International Journal of Engineering Science Invention Research & Development; Vol. 10, Issue 6, December 2023
www.ijesird.com, E-ISSN: 2349-6185

AIR PRESSURE IS (INVERSELY) RELATED TO SPECIES RICHNESS IN DALODESMIDAE COOK, 1896A

M. I. Cooper
University of South Africa.

***Abstract*- Air pressure was tested for a relationship with species richness in Dalodesmidae. There was a marginal difference between air pressure at the distribution of high (89984.983 Pa; n=97) and intermediate (92456.687 Pa; n=18) species richness (Z-test: P-value=0.058, Z score=1.575, n=97, 18) (Difference = 2471.704 Pa). Air pressure at highest species richness (89984.983 Pa; n=97) was different to air pressure at low species richness (101220.90 Pa; n=2) (P-value=0, Z score=10.063, n=97, 2) (Difference = 11235.917 Pa) while air pressure at intermediate species richness (92456.687 Pa; n=18) and air pressure at low species richness (101220.90 Pa, n=2) were also different to each other (P-value=0, Z score=7.948, n=18, 2) (Difference = 8764.212 Pa). There was a negative correlation between species richness and air pressure in Dalodesmidae (Kendall's τ=-0.04335252, Z score=-1580000, p=0, n=117) that suggested air pressure was (inversely) related to species richness when partially controlling for latitude.**

***Keywords*: air, diversity; gradient; latitude; pressure, richness; species.**

I. INTRODUCTION

Species richness is the number of different species represented in an ecological community, landscape, or region [1-4]. Species richness and biodiversity increase from the poles to the tropics for a wide variety of terrestrial and marine organisms and is referred to as a latitudinal diversity gradient (LDG) [1]. Inverse LDG in invertebrates is hypothesized and explained as the result of predation which plays an important "keystone" role in structuring the community [5]. As the abundance of the top predator, decreases, a greater number of taxa in lower trophic levels can persist. There is a higher predation risk for insect prey at lower latitudes [6]. Thus it is predicted there should be an inverse LDG in the (millipede) prey.

Dalodesmidae is family of millipedes belonging to the Order Polydesmida Leach, 1815 is distributed throughout southern Africa [7, 8]. The null historic or evolutionary hypothesis is the Tropical Conservativism Hypothesis which suggests processes of speciation, extinction, and dispersal result in higher species richness in the tropics and decline away from the equator has been tested [9,10]. The alternative is the Biogeographical Conservativism Hypothesis which suggests the processes invoked are not intrinsic to the tropics but are dependent on historical biogeography to determine the distribution of species richness was corroborated [11]. Here species richness in Dalodesmidae is tested for correlations with air pressure.

II. MATERIALS AND METHODS

117 valid species were identified as belonging to the family Dalodesmidae Cook, 1896*a* [7]. These were tabulated and known localities were also listed (Table 1). Localities were obtained from the literature [7]. GPS coordinates were obtained from internet sources for known localities using the locality followed with the keyword "GPS" or http://gps-coordinates.org. Latitude and longitude coordinates were obtained. Species richness correlations with latitude were given (Cooper, 2022). Air pressure was calculated for each type locality (https://www.mide.com/air-pressure-at-altitude-calculator). P-value calculations were produced between air pressure at neighbouring species richness and between the highest species richness and the rest (Appendix 1 & 2). A test for normality of air pressure data was performed at https://www.statskingdom.com/kolmogorov-smirnov-test-calculator.html. The outcome of this test determined what P-value test would be used in comparing the data of air pressure across species richness. If the data were normal a T-test would be used while if the data were not normal a Z-test is used. The P-value calculator can be found at https://www.gigacalculator.com/calculators/p-value-significance-calculator.php.

III. RESULTS

There was a marginal difference between air pressure at the distribution of high (89984.983299 Pa; n=97) and intermediate (92456.687222 Pa;

n=18) species richness (Z-test: P-value=0.057618, Z score=1.575085, n=97, 18) (Difference = 2471.703923 Pa). Air pressure at highest species richness (89984.983299 Pa; n=97) was different to air pressure at low species richness (101220.90 Pa; n=2) (P-value=0, Z score=10.063217, n=97, 2) (Difference = 11235.916701 Pa) while air pressure at intermediate species richness (92456.687222 Pa; n=18) and air pressure at low species richness (101220.90 Pa, n=2) were also different to each other (P-value=0, Z score=7.948107, n=18, 2) (Difference = 8764.212778 Pa). There was a negative correlation between species richness and air pressure (Fig. 1: Kendall's τ=-0.04335252, Z score=-1580000, p=0, n=117). Results of the lilliefors test indicated that there is a significant difference from the normal distribution (D(117) = 0.15, p =0.33e-7).

