SURFACE AREA, SURFACE AREA TO VOLUME RATIO, AND CLIMATIC CORRELATES IN PILL MILLIPEDES *SPHAEROTHERIUM* BRANDT, 1833.

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Abstract- The minimum temperature with the highest and lowest ocean water temperature across the distribution of pill millipedes Sphaerotherium Brandt, 1833 was calculated. There was a correlation between the minimum temperature with the highest ocean water temperature across the distribution of pill millipedes Sphaerotherium (r=0.7714, r²=0.5951, n=7, p=0.042245). There was a correlation between the minimum temperature with the lowest ocean water temperature across the distribution of pill millipedes Sphaerotherium (r=0.912, r²=0.8317, n=7, p=0.004206). The mean annual temperature with the highest and lowest ocean water temperature across the distribution of pill millipedes Sphaerotherium Brandt, 1833 was calculated. There was a correlation between the mean annual temperature with the highest ocean water temperature across the distribution of pill millipedes Sphaerotherium (r=0.7922, r²=0.6276, n=7, p=0.033684). There was a correlation between the mean annual temperature with the lowest ocean water temperature across the distribution of pill millipedes Sphaerotherium (r=0.9241, r²=0.8725, n=7, p=0.002066). The highest, lowest, and mean ocean water temperature were correlated with the month with the most daily hours of sunshine across the distribution of pill millipedes Sphaerotherium Brandt, 1833. There was a correlation between the highest ocean water temperature with the month with the most daily hours of sunshine across the distribution of pill millipedes Sphaerotherium (r=-0.9576, r2=0.917, n=7, p=0.000695). There was a correlation between the lowest ocean water temperature with the month with the most daily hours of sunshine across the distribution of pill millipedes Sphaerotherium (r=-0.8825, r²=0.7788, n=7, p=0.008524). There was a correlation between the mean ocean water temperature with the month with the most daily hours of sunshine across the distribution of pill millipedes Sphaerotherium (r=-0.74236672, Z score=-1.91146247, n=7, p=0.02797252). The hours of sunshine each month was correlated with the month with the most and least daily hours of sunshine across the distribution of pill millipedes Sphaerotherium Brandt, 1833. There was a correlation between the hours of sunshine each month with the month with the most daily hours of sunshine across the distribution of pill millipedes Sphaerotherium (Pearson's r=0.76982277, Z score=2.03978509, n=7, p=0.02068580). There was a correlation between the hours of sunshine each month with the month with the lowest daily hours of sunshine across the distribution of pill millipedes Sphaerotherium (Pearson's r=0.81607806, Z score=2.28992312, n=7, p=0.01101286). The mean annual temperature with the highest average temperature across the distribution of pill millipedes Sphaerotherium Brandt, 1833 was calculated. There was a correlation between the mean annual temperature with the highest average temperature across the distribution of pill millipedes Sphaerotherium (r=0.9646, r²=0.9305, n=7, p=0.000444). There was a correlation between the mean annual temperature with the lowest average temperature across the distribution of pill millipedes Sphaerotherium (r=0.9327, r²=0.8699, n=7, p=0.002152). These factors potentially determine the size of female pill millipedes. These factors potentially determine the size of female pill millipedes. The driest and wettest months with the distance to the closest airport across the distribution of pill millipedes Sphaerotherium Brandt. 1833 was calculated. There was a marginal correlation between the driest months with the distance to the closest airport across the distribution of pill millipedes Sphaerotherium (r=-0.7366, r²=0.5326, n=7, p=0.05782; Pearson's r=0.73655358, Z score=1.88580773, n=7, p=0.02966037). There was a correlation between the wettest months with the distance to the closest airport across the distribution of pill millipedes Sphaerotherium (r=-0.9404, r²=0.8844, n=7, p=0.00164). The difference between the driest and wettest months with the distance to the closest airport across the distribution of pill millipedes Sphaerotherium Brandt, 1833 was calculated. There was a correlation between the difference between the driest and wettest months with the distance to the closest airport across the distribution of pill millipedes Sphaerotherium (r=-0.9217, r2=8495, n=7, p=0.000248). Minimum precipitation was correlated with maximum precipitation and the month with the most daily hours of sunshine across the distribution of pill millipedes Sphaerotherium Brandt, 1833. There was a correlation between the minimum precipitation with the maximum precipitation across the distribution of pill millipedes Sphaerotherium (Pearson's r=-0.8568, r²=0.7341, n=7, p=0.013777). There was a correlation between the minimum precipitation with the month with the most daily hours of sunshine across the distribution of pill millipedes Sphaerotherium (Pearson's r=-0.68117751, Z score=-1.66261523, n=7, p=0.04819472). The male and female surface area to volume ratio was correlated with the month with the lowest and most daily hours of sunshine across the distribution of pill millipedes Sphaerotherium Brandt, 1833. There was a correlation between the male and female surface area to volume ratio with the month with the lowest daily hours of sunshine across the distribution of pill millipedes Sphaerotherium (Spearman's r=0.48385028, Z score=1.70089216, n=7, p=0.04448159; Pearson's r=0.40402675, Z score=1.42101426, n=7, p=0.07765635). There was a correlation between the male and female surface area to volume ratio with the month with the most daily hours of sunshine across the distribution of pill millipedes Sphaerotherium (Spearman's r=0.48385028, Z score=1.70089216, n=7, p=0.04448159; Pearson's r=0.37490814, Z score=1.30715411, n=7, p=0.09558025). The male surface area to volume ratio was correlated with the average temperature across the distribution of pill millipedes Sphaerotherium Brandt, 1833. There was a correlation between the male surface area to volume ratio with the average temperature across the distribution of pill millipedes Sphaerotherium (Spearman's r=-0.76376262, Z score=-1.95264152, n=7, p=0.02543097). The surface area to volume ratio with the lowest average temperature across the distribution of pill millipedes Sphaerotherium Brandt, 1833 was calculated. There was a correlation between the surface area to volume ratio with the lowest average temperature across the distribution of pill millipedes Sphaerotherium (r=-0.6074, r²=0.3689, n=7, p=0.02134). The male surface area to volume ratio was correlated with the lowest average temperature and female surface area to volume ratio across the distribution of pill millipedes Sphaerotherium Brandt, 1833. There was a correlation between the male surface area to volume ratio with the with the female surface area to volume ratio across the distribution of pill millipedes Sphaerotherium (r=-0.9126, r²=0.8328, n=7, p=0.00136). There was a correlation between the male surface area to volume ratio with the lowest average temperature across

