

Improving Aquatic Insect Identifications Made by Students and Volunteers

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Abstract

Educators and volunteer groups are increasingly using aquatic macroinvertebrate biomonitoring, not only as a way to engage the community in environmental stewardship, but also as a strategy for generating valuable water quality data. While the efforts of these groups have certainly increased understanding and concern for the health of our streams and rivers, the quality of the data collected through these programs is being called into question. To be useful in both the research and policy arenas, biomonitoring data must be accurate and conducted at a level of precision that will determine water quality within an appropriate level of certainty. Research, recently conducted at several Portland, Oregon high schools and a university, shows that student-collected data is not of sufficient quality. This paper reviews the literature on student and volunteer collected biomonitoring data, and presents results from a study on two strategies for improving students' field identifications of aquatic insects. Results from this research show that two interventions: *describing and showing Key Identification features, and using live reference specimens*, drastically improve the accuracy of aquatic insect identifications made by students.

Introduction

Education-Based Aquatic Insect Biomonitoring

The simplicity and natural wonder of aquatic insect studies is well suited to the educational setting, and teachers at all levels are increasingly using biomonitoring as a way to engage their students in scientific inquiry and research. More importantly, local volunteer and watershed management groups across the nation are using aquatic insect data to monitor and track the quality of streams and rivers. For many science teachers, there is strong incentive to partner their students' biomonitoring research with the data needs of community stakeholders and policy makers. In fact there are hundreds of organizations that promote education-biomonitoring partnerships (U.S. Geological Survey, 1995), and many of them use student-derived data in official documents and studies including 305(b) reports to congress (U.S. Environmental Protection Agency [EPA], 1998; Nerbonne & Vondracek, 2003). However, there is justifiable concern for the quality of student-collected biomonitoring data (Penrose & Call, 1995). As more biomonitoring education/research partnerships are established and promoted, it is critical that the accuracy and taxonomy of such work is considered and that biomonitoring

training and field methods reflect best practices for ensuring the accuracy of volunteer/student identifications.

Accurate identification is the cornerstone of high quality biomonitoring. Thus, incorrect identification invalidates the results of a biomonitoring study. Unfortunately, there is scant research on instructions or field conditions which may lead to highly accurate insect identification. A literature review uncovered relatively few publications specifically focused on the accuracy of aquatic insect identifications made by students or volunteers. One study published in 2001 found that Volunteer data was comparable to professionals (Fore, Paulsen, & O’Laughlin, 2001). Another study by Nerbonne and Vondracek (2003) found that the volunteer success rate in identifying families of aquatic insects was only 29.6%. Rather than *identification accuracy*, most of the published research on volunteer based biomonitoring is focused on the ability of volunteers or students to accurately determine the ecological condition of streams using multimetric indexes as evidence for correct insect identification (Ely, 2000; Engel & Voshell, 2002; Fore et al., 2001).

The purpose of this paper is to examine procedural factors and conditions that influence the accuracy of college students’ insect identifications and to make recommendations for strategies that will likely improve identification accuracy. Because professional biomonitoring data require at least family level taxonomy, this study focuses on the accuracy of identifications made at the family level.

Methods

Overview

This study examined the accuracy of insect identifications by students enrolled in an upper division science course called “Water in the Environment.” Participating students ranged in age and backgrounds, and few, if any of them had experience collecting or identifying aquatic insects. Three separate experiments (Exp 1: guide only. Exp 2: key ID, and Exp 3: reference tray) were conducted over the course of a 10-week term to determine the affect of a guide (Exp 1), and the effect of two interventions (Exp 1 & 2), on the accuracy of students’ aquatic insect identifications. Between studies, students did not receive any additional training in insect identification nor did they learn whether their identifications were correct. Due to absences and other logistical challenges, only about 70% of the students participated in all three experiments, the remaining 30% missed at least one of the experiments. The data from one group in Exp. 3 was eliminated for incorrect procedures.

To quantify identification accuracy in each experiment, students were given a white sorting tray with 50-100 live aquatic insect specimens (including debris). The students searched through the samples selecting out as many aquatic insects as they could find and placing each specimen into an ice cube tray, then sorting them into families. In all three experiments, students used one of three regional insect guides as a reference for identification. Any specimens that were too small to identify were labeled as such and not used in the calculations. Specimens categorized as unknown were counted as an incorrect

identification. Once the students were done sorting through the sample, they placed each family of insects into a separate jar and labeled each jar with the family name. The samples were then verified for correct identification and analyzed for identification accuracy. For all three experiments, the same data collection and verification procedures were followed.