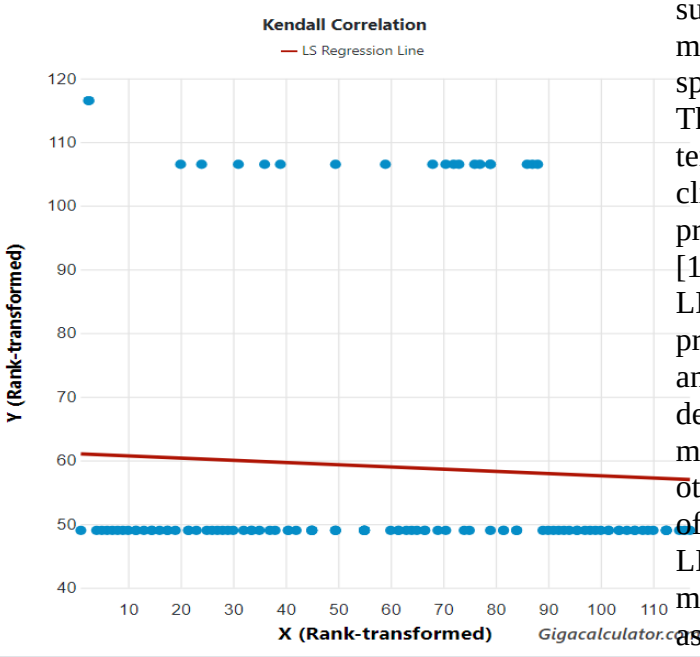

Figure 1. Negative correlation between air pressure and species richness in Dalodesmidae Cook, 1896*a*.

IV. DISCUSSION

Dalodesmidae are more temperate and show a general decline in LDG, and Dalodesmidae shows an inverse latitudinal diversity gradient showing support for the Biogeographical Conservatism Hypothesis [12]. Other groups showing an inverse LDG include aphids, European bryophytes, freshwater zooplankton, Holarctic tree frogs, ichneumonids, New World snake tribe Lampropeltini, marine benthic algae, North American breeding birds, penguins, peracarid crustaceans, pitcher plant mosquito, pond turtles, Shallow-water mollusks and shorebirds [13,14,15-17,9,18,19,20,21,22,23].

Two general explanations for the inverse trends in LDG include precipitation and predation [24]. Predation affects millipedes as all species have some form and degree of conglobation [25]. This behavior is also an adaptive response to conserve moisture [24]. Because these millipedes are shade-loving I rejected the moisture conservation hypothesis in favor of predation. There is a higher predation risk for insect prey at lower latitudes [6]. Density-dependent mortality in the millipedes is supported by differences in relative abundance, mating frequencies, and sex ratios of sympatric species [26].

There may be an evolutionary preference for temperate environments appearing to have led to climatic constraints on dispersal based primarily on precipitation or temperature seasonality gradients [11]. Air pressure variations can allude to this as LDG depends on proximate factors affecting processes of speciation, extinction, immigration, and emigration, and in millipedes, these factors are dependent on size. LDG relates to body size in millipedes which do not agree with the trends in other taxa such as birds and fishes [27]. The trend of a small body size associated with the inverse LDG is similar to the weak tendency found in mammals where there was no significant association between body mass and species-richness [28,29]. Air pressure has been associated with species richness in red millipedes [30] and no relationship was discovered in the pill millipedes [in prep.], but the Dalodesmidae showed two relationships and one marginal relationship between species richness and air pressure.

REFERENCES

[1] Colwell RK. Biodiversity: Concepts, Patterns and Measurement. In: The Princeton Guide to Ecology