the distribution of pill millipedes Sphaerotherium (r=-0.68079494, Z score=-1.66118842, n=7, p=0.04833779) (y = -12.62902082 · x + 17.52288018).

Keywords: driest, months, Pill Millipedes, wettest.

I. 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 [1-297]. Size differences occur with factors such as color, sexes, species, urbanisation and water relations. Diplopoda resemble the majority of invertebrates where SSD is reversed. SSD has consequences for the outcome of sexual encounters in diplopod mating. The macro-evolutionary patterns are being resolved in the class Diplopoda. In the present study, correlations between the male and female surface area and surface area to volume ratios with climate are performed across the distribution of pill millipedes *Sphaerotherium* Brandt, 1833.

II. MATERIALS AND METHODS

Male surface area was calculated at https://www.omnicalculator.com/math/area-of-sphere from the widths of seven millipede species (https://www.entomoljournal.com/archives/2018/vol6issue1/PartI/5-6-352-508.pdf) (Appendix 22-27). The climatic factors were obtained at https://en.climate-data.org/africa/south-africa across the distribution of seven pill millipedes Sphaerotherium Brandt, 1833 (https://www.entomoljournal.com/archives/2018/vol6issue1/PartI/5-6-352-508.pdf) (Appendix 1-21). A correlation between the factors was generated at https://www.gigacalculator.com/calculators/correlation-coefficient-calculator.php.

III. RESULTS

There was a correlation between the minimum temperature with the lowest ocean water temperature across the distribution of pill millipedes *Sphaerotherium* (Fig. 1: r=0.912, r²=0.8317, n=7, p=0.004206).

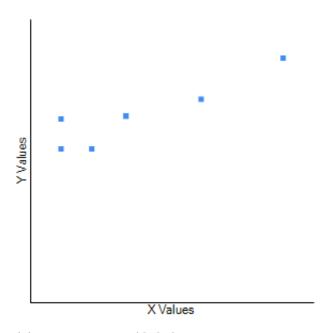
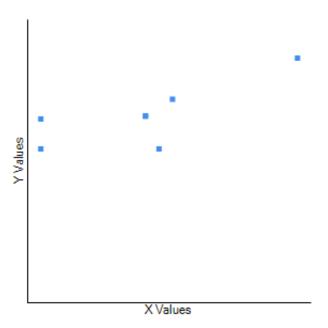


Fig. 1 A correlation between the minimum temperature with the lowest ocean water temperature across the distribution of pill millipedes *Sphaerotherium*.

