Pest-Centric versus Process-Centric Research Approaches in Agricultural Entomology

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In this essay, we contrast two research approaches used by agricultural entomologists. The first approach, which we call "pest-centric," focuses on a particular problem generated by a particular pest, and often associated with a particular crop in a particular location. The second approach, which we call "process-centric," tries to identify the more general processes underlying a problem. We have divided the essay into three parts.

First, we argue that the pest-centric approach plays a dominant role in our discipline. We attempt to support this view by reviewing papers published in two leading agricultural entomology journals published by the Entomological Society of America: the *Journal of Economic Entomology* and *Environmental Entomology*.

Second, we argue that the pest-centric approach promotes a narrower flow of information within the research community, researchers rely more heavily on work previously conducted with the same pest species that they themselves are studying, whereas the process-centric approach promotes a broader sharing of insights across different systems. We attempt to support this view by examining patterns of literature citation for papers published in the *Journal of Economic Entomology* and *Environmental Entomology*.

In the third part of the essay, we propose that the science of agricultural entomology can be advanced more efficiently by embracing the process-centric approach. Because we lack an objective means of measuring how much problem-solving a piece of research accomplishes, we offer only verbal arguments to support this proposal. We hope that this essay will stimulate work that can rigorously evaluate how key problems in agricultural entomology are solved.

We need to make two clarifications at the outset. First, we are not arguing for a shift from more "applied" to more "basic" research. Although we think that a process-centric approach will allow mission-oriented research to make larger contributions to our understanding of biology, we argue the merits of our proposal on the basis of its ability to improve problem-solving in entomology. Second, we hope that our essay is provocative enough to open a discussion in the entomological community, but not so provocative as to be offensive to our colleagues.

Pest-Centric versus Process-Centric Research

Agricultural entomology research is rightly motivated by the problems that insects generate. Almost all empirical research in agricultural entomology involves two elements: a problem process that the research is trying to characterize or solve, and a setting in which the problem process is expressed, which generally involves a particular insect pest species, a particular crop plant, and often a particular geographical region where their interaction occurs. Neither of these elements can be omitted. The question is: which of these two elements should have priority?

The traditional approach in agricultural entomology has been to give the pest the preeminent role as the driver of our science. So, for example, some years ago, one of us (JAR) was the first author of a paper in the *Journal of Economic Entomology* (83:1519-1525,1990) that began as follows:

> Melon thrips *Thrips palmi* Karny has recently expanded its range from its native Malaysian–Indonesian region to include an area from Pakistan in the east to Hawaii in the west.... *T. palmi* has become a severe pest of many commercially cultivated plants...

The first paragraph of this paper describes the pest status of this invasive herbivore, establishing the particular pest as the preeminent focus of the research. Only in the second paragraph did the authors describe the more general problem process that the research addressed. They explained that *T. palmi* and another long-established thrips pest *Frankliniella occidentalis,* often co-occur on cucumber, and it was not easy to know which herbivore was responsible for one type of observed damage (scarring of fruit). By placing the process-oriented question in the second paragraph, its importance was subordinated to that of the pest.

The alternative approach, of course, would have been to start the paper something like this:

> Crops are often attacked by complexes of herbivores, and in some cases it may not be readily apparent which consumer is responsible for observed damage. Developing a clear mapping from herbivore species to realized crop damage is crucial, however, to developing an integrated pest management program.

Had the authors introduced the paper in this way, they would have identified the process-oriented question as the primary focus of the work.

