The stats guy

C Kevin Geedey[1] and Jeffry L Dudycha[2]

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Jane and Carlos, two ecology professors at Enormous State University, are passing the line of graduate students waiting to see Kai, the statistician. "Ah, spring", says Jane, "when a young grad student's fancy turns to ANOVAs and Bonferroni corrections". Like many institutions, ESU's ecology program regularly advises students to consult with a statistician to help with experimental design and data interpretation. Of course, the students also have to take a couple of stats courses, but most admit that at the end of they still feel pretty shaky about statistics. As a result, nearly all of the students in ESU's ecology program rely on direct advice from Kai in designing their studies. Although most of the ecology faculty have some facility with statistics, Kai is recognized as the local statistics guru. His role in the department has evolved over time, from occasional consultant to a fixed part of the educational process. In fact, most graduate committees in the ecology program won't approve a student's research proposal without the coveted "Kai stamp of approval".

Jane and Carlos had often disagreed about the role Kai plays in graduate training at ESU. Jane was more critical. "I think our students rely on Kai for too much. If you can't understand enough statistics to interpret the data from your own experiments, then you probably don't deserve a PhD in ecology. Besides, we are setting a truly dangerous precedent for these students – that someone else can be held responsible for your results. Carlos, you were at that student seminar last week; he couldn't answer questions about his design beyond the basic level. He couldn't even begin to answer my question about why the factors in his analysis were fixed versus random. All he could say was that Kai told him how to interpret his output and what all the stats meant! Our students publish work whose fundamental statistical design they don't understand and can't defend. If we're going to train grad students, we have an obligation to train them to be scholars. What's more important than that, though, is that they need to understand that they must be able to defend every aspect of the research that they publish."

Carlos shrugged. "So, what are you proposing? Should students take 2 years of stats courses? How about 3 or 4 years, just to be sure they get it? Be reasonable. We're an ecology department, not a statistics department. Ecology has become complex, computationally and analytically. There's nothing wrong with a statistician becoming part of the research team. Every member of the group has a role to play. Part of the value of collaboration is that everyone can't be expert in everything. Our PhDs should understand the big picture, but I'm not too worried if they don't become statisticians in our program."

Q *What level of statistical sophistication should an ecology PhD candidate demonstrate?*

Q *What level should constitute a professional standard in ecology? Are professional standards ethical obligations?*

Q *Does an ecologist have an obligation to understand every statistical detail of his/her work, collaborative or otherwise? If so, at what point in the development from student to professional does that obligation take hold?*

Q *Does a statistics consultant have different obligations when working with students than when working with professionals? Why, or why not?*

[1]*Dept of Biology, Augustana College, Rock Island, IL (bigeedey@augustana.edu);* [2]*Dept of Biology, Indiana University, Bloomington, IN (jdudycha@bio.indiana.edu)*

Commentary on "The stats guy"

Ecology has become more and more analytically complex. Part of that complexity has come from the recognition that we must apply rigorous statistical standards to our data. Jane and Carlos disagree about the degree to which doctoral students need to master statistics, and about what role a statistical consultant ought to play in their program.

Just how much should an ecologist know about statistics? The National Academy of Science attributes instances of scientific misconduct and fraud in part to "the increasing scale and complexity of the research environment, leading to the erosion of peer review, mentorship, and educational processes in science" (NAS 1992). Students must have the tools they need to recognize fraudulent and/or incompetent use of scientific methodology, including statistics. Because today's student becomes tomorrow's reviewer and editor, students need to be able to recognize sloppy, incompetent, or possibly fraudulent work. This requires that they understand far more than just the "bottom line" *P*-value on an output sheet. Students must be able to discuss the applicability of various models and tests, and their assumptions. To the extent that students in a given graduate program do not meet this standard, that program is failing in its obligation to both its students and the field of ecology by not turning out capable researchers.

This need for statistical understanding must, however, be balanced by the huge time demand involved in mastering ecology. Jane says that students need to develop the ability to defend every aspect of the research they publish. However, very few of us can speak to models and assumptions at the same level as a professional statistician. It does not seem unreasonable to seek expert advice in cases involving complex statistical inference. In this respect, a statistician seems no different than any other specialist with whom an ecologist might collaborate, such as a molecular biologist or taxonomist. Meaningful cross-disciplinary work becomes impossible if you have to become an expert in every aspect of your collaborators' subjects in order to publish with them.

However, since statistics is a universal tool in ecology, the statistician as collaborator/consultant is a special case. Suppose that Kai is an omniscient statistics oracle. When we ask him a question, he is able to draw upon his knowledge of all possible analyses in making a recommendation. Even in this extreme case, we all ought to be able to defend our work. At the very least, this means understanding the assumptions of particular analyses, as well as being able to defend the choice of one particular method over reasonable alternatives. We might never even have heard of this test prior to Kai's recommendation, and we may not master its every computational detail, but once we have a recommendation in hand, we are obligated to learn enough to defend its use.

There is also a pedagogical issue here. Carlos wonders just how many stats classes Jane thinks are needed. Are more classes really the answer? Students need to achieve professional competency in statistics – but when? How should Kai function here in his role as a professor, distinct from his role as a consultant among professionals? Learning is an inherently developmental process. It is unreasonable to require (or expect) students to become statistically competent after one or two classes. They will need repeated opportunities to practice and apply what they have learned in the classroom. Carlos argues that Kai is just another part of the research team, but this ignores the fact that Kai is working with students, not established professionals. To the extent that the statistics consultant simply provides answers for students on demand, and Jane's account of the student seminar suggests this may be the case, he may actually be a real impediment to student learning and mastery of statistics.

If a statistics consultant is to be part of a graduate program, that consultant must learn to engage students in productive mentoring sessions about statistics – saying, for example, "Why don't you take a crack at designing that experiment, and I'll sit down and go over it with you next week?" Or, "What do you think this output means? Tell me what you think that interaction term means, and then I'll tell you my interpretation." If students see Kai as a professor who will challenge and guide them, this maximizes their chances of achieving professional competency by the time they defend their dissertation.

There is a serious drawback to having the statistics expert nudge students along the path to competency: it takes time. It is much easier simply to tell students what to do than it is to teach them. Perhaps Kai should be given some time off from his other teaching duties, if he really takes his de facto role as statistics mentor seriously. Of course, this is Jane and Carlos' job as much as it is Kai's. Perhaps the department needs to consider implementing a set of standards of increasingly sophisticated statistics knowledge a student should be able to display at their qualifying exams, proposal defense, and dissertation defense.

Carlos and Jane have some serious work ahead of them. If they agree that graduating doctoral students are not achieving professional competency in statistics, then they have a duty to try to remedy this situation. As Carlos implies, however, requiring more stats classes may not be the best answer. Perhaps it is time for a chat with "the stats guy", as well as with the rest of the department, to determine the best way ESU's students can become competent professionals.

References

National Academy Panel on Scientific Responsibility and the Conduct of Research. 1992. Responsible science: ensuring the integrity of the research process. Washington, DC: National Academy Press.

This is the sixth in our Ethical Issues series. For the introduction, please see the August issue (2003; **7**: 330–33).