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NOTE

Scorpion body size, litter characteristics, and duration of the life cycle (Scorpiones)

Julián Monge-Nájera

Universidad Estatal a Distancia, Vicerrectoría de Investigación, Laboratorio de Ecología Urbana, 2050 San José, Costa Rica; julianmonge@gmail.com

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ABSTRACT: There are no studies that quantitatively compare life histories *among* scorpion species. Statistical procedures applied to 94 scorpion species indicate that those with larger bodies do not necessarily have larger litters or longer life cycles, opposite to some theoretical predictions.

Key words: scorpion ecology; multivariate statistics; body size; offspring characteristics, K and r strategists.

RESUMEN: "Tamaño corporal, características de la camada y duración del ciclo de vida en los escorpiones (Scorpiones)". No hay estudios que comparen cuantitativamente historias de vida *entre* especies de escorpiones. Procedimientos estadísticos aplicados a 94 especies indican que las especies con cuerpos más grandes no necesariamente tienen camadas más grandes o ciclos de vida más largos, contrario a algunas predicciones teóricas.

Palabras clave: ecología de escorpiones; estadísticas multivariables; tamaño corporal; características de descendencia, estrategas K y r.

Life history characteristics, like duration of the reproductive cycle, or the size and number of offspring per female, are determined by poorly documented trade-offs between traits (Roff, Heibo, & Vøllestad, 2006). In the case of scorpions, there are a few quantitative studies of female and offspring characteristics *within populations*, but not *among species*. Larger mothers produce larger litters in *Centruroides sculpturatus* Ewing, 1928, *C. exilicauda* Wood, 1863 and *Vaejovis spinigerus* Wood, 1863 (Brown, 2004; Warburg, 2011), but not in *Scorpio maurus* Linnaeus, 1758, *Nebo hierichonticus* Simon, 1872 and *Tityus pusillus* Pocock, 1893 (Warburg, 2011; de Albuquerque & de Araujo, 2016). To my knowledge, this is the first study to quantitatively compare life histories *among species*.

Characteristics for 94 species (Table 1) were extracted from the literature (Polis, 1990: Table 4.2 in pp.184-187; Lourenço, 1992: Table 2 in p. 49); and compared between species that reproduce year-round and seasonally. The majority of species included belong in the Buthidae (N=44 species) and Vaejovidae (N=19 species), while other families (Chactidae, Diplocentridae, Ischnuridae, Scorpionidae) had 6-9 species included; the lowest numbers were for Bohriuridae (N=4 species) and Iuridae (N=2 species). Additionally to statistical significance, all trait pairs were also plotted as scattergrams and visually checked for non-linear associations. Tests checked the model proposed by Polis (1990), basically that scorpions range from species with small individuals, short life cycles and abundant offspring (r strategists or opportunist species, mostly the highly diverse family Buthidae), to larger species that live in more stable habitats, have longer life cycles and care for a few large offspring (K or "equilibrium" species, most scorpion families).

Scatter-plots indicated that these scorpion life history characteristics lacked non-linear associations, which means that the linear statistics I used were appropriate to identify any possible correlations. Species that reproduce year-round have significantly shorter first instar periods (Mann-Whitney U, $p<0,01$, mostly Buthidae), but contrary to expectation (Polis, 1990), species with larger bodies do not consistently have significantly larger litters, longer life cycles (including gestation, parturition, first instar, longevity) or more molts (Table 1).

TABLE 1
Pairs of scorpion life history characteristics that *lack* statistically significant correlations

First variable	Second variable (same units as first variable)	Rho	P	N
Postembryonic development (months)	Litter size	0,84	0,6936	23
Parturition (hours)	Gestation	0,62	0,1313	7
Age to maturity (months)	Parturition	0,60	0,0897	9
Number of molts	Parturition	0,53	0,0662	13
Age to maturity (months)	First instar	0,41	0,0757	20
Mean longevity (months)	Age to maturity	0,39	0,1862	12
Postembryonic development (months)	Parturition	0,37	0,4062	6
Body size (mm)	Number of molts	0,37	0,1272	18
Age to maturity (months)	Gestation	0,34	0,1792	17
Litter size (number of scorplings)	Gestation	0,30	0,0840	34
Body size (mm)	First instar	0,29	0,1898	21
Body size (mm)	Mean longevity	0,27	0,2091	23
Litter size (number of scorplings)	Parturition	0,23	0,3360	19
Body size (mm)	Postembryonic development	0,23	0,2797	23
Number of molts	First instar	0,23	0,2410	28
Body size (mm)	Litter size	0,21	0,2350	34
Age to maturity (months)	Litter size	0,18	0,4271	21
Postembryonic development (months)	Number of molts	0,13	0,6139	15
Body size (mm)	Gestation	0,13	0,4370	34
First instar (days)	Litter size	0,06	0,6997	42
Age to maturity (months)	Number of molts	0,06	0,8045	19
Body size (mm)	Age to maturity	0,05	0,8359	15
Mean longevity (months)	Litter size	0,02	0,9227	22

Rho= Spearman rank correlation coefficient, P= probability, N= sample size. The following combinations could not be tested because the sample size was below six: Maximum longevity (vs. Postembryonic development, Mean longevity, First instar, Number of molts, Gestation, Litter size and Body size) and mean longevity vs. Parturition.

