The Diversity and Abundance of Parasites in Age Groups of Yellow Perch in Lake Bemidji, MN Applied to a Whittaker Curve

Kelly J. Main
2905 Pine Ridge Ave. Apt. 204
Bemidji, MN 56601
15 May 2002

Abstract

Thhirty-six yellow perch *(Perca flavescens)*, ages 0 to 8, were collected from the south shore of Lake Bemidji, Minnesota and examined for parasites. Twenty-five species of parasites were identified. Mean number of parasites species per host was 10.75 and mean number of parasites per host was 379.8. Species richness and abundance were plotted against the age groups and trendlines were then established and correlations evaluated. Species richness and abundance of parasites with along with age groups showed a positive relationship. A Whittaker succession model was applied to the diversity of parasites with age, showing that parasite recruitment with age follows a geometric sequence in succession.

Introduction

Parasite species are found in almost all living organisms. Parasites have evolved to become a component of their host's community. All adaptations for transmission exploit some aspect of the host's behavior. Parasitism is a part of any natural community and generally the parasite is far less a hazard to its host than a predator. A successful parasite must be able to withstand the hostile environment on or within the host while exploiting the benefits of it's niche (food and habitat), and at the same time preserving the health of it's host (Croll 1966). Some parasites are specific to a certain host, organ or tissue with in a host (Rogers 1962). The host species response to this would be inflammation (swelling) or abnormal growth in tissue size or structure having a negative affect on normal growth, fecundity, and host mortality. Such defenses could also limit parasite numbers, but the host may tolerate these parasite-invoked responses, just as the parasite tolerates the response (Croll 1966).

Hosts generally begin their lives without parasite infections. As a fish ages it will gradually accumulate more parasite species and more individual parasites (Cloutman 1975). It would be unlikely for a fish in older age groups to contain relatively few parasite species and individuals. Although, young heavily infected hosts may have a higher mortality due to the intensity of infection and not reach maturity.

Species dominance curves have been developed showing diversity and patterns of species of composition in land plants (Whittaker 1970). Species dominance curves were later used to display succession patterns (Whittaker 1970) that I hypothesize can be used in fisheries management to show the recruitment of parasites into a host population by age groups. The purpose of this paper is to see if the parasite community of yellow perch *(Perca flavescens)* resembles the classic pattern of a Whittaker curve, (geometric series, log normal, and broken-stick), displayed by other organisms. An Example of a Whittaker curve series is located in Figure 1.

Materials and Methods

Thirty-six yellow perch were collected in the fall of 2001, by trap nets set near the shore the south basin of Lake Bemidji, Minnesota. Lake Bemidji is 6,420 acres and has 1,862 littoral acres with the maximum depth being 76 feet. The Minnesota Department of Natural Resources places Lake Bemidji in class 22, which consists of other large deep lakes with relatively clear water (MN DNR 1998).

According to the DNR Survey of Lake Bemidji in 1998, yellow perch were the most numerous species of fish in all sampling gear. Yellow perch were chosen for this research because they are common, widely known fish, and are easy to obtain in sufficient numbers, and age classes with out adversely affecting the population (MN DNR 1998). The parasites of yellow perch are also well known, researched, and documented (Carney and Dick 2000).

All fish were placed in a temperature (approximate to that of the temperature of the lake) controlled holding tank until a necropsy could be completed. There is a low risk of a fish infecting other fish in the tank because most of the parasites are in internal and intermediate stage, where they need to be consumed by another fish, bird, or mammal in order for the parasite to mature. Those that are mature and reproduce, eggs or larvae often need to be consumed by or develop in an intermediate host before infecting a fish.

Parasites attached to the skin and fins of the fish are unlikely to leave a viable host and move to another during the short time spent the tank.

