PROGRAMA DE PÓS-GRADUAÇÃO EM ECOLOGIA:
TEORIA, APLICAÇÂO E VALORES

UNIVERSIDADE FEDERAL DA BAHIA – INSTITUTO DE BIOLOGIA

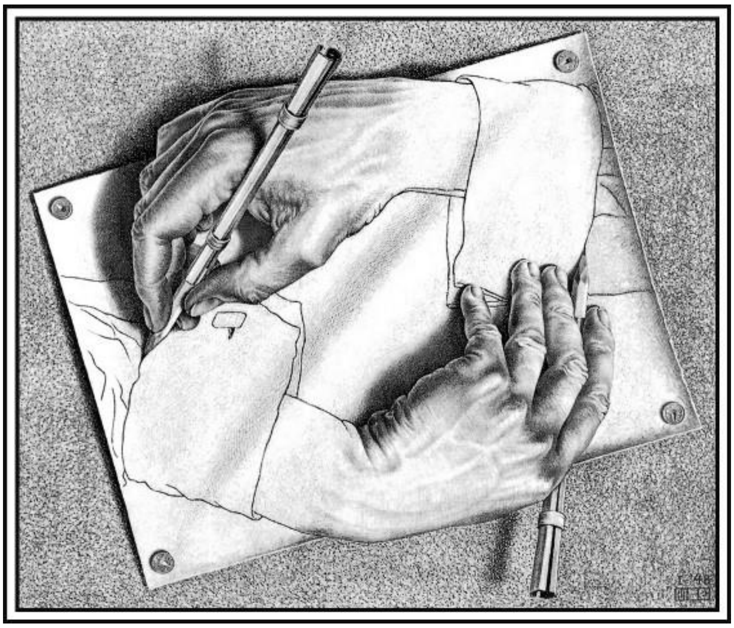
UNIVERSIDADE FEDERAL DA BAHIA - UFBA

Programa de Pós-Graduação em Ecologia: Teoria, Aplicação e Valores

Doutorado em Ecologia: Teoria, Aplicação e Valores

CAREN QUEIROZ SOUZA

Conservação e Ciências Humanas: um diálogo interdisciplinar para compreender fatores sociopsicológicos relacionados à conservação de polinizadores



"Drawing Hands" – M. C. Escher – 1948 – litogravura

Salvador, Bahia

2024

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Tese apresentada ao Programa de Pós-Graduação em Ecologia: Teoria, Aplicação e Valores, como parte dos requisistos exigidos para obtenção do título de Doutora em Ecologia.

Orientadora: Dra. Blandina Felipe Viana

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Salvador, Bahia

2024

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ATA DA SESSÃO PÚBLICA DO COLEGIADO DO PROGRAMA DE PÓS-GRADUAÇÃO EM ECOLOGIA: TEORIA, APLICAÇÃO E VALORES INSTITUTO DE BIOLOGIA – UFBA

Título da Tese: "Conservação e Ciências Humanas: um diálogo interdisciplinar para compreender fatores sociopsicológicos relacionados à conservação de polinizadores"

Doutoranda(a): **Caren Queiroz Souza**

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De acordo com o regimento geral da UFBA e com o regimento interno deste programa de pós-graduação, foram iniciados os trabalhos da Comissão Examinadora, composta pelo(a) professor(a) Dra. Blandina Felipe Viana (Presidente), Dr. Bruno Vilela de Moraes e Silva, Dra. Maria Carmen Lemos, Dra. Nirvia Ravena, Dra. Sheina Koffler às 09:18h do dia 30 de janeiro de 2024. A doutoranda fez a apresentação oral da tese durante 40 minutos. Após o encerramento das arguições, às 13 horas, a Comissão Examinadora pronunciou-se pela sua **APROVAÇÃO**, conforme parecer em anexo. Esta Ata será assinada pelos membros da Comissão Examinadora e deste Colegiado de curso, para compor o processo de emissão do diploma.

Salvador, 30 de janeiro de 2024.

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A Comissão Examinadora considera o trabalho de conclusão de curso:

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Não há considerações especificas significativas sobre os itens abaixo relacionados que condicionem a titulação. As sugestões feitas pela banca visando o aprimoramento do trabalho para publicação e essas foram enviadas diretamente à estudante, por e-mail.

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[ ] Introdução

[ ] Revisão Bibliográfica

[ ] Metodologia

[ ] Resultados Obtidos

[ ] Conclusões

Para assinatura do orientador **APENAS APÓS A EFETUAÇÃO DAS MODIFICAÇÕES SUGERIDAS**

Declaro, para fins de homologação, que as modificações, sugeridas pela banca examinadora, acima mencionada, foram cumpridas integralmente.

