

## ARE SURFACE AREA AND SURFACE-AREA-TO-VOLUME RATIO RELATED TO COPULATION DURATION IN *CENTROBOLUS* COOK, 1897?

MARK I. COOPER

UNIVERSITY OF JOHANNESBURG, SOUTH AFRICA.

**Abstract-** In this paper, I check for relationships between male and female surface area and male and female surface area to volume ratio with copulation duration in red millipedes *Centrobolus* Cook, 1897. Male surface area was not related to copulation duration (Kendall's  $\tau=0$ , Z score=0, n=4, p=0.50). Male surface area-to-volume was related to copulation duration (Kendall's  $\tau=-1$ , Z score=-2.32379001, n=4, p=0.01006835). Female surface area was not related to copulation duration (Kendall's  $\tau=-0.33333333$ , Z score=-0.77459667, n=4, p=0.21928894). Female surface-area-to-volume ratio was related to copulation duration ( $r=-1$ , Z score =-2.32379001, n=4, p=0.01006835). Surface-area-to-volume ratios were negatively related to copulation duration (Kendall's  $\tau=-0.77151675$ , Z score=-200000, n=8, p=0).

### I. 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. 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 litoral forests of the eastern half of the subcontinent [1-84].

In this paper, from the results, I check for relationships between male and female surface area and male and female surface area to volume ratio

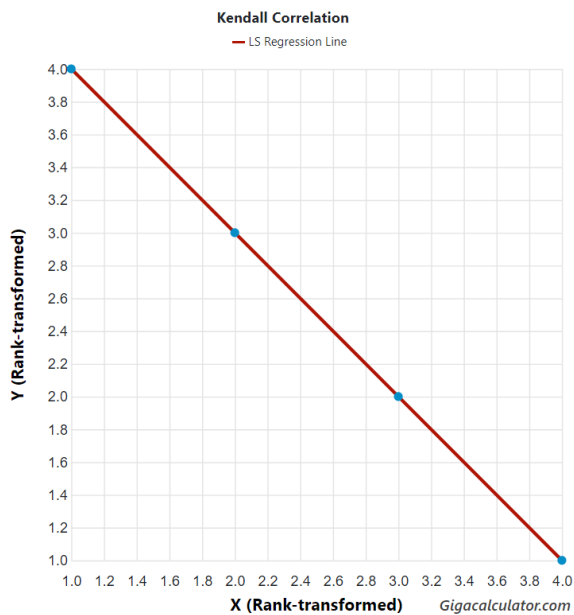
with copulation duration in red millipedes *Centrobolus* Cook, 1897.

### II. MATERIALS AND METHODS

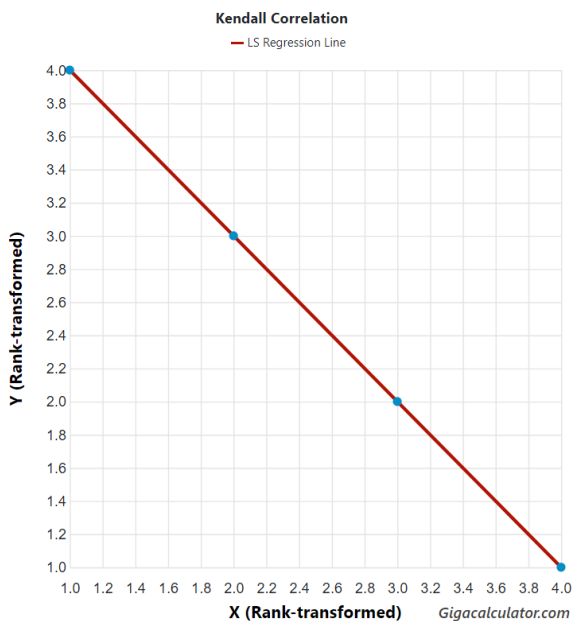
Body volumes, surface areas, and surface area to volume ratios were calculated in four forest species of red millipedes *Centrobolus*. Two morphometric parameters were used to obtain measurements, length and width, both of which were obtained from the published literature [17]. Body volumes were calculated based on the formula for a cylinder  $V = \pi r^2 h$  and surface areas were calculated based on the formula for the same cylinder  $SA = 2\pi r(r+h)$  in all species. Surface-area-to-volume ratios were calculated as proper fractions of surface area to volume. Copulation durations were given in four species of *Centrobolus* [1].