There was a correlation between the minimum temperature with the highest ocean water temperature across the distribution of pill millipedes *Sphaerotherium* (Fig. 2: r=0.7714, r²=0.5951, n=7, p=0.042245).



 $\label{eq:constraints} \textbf{Fig. 2. A correlation between the minimum temperature with the highest ocean water temperature across the distribution of pill millipedes \textit{Sphaerotherium}.$

There was a correlation between the mean annual temperature with the highest ocean water temperature across the distribution of pill millipedes Sphaerotherium (Fig. 3: r=0.7922, r²=0.6276, n=7, p=0.033684).

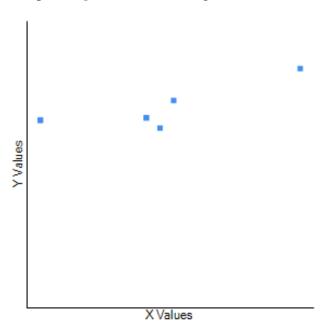


Fig. 3. A correlation between the mean annual temperature with the highest ocean water temperature across the distribution of pill millipedes *Sphaerotherium*.

There was a correlation between the mean annual temperature with the lowest ocean water temperature across the distribution of pill millipedes *Sphaerotherium* (Fig. 4: r=0.9241, r²=0.8725, n=7, p=0.002066).

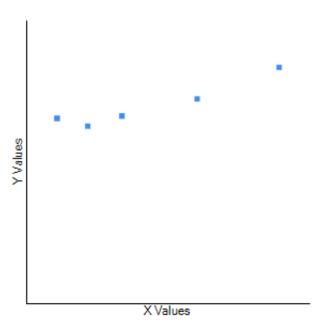


Fig. 4. A correlation between the mean annual temperature with the lowest ocean water temperature across the distribution of pill millipedes *Sphaerotherium*.

There was a correlation between the highest ocean water temperature with the month with the most daily hours of sunshine across the distribution of pill millipedes *Sphaerotherium* (Fig. 5: r=-0.9576, r2=0.917, n=7, p=0.000695).

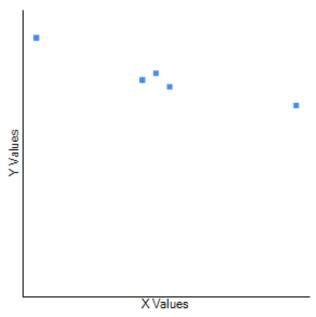


Fig. 5. A negative correlation between the highest ocean water temperature with month with the most daily hours of sunshine across the distribution of pill millipedes *Sphaerotherium*.

There was a correlation between the lowest ocean water temperature with the month with the most daily hours of sunshine across the distribution of pill millipedes *Sphaerotherium* (Fig. 6: r=-0.8825, $r^2=0.7788$, n=7, p=0.008524).

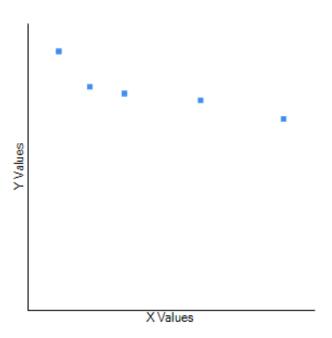


Fig. 6. A negative between the lowest ocean water temperature with month with the most daily hours of sunshine across the distribution of pill millipedes *Sphaerotherium*.

There was a correlation between the mean ocean water temperature with the month with the most daily hours of sunshine across the distribution of pill millipedes *Sphaerotherium* (Fig. 7: r=-0.74236672, Z score=-1.91146247, n=7, p=0.02797252).

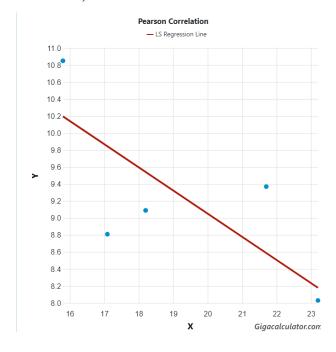


Fig. 7. A negative correlation between the mean ocean water temperature with month with the most daily hours of sunshine across the distribution of pill millipedes *Sphaerotherium*.