Profa. Dra. Blandina Felipe Viana

Orientadora

Dedicatória

Dedico este trabalho à minha família,
Minha avó Avani (*in memoriam*), Adelmo
(Painho), Eliana (Mainha), Quércia, Queila,
Pedro e Marina. Obrigada por todo apoio,
incentivo e admiração mútua! Amo vocês!

Epígrafe

Alegria e muito sonho

Espalhados no caminho

Verdes planta e sentimento

Folhas, coração, juventude e fé

Coração de Estudante – Milton Nascimento

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Muito, muito obrigada!

Texto de divulgação

O que a Psicologia e os insetos têm em comum?

Autora: Caren Queiroz-Souza

Não, insetos não fazem terapia. Mas não é bem sobre terapia que vamos falar. Na verdade, insetos são essenciais para a nossa sobrevivência e para a existência das florestas. Abelhas e outros insetos que visitam flores são necessários para produção de grande parte dos alimentos e para a manutenção das florestas, pois eles fazem a polinização. No entanto, muitos cientistas já mostraram que esses insetos envolvidos na polinização estão em declínio em algumas partes do mundo. Para mudar essa situação é preciso que humanos fiquem cientes do que está acontecendo e que participem de ações que visem mudar esse cenário como, por exemplo, plantando flores para os polinizadores ou lutando por mudanças políticas que os protejam. O uso excessivo de agrotóxicos é nocivo para os insetos, e lutar contra isso é outro exemplo de ação importante para sua sobrevivência e, consequentemente, para a nossa.

Mas, como fazer isso? Como convencer as pessoas de que esse é um tema importante?

É aí que entra a Psicologia. Quando falamos de humanos precisamos pensar formas criativas de nos comunicar, aprender e criar. Para fazer isso, primeiramente, podemos entender como os humanos pensam e se comportam. A Psicologia é uma área de conhecimento das Ciências Humanas que ajuda a entender o que nós pensamos, como agimos, e o que podemos fazer para mudar nosso comportamento. E foi a partir dessa concepção que eu fiz uma pesquisa para entender como humanos estão pensando e agindo em relação aos insetos polinizadores. Na minha pesquisa eu perguntei sobre esse tema a dois grupos de pessoas. O primeiro grupo incluiu coordenadores de projetos de ciência cidadã – um jeito de fazer ciência com pessoas que não são cientistas – e o segundo foi um grupo de agricultores, afinal, eles plantam, e precisam dos polinizadores para produzir os alimentos.

Em relação aos coordenadores de projetos de ciência cidadã, eu queria saber se eles achavam que fazer ciência sobre polinizadores com outras pessoas que não são cientistas pode ajudar na conservação dos insetos. A maioria disse que sim, mas a forma como isso pode acontecer dividiu as pessoas em três grupos com opiniões distintas. Um grupo acredita que ajuda a produzir mais conhecimento científico sobre abelhas e também ajuda na educação das pessoas, outro grupo acha que não ajuda tanto na educação das pessoas e o terceiro acha que não ajuda muito na produção de conhecimento científico de qualidade. Bem, essas opiniões influenciam muito como esses coordenadores decidem sobre o que vão fazer nos seus projetos de ciência cidadã e se eles acreditam que o benefício não é tão grande, eles precisam pensar em formas de melhorar isso. Já aos agricultores, eu perguntei se eles teriam vontade de plantar outras plantas com flores para servir de alimentos para os insetos. “Para nossa alegria”, a maioria deles disse que sim! E encontramos que essa intenção deles está relacionada à crença de que plantar flores deixa a fazenda mais bonita e também ajuda a manter os insetos por perto das culturas.

Talvez você tenha se perguntado se eu sou psicóloga. E a resposta é não! Eu sou bióloga e amo insetos, mas acredito que precisamos pensar em outras formas de produzir conhecimento, considerando também as crenças, concepções e possíveis comportamentos das pessoas. Por isso, me joguei nessa empreitada de tentar entender como outras pessoas podem, juntas, fazer a diferença diante das mudanças ambientais tão abruptas que estamos vivendo.