The Pest-Centric Approach Dominates the Agricultural Entomology Literature

We sampled the *Journal of Economic Entomology* and *Environmental Entomology* to quantify the fraction of papers that open with a focus on a particular pest. To do this, we read the first two sentences of each paper and categorized the paper as pest-centric if the focal pest species was introduced there. Papers dealing with pollinators were excluded, and all other papers were categorized by default as process-centric. This is a conservative approach. Even a casual glance at these journals shows that this rule of thumb underestimates the pest-centric nature of our discipline. For example, our rule of thumb

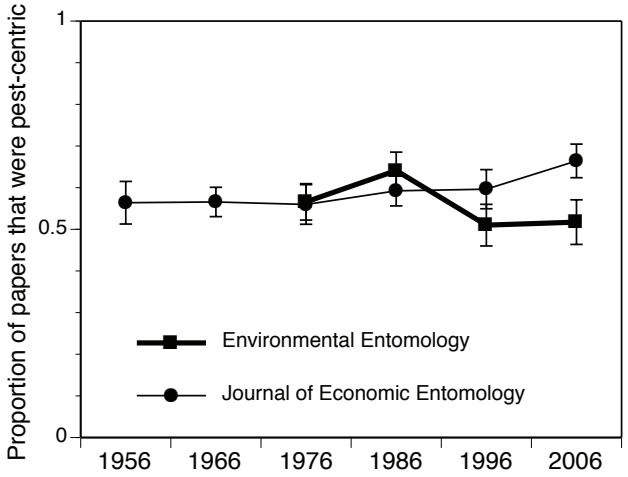

Fig. 1. Proportion of all articles published in *Environmental Entomology* (1976–2006) and the *Journal of Economic Entomology* (1956–2006) that adopted a pest-centric approach, as defined by the focal pest species being named within the first two sentences of the article. All articles in issues 1, 3, and 5 of volumes published in 2006 and at 10-year intervals back to 1956 were scored. Shown are mean ± 1 SE (SE calculated assuming a binomial distribution). Mean sample size for each data point was 126 papers (range, 87–198).

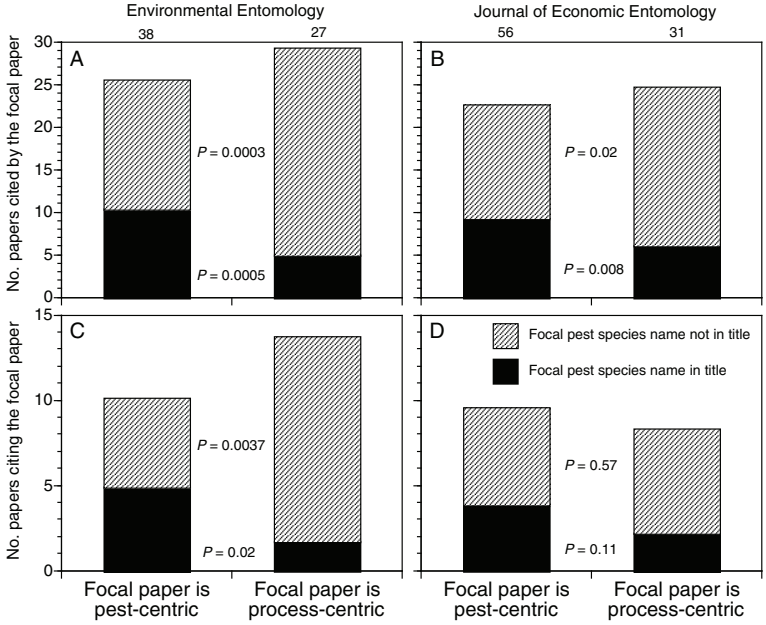

Fig. 2. Citation analysis for papers published in *Environmental Entomology* and the *Journal of Economic Entomology* that used a pest-centric versus a process-centric approach. Panels A, B: The mean number of articles found in the References Cited section of the focal paper that included (or did not include) in their title the name of the same pest species that was studied in the focal paper. Panels C, D: The mean number of subsequently published articles that cited the focal paper and that included (or did not include) in their title the name of the same pest species that was studied in the focal paper. *P*-values report pairwise contrasts between pest-centric and process-centric papers. Sample sizes are indicated at the top of the figure.

categorized 66.4% of all papers published in the *Journal of Economic Entomology* in 2006 as pest-centric, but a more careful reading identified 81.0% of these papers as pest-centric. Most of the re-categorized papers opened by introducing the pest, but used a genus or family name, rather than a full species name.