There was a correlation between the hours of sunshine each month with the month with the most daily hours of sunshine across the distribution of pill millipedes *Sphaerotherium* (Fig. 8: Pearson's r=0.76982277, Z score=2.03978509, n=7, p=0.02068580).

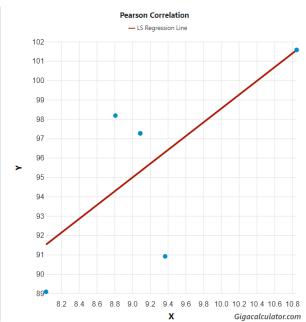


Fig. 8. A positive negative correlation between the hours of sunshine each month with month with the most daily hours of sunshine across the distribution of pill millipedes *Sphaerotherium*.

There was a correlation between the hours of sunshine each month with the month with the lowest daily hours of sunshine across the distribution of pill millipedes *Sphaerotherium* (Fig. 9: Pearson's r=0.81607806, Z score=2.28992312, n=7, p=0.01101286).

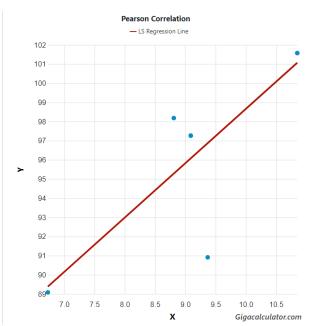


Fig. 9. A positive negative correlation between the hours of sunshine each month with month with the most daily hours of sunshine across the distribution of pill millipedes *Sphaerotherium*.

There was a correlation between the mean annual temperature with the highest average temperature across the distribution of pill millipedes *Sphaerotherium* (Fig. 10: r=0.9646, r²=0.9305, n=7, p=0.000444).

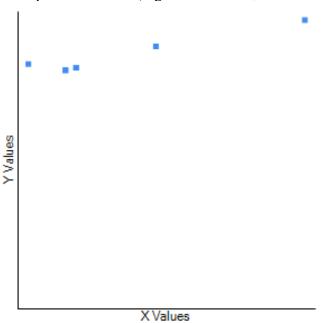


Fig. 10. A correlation between the mean annual temperature with the highest average temperature across the distribution of pill millipedes *Sphaerotherium*.

There was a correlation between the mean annual temperature with the lowest average temperature across the distribution of pill millipedes *Sphaerotherium* (Fig. 11: r=0.9327, r²=0.8699, n=7, p=0.002152).

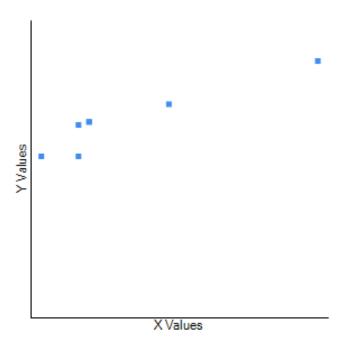


Fig. 11. A correlation between the mean annual temperature with the lowest average temperature across the distribution of pill millipedes *Sphaerotherium*.

There was a marginal correlation between the driest months with the distance to the closest airport across the distribution of pill millipedes *Sphaerotherium* (Fig. 12: r=-0.7366, r²=0.5326, n=7, p=0.05782).

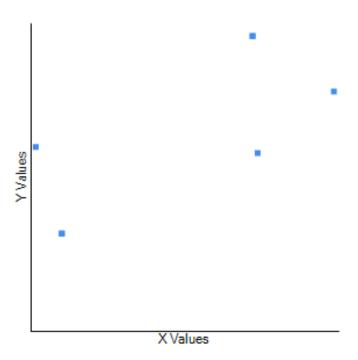


Fig. 12. A correlation between the driest months with the distance to the closest airport across the distribution of pill millipedes Sphaerotherium.

There was a correlation between the wettest months with the distance to the closest airport across the distribution of pill millipedes *Sphaerotherium* (Fig. 13: r=-0.9404, r²=0.8844, n=7, p=0.00164).