During the necropsy each fish was weighed to the nearest 0.1g and measured (total length) to the nearest millimeter. Otoliths were used to age the fish (Murphy and Willis 1996). Fish were completely necropsied; all visceral organs, eyes, fins, skin, gills, and muscle were examined. The gills were removed and preserved in 5% formalin and examined later. A dissecting scope (up to 8x power) was used to examine the fish organs and identify parasites. Parasites were removed, identified, and counted. Those needing further identification were preserved in 5% formalin and later examined. Identifications were made using Hoffman, (1999) and Roberts, (1970). Each necropsy took approximately two to three and a half hours per fish, depending on the size of the fish and extent of infection.

Mean abundance, mean intensity, and prevalence were calculated for each parasite species found. Calculations were based on the definitions given in Bush et. al. 1997. Mean intensity is defined as the average number of individual parasites of a species in an infected host. Mean abundance in the total number of individuals of a parasite species in a sample of a particular host species, divided by the number of hosts examined regardless of whether or not the host is infected. Prevalence is the number of hosts infected divided by the number of hosts examined for a particular parasite species, expressed as a percent.

By plotting the mean numbers of parasite species for each age group a trend can be seen correlating age groups to species richness and parasite abundances. Significance was shown through standard statistical analysis of standard deviation and 95%

confidence intervals. Species richness refers to the mean number of parasite species for an age group. Parasite abundance refers to the mean number of parasites for each age group. When mean numbers are used, age group 7 refers to both the age seven and eight year old fish; only one of each age was in the sample.

A species dominance curve (Whittaker 1970) was created to show the succession as more species of parasites are accumulated as fish age. The natural log of the number of parasite species are ranked from most to least abundant within their age groups and plotted on a graph. Trendlines were established for each age group, revealing the geometric pattern of succession. Calculations were made with Microsoft Excel.

Results

Twenty-five parasite species were identified and 13,673 individual parasites were observed from the thirty-six necropsied yellow perch. The mean abundance of parasites per host was 379.8 and the mean number of parasite species per host was 10.75 (Table 1). Table 2 contains the names of the twenty-five parasite species, the quantities found, the number of hosts infected (one or more individuals of a parasite species in any life stage), Mean intensity, mean abundance, prevalence, and the range of parasites in hosts show infection levels.

Yellow perch of all age groups showed parasite infections. A succession plot was derived from the species diversity data for the total species richness and the mean species richness and trendlines were established. There is positive correlation through linear regression between species diversity and age group (Figure 2). The significance between the mean species diversity of parasites and age where n=8, and the standard error is 0.815 is shown with a 95% confidence interval of ±1.63. Regressions were also made with the parasite abundance data, and trendlines established (Figure 3). There was a 95% confidence level of ±113 between mean parasite abundance per host age group where (n=8), mean= 406.9 and standard error was 56.48.

Discussion

Correlating Parasite Richness with the age groups, in a regression plot significantly shows that there is a relationship between ages of yellow perch and the number of parasite species they contain (Figure 2). As young fish are gradually recruited into the population, so are parasites. As a fish ages it will accumulate parasite species on average with the confidence level (95%) of ±1.63 per year. Parasite abundance also follows this trend (Figure 3). Parasite numbers are steadily increasing with fish age groups. The greater number of parasites could be attributed to a larger body size of older fish, having more places for parasites to infect and exploit (Table 1). Although the 95% confidence interval is ±112.898, it is not too far off, considering the number of parasites per host does range into the 700's.

The range of parasite species found in yellow perch can be attributed to their feeding habits; they regularly feed across most trophic levels, and other fish species also influence the parasite community (Carney and Dick 1999). This could be why fish accumulate different parasite species as they age. Expanding their diet, younger fish are eating a wider variety of prey species as they become larger.

The Whittaker curve model shows a trend for each age group (Figure 4). A series of straight downward sloping trends are shown from age 0 to age group 4. At age 5 a wider variety of parasite diversity is shown on the curve with a lognormal-like distribution. The trendline for age group 6 is slightly curved but does clearly not share the variety in parasite diversity as the age 5 yellow perch. This could be the start of the broken-stick portion of the series. There was not enough fish of age 7 and 8 collected to determine the more of the series. But, by looking where the samples of the age 7 and 8 fish are on the graph I can assume that they might show a similar trend.

