2-2017

Teaching Morphological Species Identification to Forensic Science Students: Advantages, Problems and Results

Gregory Nigoghosian
Purdue University

Lauren Weidner
Purdue University

Ludmila Nunes
Purdue University

Trevor Stamper
Purdue University, stampert@purdue.edu

Teaching Morphological Species Identification to Forensic Science Students: Advantages, Problems and Results

Gregory Nigoghosian[1], Lauren Weidner[1], Ludmila Nunes[2] and Trevor Stamper[1]
1) Purdue University, Department of Entomology, West Lafayette, IN 47906
2) Purdue University, Department of Psychological Sciences, West Lafayette, IN 47906

Abstract & Background

Following this presentation attendees will have a better understanding of instructing students in morphological species identification through the use of dichotomous keys. A dichotomous key guides the user through species determination for a specimen by providing a series of dual-choice nodes that center around morphological differences. Each choice leads to either a new set of dichotomous choices or a species decision. Attendees will also observe the ability of students to successfully apply this method to unknown entomological specimens. Of central focus to training students in species identification is the idea that dichotomous key nodal decisions take the user down specific pathways to a final species designation by not focusing on the organism whole, but rather specific parts that the alpha taxonomist has designated as important diagnostically. Thus, if followed correctly, the user should arrive at the correct species designation as long as the species evaluated are included in the dichotomous key.

This presentation will impact the forensic community by providing an understanding on how accurately students can identify adult blow flies (Diptera: Calliphoridae) using a dichotomous key. Insects present at crime scenes need to be successfully and accurately identified to aid in these investigations by providing information such as time of colonization (TOC), which can be linked back to a time since death. Species identification using a morphological dichotomous key cognitively falls under pattern recognition, which is part of the perception and problem solving aspect of cognitive science. The critical difference between other forms of pattern recognition and dichotomous keyed species identification is that the dichotomous key approach provides rigorous, step-by-step, pre-determined instructions to arrive at the pattern conclusion (a species). These patterns are grounded in an extensive scientific literature going back to the *Systema Naturae* by Carl Linnaeus in 1735 and currently outlined by the International Code of Zoological Nomenclature (ICZN code). If followed, this approach forces the user out of top-down processing mode and into a bottom-up processing mode, whereby the parts of the organism are first understood and from those partial understandings a full understanding of the species identity of the specimen is achieved. This bottom-up approach has a critical advantage—it eliminates the possibility of forming biases that result from top-down processing.

These data were evaluated from an introductory level forensic analysis course to understand the student's ability to utilize a dichotomous key. There were several opportunities for the students to record their nodal decisions along with their confidence level with the use of a tabular format. For each decision the student made, they ranked their confidence level using a Likert scale (1-5). Along with individual decision recording, they also conducted a post-decision comparison with their partner, following a think-pair-share active learning model. If their answers were not the same, they re-evaluated their decision making, along with a re-analysis of the specimen until a mutual evidence-based decision was reached. How successful the students were in making the correct identification was analyzed along with examining the correlation between confidence and correctness. From these data we aim to improve student training in the use of dichotomous keys for species identification, which can then be used to provide standard operating procedures for how forensic entomologists should approach and document the pattern recognition task at hand in a way that limits the influence of bias.

Methods

Subjects
- Subjects in this study were undergraduate students in ENTM 22820: Forensic Analysis
- 96 students participated during scheduled lab time

Specimens
- 15 sets of 8 specimens - 4 blow flies and 4 beetles (Figure 1)
- Blow fly specimens were sampled from the Stamper Lab collection
  - 5 different species of blowflies (*L. coeruleiviridis, L. illustris, L. sericata, P. regina* and *C. macellaria*) randomly labeled 1-4 or with Accession number
- Beetle specimens were sampled from the Stamper Lab collection and Lauren Weidner's personal collection
  - 8 different species of beetles (*N. tomentosus, O. rugulosum, O. noveboracense, N. orbicollis, N. americana, C. maxillosus*, Histerida and Dermestidae) randomly labeled 5-8 in the set or with Accession numbers

Figure 1

Procedure
- Working in pairs, students obtained specimen sets and microscopes
- Student #1 used dichotomous key (Cutter & Dahlem 2004) to identify the flies, while Student #2 used field guide (Castner et al. 1995) for beetles
- Once both had identified their specimens they would trade specimens and identify those for themselves
- After individual identifications, students shared results and made corrections to initial identifications if partners in disagreement

Nodal decisions
- Students started identifications at first node of the online key for Calliphoridae (Diptera) (Cutter & Dahlem 2004)
- At each node students would record observations and nodal decision (Figure 2)
- Process repeated until identification of specimen was achieved

Specimen Set Number: _____ Sample #: _____

Node	Decision Criteria	Decision	Confidence
			1 2 3 4 5
			1 2 3 4 5
			1 2 3 4 5
			1 2 3 4 5
			1 2 3 4 5
			1 2 3 4 5
			1 2 3 4 5

My Identification: _____ Partner's Identification: _____
Final Identification of sample: _____

Figure 2

Confidence
- At each node, the subjects also recorded confidence in decisions on a Likert scale from 1 through 5 (1 strongly doubtful – 5 strongly confident)

Statistics
- Data were analyzed using Paired Samples T-tests and Independent Samples T-tests where appropriate
- Data were considered significant when $p < 0.05$

Results

Following are the results for a sample size of 82:

