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Perspective

Toward functional pollinator abundance and diversity: Comparing policy response for neonicotinoid use to demonstrate a need for cautious and well-planned policy

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ABSTRACT

Functional pollinator abundance and diversity reflects global ecosystem health. Declines imply consequences for ecosystems, food production and human health. While broader objectives away from monoculture conventional agriculture is not addressed smaller scale approaches for land management require analysis to improve pollinator conservation outcomes. Policy response to neonicotinoid use can provide valuable lessons for developing well-informed, cautious and planned policy that encourages pollinator abundance and diversity. Response is inconsistent around the world with harm considered scientifically inconclusive by companies, governments and policy makers, and varied responses reflecting this position. Bans demonstrate how strong precautionary policy can assist pollination conservation despite a multitude of contrasting stakeholder opinions. Approach to implementation of such bans influences longevity and influence on conservation.

This article presents findings from analysis of policy response by country to neonicotinoid use and suggests that variation in response be attributed to three non-exclusive areas; translation of research findings – influencing how inconclusive research findings could increase motivation for strong precaution, vested interest and approach to implementation. Scholarly articles and research findings clarifying information available to inform policy decisions are summarised through literature review, organised by key theme of article and additionally-mentioned themes. Meta-analysis of the scholarly articles provides statistical representation of mention rates indicative of how pollinator research is considering multiple stressors, associated or concurrent as contributing to declines. The policy process for neonicotinoid use is suggested as a space for learning where other conservation approaches, including introducing new species becomes relevant for policy.

1. Introduction

Pollinator population declines reflect global ecosystem health and can affect human health (Chivian and Bernstein, 2002; Janjua et al., 2009; Jones et al., 2008; McMichael et al., 2008; Subramanian, 2012; Walker et al., 2013; You et al., 2015). Declines in numbers and diversity of pollinators positively associates with yield and quality of key food crops (Aizen and Harder, 2009; Bartomeus et al., 2014; Champetier et al., 2015; Gallai et al., 2009; Lautenbach et al., 2012) and motivates policy response around the world. The focus for associated research demonstrates an evolving understanding of the cause of declines. Honeybee colony decline and crop pollination service (Lundin et al., 2015) dominate studies and their discussion due to associated risks to food production. While honeybees contribute significantly to food crop pollination, crop production value from managed honeybees and wild bee species is similar (Garibaldi et al., 2013; Greenleaf and Kremen, 2006; Kleijn et al., 2015). However only a few species of pollinators have a direct and easily recognised economic value for pollination service. Conserving or restoring pollinator diversity and abundance does not align with prioritisation of pollinator dependent crops (Lautenbach et al., 2012; Potts et al., 2010; Senapathi et al., 2015) or with conventional, monoculture high-external-input agricultural land use.

Between 78% of flowering plant species in temperate and 94% in tropical regions depend on animal pollinators (Ollerton et al., 2011). Pollinators include 25,000 bee species (Abrol, 2012), butterflies, insects and birds. A two-year global assessment estimates that 16.5% of vertebrate pollinators are threatened with extinction globally and 40% of invertebrate pollinator species particularly bees and butterflies are facing extinction (IPBES, 2016). Within agricultural landscapes pollinator diversity and abundance is higher in diversified and organic fields and landscapes of high quality habitat (Carvalheiro et al., 2013; Kennedy et al., 2013; Vinod and Sattagi, 2016), a contrast to conventional monoculture farming and associated maintenance practices (Kleijn

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et al., 2015; Kremen et al., 2002; Maxim and van der Sluijs, 2013; Andersson, 2014). Definitions of organic farming and agriculture vary. Reference is made to organic to indicate reduced synthetic inputs. Replacement inputs where necessary would have to reduce negative impact, biodiversity within agricultural areas as integrated management can assist. This is in comparison to monoculture and intense input agricultural land use. The process of becoming organic is therefore indicative of a knowledge set for agricultural practices which complements reduced reliance on potentially harmful synthetics. It may also reduce reliance on external-inputs particularly where diversified fields to assist with management are part of the process (Liebman and Davis, 2000).

The precautionary principle ceases activity of a practice that is certainly or inconclusively damaging to anticipate and prevent harm, rather than seek a cure post-damage. This means that practices demonstrating a hint of a risk would by strong precaution cease. Compromised pollinator conservation reveals a complex area of cause and effect, with far reaching implications for ecosystem and human health (Cimino et al., 2016; Kimura-Kuroda et al., 2012; Wu et al., 2009). Neonicotinoid use is a specific agricultural practice which may negatively influence pollinator populations, scientific research is considered inconclusive by some (LeBuhn et al., 2013; Muli et al., 2014; Roubik, 2001) and use of the precautionary principle in policy and practice is therefore relevant. The degree to which it is engaged varies. The EU set a regional precedent by banning the three most lethal neonicotinoid containing insecticides in 2013. The ban is under review and due to conclude in 2017. These bans directly address a threat to crop pollination service and may indirectly promote pollinator abundance and diversity. They demonstrate that precautionary policy is possible for pollinator conservation even where multiple contrasting stakeholder interests exist.