The parasite population of yellow perch does resemble the classic pattern of a Whittaker curve. I speculate with a larger sample of yellow perch distributed equally in age groups, a stronger pattern may be evident. With this information more research could be done on specific parasite species. An age could be pinpointed to when a yellow perch is most susceptible to acquire a certain species of parasite and what environmental factors support and influence the recruitment of that parasite into the host's parasite population. Heavy infections of parasite species could also be monitored if they are suspect of causing slow or abnormal growth, or premature mortality.

Acknowledgements

I wish to thank Ross Sportel for collaboration on perch necropsies and collection of fish and Dr. Donald Cloutman for insight, equipment, and literature references.

References

Bush, A. O., Lafferty, K. D., Lotz, and J. M., Shostak, A. W. 1997. Parasitology meets ecology on its own terms: Margolis et al. revisited. Journal of Parasitology 83(4): 575-583

Carney, J. P. and Dick, T. A. 1999. Enteric helminths of perch (*Perca fluviatilis* L.) and yellow perch (*Perca flavescens* Mitchell): Stochastic or predictable assemblages? Journal of Parasitology 85(5): 785-795.

Carney, J. P. and Dick, T. A., 2000. Helminth communities of yellow perch (*Perca flavescens* (Mitchell)): Determinants of pattern. Canadian Journal of Zoology 78:538-555.

Cloutman, D. G. 1975. Parasite community structure of largemouth bass, warmouth, and bluegill in Lake Fort south, Arkansas. Transactions of the American Fisheries society 104(2)277-283.

Croll, N. A.1966. Ecology of Parasites, Harvard University Press, Massachusetts. 136 p.

Hoffman, G. L. 1999. Parasites of North American Freshwater Fishes, 2nd Edition. Cornell University, New York. 539 p.

Minnesota Department of Natural Resources. 1998 Lake Finder. www.dnr.state.mn.us/perl/lk_survey

Murphy, B. and Willis, D. 1996. Fisheries Techniques 2nd Edition. American Fisheries Society, Maryland.

Roberts, L. S. 1970. *Ergasilus* (Copepoda and Cyclopodia): Revision and key to species in North America. Transactions of the American Microscopical Society 89:134-161.

Rogers, W. P. 1962. The nature of parasitism. Academic Press, New York. 287 p.

Smith, R. L. 1986. Succession (chapter 23), Elements of Ecology 2nd Edition. Harper and Row Publishers Inc. New York. pp.473, 476.

Whittaker, R. H. 1970. Communities and Ecosystems. Cornell University, London.162 p.

Age	Length (mm)	Weight (g)	Total Parasites	# ParasiteSpecies
0	38	0.742	107	5
0	65	2.634	257	8
0	50	0.964	173	6
0	60	1.739	252	7
0	101	10.853	113	7
1	54	1.495	106	10
1	125	21.7	395	11
1	120	16.71	501	13
1	100	10.1	346	9
1	95	7.424	158	8
1	93	71.5	126	9
2	155	46.6	712	10
2	155	49.73	88	7
2	155	47.2	317	9
3	180	159.7	513	11
3	206	115.3	237	13
3	229	127.5	286	10
4	225	135.4	700	14
4	225	174.5	283	13
4	250	182.1	356	13
4	226	124.76	417	10
4	251	213.8	444	11
4	255	193	310	12
5	245	208	723	11
5	265	239.5	180	9
5	245	208	400	10
5	235	151.76	315	9
5	253	205	381	17
6	270	250.9	483	15
6	265	249.2	484	12
6	265	249.2	578	14
6	270	241.9	657	13
6	260	216.3	306	12
6	267	239.1	730	12
7	270	253.8	660	14
8	300	292.3	579	13
			Ave=379.8	**Ave= 10.75**
			Total= 13673	Total= 387