- Significant difference between the Initial Identifications of Flies and Beetles (Paired T-test: p=<0.001)
- Significant difference between the Final identifications of Flies and Beetles (Paired T-test: p=<0.001)
- No significance was found with the Fly Initial and Final Identifications (Paired T-test: p= 0.117) or the Beetle Initial and Final Identifications (Paired T-test: p= 0.287)
- No significant differences between males and females identification or either flies or beetles ($p > 0.05$)

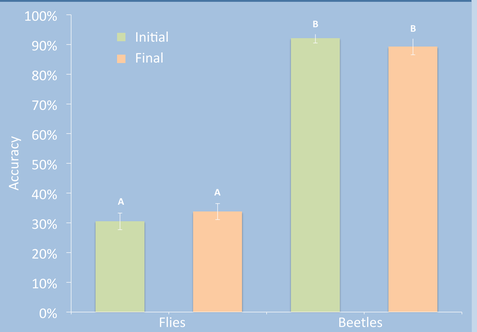


Figure 3: Percentage of students who correctly identified specimens initially and after partner consultation (Final).

Figure 4: Percentage of males and females that changed answers from correct to incorrect.

The sample was split into 53 females and 29 males:

- No significant differences between males and females changing answers from correct to incorrect
- Independent T-tests:
  - Female vs. Male change from correct to incorrect Fly Identifications: p = 0.687
  - Female vs. Male change from correct to incorrect Beetle Identifications: p = 0.736

Results (Cont.)

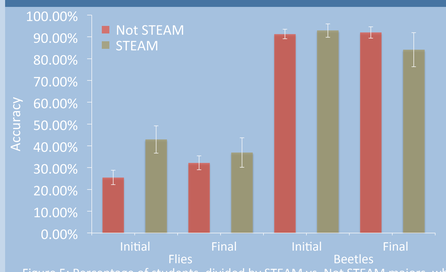


Figure 5: Percentage of students, divided by STEAM vs. Not STEAM majors, who correctly identified specimens

Of 82 students, there were 21 STEAM and 52 Non STEAM, and 9 undecided (Not Used):

- Significance was found only in the difference between STEAM and Non STEAM Initial Identifications of Flies (Independent T-test: p=0.01)
- No significant differences between STEAM and Non STEAM majors for subsequent identifications

Confidence data comparing male vs. female students and students in STEAM vs. Non STEAM majors:

- No significant difference observed between males and females in confidence ($p > 0.05$)
- No significant difference observed between students in STEAM vs. Non STEAM majors ($p > 0.05$)
- Overall student s had high confidence scores, even though accuracy was not high for fly identification.

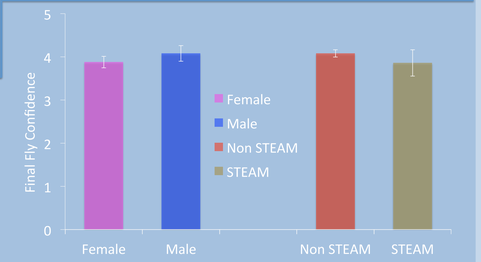


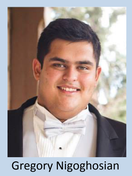
Figure 6: Student confidence in their final identification decision separated by sex and major.

Discussion

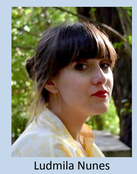
- Students were more successful at using the single photo pictorial guide booklet (Castner et al. 1995) to identify beetles, rather than the dichotomous key (Cutter & Dahlem 2004) to identify adult blow flies.
  - This is likely due to the identification of the selected beetles being easier.
  - The differences between a pictorial guide book and a dichotomous key would be better observed by using the family of insects for both.
- No significant difference found between males and females for accuracy or changing answers.
  - This should be revisited with larger and more evenly distributed sample sizes, to conclude that there is no difference between males and females in identifying specimens.
- STEAM students showed higher accuracy of initial identifications of flies, than non STEAM students.
  - This difference could stem from prior technical experience using keys in their field or from understanding scientific terms, such as dorsal or ventral.
  - Even though there was significance, this should also be re-evaluated with a larger sample size with similar numbers of STEAM vs. Non STEAM students.
- No significant difference observed in confidence between sexes , and majors.
  - Everyone rated confidence fairly high, which indicates overconfidence when compared to the low accuracy for fly identifications, a bottom-up cognitive approach.
  - Students also likely looking at wrong parts and features while thinking they were following the key.
- Control of sample size and demographic information was difficult because this study was done as part of a lab in a Forensic Analysis course that does not discriminate in enrollment.
  - Ensuring an evenly distributed number of students of different sexes and majors is unlikely.
  - Pooling samples across semesters will help with sample size.

Acknowledgements

Our work would not have been possible without the effort put forth by the ENTM 22820 Students from the Spring of 2016. We also wish to thank Emily Bonem from the Purdue University Center for Instructional Excellence for her work in helping us obtain the IRB approval for this study.


Gregory Nigoghosian


Lauren Weidner


Ludmila Nunes


Trevor Stamper

References

1. Castner, J. L., Byrd, J. H., & Butler, J. F. (1995). *Forensic insect field identification cards.* Colorado Springs, CO: Forensic Sciences Foundation.
2. Cutter, R. M., & Dahlem, G. (2004). *Identification key to the common forensically important adult flies (Diptera) of northern Kentucky.* Department of Biological Sciences, Northern Kentucky University, Highland Heights, KY.