### III. RESULTS

Male surface area was not related to copulation duration (Kendall's  $\tau=0$ , Z score=0, n=4, p=0.50). Male surface area-to-volume ratio was related to copulation duration (Figure 1: Kendall's  $\tau=-1$ , Z score=-2.32379001, n=4, p=0.01006835). Female surface area was not related to copulation duration (Kendall's  $\tau=-0.33333333$ , Z score=-0.77459667, n=4, p=0.21928894). Female surface-area-to-volume ratio was related to copulation duration ( $r=-1$ , Z score =-2.32379001, n=4, p=0.01006835). Surface-area-to-volume ratios were related to copulation duration (Kendall's  $\tau=-0.77151675$ , Z score=-200000, n=8, p=0).



**Figure 1.** Relationship between male surface-area-to-volume ratio and copulation duration in *Centrobolus* Cook, 1897.



**Figure 2.** Relationship between female surface-area-to-volume ratio and copulation duration in *Centrobolus* Cook, 1897.

#### IV. DISCUSSION

Two new relationships are documented between the male surface area-to-volume ratio which was related to copulation duration and the female surface area-to-volume ratio which was related to copulation duration. It suggests there are

precipitation-size patterns in worm-like millipedes that may affect the adaptability to and validity of biological rules [85, 86]. The significantly higher surface area-to-volume ratios of female forest millipedes is known [17]. The relationship between male and female surface area-to-volume ratios and copulation duration provides new evidence for lower surface areas associated with prolonged mate-guarding in eastern species. The female surface-area-to-volume ratio was related to copulation duration may suggest that species with smaller females which are also found further east endure shorter copulations.

#### REFERENCES

1. O. F. Cook, "New relatives of *Spirobolus giganteus*," *Brandtia* (A series of occasional papers on Diplopoda and other Arthropoda), vol. 18, pp. 73-75, 1897.
2. M. Cooper, "Mating dynamics of South African forest millipede *Centrobolus* (Diplopoda: Pachybolidae)," Thesis, University of Cape Town, 1-141, 1998.
3. M. I. Cooper, "Elaborate gonopods in the myriapod genus *Chersastus* (Diplopoda: Trigoniulidae)," *JOURNAL OF ENTOMOLOGY AND ZOOLOGY STUDIES* 3(4):235-238. DOI: 10.22271/j.ento.2015.v3.i4d.573.
4. M. I. Cooper, "Fire millipedes obey the female sooner norm in cross mating *Centrobolus*," *JOURNAL OF ENTOMOLOGY AND ZOOLOGY STUDIES*, vol 4, no. 1, pp. 173-174, 2016. DOI:10.22271/j.ento.2016.v4.i1c.05.
5. M. I. Cooper, "Sexual bimaturism in the millipede *Centrobolus inscriptus*," *Journal of Entomology and Zoology Studies*, vol. 4, no. 3, pp. 86-87, 2016. DOI: 10.22271/j.ento.2016.v4.i3b.02.
6. M. Cooper, "Post-insemination associations between males and females in Diplopoda: A remark on Alcock's (1994) predictions of the mate-guarding hypothesis," *JOURNAL OF ENTOMOLOGY AND ZOOLOGY STUDIES*, vol. 4, no. 2, pp. 283-285, 2016. DOI: 10.22271/j.ento.2016.v4.i2d.908.
7. M. I. Cooper, "Heavier-shorter-wider females in the millipede *Centrobolus inscriptus* Attems (Spirobolida: Trigoniulidae)," *JOURNAL OF ENTOMOLOGY AND ZOOLOGY STUDIES*, vol. 4, no. 2, pp. 509-510, 2016. DOI: 10.22271/j.ento.2016.v4.i2g.08.
8. M. I. Cooper, "Confirmation of four species of *Centrobolus* Cook based on gonopod ultrastructure," *INTERNATIONAL JOURNAL OF ENTOMOLOGY RESEARCH*, vol. 3, no. 1, pp. 07-09, 2016. <https://www.entomologyjournals.com/archives/2016/vol1/i3sue3/1-2-13>.
9. 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.
10. The affect of female body width on copulation duration in *Centrobolus inscriptus*. *JOURNAL OF ENTOMOLOGY*