(Levin SA, ed). Princeton University Press, Princeton, USA. 2009;257-263.
[2] Colwell RK, Hurtt GC. Nonbiological gradients in species richness and a spurious Rapoport effect. American Naturalist.1994;144:570-595.
[3] Colwell RK, Lees DC. The mid-domain effect: geometric constraints on the geography of species richness. Trends in Ecology and Evolution. 2000;15:70-76.
[4] Colwell RK, Rahbek C, Gotelli NJ. The mid-domain effect and species richness patterns: what have we learned so far? American Naturalist. 2004;163:E1-E23.
[5] Power ME. Tilman D, Estes JA, Menge BA, Bond WJ, Mills LS, Daily G, Castilla JC, Lubchenco J, Paine RT. Challenges in the Quest for Keystones. Wildlife Biology Faculty Publications. 1996; 1.
[6] Roslin T, Hardwick B, Novotny V, Petry WK, Andrew NR, Asmus A, Barrio IC, Basset Y, Boesing AL, Bonebrake TC, Cameron EK, Dáttilo W, Donoso DA, Drozd P, Gray CL, Hik DS, Hill SJ, Hopkins T, Huang S, Koane B, Laird-Hopkins B, Laukkanen L, Lewis OT, Milne S, Mwesige I, Nakamura A, Nell CS, Nichols E, Prokurat A, Sam K, Schmidt NM, Slade A, Slade V, Suchanková A, Teder T, Nouhuys S van, Vandvik V, Weissflog A, Zhukovich V, Slade EM. Higher predation risk for insect prey at low latitudes and elevations. Science. 2017;356(6339): 742–744.
[7] Hamer ML. Checklist of Southern African millipedes. Annals of the Natal Museum. 1998;39(1): 39-43.
[8] Theron LJ. Distribution And Abundance of Rodents, Millipedes and Trees In Coastal Dune Forests In Northern Kwa Zulu-Natal. University of Pretoria, South Africa; 2001.
[9] Mittelbach GG, Schemske GW, Cornell HV, et al. Evolution and the latitudinal diversity gradient: speciation, extinction and biogeography. Ecology Letters. 2007;10:315-331.
[10] Hillebrand H. On the Generality of the Latitudinal Diversity Gradient. The American Naturalist. 2004;163(2):192-211.
[11] Pyron RA, Burbrink FT. Can the Tropical Conservatism Hypothesis explain temperate species richness patterns? An inverse latitudinal biodiversity gradient in the New World snake tribe Lampropeltini. Global Ecology and Biogeography. 2009;18:406-415.
[12] Pitz KM, Sierwald P. Phylogeny of the millipede Order Spirobolida (Arthropoda: Diplopoda: Helminthomorpha). Cladistics. 2010;26:497-525.
[13] Kindlmann P, Dixon AFG, Traxmandlová-Schödelbauerová I. Inverse latitudinal gradients in species diversity. In: Storch D, Marquet PA. (ed.). Scaling Biodiversity. Cambridge University Press, Cambridge, UK; 2007.
[14] Krug AZ, Jablonski D, Valentine JW. Contrarian clade confirms the ubiquity of spatial origination patterns in the production of latitudinal diversity gradients. Proceedings of the National Academy of Sciences of USA. 2007;104(46):18129-18134.
[15] Lawrence RF. Four new forest millipedes from Lesotho and the Eastern Cape. Annals of the Cape Provincial Museums Natural History. 1970; 8 (5): 49-55.
[16] Marshall KE, Baltzer JL. Decreased competitive interactions drive a reverse species richness latitudinal gradient in subarctic forests. Ecology. 2015;96(2):461-470.
[17] Mateo RG, Broennimann O, Normand S, Petitpierre B, AraOyújo MB, Svenning J-C, Baselga A, Fernández- Gozález F, Rubio VG, Muñoz J. The mossy north: An inverse latitudinal diversity gradient in European bryophytes. Scientific Reports. 2016;6:25546.
[18] Morinière J, Van Dam MH, Hawlitschek O, Bergsten J, Michat MC, Hendrich L, Ribera I, Toussaint EFA, Balke M. Phylogenetic niche conservatism explains an inverse latitudinal diversity gradient in freshwater arthropods. Scientific Reports. 2016;6:2634.
[19] Rivadeneira MM, Thiel M, Gonzalez ER, Haye PA. An inverse latitudinal gradient of diversity of peracarid crustaceans along the Pacific Coast of South America: Out of the deep south. Global Ecology and Biogeography. 2011;20(3):437-448.
[20] Silva RR, Brandão CRF. Ecosystem-wide morphological structure of leaf-litter ant communities along a tropical latitudinal gradient. PLoS ONE. 2014;9(3):e93049.
[21] Sime KR, Brower AVZ. Explaining the latitudinal gradient anomaly in ichneumonid species richness: evidence from butterflies. Journal of Animal Ecology. 1998;67:387-399.
[22] Wang J, Tong X, Donghui W. The effect of latitudinal gradient on the species diversity of Chinese litter-dwelling thrips. Zookeys. 2014;417:9-20.
[23] Kwon Y, Lee T, Lang A, Burnette D. Assessment on latitudinal tree species richness using environmental factors in the southeastern United States. Peer J. 2019;7:e6781.
[24] Fergusen S. Does Predation or Moisture Explain Distance to Edge Distribution of Soil Arthropods? The American Midland Naturalist. 2004;152(1):75-87.
[25] Cooper MI. Syncopulatory mate-guarding affected by predation in the aposematic millipede Centrobolus inscriptus in a swamp forest. Journal of Entomology and Zoology. 2016;Studies, 4(6):483-484.
[26] Cooper MI. Sex ratios, mating frequencies and relative abundance of sympatric millipedes in the genus Chersastus (Diplopoda: Pachybolidae). Arthropods. 2014;3(4):174-176.