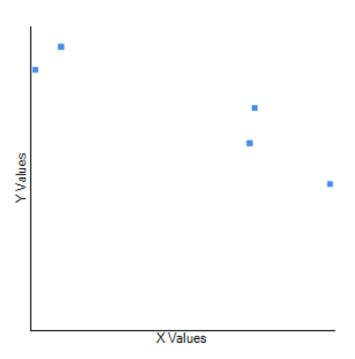


Fig. 13. A correlation between the wettest months with the distance to the closest airport across the distribution of pill millipedes Sphaerotherium.

There was a correlation between the difference between the driest and wettest months with the distance to the closest airport across the distribution of pill millipedes *Sphaerotherium* (Fig. 14: r=-0.9217, $r^2=8495$, n=7, p=0.000248).

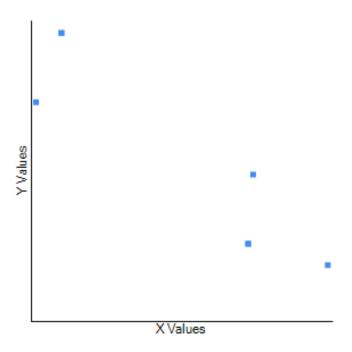


Fig. 14. A correlation between the difference between the driest and wettest months with the distance to the closest airport across the distribution of pill millipedes *Sphaerotherium*.

There was a correlation between the minimum precipitation with the maximum precipitation across the distribution of pill millipedes *Sphaerotherium* (Fig. 15: Pearson's r=-0.8568, r²=0.7341, n=7, p=0.013777).

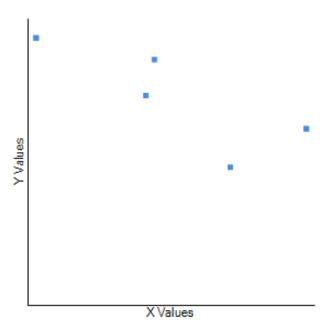


Fig. 15. A negative correlation between the minimum precipitation with the maximum precipitation across the distribution of pill millipedes *Sphaerotherium*.

There was a correlation between the minimum precipitation with the month with the most daily hours of sunshine across the distribution of pill millipedes *Sphaerotherium* (Fig. 16: Pearson's r=-0.68117751, Z score=-1.66261523, n=7, p=0.04819472).

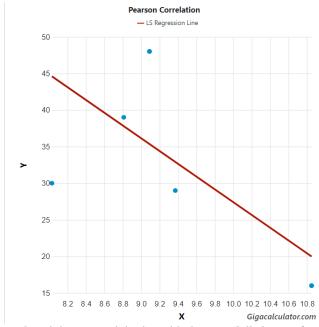


Fig. 16. A negative correlation between the minimum precipitation with the most daily hours of sunshine across the distribution of pill millipedes *Sphaerotherium*.

There was a correlation between the male and female surface area to volume ratio with the month with the lowest daily hours of sunshine across the distribution of pill millipedes *Sphaerotherium* (Fig. 17: Spearman's r=0.48385028, Z score=1.70089216, n=7, p=0.04448159).

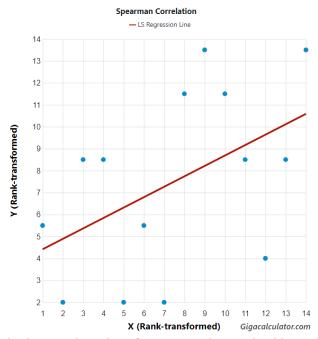


Fig. 17. A positive negative correlation between the male surface area to volume ratio with month with the lowest daily hours of sunshine across the distribution of pill millipedes *Sphaerotherium*.

There was a correlation between the male and female surface area to volume ratio with the month with the most daily hours of sunshine across the distribution of pill millipedes *Sphaerotherium* (Fig. 18: Spearman's r=0.48385028, Z score=1.70089216, n=7, p=0.04448159).

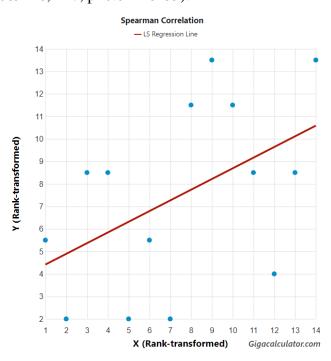


Fig. 18. A positive negative correlation between the male surface area to volume ratio with month with the most daily hours of sunshine across the distribution of pill millipedes *Sphaerotherium*.