Resumo

O declínio de insetos polinizadores e dos serviços ecossistêmicos associados é um problema que afeta diretamente a manutenção dos sistemas e processos socioecológicos, desde a dinâmica das comunidades biológicas até a produção e a qualidade de alimentos para a humanidade. Ameaças aos polinizadores já estão documentadas na literatura, embora com lacunas sobre o tamanho do impacto em diferentes escalas espaço-temporais. Dentre essas ameaças estão a perda de habitat – principalmente devido à expansão e intensificação da agricultura – o uso de pesticidas, as mudanças climáticas e as espécies invasoras. Algumas soluções visando proteger e aumentar as populações de insetos polinizadores frente a tais ameaças, bem como, manter a riqueza de suas comunidades, já foram estabelecidas. No entanto, o desenvolvimento e a efetivação dessas soluções são extremamente complexas e dependem de vários fatores que vão do aporte de dados para gerar evidências ecológicas sobre o status dos polinizadores ao engajamento das pessoas em ações pro-polinizadores. No campo da Ecologia e da Biologia da Conservação, diversas abordagens são usadas com essa finalidade, no entanto, há um déficit de estudos que visam entender como aspectos sociopsicológicos afetam a aplicação e efetivação das soluções para engajamento das pessoas em tais ações. A presente tese visa, assim, investigar fatores sociopsicológicos relacionados à conservação dos polinizadores à luz de uma abordagem interdisciplinar envolvendo Ciências Humanas e Conservação (*Conservation Social Science*) abrangendo dois grandes temas: Ciência Cidadã e Agricultura. No primeiro capítulo defendo que a Ciência Cidadã é um modelo de co-produção que pode aumentar e acelerar a conservação de polinizadores em sistemas socioecológicos trazendo também benefícios

para a ciência e indíviduos e apresento algumas evidências científicas que sustentam esta proposição. Posteriormente, no segundo capítulo, investiguei empiricamente as similaridades e diferenças nos pontos de vista de coordenadores de projetos de ciência cidadã focados em insetos polinizadores sobre a importância da ciência cidadã para conservação de polinizadores. Para tal, utilizei a Metodologia Q para realizar uma análise quali- quantitativa com coordenadores no Brasil e no Reino Unido. Encontrei que três pontos de vista descrevem as percepções dos coordenadores: (1) A ciência cidadã tem um duplo propósito, fornecendo resultados tanto científicos quanto de engajamento público; (2) A ciência cidadã pode ter limitações em sua abrangência; e (3) a ciência cidadã serve principalmente como uma ferramenta para o engajamento cidadão com resultados limitados. Esses pontos de vista diferem principalmente sobre o papel da ciência cidadã na conservação de polinizadores, especialmente em sua capacidade de gerar dados. No entanto, há consenso entre os pontos de vista quanto ao papel da ciência cidadã na promoção do engajamento público e na conscientização sobre polinizadores, promovendo conexões com a natureza e estimulando o interesse pela ciência dos polinizadores. Partindo então para o contexto da Agricultura, apresento, no terceiro capítulo, uma revisão narrativa da literatura para indicar o estado-da-arte sobre estudos que utilizam de variáveis e teorias da Psicologia com agricultores e os determinantes à conservação de polinizadores. No quarto e último capítulo, apresento um estudo empírico no qual utilizei a Teoria do Comportamento Planejado (TPB) para quantificar os determinantes psicológicos à intenção de plantar flores como recursos de pólen e néctar em áreas de cultivo utilizando um caso de agricultores do Reino Unido. Encontramos que as atitudes e percepção de controle do comportamento são

determinantes às intenções dos agricultores, mas as normas sociais não. Baseado nesses resultados, apresento algumas recomendações para orientar ações de conservação em ambientes agrícolas que incentivem a intensificação ecológica da agricultura, considerando este um sistema socioecológico. Em suma, a presente tese apresenta evidências sobre variáveis sociopsicológicas que servem tanto para assegurar a execução de ações de conservação de polinizadores, já advertidas na Ecologia e Conservação, bem como para compreender e assegurar o bem-estar humano.

Palavras-chave: Ciência Humanas e Conservação, Ciência Cidadã, comportamento pró-polinizadores, comportamento pro-ambiental, agricultura, Teoria do Comportamento Planejado

Abstract

The decline of pollinating insects and associated ecosystem services is a problem that directly affects the maintenance and processes of socioecological systems, from the dynamics of biological communities to the production and quality of food for humanity. Threats to pollinators are already documented in the literature, although with gaps regarding the size of the impact on different spatial and temporal scales. Among these threats are habitat loss—mainly due to the expansion and intensification of agriculture—pesticide use, climate change, and invasive species. Some solutions aimed at protecting and increasing pollinator populations in the face of such threats, as well as maintaining the richness of their communities, have already been established. However, the development and implementation of these solutions are extremely complex and depend on various factors ranging from data input to generate ecological evidence on the status of pollinators to engaging people in pro-pollinator actions. In the field of Ecology and Conservation Biology, various approaches are used for this purpose; however, there is a deficit of studies aiming to understand how sociopsychological aspects affect the application and implementation of solutions for engaging people in such actions. This thesis aims to investigate sociopsychological factors related to pollinator conservation in the light of an interdisciplinary approach involving Human Sciences and Conservation (Conservation Social Science) covering two major themes: Citizen Science and Agriculture. In the first chapter, I argue that Citizen Science is a co-production model that can increase and upscale pollinator conservation in socioecological systems, also bringing benefits to science and individuals, and I present scientific evidence supporting this proposition. Subsequently, in the second chapter, I