Baseline Study

Experiment 1: Guide Only

This study, conducted in April of 2004, determined the accuracy of insect identifications made by inexperienced students using only field guides. In this case, students were not given any prior identification training or practice. The purpose of this experiment is twofold: First, is to determine the effect of a field guide on identification accuracy; second, is to provide a baseline data set for comparison with the two interventions - Experiments 1 and 2.

Interventions

Experiment 2: Key ID Characteristics

In this intervention, conducted in April of 2004, students viewed photographic slides of 15 aquatic insect families and learned to recognize the key identifying features of each family. For example, several slides of *Ephemeroptera heptageniidae* (flathead mayfly) were shown with the following list of Key ID features:

- “One set” of wingpads
- Large head that is wider than body
- Large oval-shaped gills
- Light brown to dark brown in coloration

The students were then given the same set of aquatic insect guides and a handout summarizing the previous lecture on key identification features. Live insects from a local river were provided in the classroom for identification.

Experiment 3: Reference Tray:

This final intervention took place in May of 2004 using insects students collected from three different streams on the west slope of the Cascades Range in Oregon. In addition to the same guides and the *Key ID* handout, students were also given a reference ice cube tray containing live examples of all insect families collected. Using all three resources, including the reference set of live insects, students followed the same procedures to sort and identify insects.

Determining Identification Accuracy

The accuracy of students’ data was recorded by: 1) determining if the insect family was correctly identified, and 2) if each specimen identified by the students was actually present in the jar. So for example, if jar #1 contained 6 specimens and was identified as five *Baetidae*, but it actually had four *Baetidae* and one *Heptageniidae*, the data were recorded as follows (Table 1):

Jar #	Students ID's	Instructor Verification	Correct?
1	6 <i>Baetidae</i>	4 <i>Baetidae</i> , 1 <i>Heptageniidae</i>	Yes
2	5 <i>Ephemerillidae</i>	1 <i>Ephemerillidae</i> , 4 <i>Baetidae</i>	No
3	75 <i>Heptageniidae</i>	70 <i>Heptageniidae</i> , 4 <i>Baetidae</i>	Yes

Table 1: Shows how student data were organized and recorded.

The data from all jars per group were combined and each groups' data were summarized and analyzed (Table 2). To fully characterize the accuracy of students' identifications, two calculation methods, Percent Correct and Percent Taxonomical Difference, were used:

- *Percent Correct* is calculated by determining the percent of total families correctly identified by the students. This method of calculating accuracy is limited in that it does not accurately distinguish between families that are partially identified correctly. For example, students may have only correctly identified a portion of individual specimens within a particular family. If they identified more than 75% correctly, it was considered a correct identification (Table 1).
- *Percent Taxonomical Difference (PTD)* represents the percent difference between the students' identifications and the verified sample. The PTD is calculated using the following formula where $comp_{pos}$ is the total number of correctly identified insects and N is the total number of insects in the larger of the two counts (Stribling, Moulton, & Lester, 2003):

$$PTD = [1 - (comp_{pos} / N)] \times 100$$

A low PTD value indicates agreement between the students' data and the verified data. Thus, the lower the PTD the higher is the accuracy of the students' data. An article published in the *Journal of the North American Benthological Society* (Stribling et al., 2003) suggested a maximum PTD value of 15% as a benchmark for identification accuracy. The PTD is limited in samples where one or two families are represented by a high number of individuals. For example, in the results presented in table 1, the *Heptageniidae* family represents the majority of specimens from all three jars but only one of four families found. In this example, the Percent Correct for Group A = .66, but the PTD = .13.

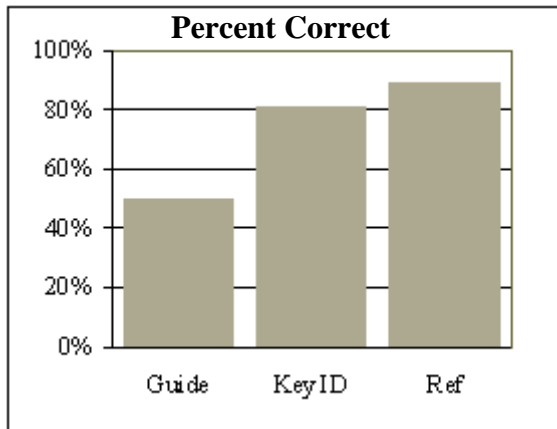
The results of both analyses (% Correct and PTD) were summarized for each group, averaged, and statistically analyzed using an ANOVA analysis.