In scorpions, reproductive seasonality can be highly variable and strongly correlated with environmental factors (e.g., Yamaguti & Pinto-da-Rocha, 2006). Scorpions may increase survival by having more reproductive episodes each year, explaining the shorter first instar periods found here for species with year-round reproduction. Apparently, seasonal species are more limited and invest in "quality" litters that need more time to reach independence, just as hypothesized earlier by Brown (2003).

Despite the lack of previous studies about maternal size and characteristics of offspring *across* species, it is known that *within* a species, not all large females have large litters (by both body mass and length: Brown, 2004; length: Outeda-Jorge, Pinto-da-Rocha, & Mello, 2009; body mass: Warburg, 2011), and the same trend was found in this study for species: species with larger (i.e. longer) mothers do not consistently have litters with more scorplings or offspring with longer life cycles and better longevity. These results fail to support the r and K model (Polis, 1990; Monge-Nájera & Lourenço, 1995; Romiguier et al., 2014), a model that is based on few large and longevous individuals, *versus* many small and short lived individuals: the field is open for a new model. Additionally, the data summarized by Polis (1990) and Lourenço (1992), which are the basis of this note, should be taken with caution because they are of varied quality (some from formal studies, some from personal communications, many from the laboratory, few from the field). I hope this note will inspire future researchers to collect additional, better data, and to test these ideas again.

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REFERENCES

Brown, C.A. (2003). Offspring size-number trade-offs in scorpions: an empirical test of the van Noordwijk and de Jong model. *Evolution*, *57*(9), 2184-2190. DOI: 10.1554/03-014

Brown, C.A. (2004). Life Histories of Four Species of Scorpion in Three Families (Buthidae, Diplocentridae, Vaejovidae) From Arizona and New Mexico. *The Journal of Arachnology, 32*, 193-207. DOI: 10.1636/M02-56

de Albuquerque, C.M.R., & de Araujo Lira, A.F. (2016). Insights into reproductive strategies of *Tityus* (Archaeotityus*)* *pusillus* Pocock, 1893 (Scorpiones, Buthidae). *Comptes Rendus Biologie, 339*(5-6), 179-184. DOI: 10.1016/j.crvi.2016.03.003

Lourenço, W.R. (1992). Les peuplements des Scorpions des Antilles: facteurs historiques et écologiques en association avec les stratégies biodémographiques. *Studies on Neotropical Fauna and Environment, 27*(1), 43-62. DOI: 10.1080/01650529209360865

Monge-Nájera, J., & Lourenço, W. (1995). Biogeographic implications of evolutionary trends in onychophorans and scorpions. *Biogeographica, 71*(4), 179-185.

Outeda-Jorge, S., Pinto-da-Rocha, R., & Mello, T. (2009). Litter size, effects of maternal body size, and date of birth in South American scorpions (Arachnida: Scorpiones). *Zoologia, 26*(1), 45-53. DOI: 10.1590/S1984-46702009000100008

Polis, G.A. (1990). *The biology of scorpions.* California, USA: Standford University Press.

Roff, D.A., Heibo, E., & Vøllestad, L.A. (2006). The importance of growth and mortality costs in the evolution of the optimal life history. *Journal of Evolutionary Biology, 19*(6), 1920-1930. DOI: 10.1111/j.1420-9101.2006.01155.x

Romiguier, J., Gayral, P., Ballenghien, M., Bernard, A., Cahais, V., Chenuil, A., ... Loire, E. (2014). Comparative population genomics in animals uncovers the determinants of genetic diversity. *Nature, 515*(7526), 261-271. DOI: 10.1038/nature13685

Warburg, M.R. (2011). Scorpion reproductive strategies, allocation and potential; a partial review. *European Journal of Entomology, 108*(2), 173-181. DOI: 10.14411/eje.2011.023

Yamaguti, H.Y., & Pinto-da-Rocha, R. (2006). Ecology of *Thestylus aurantiurus* of the parque Estadual da Serra da Cantareira, Sao Paulo, Brazil (Scorpiones, Bothriuridae). *Journal of Arachnology, 34*(1), 214-220. DOI: 10.1636/T04-37.1

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