- AND ZOOLOGY STUDIES, vol. 5, no. 1, pp. 732-733, 2017. DOI: 10.22271/j.ento.2017.v5.i1j.10.
11. M. I. Cooper, "Relative sexual size dimorphism in *Centrobolus digrammus* compared to 18 congeners," JOURNAL OF ENTOMOLOGY AND ZOOLOGY STUDIES, vol. 5, no. 2, pp. 1558-1560, 2017. DOI: 10.22271/j.ento.2017.v5.i2u.04.
  12. Cooper M, "Allometry in *Centrobolus*," Journal of Entomology and Zoology Studies, vol. 6, no. 6, pp. 284-286, 2018.
  13. Cooper M, "*Centrobolus silvanus* dimorphism based on tergite width," Global Journal of Zoology, vol. 3, no. 1, 003-005, 2018. DOI: 10.17352/gjz.000010.
  14. M. Cooper, "*Centrobolus* size dimorphism breaks Rensch's rule," Arthropods, vol. 7, no. 3, pp. 48-52, 2018.
  15. M. I. Cooper, "Trigoniulid size dimorphism breaks Rensch," Journal of Entomology and Zoology Studies, vol. 6, no. 3, pp. 1232-1234, 2018.
  16. M. Cooper, "Julid and spirobolid millipede gonopod functional equivalents," JOURNAL OF ENTOMOLOGY AND ZOOLOGY STUDIES, vol. 7, no. 4, pp. 333-335, 2019. DOI: 10.22271/j.ento.2019.v7.i4f.5465.
  17. M. Cooper, "Xylophagous millipede surface area to volume ratios are size dependent in forests," Arthropods, vol. 8, no. 4, pp. 127-136, 2019.
  18. 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. <https://www.paperpublications.org/issue/IJRRTD/Issue-1-January-2022-June-2022>.
  19. 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..>
  20. 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>.
  21. 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/doi/10.22271/j.ento.2017.v5.i1j.10>.
  22. 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/doi/10.22271/j.ento.2017.v5.i2u.04>.
  23. 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>.
  24. 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>.
  25. 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/doi/10.22271/j.ento.2017.v5.i1j.10>.
  26. 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/doi/10.22271/j.ento.2017.v5.i1j.10>.
  27. 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>.
  28. 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>.
  29. 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>.
  30. 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>.
  31. 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>.
  32. 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>.
  33. 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>.
  34. 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/doi/10.22271/j.ento.2017.v5.i1j.10>.
  35. 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](https://www.munisentzool.org/Issue/abstract/does-sexual-size-dimorphism-vary-with-precipitation-in-forest-millipedes-centrobolus-cook-1897_13813).
  36. 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>.
37. 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>.
38. 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/doi/10.2022-83544225/UIJIR>.
39. 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.html>. <https://doi.org/10.33545/27080013.2022.v3.i1a.64>.
40. M. Cooper, "DOES SEXUAL SIZE DIMORPHISM VARY WITH FEMALE LENGTH INFOREST MILLIPEDES CENTROBOLUS COOK, 1897?" Universe Int. J. Interdiscip. Res., vol. 2, no. 12, pp. 1-7, 2022. <https://www.doi-ds.org/doi/10.2022-69939779/UIJIR>.
41. M. Cooper, "DOES SEXUAL SIZE DIMORPHISM VARY WITH PRECIPITATION INFOREST MILLIPEDES CENTROBOLUS COOK, 1897?" Munis Entomology and Zoology, vol. 17, no. 2, pp. 1185-1189, 2022. <https://www.munisentomology.org/Issue/abstract/does-sexual-size-dimorphism-vary-with-precipitation-in-forest-millipedes-centrobolus-cook-1897-13813>.
42. 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>.
43. 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>.
44. 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/doi/10.2022-83544225/UIJIR>.
45. 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/doi/10.2022-51527898/UIJIR>. URL: <http://hdl.handle.net/10019.1/125464>.
46. 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/doi/10.2022-88932399/UIJIR>.
47. 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](http://www.ijesird.com/1_june_22.PDF).
48. 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](http://www.ijesird.com/2_june_22.PDF).
49. M. I. Cooper, "COPULATION DURATION IS RELATED TO EJACULATING VOLUME IN CENTROBOLUS INSCRIPTUS (ATTEMPS, 1928)," International Journal of Engineering Science Invention Research & Development, vol. 8, no. 12, pp. 32-40, 2022. [http://www.ijesird.com/3\\_june\\_22.PDF](http://www.ijesird.com/3_june_22.PDF).
50. 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](http://www.ijesird.com/1_jul_22.PDF).
51. 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](http://www.ijesird.com/2_jul_22.PDF).
52. 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](http://www.ijesird.com/3_jul_22.PDF).
53. 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](http://www.ijesird.com/4_jul_22.PDF).
54. 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](http://www.ijesird.com/5_jul_22.PDF).
55. 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](http://www.ijesird.com/6_jul_22.PDF).
56. 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](https://www.ijesird.com/7_jul_22.PDF).
57. 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](https://www.ijesird.com/8_jul_22.PDF).
58. 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](http://www.ijesird.com/2_jul_22.PDF).