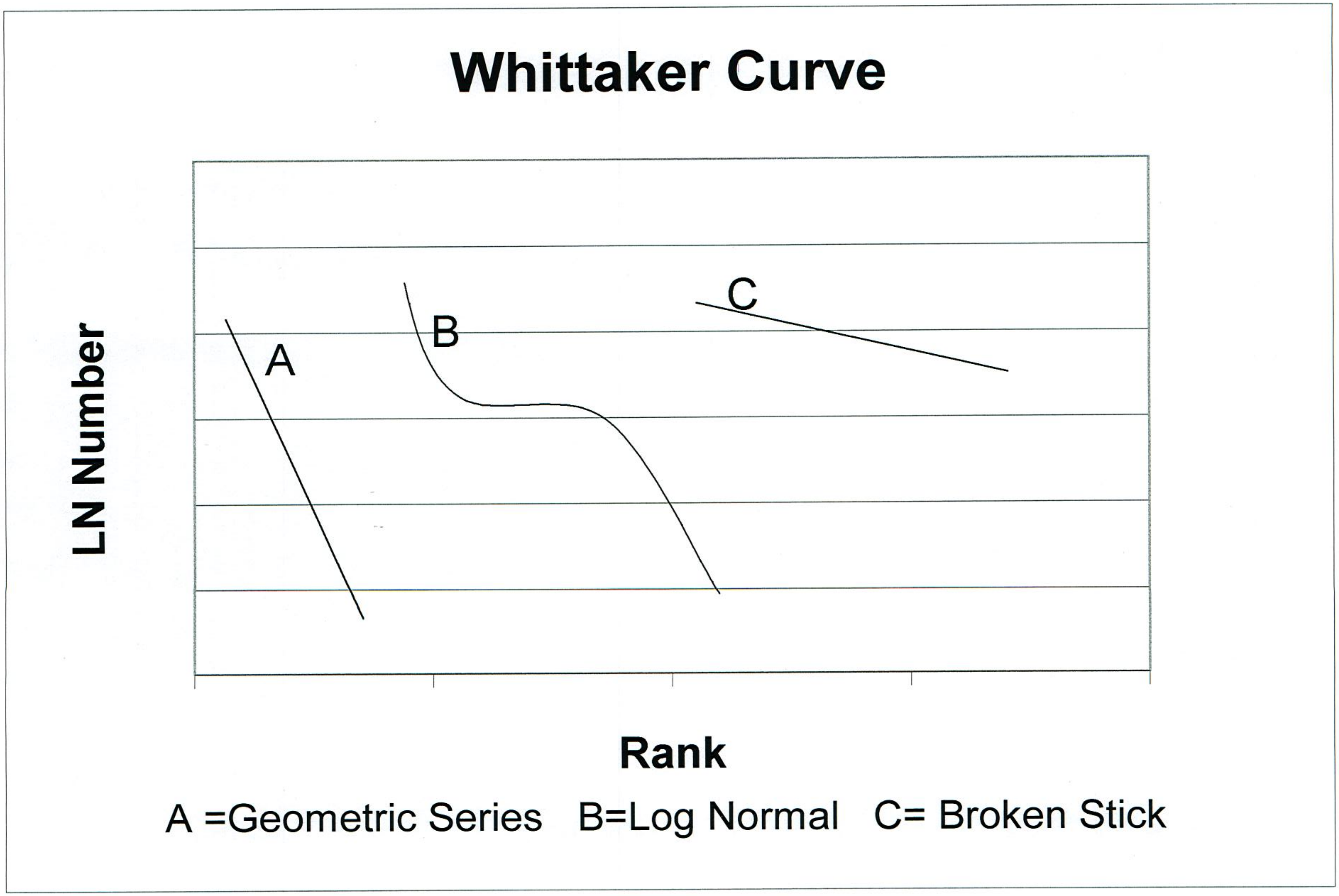
Table 1. Distribution of parasites along with host fish attributes.

