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Species Specific Odds of Occurrence of Blackspot Among Fish From The Maple River In Western Iowa

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Odds ratio analysis was used to evaluate the relative likelihood of occurrence of blackspot (*Neascus pyriformis*, Chandler) infections among 14 species of fish collected from the Maple River in Buena Vista and Ida Counties in western Iowa. Prevalence estimates ranged from 0% to 47.4% with a mean prevalence of 11.9%. The rank ordering of odds ratios of infection allowed the species to be categorized as those with risks greater than, less than, and not different from average risk to infection within the Maple River sample. The species with the largest odds ratio was the bluntnose minnow, (*Pimephales notatus*) (odds ratio = 7.78), whereas bigmouth shiners (*Notropis dorsalis*) and sand shiners (*Notropis stramineus*) had statistically significant odds ratios of zero.

INDEX DESCRIPTORS: blackspot, *Neascus pyriformis*, odds ratio, host range.

Blackspot caused by the metacercarial larvae of *Neascus pyriformis* (Chandler), occurs on a wide range of minnows in western Iowa and southeastern South Dakota, although some fish species may be more suitable hosts than others. In Brule Creek, South Dakota, Blouin et al. (1984) found infections in seven of ten species of fish examined and concluded that *N. pyriformis* is better adapted to some cyprinids than to others in that system. Their conclusion was based on prevalence and intensity of blackspot disease among the host species present; they did not quantify the relationships of risk of infection occurrence among the potential host species. Odds ratio analysis is a method that can provide a score of odds of infection within a sample by comparison of disease occurrence in groups with and without specific risk factors (Mausner and Bahn 1974).

Within a fish assemblage, members of each species are associated with inherent risks of infection according to each species' physiology and ecological context. Odds ratios can be used to measure each species' risk of infection relative to the average risk experienced by all other individuals of all species in a sample. The odds ratio belongs to a class of association statistics with a long history of use in ecology (Cole 1949). Although a common tool in public health, odds ratio analysis has not been widely applied to the study of occurrence of parasitic infection among an array of host species. This paper reports the results of the application of odds ratio analysis to determine species specific odds of infection to blackspot disease among an assemblage of fish from a river in western Iowa.

METHODS

A collection of 2,506 fish representing 14 species from a faunal survey of the Maple River in Buena Vista and Ida Counties in western Iowa was examined for the presence of blackspot. Fish were collected using a knot mesh minnow seine and were preserved in 10% formalin. The number of infected fish and the total number of individuals of each species was recorded. Odds ratios were calculated as: Odds Ratio = (A/B)/(C/D) where A, B, C, and D are identified as:

	Infected	Uninfected
Number of individuals in the species considered	A	B
Total individuals of all other species in host assemblage	C	D

Odds ratio comparisons were tested for significance using Fisher's Exact Test. Computation of odds ratio and Fisher's Exact Test were conducted using EPI-INFO ver 6.0 (Dean et al. 1996) from the Centers of Disease Control and Prevention. The Sign Test (Zar 1974) was used to test for differences likelihood of occurrence based on rankings by odds ratios versus rankings by prevalence.

RESULTS AND DISCUSSION

The most frequently infected fish species was the bluntnose minnow (Table 1). Four species have a prevalence of zero, and consequently the confidence interval for the prevalence estimates of these species is undefined (Table 1). The prevalence of blackspot among fish from the Maple River was generally less than that found by Blouin et al. (1984) in Brule Creek, South Dakota. However, johnny darters in the Maple River had a low prevalence (4.0%) while johnny darters from Brule Creek were free of infection. As in Brule Creek, bigmouth shiners and sand shiners were free from infection in the Maple River.

The shorthead redhorse was excluded from odds ratio analysis because only a single specimen was included in the sample (Table 2). An odds ratio greater than one indicates a risk of infection greater than that experienced in the host assemblage at large, and an odds ratio less than one indicates a lower risk. The overall prevalence of blackspot among the 14 species of fish in this sample was 11.7%. Consequently, for this sample, as species prevalence estimates differ from 11.7%, they generate differences in species specific odds of infection.

Five species of fish from the Maple River had odds ratios that were not significantly different from one, including the brook stickleback which had a prevalence estimate of zero (Table 2). This indicates that

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Table 1. Summary of blackspot occurrence in fish from the Maple River in order of prevalence of infection.

Host Species	Number Examined	Number Infected	Prevalence % ± 95% C. I.
Bluntnose minnow, <i>Pimephales notatus</i> (Rafinesque)	95	45	47.4 ± 10.0
Central stoneroller minnow, <i>Campostoma anomalum</i> (Rafinesque)	31	11	35.5 ± 16.8
Blacknose dace, <i>Rhinichthys atratulus</i> (Hermann)	57	19	33.3 ± 12.2
Creek chub, <i>Semotilus atromaculatus</i> (Mitchill)	346	113	32.6 ± 4.9
Fathead minnow, <i>Pimephales promelas</i> (Rafinesque)	504	72	14.3 ± 3.0
Red shiner, <i>Notropis lutrensis</i> (Baird & Girard)	96	10	10.4 ± 6.1
Southern red belly dace, <i>Phoxinus erythrogaster</i> (Rafinesque)	106	7	6.6 ± 4.7
White sucker, <i>Catostomus commersoni</i> (Lacepede)	21	1	4.8 ± 9.1
Johnny darter, <i>Etheostoma nigrum</i> (Rafinesque)	148	6	4.0 ± 3.7
Common shiner, <i>Notropis cornutus</i> (Mitchell)	279	11	3.9 ± 2.3
Bigmouth shiner, <i>Notropis dorsalis</i> (Agassiz)	756	0	0
Sand shiner, <i>Notropis stramineus</i> (Cope)	53	0	0
Brook stickleback, <i>Culea inconstans</i> (Kirtland)	13	0	0
Shorthead redhorse, <i>Moxostoma macrolepidotum</i> (LeSueur)	1*	0	0

