Is *Hexanchorus caraibus* Coquerel Associated with Highly Oxygenated Water (Coleoptera: Elmidae)?

By: Hannah J. Blackburn

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Dr. James Woolley and Dr. Thomas Lacher
Texas A&M University

Abstract

The alleged association of the laraine *Hexanchorus caraibus* Coquerel with highly oxygenated water was tested with a multivariate analysis of beetle abundance across three habitat types, testing environmental variables of dissolved oxygen, oxygen PPM and temperature. The species' distribution was not explained by any of the three environmental variables. *Hexanchorus caraibus* is now hypothesized to prefer fast water rather than highly oxygenated water.

Introduction

Beetles of the family Elmidae are commonly known as riffle beetles, because of their association with rapidly moving water (Triplehorn and Johnson, 2005). They are generally considered to be associated with "rapid, cool, and highly oxygenated streams" (Shepard 2002). *Hexanchorus caraibus* Coquerel is the only member of the family known from Dominica, and also occurs on neighboring islands (Peck 2006, M. Ivie pers. com.). It is a member of the subfamily Larainae, lives in rapids and waterfalls, and has been observed to fly repeatedly over and into its white water habitat (Spangler and Santiago, 1992). Although it can be found in various parts of a stream, it is highly concentrated in white water sections (Spangler and Santiago 1992). Shaw (2009) filmed this behavior, and the question of why the beetles only seem to fly over and into the white water lead to this project.

Virtually every reference on this group mentions highly oxygenated water as a factor defining the habitat. Therefore, I decided to investigate the relationship of oxygen to the distribution of *H. caraibus* in the Checkhall River, Dominica, at the Archbold Research Center. Three intercorrelated, closely related factors were considered likely to contribute to the habitat preference of beetles that allegedly prefer highly oxygenated water – O2 parts per million (PPM), dissolved oxygen (DO) and temperature. The PPM of a particular DO is dependent on temperature and pressure, so together these factors should capture the data needed to answer the question: "are *H. caraibus* limited by highly oxygenated water?"

Materials and Methods

A section of stream that included white-water-riffle/waterfall, clear stream and pool habitats was chosen for the study. A "pool" was an area of the river where you could see to the bottom clearly with little to no ripples on the water surface. A "stream" was considered to be an area where the water was moving swiftly but not enough that it reached its Reynolds Number. A waterfall was a spot at which the river had an abrupt drop over a fall point, with the water reaching or exceeding its Reynolds Number, giving the appearance of white-water.

Five stream sections were selected as replicates on the basis of the presence of each habitat/treatment. Sections were a minimum of 3 meters apart. Within each treatment and stream section, 10cm X 10cm sample quadrats were selected. A CyberScan DO 110 Hand-held Dissolved Oxygen Meter was used to record PPM, DO and temperature. The DO meter probe had been soaked for 30 minutes prior to sampling, as per the manufacturers instructions.

Samples were taken on 05 and 07 June 2011. Table 1 provides details of the locations and dates of collection of data in each replicate. Coordinates were obtained using a Garmin eTrex Legend H.

Table 1: Coordinates & Dates of Project Activity		
Location	**Coordinates**	**Dates**
Location A	15.34545 °N, 61.37011 °W	5-Jun-2011
Location B	15.34564 °N, 61.36926 °W	5-Jun-2011
Location C	15.34555 °N, 61.36820 °W	7-Jun-2011
Location D	15.34525 °N, 61.36744 °W	7-Jun-2011
Location E	15.34514 °N, 61.36713 °W	7-Jun-2011

At each quadrat, numbers of elmids were estimated by placing a net downstream from quad, held so that the base of the net entrance was snug against the river bottom, with a tilt towards the sample area. The 10 cm. X 10 cm. quadrat was briskly rubbed by hand to dislodge any elmids present. The net was then removed and specimens were forced to the base of the net by swinging it through the air, and transferred to a vial of 70% ETOH. The adult elmids present were counted and the data recorded. These data are presented in Table 2.

Immediately following the beetle-sampling of each quad, PPM, DO and temperature were recorded. Seven values were recorded, one each 20 seconds for 2 minutes, alternating between DO and PPM (3 each), followed by a temperature reading. These data are presented in Table 2.

A multiple regression (using SPSS® ver. 18.), was used to determine if the environmental variables (DO, ppm, T) can predict the abundance of elmids.

Table 2. Data for Treatments, locations, abundance, temperature, DO and PPM

Treatment	**Loc.**	**Elmids (N)**	**Temp (°C)**	**%DO 1**	**%DO 2**	**%DO 3**	**Mean DO%**	**ppm1**	**ppm2**	**ppm3**	**Mean ppm**
Pool	1	0	23.8	83.30	82.10	84.10	83.17	6.85	7.00	7.03	6.96
Pool	2	0	23.8	92.20	93.90	93.60	93.23	7.71	7.80	7.98	7.83
Pool	3	0	23.1	92.20	91.10	92.00	91.77	7.88	7.90	7.82	7.87
Pool	4	0	23.3	96.50	96.70	96.70	96.63	8.20	8.22	8.28	8.23
Pool	5	0	23.1	96.1	93.8	95.1	95.00	8.13	8.02	8.08	8.08
Stream	1	2	23.6	96.60	96.60	96.80	96.67	8.25	8.18	8.20	8.21
Stream	2	0	23.4	97.00	96.90	97.10	97.00	8.25	8.25	8.25	8.25
Stream	3	0	23.1	97.80	97.80	98.00	97.87	8.36	8.37	8.38	8.37
Stream	4	0	23.5	94.90	96.40	97.20	96.17	8.10	8.21	8.26	8.19
Stream	5	0	23.1	96.80	97.00	97.10	96.97	8.31	8.30	8.31	8.31
Falls	1	3	23.7	96.90	96.90	97.40	97.07	8.22	8.22	8.24	8.23
Falls	2	7	23.4	98.00	97.90	98.00	97.97	8.33	8.33	8.34	8.33
Falls	3	0	23.2	97.60	97.90	98.00	97.83	8.35	8.36	8.37	8.36
Falls	4	6	23.3	97.40	98.40	98.50	98.10	8.38	8.38	8.42	8.39
Falls	5	15	23.1	96.6	96.9	97	96.83	8.25	8.31	8.29	8.28

Results

The multiple regression determined that the environmental variables (DO, ppm, T) cannot predict the abundance of elmids. All variables were entered into the equation (Table 3). The amount of variation in Elmid abundance explained by the environmental variables is only 0.078 (Table 4, R-squared variable). The analysis of variance of elmid abundance as a function of the environmental variable predictors is highly non-significant (Table 5, p = 0.816).

Table 3

Variables Entered/Removed[b]

Model	Variables Entered	Variables Removed	Method
1	Mean ppm, T, Mean %[a]	.	Enter

a. All requested variables entered.
b. Dependent Variable: Elmids

Table 4

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.280[a]	.078	-.173	4.580

a. Predictors: (Constant), Meanppm, T, Mean%
b. Dependent Variable: Elmids

Table 5

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	19.632	3	6.544	.312	.816[a]
	Residual	230.768	11	20.979		
	Total	250.400	14			

a. Predictors: (Constant), Meanppm, T, Mean%
b. Dependent Variable: Elmids

Discussion

The hypothesis that elmid distribution is explained by oxygenation is strongly refuted by these results, indicating that the physical attributes of the habitat, i.e. speed of the water and possibly suitable rock surfaces, is more important than the amount of available oxygen. The calls into question the often-repeated, but seldom tested assertions in standard references on this group. A next step in this study would be to use water speed as a factor in a similar analysis to test this idea.

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