Parasite	Total Quantity	Infected	Mean Intensity	Mean Abundance	Prevalence (%)	Range
Phylum Acanthocephala						
Leptorhynchoides thecatus	6	5	1.20	0.17	13.89	1--5
Neoechinorhynchus cylindratus	94	23	4.09	2.61	63.89	1--14
Pomphorhynchus bulbocoli	20	7	2.86	0.56	19.44	1--7
Phylum Annelida						
Myzobdella lugubris	14	14	1.00	0.39	38.89	1--4
Phylum Arthropoda						
Subphylum Crustacea						
Ergasilus luciopercarum	85	19	4.47	2.36	52.78	1--31
Phylum Cilophora						
Class Oligohymenophorea						
Ichthyophthirius multifiliis	9	2	4.50	0.25	5.56	1--8
Phylum Nematoda						
Rhapidascaris sp.	2089	32	65.28	58.03	88.89	1--440
unidentified sp.	2	1	2.00	0.06	2.78	*
Phylum Platyhelminthes						
Class Cestoidea						
Bothriocephalus cuspidatus	102	20	5.10	2.83	55.56	1--31
Eubothrium sp.	3	1	3.00	0.08	2.78	*
Ligula intestinalis	1	1	1.00	0.03	2.78	*
Proteocephalus ambloplitis	778	28	27.79	21.61	77.78	1--83
Proteocephalus pearsei	626	27	23.19	17.39	75.00	1--175
Triaenophorus nodulosus	8	6	1.33	0.22	16.67	1--2
Class Monogenea						
Gyrodactylus freemani	4	3	1.33	0.11	8.33	1--2
Urocleidus adspectus	320	25	12.80	8.89	69.44	1--102
Class Trematoda						
Subclass Digenea						
Azygia longa	308	29	10.62	8.56	80.56	1--111
Bunodera sacculata	332	29	11.45	9.22	80.56	1--35
Clinostomum complanatum	340	30	11.33	9.44	83.33	1--45
Crepidostomum cooperi	68	10	6.80	1.89	27.78	1--29
Dichelyne cotylopora	6	3	2.00	0.17	8.33	1--4
Diplostomulum huronense	5731	36	159.19	159.19	100.00	8--420
Ornithodiplostom ptychocheilus	45	1	45.00	1.25	2.78	*
Phylodistomum supertbum	3	1	3.00	0.08	2.78	*
Uvulifer ambloplitis	2680	35	76.57	74.44	97.22	1--260