empirically investigated the similarities and differences in the viewpoints of citizen science project coordinators focused on pollinating insects regarding the importance of citizen science for pollinator conservation. To do so, I used the Q Methodology to perform a qualitative-quantitative analysis with coordinators in Brazil and the United Kingdom. I found that three viewpoints describe the perceptions of coordinators: (1) Citizen science has a dual purpose, delivering both scientific and public engagement outcomes; (2) Citizen science may have limitations in its scope; and (3) Citizen science primarily serves as a tool for citizen engagement with limited outcomes. These viewpoints differ primarily on the role of citizen science in pollinator conservation, especially in its capacity to generate good quality data. However, there is consensus among the viewpoints regarding the role of citizen science in promoting public engagement and awareness of pollinators, fostering connections with nature, and stimulating interest in pollinator science. Moving on to the context of Agriculture, in the third chapter, I present a narrative literature review to indicate the state-of-the-art on studies using variables and theories from Psychology with farmers and determinants of pollinator conservation. In the fourth and final chapter, I present an empirical study in which I used the Theory of Planned Behavior (TPB) to quantify the psychological determinants of intention to plant flowers as pollen and nectar resources in cultivated areas using a case of farmers in the United Kingdom. We found that attitudes and perceived behavioral control are determinants of farmers' intentions, but social norms are not. Based on these results, I present some recommendations to guide conservation actions in agricultural environments that encourage ecological intensification of agriculture, considering it a socioecological system. In summary, this thesis presents

evidence on sociopsychological variables that serve both to ensure the implementation of pollinator conservation actions, already warned in Ecology and Conservation, as well as to understand and ensure human well-being.

Keywords: Conservation Social Science, citizen science, pro-pollinators behaviour, pro-environmental behaviour, agriculture, Theory of Planned Behaviour

Sumário

Introdução geral

A relação planta-polinizador, notadamente planta-insetos polinizadores, é uma das interações mais essenciais à manutenção da integridade funcional da vida na Terra e da sobrevivência e qualidade de vida humana. Tal relação está diretamente envolvida na reprodução de 90% das Angiospermas e 75% das plantas cultivadas (IPBES, 2016a). Indiretamente, a relação planta-polinizador também contribui para as redes tróficas, provendo recursos alimentares para consumidores primários, para o ciclo da água, a partir da reprodução da vegetação de matas ciliares, e para a estabilidade climática, uma vez que também contribui para a manutenção das florestas (OLLERTON; WINFREE; TARRANT, 2011; OLLERTON, 2017). Assim como outros organismos e processos ecossistêmicos, os insetos polinizadores e a polinização estão sob ameaça devido às ações antrópicas e modo de produção capitalista. As ameaças aos polinizadores já são bem documentadas na literatura, embora com muitas lacunas sobre o tamanho do impacto em diferentes escalas espaço-temporais (RADER et al., 2015; LEWINSOHN et al., 2022). Dentre estas, estão a perda de habitat – principalmente devido à expansão e intensificação da agricultura – o uso de pesticidas, as mudanças climáticas e as espécies invasoras (POTTS et al., 2016). Diante da sua importância, é extremamente necessário reverter a perda da biodiversidade de polinizadores.

Em 2016, a Plataforma Intergovernamental de Biodiversidade e Serviços Ecossistêmicos foi responsável por sintetizar um corpo massivo de evidências sobre os riscos aos polinizadores, bem como, as respostas para sua conservação. O lançamento do relatório do IPBES (2016) é um marco na história da conservação de polinizadores, tendo incentivado diversas iniciativas, políticas públicas e pesquisas científicas. Uma das principais contribuições do relatório do IPBES reside na ênfase dada à interdependência entre seres humanos e biodiversidade, destacando a complexa relação humano-natureza (DÍAZ et al., 2019). De modo mais amplo, essa perspectiva é também parte de uma mudança de paradigma na Biologia da Conservação. MACE (2014) indica que a Biologia da Conservação se iniciou como um campo em que priorizava a "natureza por si mesma", passando por uma perspectiva da "natureza apesar das pessoas", para então "natureza para as pessoas" e, mais recentemente, "pessoas e natureza". A autora assume que estas são perspectivas coexistentes e destaca que cada uma orienta uma forma de pensar e agir no campo. No entanto, a presença do paradigma "pessoas e natureza" apresenta ao campo um novo desafio – o desafio da inter- e transdisciplinaridade – pois compreender a complexa relação entre pessoas e natureza extrapola o escopo das ciências ambientais que é predominantemente focado no estudo biológico dos organismos vivos e de seu status frente às mudanças ambientais, demandando um diálogo com teorias e métodos das Ciências Humanas.

