

Poster 35: ‘Nothing Kills Insects’, or How Public and Farmer Perceptions Affect Success Rates of Biological Control

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Though regularly overlooked, social science is of paramount importance to the practice of biological control. On the one hand, cultural trends have major influences on local, national and global adoption rates of certain technologies or practices, and public perceptions are not always favorable towards biological control practices. On the other hand, knowledge, attitudes and beliefs of farmers themselves greatly influence field-level adoption rates and subsequent diffusion of biocontrol technologies. In this study, we conduct a critical analysis of the extent to which ‘social science’ aspects have been taken into account in biological control research worldwide, and have a closer look at (historic trends in) public and farmer attitudes towards particular biological control technologies and approaches.

First, we conducted a retrospective analysis of the degree to which social science facets have been incorporated into biological control research over the past 25 years. We ran an ISI Web of Knowledge search for insect biological control studies that deliberately took into account social science aspects. Covering nearly 12,000 journals, our search was restricted to papers that were published over the time period 1990-2016. Within the resulting literature base of 11,732 manuscripts, a total of 161 studies (or 1.4%) were found in which reference was made to farmers, stakeholders or the general public. Even fewer papers (i.e., a total of 28) covered aspects such as knowledge transfer and technology diffusion. As little as four publications made reference to gender aspects, and no studies were found in which explicit emphasis was given to youth or young farmers.

Next, we made use of powerful text-mining tools and social-media analytics, to assess temporal and geographic trends in cultural visibility of the topic of ‘biological pest control’ and particular globally-important case studies. As systematic surveys of public perceptions and attitudes have rarely been conducted, we opted for the use of Google-based search engines to obtain quantitative metrics of global public interest in biological control. To investigate cultural trends quantitatively, we employed a new data collection and analysis technique, i.e. ‘culturomics’. Culturomics provides text-mining tools and social-media analytics to classify, quantify, and visualize cultural values on a range of topics. First, we used Google Ngram Viewer as an online search engine to look for coverage of different terms in sources printed between 1950 and 2008 (covering a corpus of >15 million digitized books). Next, we conducted time series analyses through Google Trends in online search data from 2004 to 2016 to investigate whether (a) public interests in ‘biological pest

control' has declined over time and (ii) online interest patterns for particular topics related to pest management differ between continents.

Google Ngrams depict how the search string 'biological control' was most frequently recorded in digitized books in 1993, after which it gradually dropped until 2001 and then steeply declined. On the other hand, interest in 'ecological safety' steadily built up from the early 1980s until 1997-98, and then dropped from 2002 onwards. For a select set of (classical) biological control cases, Google Ngrams show highly variable and shifting temporal patterns in cultural visibility over a 1950-2008 time window. As a positive note, successful biocontrol cases such as the cottony cushion scale x *Vedalia* beetle (1888) or the *Anagyrus lopezi* Desantis (Hymenoptera: Encyrtidae) x cassava mealybug biocontrol programs (mid-1980s) continue to be featured. The *Vedalia* beetle case continues to be celebrated, although its target pest nearly disappeared from California's citrus orchards, in similar ways as e.g., extinct North American birds. On the other hand, public interest in either success story has gradually dropped from 1974 and 1996 onward. Surprisingly, similar drops in cultural visibility were recorded after 1995, 1985 and 1996 for *Encarsia formosa* Gahan (Hymenoptera: Aphelinidae), *Phytoseiulus persimilis* Athias-Henriot (Megostigmata: Phytoseiidae) or *Trichogramma* spp. (Hymenoptera: Trichogrammatidae); flag-bearers for augmentation biological control that continue to be used extensively in greenhouse and open-field cultivation. Lastly, the rare cases in which introduced agents caused un-intended ecological side-effects (e.g., cane toad, *Harmonia axyridis* (Pallas) (Coleoptera: Coccinellidae) currently receive comparatively high, if not escalating, cultural visibility. Hence, at least up till 2008, cultural saliency of the world's reliable, effective natural enemies was dramatically lower than that of the handful of cases where (classical) biological control failed.

Next, Google Trends analyses were run for several topics related to crop protection and invasive species management. Google Trends is regularly used to track levels of public interest and awareness at a global or country-specific level. We assessed trends in Google search volume for the topic 'biological pest control' over a 2004–2016 time frame, recording proportionate traffic to the search volume of all keywords submitted in Google, scaled on a range of 0 to 100. We corrected for this shifting baseline in Google search data by dividing search volume for 'biological pest control' by that of benchmark keywords "computer" and "life". Seasonal Mann-Kendall tests were performed on corrected search data, using package Kendall in R. When using "life" as the benchmark, a statistically significant downward trend was found ($\tau = -0.317$, $p < 0.001$). Also, when examining country-specific patterns, 'biological pest control' represents a substantial part of Google search volume in countries such as Costa Rica, Colombia, New Zealand or Algeria.

Internet search analysis thus provided a powerful, systematic and data-driven means to gauge (online) public interest in biological control. While 'biological control' clearly is not a "trendy" search-term and faces a stagnating or even downward trend in Google search volume and Ngram string frequency, similar patterns are reported for other environmental topics. Despite their drawbacks and limitations, culturomics could be used to strategically reposition biological control, e.g., by a) picking 'winners' for targeted communication campaigns, based upon the extent to which particular species resonate with the general public; b) assessing cultural impacts of specific invasive species, and eventual biocontrol interventions; and c) identifying geographies where biological control continues to have a soundboard with online communities and interest groups.

Aside from examining (online) public interest and the degree of attention that's been paid to 'social science' aspects in biological control publications, it is crucial to take into account the ultimate adopters and have a closer look at patterns in farmer knowledge.

Anthropologists and sociologists have realized, since the early 1990s, that the vast majority of farmers is largely unaware and un-informed about natural pest control. Even (smallholder) growers who maintain a close bond with nature were either entirely unaware of natural pest control, or expressed doubt about the actual value of these services on their farm. We examine a number of case studies in the developing-world tropics, covering farmer knowledge of weaver ants in Vietnamese citrus orchards, mealybug parasitoids in Asian cassava fields, and lepidopteran pests in Central American maize x bean systems. Overall, we conclude that local (smallholder) farmers have very limited understanding of the entomofauna in their fields, and only occasionally realize the beneficial role of resident parasitoids, predators or (even less) entomopathogens. With those farmers, the promotion of (knowledge-intensive) technologies such as biological control likely will be particularly challenging and if not impossible.

In conclusion, biological control has rapidly lost cultural saliency and biological control failures have come to receive disproportionately high public attention since the early 2000s. Sustained (online) public interest though does exist in multiple vestiges around the world, particularly in the developing world. Though a number of high-profile biological control programs are underway (e.g., cassava mealybug biocontrol in Asia; biocontrol of parasitic flies on Darwin's finches), these so far receive relatively minor attention. Also, after decades of promoting IPM and biocontrol across the developing world, we realize that the bulk of (resource-poor, illiterate) smallholders simply has no understanding of beneficial organisms within their fields (or, for that matter, of ways to enhance their abundance or efficacy). Now more than ever, biological control is at a crossroads and cross-disciplinary science is promptly needed to help bolster adoption rates, counter-act surging insecticide use, and restore public trust in one of nature's prime services.