Our survey shows that most papers published in the *Journal of Economic Entomology* and in *Environmental Entomology* adopted a pest-centric approach and that there has been little change over the past 50 years (Fig. 1). The pest-centric approach has deep roots in our discipline and continues to be the dominant approach.

Pest-Centric Papers Cite a Narrower Literature and Are Cited by a Narrower Literature

Does the order in which the pest species and the process-oriented question are introduced in a paper really matter? If both are necessary components of experimental research, why pay attention to their sequence of introduction? We suggest that the introduction of the pest species at the outset of a paper narrows the researcher's mindset and reduces the likelihood that useful insights will be borrowed from other systems in which the same problem process has been studied. We also argue that by introducing the pest species first, the pool of researchers for whom the research will be relevant is similarly narrowed because the research may not be designed to advance the understanding of the general processes and because the researcher flags readers that the manuscript will only be relevant to those working on the same pest.

In contrast, we suggest that the simple expedient of opening a paper with an explanation of the process to be studied (and, even more importantly, adopting the process-centric approach at the outset of the research project) generates a cascade of constructive events. For example, awareness of the relationship of the current research to previous work is heightened, and there is a sharper motivation to go beyond previous knowledge to advance our science.

To evaluate these ideas, we analyzed which earlier published papers were cited by the focal study, and which papers published later cited the study. We asked how the dichotomy between pest-centric papers and process-centric papers influences the flow of scientific insight from past work to the focal study, and from the focal study to future studies. Our underlying assumption is that narrowing the focus in either temporal direction is counterproductive. It represents movement away from the synergy of collaborative efforts made by a broad community of researchers and toward a more highly fragmented literature. We reason that solutions to pest problems may be borrowed from researchers working on the same or similar problem process in a different setting. Thus, we posit that every pest problem is not unique; at least some aspects of the problem can be generalized, and the generalized aspects of the problem need not be solved from scratch in every setting (i.e., reinventing the wheel).

As a crude but objective metric of the breadth of literature cited in our focal paper, and the breadth of literature in which our paper is subsequently cited, we asked whether or not the name of the pest species (either the scientific name or the common name) that was studied in the focal paper was present in the title of the cited or citing papers.

To complete this "citation analysis," we looked at the articles in issues 1, 3, and 5 of the 1996 volumes of *Environmental Entomology* and the *Journal of Economic Entomology* that reported on a single pest species. We then looked at the references cited in those articles. If the references were heavily populated with papers that had the same focal pest species in the title, we deemed those articles to be narrow in their use of prior work. If cited references were written primarily by authors whose papers included the same pest species name in the title, we deemed the work to have influenced a narrow segment of the researcher community. We used the Web of Science (http://scientific.thomson.com/products/wos) to identify articles that cited our focal articles from the time of the publication in 1996 through

August of 2007.

We found that pest-centric and process-centric papers did not differ significantly in either the total number of cited publications or in the total number of citations they received ($P > 0.10$ in all cases; Fig. 2). Authors of process-centric papers, however, cited a broader range of literature: more papers were cited that did not name the focal pest species in the title, and fewer papers were cited that did name the focal pest species in the title. Process-centric papers were associated with utility to a more diverse community of scientists. Process-centric papers were cited more often by authors of papers whose titles did not include the focal pest's species name, and they were cited less often by authors of papers whose titles did include the focal pest's species name (Fig. 2). These trends were consistent for papers published in *Environmental Entomology* and the *Journal of Economic Entomology*; however, trends in citations received were not statistically significant for manuscripts published in *Journal of Economic Entomology*.

Because these are correlative rather than experimental results, we must be cautious in drawing inferences. In particular, there are two non-mutually exclusive explanations for the differences shown in Fig. 2. First, it may be that by beginning a paper with a focus on a particular pest, researchers are influenced in a way that narrows their use of previous research and narrows the pool of future researchers who will use their results. Or, second, it may be that some studies are fundamentally narrow in their scope, addressing questions of relevance only to the focal pest on a particular crop. Other studies are fundamentally of broader potential importance to other researchers. In this case, there would be no way to move a study from a pest-centric to a process-centric approach.