*" species excluded from analysis because of small sample size.

Table 2. Occurrence of blackspot among fish from the Maple River in descending order of odds ratio (O.R.).

Host Species	Odds Ratio	95% Conf. Interval of O.R.†	Rank by O.R.	Rank by Prev.
Bluntnose minnow	7.78	4.96–12.13	1	1
Creek chub	5.27	3.96–6.96	2	4
Central stoneroller	4.24	1.81–9.39	3	2
Blacknose dace	3.93	2.11–7.11	4	3

Fathead minnow	*1.33	0.98–1.78	7.0	5
Red shiner	*0.87	0.40–1.70	7.0	6
Southern Red-bellied dace	*0.52	0.20–1.12	7.0	7
White sucker	*0.37	0.01–2.35	7.0	8
Brook stickleback	*0.00	0.00–2.46	7.0	12

Johnny darter	0.30	0.11–0.68	10	9
Common shiner	0.28	0.14–0.52	11	10
Sand shiner	0.00	0.00–0.53	12.5	12
Bigmouth shiner	0.00	0.00–0.02	12.5	12

*Dotted lines separate three classes of odds of infection by blackspot: greater than background, indicated statistically indistinguishable from background (two-tailed, $p > .05$), and less than background.

†The confidence intervals around the odds ratio are not symmetrical because they conform to a chi-square distribution.

a significant difference between a prevalence of 0 and 11.7% was not detectable for a sample as small as 13 sticklebacks. This lack of sensitivity in prevalence is not apparent from inspection of the magnitudes of prevalence alone and demonstrates the potential for possible error when rankings of prevalence are used as the basis of comparisons of likelihood of infection.

Four species of fish, bluntnose minnow, creek chub, central stoneroller minnow, and blacknose dace, had significantly greater risk of infection from blackspot than the rest of the assemblage. Within this sample, bluntnose minnows had the greatest odds ratio and were 7.78 times more likely to be infected than individuals of all other species combined within the sample. Four species of fish, johnny

darter, common shiner, sand shiner, and bigmouth shiner, had significantly less risk of infection than the other species of fish in this collection. Two of these, the bigmouth shiner and the sand shiner had odds ratio of zero. Blouin et al. (1984) concluded that the seven parasitized species of fish in Brule Creek were predominantly pool dwellers whereas the three species uninfected were more often found in riffles and runs. Results of the current study were similar. Additionally, in the current study, three of the four species with greater than background risks to infection by blackspot have reported associations with vegetation (Becker 1983).

A comparison between the rank order of likelihood of occurrence of blackspot using odds ratio and prevalence is provided in Table 2. The rankings of only two species were the same under both measures. A sign test for differences between the two rankings showed a significant statistical difference ($P = 0.033$). The difference between rankings is in large part due to the detection of species with odds ratios not significantly different from one, including the brook stickleback, with a prevalence of zero whose ranking differs between measures of occurrence by four and one-half positions. Despite a significant statistical difference, the rankings by both measures of occurrence had important similarities. The four species with increased risk of infection also had the four highest prevalence scores. With the exception of the brook stickleback, which tied for lowest prevalence but had an odds ratio not significantly different than one, the species with decreased risk of infection were also the species with the lowest rankings by prevalence.

The magnitude of the odds ratios emphasized the difference in risk of infection compared to prevalence. For example, in terms of prevalence, the bluntnose minnow (47.4%) experienced only 12% greater occurrence of blackspot than the central stoneroller minnow (35.5%); however, the odds ratio for the bluntnose minnow (7.78) was nearly double that associated with the central stoneroller minnow (4.24).

Odds ratio analysis is a common epidemiological tool used to identify associations between exposure risk and disease occurrence. The application of odds ratio analysis to blackspot in the Maple River allowed the fish species present to be ranked according to their likelihood of being infected relative to all other fish species present. The differences in odds of infection are likely to be associated with differences in physiological characteristics or ecological associations that place the various host species at different risks to infection. The

stratification of the host assemblage by odds ratio of infection provides a more rigorous means than inspection of prevalence for selecting species likely to provide strong contrasts for comparative studies needed to evaluate potential physiological or ecological factors that contribute to infection risk. In the Maple River, future comparisons between the biology of the species at high risk of infection, the bluntnose minnow and creek chub, with species at low risk to infection, sand shiner and bigmouth shiner are likely to provide such strong contrasts.

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