleopod spine length, and spine number related to mating frequencies in *Centrobolus* Cook, 1897?" International Journal of Engineering Science Invention Research& Development, vol. 9, no. 1, pp. 12-15, 2022. http://www.ijesird.com/4_jul_22.PDF.
[56] M. I. Cooper, "Are coleopod spine length and number related to weather in *Centrobolus* Cook, 1897?" International Journal of Engineering Science Invention

Research & Development, vol. 9, no. 1, pp. 16-23, 2022. http://www.ijesird.com/5_jul_22.PDF.

[57] M. I. Cooper, "Are coleopod spine length and number related to mass in *Centrobolus* Cook, 1897?" International Journal of Engineering Science Invention Research & Development, vol. 9, no. 1, pp. 24-26, 2022. http://www.ijesird.com/6_jul_22.PDF.

[58] M. I. Cooper, "Is mass related to latitude, longitude, and weather in *Centrobolus* Cook, 1897?" International Journal of Engineering Science Invention Research & Development, vol. 9, no. 1, pp. 27-32, 2022. https://www.ijesird.com/7_jul_22.PDF.

[59] M. I. Cooper, "ARE MATING FREQUENCIES RELATED TO ABSOLUTE ABUNDANCE IN *CENTROBOLUS* COOK, 1897?" International Journal of Engineering Science Invention Research & Development, vol. 9, no. 1, pp. 33-37, 2022. https://www.ijesird.com/8_jul-22.PDF.

[60] M. I. Cooper, "Does sex ratio vary with absolute abundance in red millipedes *Centrobolus* Cook,1897?" International Journal of Engineering Science Invention Research & Development, vol. 9, no. 1, pp. 5-8, 2022. http://www.ijesird.com/2_jul_22.PDF.

[61] M. I. Cooper, "Does copulation duration vary with absolute abundance in red millipedes *Centrobolus* Cook, 1897?" International Journal of Engineering Science Invention Research & Development, vol. 9, no. 1, pp. 9-11, 2022. http://www.ijesird.com/3_jul_22.PDF.65).

[62] M. I. Cooper, "Are a prominent sternite, coleopod spine length, and spine number related to mating frequencies in *Centrobolus* Cook, 1897?" International Journal of Engineering Science Invention Research& Development, vol. 9, no. 1, pp. 12-15, 2022. http://www.ijesird.com/4_jul_22.PDF.

[63] M. I. Cooper, "Are coleopod spine length and number related to weather in *Centrobolus* Cook, 1897?" International Journal of Engineering Science Invention Research & Development, vol. 9, no. 1, pp. 16-23, 2022. http://www.ijesird.com/5_jul_22.PDF.

[64] M. I. Cooper, "Are coleopod spine length and number related to mass in *Centrobolus* Cook, 1897?" International Journal of Engineering Science Invention Research & Development, vol. 9, no. 1, pp. 24-26, 2022. http://www.ijesird.com/6_jul_22.PDF.

[65] M. I. Cooper, "Is mass related to latitude, longitude, and weather in *Centrobolus* Cook, 1897?" International Journal of Engineering Science Invention Research & Development, vol. 9, no. 1, pp. 27-32, 2022. https://www.ijesird.com/7_jul_22.PDF.

[66] M. I. Cooper, "ARE MATING FREQUENCIES RELATED TO ABSOLUTE ABUNDANCE IN *CENTROBOLUS* COOK, 1897?" International Journal of Engineering Science Invention Research & Development, vol. 9, no. 1, pp. 33-37, 2022. https://www.ijesird.com/8_jul-22.PDF.

[67] M. I. Cooper, "DOES COPULATION DURATION VARY WITH SEX RATIO IN THE RED MILLIPEDE *CENTROBOLUS* INSCRIPTUS (ATTEMS, 1928)?" International Journal of Engineering Science Invention Research & Development, vol. 9, no. 1, pp. 38-40, 2022. https://www.ijesird.com/9_jul_22.PDF.