Results

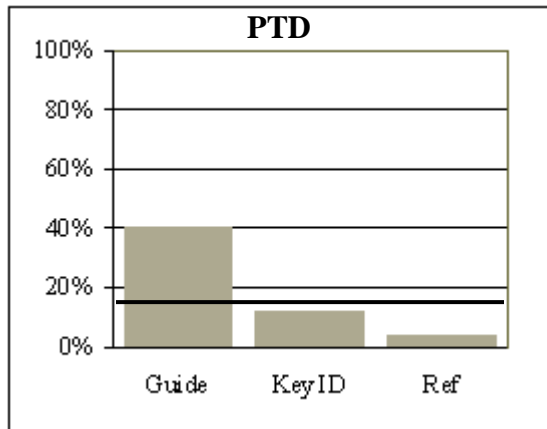
All Interventions: Guides (baseline), Key ID Characteristics, and Reference Tray

	# of student Groups	# of Specimens per group (max/min)	# of insect Families	Too small to ID	% Avg Correct	% Correct Range (max/min)	Avg PTD	PTD Range (max/min)
Exp1: Guides (baseline)	11	8-52	9	14	50%	0 -100%	40%	7%-100%
Exp 2: Key ID Characteristics	5	6 -13	10	9	81%	66%-100%	11.1%	0%-22%
Exp 3: Reference Tray	4	41-75	17	1	89%	77%-100%	4.3%	0%-11%

Table 2: Results from baseline study and interventions for both **PTD (p< .25)** and **% Correct (p< .0025)**. “Too small to ID” and “# of insect families” are total amounts for each experiment, not total per group.



Graph 1: Percent Correct for all interventions and guide (baseline). p<.0025



Graph 2: Percent Taxonomical Difference for all interventions and guide (baseline). A low PTD value indicates higher accuracy. Line represents suggested max PTD. p<.25

The results show that both the Key ID and Reference Tray interventions drastically improve the accuracy of students’ identifications. Simply describing and showing students Key ID features to look for when identifying insects improved their identifications from a baseline of 50% correct to 81% correct and the PTD from 40% to 18%. With live insects as a visual reference, students further improved their accuracy rates from 81% Correct to 89% Correct and 11.1% PTD to 4.3% PTD. More importantly, both interventions result in data that meet and exceed the standards proposed by Stribling et al (2003).

Discussion

This study demonstrates that under certain field conditions and with appropriate instruction, students and volunteers can identify aquatic insects relatively accurately. The increase in identifications accuracy is likely attributed to two factors:

1. Learning to recognize key features to look for when identifying insects provides students with the same skills and knowledge that professional taxonomists rely on to distinguish different families of insects.
2. Students easily match their specimen to the reference insect when they have a live insect for reference.

In fact, highly accurate insect identifications may be achieved with very little instruction by simply pre-collecting reference insects to be used by volunteers and students during their biomonitoring study. This approach will not only result in higher quality biomonitoring data, but also smooth the rather complicated process of collecting and identifying insects.

While the results of this study seem to support the claim that students and volunteers can identify insects at a level accurate for use by professional scientists, there are several limitations worth considering.

The data used for this research is derived from non-randomized samples that get smaller as the study proceeds. This is due to the fact that Experiment 1 took place in the field with small groups, Experiment 2 was conducted in the classroom with larger groups, and Experiment 3 took place on an optional field trip. This suggests the results could be due to group size or self-selection for the field trip. In all experiments, however, there were students that missed an earlier experiment and thus had very little familiarity with insect identification, thereby partially mitigating the effect of experience on identification accuracy. Also, this study focuses only on identification accuracy, not how accurately students can conduct biomonitoring research, which is heavily dependent on randomization of site selection and subsampling procedures.

Another important consideration is the fact that Experiments 2 and 3 do not reflect best practices for teaching how to identify insects. It is well known that trial and error is an effective strategy for teaching and learning. Because this project simply gives students the information needed to identify insects, it does not provide a framework for students to build identification skills through trial and error. So for example, it would not be a good idea to use the strategies presented here to train teachers or volunteer coordinators to identify insects. However, if the goal is to ensure accurate field identifications in a limited educational setting, then both interventions (Key ID characteristics and reference insects) are an effective practice for facilitating a volunteer or education based biomonitoring study.

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