Proportionality of Population Descriptors of Helminth Infections of Smallmouth Bass from the Buffalo National River

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Cover Page Footnote

Proportionality of Population Descriptors of Helminth Infections of Smallmouth Bass (*Micropterus dolomieu*) from the Buffalo National River

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Running title: Proportionality of Helminths Descriptors

Mean abundance (MA), standard deviation (SD), maximum number (Max) and prevalence (Prev) are standard descriptors for defining helminth parasite populations in their hosts with mean intensity and its standard deviation used less often.   Daly and coworkers (Daly Sr. *et al*. 2013; Daly Sr. 2014) previously demonstrated that these population descriptors in infections of *Clinostomum* metacercariae in smallmouth bass exhibited a principal of proportionality between the factors where each one effects the value of the other *as a given ratio*.   These relationships could be seen where the descriptors are used as the x and y variables in regression analyses in which very significant R and probability values are seen.   Also, it was found that ratios of descriptive values of standard deviation/mean abundance, maximum abundance/mean abundance, and maximum abundance/standard deviation produced normal distributions with low standard deviations. The values of these ratios, obtained from a collective of population infections, would produce numbers that were relatively predictive for *Clinostomum* infections in any bass population from Ozark and Ouachita mountain streams (Daly Jr. *et al*. 1999; Daly 2014). Importantly, the ratio of SD/mean of *Clinostomum* populations in 16 smallmouth bass populations were mostly above 1 (with 3 exceptions) indicting a tendency toward non-normal, non-parametric, overdispersed distributions rather than randomly acquired infections.   Overdispersion or aggregation is where a few hosts have the largest number of parasites and is commonly found in helminth infections. Daly and Wagner (2016), using data from a study of an acanthocephalan infection in stream *Gammarus* in England (Croft 1971) demonstrated that another helminth beside *Clinostomum* can also show proportionality in their population descriptors.

The study of Kilambi and Becker (1977) on populations of 24 helminth parasites of smallmouth bass from the Buffalo National River in North Central Arkansas offered the opportunity to use their data to determine if the same principal of proportionality and

overdispersion also existed in helminths other than *Clinostomum* infections of stream smallmouth bass or an acanthocephalan in *Gammarus*. Those investigators collected bass hosts by electro-shocking from three locales; one upstream (Ponca), one halfway (Hasty), and one close to the terminus of the stream (Rush). Collections were taken in spring, summer, fall and winter. A total of 127 hosts were examined. Analysis was presented for all collections but for our purpose we used the refined data from their table 5 that combined the data from all of the collections. Regression analysis was done with the Excel analytical package (2010). Table 1 shows the data that was used for this study. Table 2 shows the results of the regression analysis for the smallmouth helminth populations.   Monogenea, digenea, and nematoda populations all show very high correlation coefficients between the three major population descriptors of mean abundance,

We have found that this agrees with data from previous host-parasites relationships in smallmouth data from Ozark and Ouachita mountain streams.   The exception is the tapeworm correlations.   The mean abundance – standard deviation shows a strong R but a less than significant probability using p = 0.05 as the baseline. However, the number of populations was only three. Still it may mean that cestodes may not fit the principle of proportionality that is seen with other helminths. The density of infections with stream tapeworm infections are light compared to those from hosts from lakes (Daly Sr. *et al.* 2006). Another special case is with the acanthocephalan *Neochinorhynchus cylindratus* since only one set of descriptor values was available therefore the four seasons and the three locales were used herein as separate populations.   The regression relationships for these populations were similar to the other helminths (Table 2). Prevalence for all infections (Table 3) was poorly related to other descriptors. This is usual for helminth infections where prevalence can be significant or not. We have found that density of infection is a primary cause of this (Daly and

Wagner; manuscript *in preparation*). The prevalence of light infections is significantly correlated with mean abundance but heavy infections are not.

The major value of the principle of proportionality is as an estimate of where the population fits in the spectrum of randomness to aggregation. All of the helminth populations from the Buffalo River data tend toward aggregation (Table 4). From our previous data only three of the sixteen individual *Clinostomum* populations from streams tended toward randomness (Daly 2014). Other such random populations from our studies are *Clinostomum* in pond-raised channel catfish (Singleton *et al.* 2018) and tapeworm plerocercoids in lake bass (Daly *et al.* 2006). Catfish in a pond would be moving about and would be randomly exposed to cercaria from snail hosts that would probably be

territorial and limited in their dispersal in the pond. As for lake bass it is known that *Micropterus punctulatus* roam the lakes in schools and would randomly ingest infected small fish hosts. Some investigators prefer to use variance as the numerator in the overdispersion ratio Poulin (2007) has pointed out that variance has a power function and violates a rule of not using an exponential value in regression studies. It's not clear what the other ratios represent and to our knowledge they have not been studied to any extent.

In conclusion helminth infections in Buffalo River smallmouth hosts show strong proportionality indicating similar life cycle structures. Also, a tendency toward aggregated populations was similar to most other helminths studied elsewhere and it indicates a general principle of proportionality in helminth ecology.

Table 1. Data from Kilambi and Becker (1977) for population descriptors from monogenean, digenean, cestode, acanthocephalan, and nematode helminths from smallmouth bass (*Micropterus dolomieu*) collected from the Buffalo National River, Arkansas and used for regression and ratio analysis in this study. Mean = mean abundance, SD = standard deviation, and Maximum = maximum abundance.