[68] M. I. Cooper, "IS A PROMINENT STERNITE RELATED TO WEATHER IN *CENTROBOLUS* COOK, 1897?" International Journal of Engineering Science Invention Research & Development, vol. 9, no. 1, pp. 41-44, 2022. https://www.ijesird.com/10_jul_22.PDF.

[69] M. I. Cooper, "ARE MATING FREQUENCIES RELATED TO SEX RATIO IN *CENTROBOLUS* COOK, 1897?" International Journal of Engineering Science Invention Research & Development, vol. 9, no. 1, pp. 45-48, 2022. https://www.ijesird.com/11_jul_22.PDF.

[70] M. I. Cooper, "ARE MATING FREQUENCIES RELATED TO SEXUAL SIZE DIMOROPHISM IN *CENTROBOLUS* COOK, 1897?" International Journal of Engineering Science Invention Research & Development, vol. 9, no. 1, pp. 49-51, 2022. https://www.ijesird.com/12_jul_22.PDF.

[71] M. Cooper, "ARE MATING FREQUENCIES RELATED TO MOMENTS OF INERTIA ACROSS THE SEXES IN CENTROBOLUS COOK, 1897?" International Journal of Engineering Science Invention Research & Development, vol. 9, no. 1, pp. 52-55, 2022. https://www.ijesird.com/13_jul_22.PDF.

[72] M. I. Cooper, "ARE MATING FREQUENCIES RELATED TO TARSAL PAD LENGTH IN *CENTROBOLUS* COOK, 1897?" International Journal of Engineering Science Invention Research & Development, vol. 9, no. 2, pp. 1-4, 2022. https://www.ijesird.com/1_aug_22.PDF.

[73] M. Cooper, "IS COPULATION DURATION RELATED TO TARSAL PAD LENGTH IN *CENTROBOLUS* COOK, 1897?" International Journal of Engineering Science Invention Research &Development, vol. 9, no. 2, pp. 65-67, 2022. https://www.ijesird.com/3_aug_22.PDF.

[74] M. Cooper, "ARE ABSOLUTE ABUNDANCES RELATED TO TARSAL PAD LENGTH IN *CENTROBOLUS* COOK, 1897?" International Journal of Engineering Science Invention Research &Development, vol. 9, no. 2, pp. 68-70, 2022. https://www.ijesird.com/4_aug_22.PDF.

[75] M. I. Cooper, "ARE MATING FREQUENCIES RELATED TO MALE AND FEMALE SIZE IN *CENTROBOLUS* COOK, 1897?" International Journal of Engineering Science Invention Research & Development, vol. 9, no. 2, pp. 71-76, 2022. https://www.ijesird.com/5_aug_22.PDF.

[76] M. Cooper, "DOES EJACULATE VOLUME VARY WITH ABSOLUTE ABUNDANCE IN RED MILLIPEDES *CENTROBOLUS* COOK, 1897?" International Journal of Engineering Science Invention Research & Development, vol. 9, no. 2, pp. 77-79, 2022. https://www.ijesird.com/6_aug_22.PDF.

[77] M. I. Cooper, "THE MOMENTS OF INERTIA TIE-UP WITH FEMALE SIZE, HOURS OF SUNSHINE THROUGHOUT THE YEAR, LATITUDE, LONGITUDE, AND MINIMUM TEMPERATURE IN RED MILLIPEDES *CENTROBOLUS* COOK, 1897," Universe Int. J. Interdiscip. Res., vol. 3, no. 2, pp. 6-12, 2022. https://www.doi-ds.org/doilink/08.2022-76913842/UIJIR.

[78] M. I. COOPER, "ARE MATING FREQUENCIES RELATED TO EJACULATE VOLUMES IN *CENTROBOLUS* COOK, 1897?" International Journal of

Engineering ScienceInvention Research & Development, vol. 9, no. 3, pp. 93-95, 2022. https://www.ijesird.com/aug_ten.PDF.