59. 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](http://www.ijesird.com/3_jul_22.PDF).
60. 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](http://www.ijesird.com/4_jul_22.PDF).
61. 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](http://www.ijesird.com/5_jul_22.PDF).
62. 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](http://www.ijesird.com/6_jul_22.PDF).
63. 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](https://www.ijesird.com/7_jul_22.PDF).
64. 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](https://www.ijesird.com/8_jul_22.PDF).
65. M. I. Cooper, "DOES COPULATION DURATION VARY WITH SEX RATIO IN THE RED MILLIPEDE *CENTROBOLUS INSCRIPTUS (ATTEMPS, 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](https://www.ijesird.com/9_jul_22.PDF).
66. 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](https://www.ijesird.com/10_jul_22.PDF).
67. 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](https://www.ijesird.com/11_jul_22.PDF).
68. M. I. Cooper, "ARE MATING FREQUENCIES RELATED TO SEXUAL SIZE DIMORPHISM 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](https://www.ijesird.com/12_jul_22.PDF).
69. 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](https://www.ijesird.com/13_jul_22.PDF).
70. 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](https://www.ijesird.com/1_aug_22.PDF).
71. 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](https://www.ijesird.com/3_aug_22.PDF).
72. 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](https://www.ijesird.com/4_aug_22.PDF).
73. 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](https://www.ijesird.com/5_aug_22.PDF).
74. 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](https://www.ijesird.com/6_aug_22.PDF).
75. 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/doi/10.2022-76913842/UIJIR>.
76. M. I. COOPER, "ARE MATING FREQUENCIES RELATED TO EJACULATE VOLUMES IN *CENTROBOLUS COOK, 1897?*" International Journal of Engineering Science Invention Research & Development, vol. 9, no. 3, pp. 93-95, 2022. [https://www.ijesird.com/aug\\_ten.PDF](https://www.ijesird.com/aug_ten.PDF).
77. 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](https://www.munisentzool.org/Issue/abstract/does-sexual-size-dimorphism-vary-with-female-width-in-forest-millipedes-centrobolus-cook-1897_13854).
78. 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](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).
79. 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\\_13862](https://www.munisentzool.org/Issue/abstract/does-sexual-size-dimorphism-vary-with-body-mass-in-forest-millipedes-centrobolus-cook-1897_13862).

- [size-dimorphism-vary-with-body-mass-in-forest-millipedes-centrobolus-cook-1897\\_13861.](#)
80. 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](https://www.ijesird.com/sep_one.PDF).
  81. M. I. COOPER, "IS A PROMINENT STERNITE RELATED TO SEX RATIOS AND ABUNDANCE 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](https://www.ijesird.com/sep_two_6.PDF).
  82. 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/doi/10.2022-94655978/UIJIR>.
  83. M. COOPER, "DOES (PREDICTED) MASS CORRELATE WITH MATING FREQUENCIES IN CENTROBOLUS COOK, 1897?" Universe Int. J. Interdiscip. Res., vol. 3, no. 4, 141-19.
  84. M. I. COOPER, "IS MASS CORRELATED WITH LENGTH AMONG RED MILLIPEDES CENTROBOLUS COOK, 1897?" (ACCEPTED).
  85. S. Meiri, T. Dayan, "On the validity of Bergmann's rule," Journal of Biogeography, vol. 30, no. 3, pp. 331-351, 2003.
  86. K. Schmidt-Nielsen, "Scaling: Why is Animal Size so Important?" Cambridge University Press, New York, USA, 1984.