There was a correlation between the male surface area to volume ratio with the average temperature across the distribution of pill millipedes *Sphaerotherium* (Fig. 19: Spearman's r=-0.76376262, Z score=1.95264152, n=7, p=0.02543097).

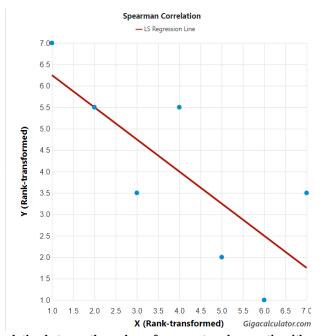


Fig. 19. A positive negative correlation between the male surface area to volume ratio with average temperature across the distribution of pill millipedes *Sphaerotherium*.

There was a correlation between the surface area to volume ratio with the lowest average temperature across the distribution of pill millipedes *Sphaerotherium* (Fig. 20: r=-0.6074, r²=0.3689, n=7, p=0.02134).

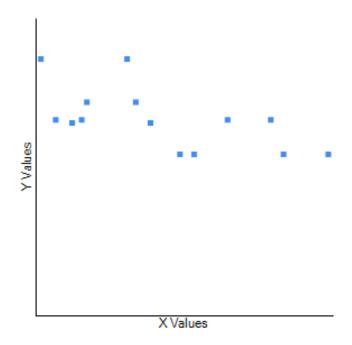


Fig. 20. A negative correlation between the surface area to volume ratio with the lowest average temperature across the distribution of pill millipedes *Sphaerotherium*.

There was a correlation between the male surface area to volume ratio with the with the female surface area to volume ratio across the distribution of pill millipedes *Sphaerotherium* (Fig. 21: r=-0.9126, $r^2=0.8328$, n=7, p=0.00136).

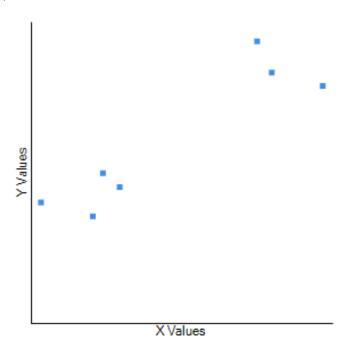


Fig. 21. A positive correlation between the male surface area to volume ratio with female surface area to volume ratio across the distribution of pill millipedes *Sphaerotherium*.

There was a correlation between the male surface area to volume ratio with the lowest average temperature across the distribution of pill millipedes *Sphaerotherium* (Fig. 22: r=-0.68079494, Z score=-1.66118842, n=7, p=0.04833779).

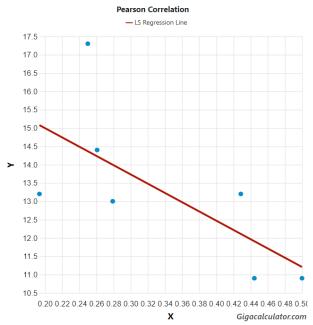


Fig. 22. A negative correlation between the male surface area to volume ratio with the lowest average temperature across the distribution of pill millipedes *Sphaerotherium*.

IV. DISCUSSION

The significant effect of weather on males and females in size are known in this genus. There is a correlation between the minimum temperature with the highest and lowest ocean water temperature. There is a correlation between the mean annual temperature with the highest and lowest ocean water temperature. There are correlations between the highest and lowest ocean water temperature and month with the most daily hours of sunshine. There is a positive correlation between the hours of sunshine each month and month with the most/least daily hours of sunshine. There is a correlation between the mean annual temperature with the highest and lowest average temperature. There is a correlation between driest months and there difference with the distance to the closest airport. There are correlations between the minimum precipitation, the month with the most daily hours of sunshine, and maximum precipitation. There is a positive correlation between the male surface area and months with the lowest and highest daily hours of sunshine. There is a negative correlation between the male surface area and average temperature. There is a positive correlation between the surface area to volume ratio and the lowest average temperature. There is a positive correlation between the male and female surface area to volume ratios and between the male surface area to volume ratios and between the male surface area to volume ratios and between the many potential environmental effects on body size in pill millipedes.