[79] M. Cooper, "DOES SEXUAL SIZE DIMORPHISM VARY WITH FEMALE WIDTH IN FOREST MILLIPEDES *CENTROBOLUS* COOK, 1897?" Munis Entomol. Zool., vol. 17(supplement), pp. 1562-1565, 2022. https://www.munisentzool.org/Issue/abstract/does-sexual-size-dimorphism-vary-with-female-width-in-forest-millipedes-centrobolus-cook-1897_13854.

[80] M. Cooper, "DOES SEXUAL SIZE DIMORPHISM VARY WITH THE HIGHEST TOTAL HOURS OF SUNSHINE IN A MONTH IN FOREST MILLIPEDES *CENTROBOLUS* COOK, 1897?" Munis Entomol. Zool., vol. 17(supplement), pp. 1596-1602, 2022. https://www.munisentzool.org/Issue/abstract/does-sexual-size-dimorphism-vary-with-the-highest-total-hours-of-sunshine-in-a-month-in-forest-millipedes-centrobolus-cook-1897_13858.

[81] M. Cooper, "DOES SEXUAL SIZE DIMORPHISM VARY WITH BODY MASS IN FOREST MILLIPEDES *CENTROBOLUS* COOK, 1897?" Munis Entomol. Zool. Suppl., vol. 17(supplement), pp. 1621-1624, 2022. https://www.munisentzool.org/Issue/abstract/does-sexual-size-dimorphism-vary-with-body-mass-in-forest-millipedes-centrobolus-cook-1897_13861.

[82] M. COOPER, "IS SIZE OR SSD RELATED TO ABUNDANCE IN *CENTROBOLUS* COOK,1897?" International Journal of Engineering Science Invention Research & Development., vol. 9, no. 3, pp. 96-102, 2022. https://www.ijesird.com/sep_one.PDF.

[83] M. I. COOPER, "IS A PROMINENT STERNITE RELATED TO SEX RATIOS ANDABUNDANCE IN *CENTROBOLUS* COOK, 1897?" International Journal of Engineering Science Invention Research & Development, vol. 9, no. 3, pp. 103-106, 2022. https://www.ijesird.com/sep_two_6.PDF.

[84] M. I. Cooper, "DOES SEXUAL SIZE DIMORPHISM VARY WITH FEWEST DAILY HOURS OF SUNSHINE IN RED MILLIPEDES *CENTROBOLUS* COOK, 1897?" Universe Int. J. Interdiscip. Res., vol. 3, no. 3, pp. 89-92, 2022. https://www.doi-ds.org/doilink/09.2022-94655978/UIJIR.

[85] M. COOPER, "DOES (PREDICTED) MASS CORRELATE WITH MATING FREQUENCIES IN *CENTROBOLUS* COOK, 1897?" Universe Int. J. Interdiscip. Res., vol. 3, no. 4, 141-19.

[86] M. I. COOPER, "IS MASS CORRELATED WITH LENGTH AMONG RED MILLIPEDES *CENTROBOLUS* COOK, 1897?" (SUBMITTED).

[87] M. I. Cooper, "Sexual conflict over the duration of copulation in Centrobolus inscriptus," JOURNAL OF ENTOMOLOGY AND ZOOLOGY STUDIES, vol. 4, no. 6, pp. 852-854, 2016. DOI: 10.22271/j.ento.2016.v4.i6l.04.

[88] Dangerfield JM, Telford SR. 1991. Seasonal activity patterns of Julid millipedes in Zimbabwe. J. Trap. Ecol. 7, 281-285.

[89] Dangerfield jM, Telford SR. 1993. Ingestion of mineral soil/litter mixtures and faecal pellet production in the southern African millipede Alloporus uncinatus (Attems). Pedobiologia 37, 159-166.

[90] Dangerfield JM. Abundance and diversity of soil macrofauna in northern Botswana. Journal of Tropical Ecology. 1997 Jul;13(4):527-538. DOI: 10.1017/s0266467400010695.

[91] R. F. Lawrence, "The Spiroboloidea (Diplopoda) of the eastern half of Southern Africa*," Annals of the Natal Museum, vol. 18, no. 3, pp. 607-646, 1967.

[92] Schubart O. 1966. Diplopoda III. South African Animal Life, 12: 1-227.