Both of these interpretations probably are partially correct. However, we suggest that a large fraction of studies that begin with a narrow, pest-centric approach could be transformed into studies of broader significance if the researchers were to adopt a process-oriented mindset from the beginning (it may be too late by the time the manuscript is written). In many cases, what is needed is simply an inquisitive mind and a receptivity to broader research opportunities that are presented by most empirical investigations.

To make these ideas more tangible, let us return to the example of the two thrips species feeding on cucumber. This study cited 22 papers, of which 9 (41%) also focused on the pest *T. palmi*. Perhaps it is most striking that not a single reference was made to any other study that addressed the same problem process. No attempt was made to capitalize on the body of research that focuses on how to separate damage generated by a complex of pests into component contributions made by individual species.

We submit that this failure to learn from previous researchers would have been almost inconceivable had a process-centric approach been adopted. In the 17 years since this article was published, it has been cited 29 times. Only 4 of those citations were in other papers on *T. palmi*; 25 of the 29 (86%) citations were in papers reporting on either *T. palmi* or *F. occidentalis*, the second thrips pest in the original article. Either the article failed to generate insights useful to someone who was not studying the same thrips species, or if there were useful insights, they were largely unrecognized.

As the first author of this paper, JAR can say with confidence that nothing prevented the authors from adopting a more process-oriented approach in conducting the original study or in writing the paper. And yet, this article is a clear example of why it is important to look at a variety of study systems as sources of key advances that can be borrowed in the current work.

Researchers studying the impact of multiple plant exploiters on a shared host plant have demonstrated the advantages of a factorial experimental design, in which the effect of each herbivore on the host plant is assessed singly and in combination. Such designs produce strong inferences about the damage generated by each species and the potential interacting effects on plant performance. The narrow literature on *T. palmi* did not include studies using this design. Instead of using this approach in Hawaii, we relied on a series of correlative analyses in an attempt to disentangle the effects of the two herbivores; our methods produced defensible but less definitive results. Whereas a correlative approach can be a useful complement to a manipulative experiment, it is less sound as a stand-alone approach. This study demonstrates how important it can be to build mission-oriented research based on a broad platform of previous work, including work conducted with the same focal pest species as well as work with other systems in which the same problem process has been examined.

A Proposal to Move toward a Process-Centric Approach

We think there are three reasons that an enhanced use of a process-centric approach could accelerate progress in our discipline. First, a modest number of processes underlie most pest problems, and we have a realistic hope of developing a significant understanding of these processes, whereas a much larger number (thousands) of pest species/crop/location settings creates a challenge that may be too vast to master. Although research on the specifics of a particular applied setting is always needed to craft implementable solutions, the research will be much simpler if the underlying processes are well understood.

Second, as we have argued, we think the process-centric approach enhances the flow of information within the scientific community and brings the collective efforts of researchers to bear on shared problems.

Third, and perhaps most importantly, by adopting a process-centric approach, scientists are challenged to conduct their research in such a way that they can solve the problem at hand and push forward the frontiers of our applied science. In this way, a contribution can be made to solving a whole class of similar problems in the future.

Adopting a process-centric approach is not always feasible or appropriate. In some cases, additional resources are needed to allow a research project to go beyond the confines of a particular pest setting and advance our understanding of the underlying processes. These extra resources may not be available. Pest problems may be so urgent that a single-minded focus on the problem is of the utmost importance. In some cases, funding agencies with short-term and narrowly focused research needs (e.g., commodity boards) may demand tightly focused proposals and be less interested in supporting research that can make broader contributions. Our sense, however, is that in most cases, short-term, problem-oriented research is not incompatible with research that can simultaneously make broader contributions. We believe that a changing mindset is the key to enhancing the efficiency with which agricultural entomologists solve problems in the ongoing struggle with insect pests.

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