[27] Yen JDL, Thomson JR, Keith J, Paganin DM, Fleishman E, Bennett AF, Dobkin DS, Mac Nally R. Linking species richness and size diversity in birds and fishes. Ecography. 2018;41(12): 1979-1991.
[28] Gittleman JL, Purvis A. Body size and species-richness in carnivores and primates. Proceedings of the Royal Society B: Biological Sciences. 1998;265(1391):113-119.
[29] Pianka ER. Latitudinal Gradients in Species Diversity. Trends in Ecology and Evolution. 1989; 4(6):223
[30] Cooper, M. AIR PRESSURE IS RELATED TO SPECIES RICHNESS IN FOREST RED MILLIPEDES CENTROBOLUS COOK, 1897. Int. j. eng. sci. invention res. dev. 2023; 10(6): 1510-1534. http://www.ijesird.com/december_7.pdf.
[31] Attems, C. M. T. Graf von (1926). Myriopoda. In: Kükenthal, Willy: Handbuch der Zoologie. Vierter Band. Erste Hälfte., 4(1): 1-6. Berlin, Leipzig
[32] Cook, O. F. (1896). Cryptodesmus and its allies. Brandtia (A series of occasional papers an Diplopoda and other Arthropoda), 5: 19-28, available online at https://biodiversitylibrary.org/page/52583870.

Appendix 1. Air pressure (Pa) followed by mean species richness in *Gnomeskulus.*

91075.18, 18
89442.61, 97
94441.29, 18
66812.02, 97
85449.54, 97
81714.43, 97
83968.52, 97
99635.92, 97
88323.78, 18
78958.95, 97
89871.72, 97
94571.93, 97
99832.76, 97
95857.53, 97
100823.40, 97
88323.78, 18
91133.82, 18
101220.90, 2
67737.96, 97
101149.79, 97
98589.65, 97
78958.95, 97
81296.75, 97
100906.33, 97
95190.49, 97
100126.85, 97
94638.86, 97
67993.92, 97
94638.86, 97
87697.84, 97
87697.84, 97
94638.86, 97
101220.20, 97
94571.93, 97
92686.79, 97
90485.32, 18
96591.52, 18
66812.02, 97
94571.93, 97
82997.39, 97
87697.84, 97
100688.07, 97
100988.76, 97
93338.75, 97
68885.96, 97
93558.26, 97
100138.81, 18
66321.95, 97
101185.75, 97
100823.40, 97
93558.26, 97
86725.79, 18
66812.02, 97
92642.55, 97
94571.93, 97
99930.20, 97
91133.82, 97
95857.53, 97
66812.02, 97
101218.77, 97
98134.95, 18
100688.07, 97
101243.21, 97
101220.90, 2
87043.39, 18
83952.54, 97
87527.13, 18
89384.66, 18
101052.68, 97
99009.01, 18
89092.88, 18
91774.79, 18
94638.86, 18
88323.78, 97
93897.20, 97
66018.80, 97
68885.96, 97

Appendix 2. Air pressure (Pa) followed by mean species richness in Dalodesmid species not in the genus *Gnomeskelus.*

100375.41, 18
97462.53, 97
100468.87, 97
99306.31, 97
100468.87, 97
100704.02, 97
88026.69, 97
77309.02, 97
79153.96, 97
100304.51, 97
94863.33, 97
92293.75, 97
91232.36, 97
94863.33, 97
100304.51, 97
97762.96, 97
94863.33, 97
98205.63, 97
99123.78, 97
83104.89, 97
98287.24, 97
98287.24, 97
68303.50, 97
77309.02, 97
83170.66, 97
69283.94, 97
92293.75, 97
83104.89, 97
88026.69, 97
94571.93, 97
84241.97, 97
66302.29, 97
94571.93, 97
94571.93, 97
84224.50, 97
100293.68, 97
94863.33, 97
94863.33, 97
100428.21, 97
100570.08, 97