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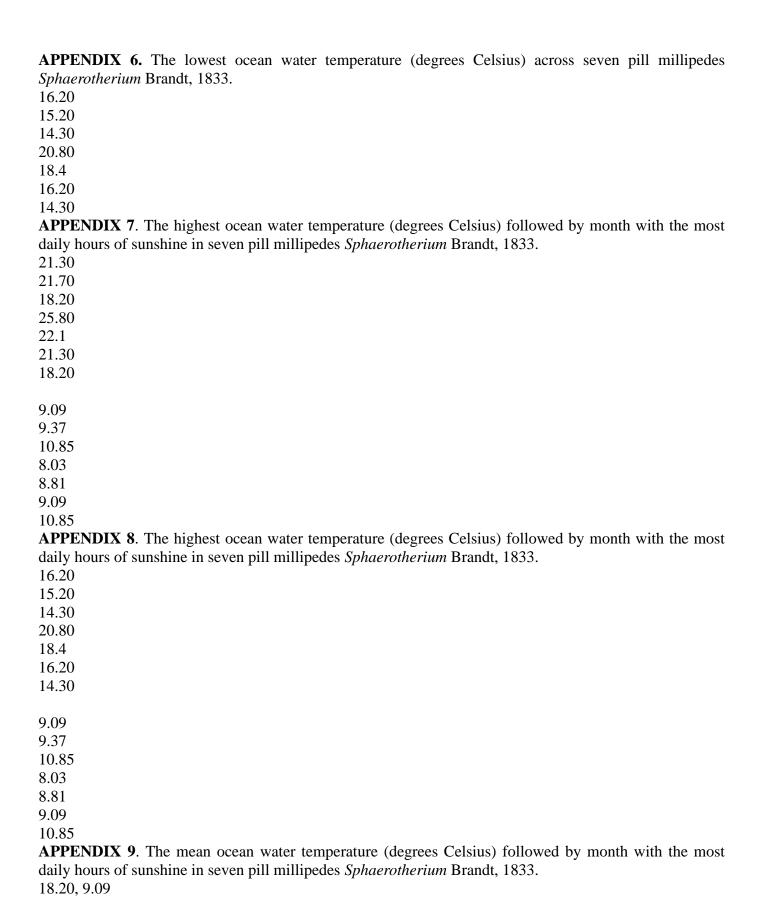
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APPENDIX 1 . The minimum temperature (degrees Celsius) in seven pill millipedes <i>Sphaerotherium</i> Brandt, 1833.
13.2
10.9
13.0
17.3
14.4
13.2
10.9
APPENDIX 2. The lowest ocean water temperature (degrees Celsius) across seven pill millipedes
Sphaerotherium Brandt, 1833.
16.20
15.20
14.30
20.80
18.4
16.20
14.30
APPENDIX 3. The highest ocean water temperature (degrees Celsius) across seven pill millipedes
Sphaerotherium Brandt, 1833.
21.30
21.70
18.20
25.80
22.1
21.30
18.20
APPENDIX 4. The mean annual temperature (degrees Celsius) in seven pill millipedes Sphaerotherium
Brandt, 1833.
16.6
15.7
16.4
20.9
18.1
16.6
16.4
APPENDIX 5. The highest ocean water temperature (degrees Celsius) across seven pill millipedes
Sphaerotherium Brandt, 1833.
21.30
21.70
18.20
25.80
22.1
21.30
18.20



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21.70, 9.37
15.80, 10.85
23.20, 8.03
17.09, 8.81
18.20, 9.09
15.80, 10.85
APPENDIX 10. The hours of sunshine each month preceded by month with the most daily hours of
sunshine in seven pill millipedes Sphaerotherium Brandt, 1833.
9.09, 97.26
9.37, 90.91
10.85, 101.57
8.03, 89.08
8.81, 98.18
9.09, 97.26
10.85, 101.57
APPENDIX 11. The hours of sunshine each month (h) preceded by month with the lowest hours of
sunshine in seven pill millipedes Sphaerotherium Brandt, 1833.
9.09, 97.26
9.37, 90.91
10.85, 101.57
6.73, 89.08
8.81, 98.18
9.09, 97.26
10.85, 101.57
APPENDIX 12. The mean annual temperature (degrees Celsius) in seven pill millipedes Sphaerotherium
Brandt, 1833.
16.6
15.7
16.4
20.9
18.1
16.6
16.4
APPENDIX 13. The highest temperature (degrees Celsius) across seven pill millipedes Sphaerotherium
Brandt, 1833.
20.3
20.6
20.1
24.3
22.1
20.3
20.1
APPENDIX 14. The lowest temperature (degrees Celsius) across seven pill millipedes Sphaerotherium
Brandt, 1833.
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13.2