	Helminth	**Prevalence**	**Mean**	**SD**	**Mean**
Monogenea	*Alcolpenteron uretereroecetes*	16	<0.0	0.2	2
	Acinocleidus fusifornos	31.5	1.3	2.94	15
	Clavunculus bursatus	15.7	0.4	1.31	9
	Cleidodiscus banghami	23.6	0.8	2.48	15
	Leptocleidus megalonchus	0.8	0.1	0.71	8
	Urocleidus principalis	31.5	15.3	64.4	541
Digenea	*Clinostomum marginatum*	33.1	1.4	5.54	59
	Crepidostomum cornutum	38.6	6.2	28.07	298
	Cryptogonimus chyli	44.9	73.6	335.6	3480
	Leuceruthrus micropteri	44.9	1	1.58	8
	Neascus sp.	78.7	9.2	13.58	83
	Pisciamphistoma reynoldsi	10.2	0.2	0.88	6
	Posthodiplostomum minimum	7.9	3.4	17.45	51
	Rhipidocotyl papillosum	20.5	0.7	2.04	14
	Rhipidocotyl septpapillota	7.9	0.2	0.9	8
	Rhipidocotyl sp.	64.6	26.9	66.56	587
Cestoda	*Bothriocephalus cuspidatus*	3.2	0.1	0.59	6
	Proteocephalus ambloplites adult	15.7	0.4	1.49	15
	Proteocephalus ambloplites larva	14.2	0.4	1.08	7
Acanthocephala	*Neochinorhynchus cylindratus*	79.5	11.6	16.53	88
Nematoda	*Capillaria catenate*	7.1	0.4	3.07	34
	Contracoecum sp.	19.7	2.8	9.5	59
	Philometra sp.	12.6	0.4	1.4	8
	Spinitectus carolina	59.8	4.2	7.2	34
	Nematode cyst	93.7	190.9	336.9	2055
	Rhabdochona cascadilla	2.4	<0.0	0.15	1

Table 2. Regression analysis of helminth populations collected from smallmouth bass (*Micropterus dolomieu*) hosts from the Buffalo River.

	N	X variable	Y variable	R	*p*	Intercept	Slope
Monogenea	5	Mean	SD	0.99	2.4E-05	-0.88	4.3
		Mean	Max.	0.99	7.6E-05	-11.2	36
		SD	Max.	0.99	2.8E-06	-1.99	8.5
Digenea	10	Mean	SD	0.98	3.0E-07	-7	54.4
		Mean	Max.	0.94	4.9E-05	-1902	448.3
		SD	Max	0.98	2.9E-07	-1328	104.4
Cestoda	3	Mean	SD	0.89	0.3	0.36	2.32
		Mean	Max	0.59	0.6	4.3	16.7
		SD	Max.	0.89	0.3	-0.93	19.7
Acanthocephala	1	Mean	SD	0.97	3.7E-07	0.29	0.97
		Mean	Max.	0.97	6.5E-07	-1.93	3.59
		SD	Max.	0.99	1.5E-08	0.91	0.27
Nematoda	5	Mean	SD	0.98	0.004	5	0.17
		Mean	Max.	0.99	7.5E-06	18.4	10.7
		SD	Max.	0.98	0.003	-271.9	61.1

Table 3. Regression analysis of mean, standard deviation (SD), and maximum number (Max.) population descriptors as the X variables and population prevalence (% hosts infected) as the Y variable from helminth populations collected from smallmouth bass (*Micropterus dolomieu*) from the Buffalo River.

	N	X Variable	Y Variable	R	*p*	Intercept	Slope
Monogenea	5	Mean	Prevalence	0.53	0.36	-1.99	0.3
		SD	Prevalence	0.5	0.39	-8.0	1.1
		Max.	Prevalence	0.48	0.41	-65.7	8.9
Digenea	10	Mean	Prevalence	0.36	0.36	0.3	0.35
		SD	Prevalence	0.51	0.51	0.51	0.06
		Max.	Prevalence	0.15	0.15	0.68	67.5
Cestoda	3	Mean	Prevalence	0.99	0.07	-0.72	39.2
		SD	Prevalence	0.94	0.23	-3.9	14.2
		Max.	Prevalence	0.67	0.53	2.37	0.93
Acanthocephala	1	Mean	Prevalence	0.65	0.03	-6.4	0.19
		SD	Prevalence	0.53	0.1	58.5	1.83
		Max.	Prevalence	0.52	0.1	60.2	0.48
Nematoda	6	Mean	Prevalence	0.84	0.07	24	0.37
		SD	Prevalence	0.87	0.053	12.6	2.2
		Max.	Prevalence	0.83	0.08	23.5	0.03

Table 4. The SD/Mean and other ratios of Buffalo River helminth parasite populations of smallmouth bass (*Micropterus dolomieu*).

Host Populations	N	Sd/Mean	Max/Mean	Max/Sd
All helminths	24	3.6±1.7	31.1±21.7	7.8±2.2
Monogenea	5	4.0±1.3	33.6±27.3	7.5±2.4
Digenea	10	3.6±1.3	31.2±15.5	8.3±2.0
Nematoda	5	3.6±2.4	29.3±32	6.7±2.5

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