This strong precautionary response for neonicotinoid use was not at a global scale and as such multiple policies for neonicotinoid use are reviewed against emerging research findings which discuss cause, status and ideas of uniformity in pollinator declines. There is still much research to complete to better define specific threats to pollinator abundance and diversity. Meta-analysis provides examples of areas for increased attention. Divergence from precautionary policy response is explained within three non-exclusive areas (1) vested interest (2) translation of research findings on three levels: interpreting data from empirical studies for risk assessments and management solutions; misrepresentation of findings or how findings are perceived by non-scientist stakeholders and (3) approach to implementation. Within ideas of a need for precaution, the introduction of species as a technique to address declining populations is compared to neonicotinoid use in terms of research available and potential areas for future policy response.

2. Materials and methods

2.1. Literature selection criteria

Selected literature facilitates an overview of existing policy process, institutional arrangements and action plans for pollinator management and protection internationally, alongside peer-reviewed scientific research. Criteria for identifying sources were guided by an ability to compare policy and stakeholder reaction with scholarly and scientific research. Preference for this comparison was given to those articles that consider policy and management implications for pollinators, the interconnected nature of cause and plant-pollinator mutualisms. Policy response to use of neonicotinoids is selected as a centralising theme, with introduction of species and commercial breeding identified as an area for future policy considerations. Information sources that present stakeholder perspective and variance in research findings guided selection criteria. Search engines included university library search for journal articles and books; ProQuest and JSTOR; google scholar, and government department, non-governmental organisation, farmer and environmental group websites and documents. Computerised searches involved multiple combinations of terms including neonicotinoids, pollinator population decline, pollinator health and neonicotinoid use, interconnecting influencing factors for pollinator population decline, pollinator abundance and diversity, ecosystem health and pollinators, conventional versus organic agriculture; threats to pollinators. Documents reviewed include official government documents from each country or region; political commentary including political quotes and statements, non-governmental, farmer and environmental group commentary and studies, and corporate/commercial documents. Such documents evidence the numerous perspectives and stakeholders involved in policy reform.

The words used for searches were selected to reflect a process someone with minimal or medium level knowledge of the topic and limited time may engage in to find relevant information. Broader criteria included peer reviewed information sources that discuss pollinator declines, pollinator-plant communities and mutualisms, multiple species and impacts of neonicotinoid use from the last 30 years. The year range of all peer reviewed articles is 1987–2016 ($N = 76$). Proportions are uneven for this reason, particularly for pollinator epidemiology, 9% of all articles. It was a topic found commonly within literature but not often as a central consideration. Search criteria didn't require such articles. An additional article search was carried out using more specific words including *Nosema* and neonicotinoid exposure; pollinator immune system strength and stressors; interaction between wild and commercial pollinator species; varying approaches to determine lethal exposure to neonicotinoids; biodiversity and pollinator abundance and diversity; agricultural landscapes and pollinator abundance and diversity. This additional search was used to develop discussion and demonstrate existing research of high quality which may not be easily found.

2.2. Meta-analysis

Meta policy analysis of pollinator policy for neonicotinoid use, and systematic and contextual policy process analysis across three regions was carried out. Contextual factors identified as most relevant for such policy processes include (1) translation of research findings (2) vested interest and (3) approach to implementation. In total 100 information sources were reviewed; 76 peer reviewed journal articles and 6 books demonstrating variance in research findings; 18 website documents providing government positions, policies and statement, legislative acts, corporate statements. Information sources include scientific, national, regional and departmental policy documents and statements, corporate stakeholder position statements, pollinator strategy and action plans, web content, conference documents and reports, national reports and pollinator research institutions and cohort sourced articles; and scientific journal articles. Non-peer reviewed information sources are recognised as representing the perspective or opinion of a stakeholder. Reliability is determined by peer reviewed information sources or official documents stating stakeholder position and decision. Where reliability is not confirmed by peer review or official document, additional reliable literature and information sources are provided to complement and confirm information.

A consistent influencing factor in policy development and reform is analysis and findings available, either directly or indirectly sourced from scientific peer-reviewed research. Literature reviewed for pollinator conservation research only is organised by key topic areas and