10.9
13.0
17.3
14.4
13.2
10.9
APPENDIX 15 . The driest months (mm) in seven pill millipedes <i>Sphaerotherium</i> Brandt, 1833.
48
29
16
30
39
48
16
APPENDIX 16. The distance to the closest airport across the distribution of seven pill millipedes
Sphaerotherium Brandt, 1833.
61.52
62.72
17.12
11.09
80.45
61.52
17.12
APPENDIX 17 . The wettest months (mm) in seven pill millipedes <i>Sphaerotherium</i> Brandt, 1833.
74
88
112
103
58
74
112
APPENDIX 18. The difference between the driest and wettest months (mm) in pill millipedes
Sphaerotherium Brandt, 1833.
26
49
96 73
73
19
26
96 ADDENING 10 The distance to the elegant signest course the distribution of pill millimeder
APPENDIX 19. The distance to the closest airport across the distribution of pill millipedes
Sphaerotherium Brandt, 1833.
61.52 62.72
17.12
11.09
11.07

80.45 61.52 17.12 **APPENDIX 20**. Minimum precipitation followed by maximum precipitation in seven pill millipedes Sphaerotherium Brandt, 1833. 48 29 16 30 39 48 16 74 88 112 103 58 74 112 APPENDIX 21. Minimum precipitation preceded by month with the most daily hours of sunshine in seven pill millipedes Sphaerotherium Brandt, 1833. 9.09, 48 9.37, 29 10.85, 16 8.03, 30 8.81, 39 9.09, 48 10.85, 16 APPENDIX 22. The male and female surface area to volume ratios (1/mm) followed by month with the lowest hours of sunshine in seven pill millipedes Sphaerotherium Brandt, 1833. 0.19355, 9.09 0.5, 9.37 0.27907, 10.85 0.25, 6.73 0.26087, 8.81 0.4286, 9.09 0.4444, 10.85 0.1613, 9.09 0.3158, 9.37 0.1818, 10.05 0.14286, 6.73 0.2, 8.81 0.375, 9.09

0.3333, 10.85

APPENDIX 23 The male and female surface area to volume ratios (1/mm) followed by month with the most daily hours of sunshine in seven pill millipedes *Sphaerotherium* Brandt, 1833.

0.19355, 9.09

0.5, 9.37

0.27907, 10.85

0.25, 8.03

0.26087, 8.81

0.4286, 9.09

0.4444, 10.85

0.1613, 9.09

0.3158, 9.37

0.1818, 10.05

0.14286, 8.03

0.2, 8.81

0.375, 9.09

0.3333, 10.85

APPENDIX 24. The male surface area to volume ratios (1/mm) followed by average temperature in seven pill millipedes *Sphaerotherium* Brandt, 1833.

0.19355, 16.6

0.5, 15.7

0.27907, 16.4

0.25, 20.9

0.26087, 18.1

0.4286, 16.6

0.4444, 16.4

APPENDIX 25. The surface area to volume ratios (1/mm) followed by the lowest environmental temperature (degrees Celsius) in seven pill millipedes *Sphaerotherium* Brandt, 1833.

0.19355

0.5

0.27907

0.25

0.26087

0.4286

0.4444

0.1613

0.3158

0.1818

0.14286

0.2

0.375

0.3333

13.2

10.9

13.0

17.3

14.4

13.2

10.9

13.2

10.9

13.0

17.3

14.4

13.2

10.9

APPENDIX 26. The male surface area to volume ratios (1/mm) followed by female surface area to volume ratios (1/mm) in seven pill millipedes *Sphaerotherium* Brandt, 1833.

0.19355, 0.1613

0.5, 0.3158

0.27907, 0.1818

0.25, 0.14286

0.26087, 0.2

0.4286, 0.375

0.4444, 0.3333

APPENDIX 27. The male surface area to volume ratios (1/mm) followed by the lowest environmental temperature (degrees Celsius) in seven pill millipedes *Sphaerotherium* Brandt, 1833.

0.19355, 13.2

0.5, 10.9

0.27907, 13.0

0.25, 17.3

0.26087, 14.4

0.4286, 13.2

0.4444, 10.9