* No range data available, only one parasite found

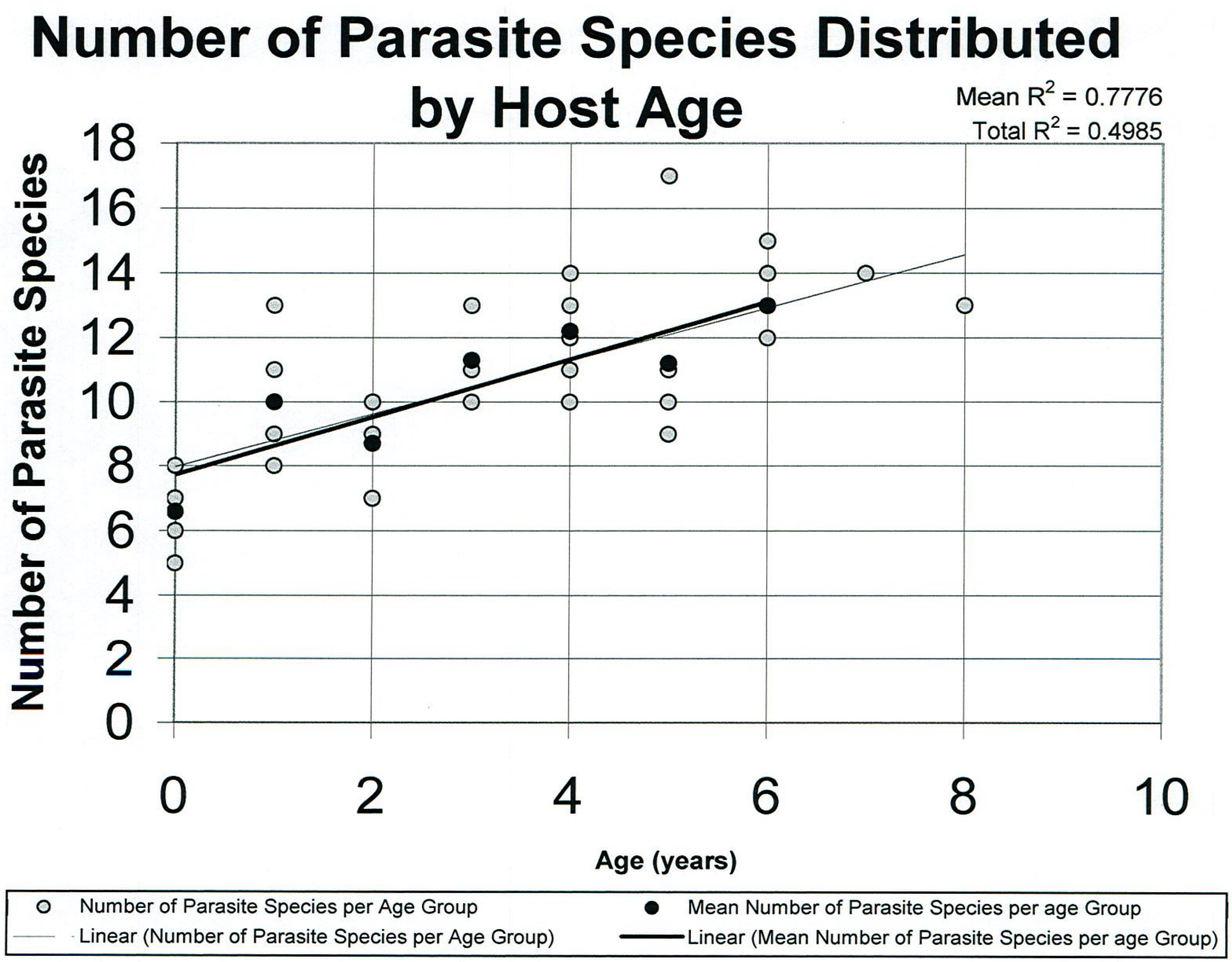
Table 2. List of all parasite species found, number of yellow perch infected (1 or more parasites), mean intensity(mean number of parasties in infected fish), mean abundance (mean number of parasites in all hosts reguardless of infection), prevalence (percent of hosts infected), and range of parasites found in the host fish.

Figure 1. An example of a Whitaker's succession curve, graphically represented.



Whittaker Curve
LN Number
A
B
C
Rank
A =Geometric Series B=Log Normal C= Broken Stick

Figure 2. The positive correlation between the regression of yellow perch age groups and species richness and mean species richness.



Number of Parasite Species Distributed by Host Age
Mean R^2 = 0.7776
Total R^2 = 0.4985
Number of Parasite Species
18
16
14
12
10
8
6
4
2
0
0
2
4
6
8
10
Age (years)
Number of Parasite Species per Age Group
Mean Number of Parasite Species per age Group
Linear (Number of Parasite Species per Age Group)
Linear (Mean Number of Parasite Species per age Group)

Figure 3. Regression showing the positive correlation between parasite abundance mean parasite abundance in yellow perch age groups.

Figure 4. Representation of Whittaker's geometric succession model showing parasite diversity succession with the age of yellow perch.

Whittaker Curve of Number of Species Found in Host Groups