O paradigma "pessoas e natureza" apresenta um repertório de novas práticas, conhecimentos e saberes que foram negligenciados pela Biologia da Conservação ao longo de décadas. Discussões sobre as limitações no aprofundamento do paradigma "pessoas e natureza" têm ocorrido por diversas correntes de pensamento, mas aqui destaco duas. Primeiramente, uma mais funcional –, que diz respeito à lacuna pesquisa-prática. A discussão sobre a lacuna pesquisa-prática (KNIGHT et al., 2008; PARDINI et al., 2013) indica que as evidências presentes no campo da Ecologia, bem como a forma de pensamento e de investigação de problemas ambientais neste campo, não estão sendo suficientemente aplicadas para resolver problemas reais, notadamente, para a tomada de decisão. Essa corrente de pensamento indica que a lacuna entre o conhecimento científico ecológico e sua aplicação na resolução de problemas reais ocorre, entre outras razões, devido à formação disciplinar de ecólogos em instituições igualmente disciplinares (ROCHA et al., 2020), à carência no diálogo entre cientistas e tomadores de decisão (HIPÓLITO et al., 2021) e à prevalência de visões unidirecionais em que se supõe que a ciência deva apenas informar os tomadores de decisão que são responsáveis por aplicar o conhecimento científico (BERTUOL-GARCIA et al., 2018).

A segunda é a Ecologia Decolonial, uma corrente de pensamento que apresenta fatos históricos e evidências empíricas sobre práticas na ciência ecológica que trazem limites à justiça ambiental e à conservação (MALCOM, 2022), como, por exemplo, a predominância do pensamento europeu nas soluções aos problemas socioambientais (NUÑEZ et al., 2021). Esta corrente de pensamento também indica os desafios e as necessidades de integrar diversas ontologias no debate sobre problemas ambientais e na interação com o ambiente (LUDWIG; POLISELI, 2018; LUDWIG et al., 2023), haja vista que a troca de saberes pode promover acordos mais consensuais entre as partes interessadas e pode combater a injustiça social (SCHOLZ; STEINER, 2015; MALCOM, 2022)(SCHOLZ; STEINER, 2015). E, por fim, evidencia a carência da participação pública na ciência, notadamente de pessoas e povos marginalizados, apontando para práticas de cima-para-baixo na Ecologia e questionando a ausência da voz de pessoas atingidas por alterações ambientais (MALCOM, 2022).

A superação da disciplinaridade e compreensão da relação entre pessoas e natureza não é simples e precisa começar por uma mudança interna no campo. É necessário apelar para abordagens que contribuam para o incentivo à ação em diversas esferas desde individuais até comunitárias e também no campo político. Não à toa, o apelo ao engajamento de partes interessadas (cientistas, sociedade civil, gestores ambientais, agricultores, professores/educadores, estudantes etc.) é uma solução bastante presente na literatura que discute as estratégias de enfrentamento aos diversos problemas ambientais como, por exemplo, a perda de polinizadores, sejam em escalas locais

(DICKS et al., 2016; STOUT; DICKS, 2022) ou da paisagem (GARIBALDI et al., 2023). Abordagens de pesquisa que incentivem uma nova práxis diante dos problemas socioambientais são cruciais na definição e orientação de estratégias para potencializar, implementar e analisar soluções para perda de polinizadores. Nesse contexto, torna-se inevitável o desenvolvimento e fomento de práticas inter- e transdisciplinares.

Inter- e transdisciplinaridade na Conservação[1]

Para os propósitos dessa tese, é importante esclarecer as diferenças entre estudos disciplinares, multidisciplinares, interdisciplinares e transdisciplinares. Nesta tese adotarei os conceitos apresentados por TRESS, TRESS e FRY, 2005. Para esses autores, o termo “disciplinaridade” se refere a pesquisas que se concentram em um objeto específico dentro dos limites de uma única disciplina acadêmica. “Multidisciplinaridade”, por sua vez, se refere ao envolvimento de diferentes disciplinas acadêmicas investigando um mesmo tema ou problema, mas sem o objetivo de criar novos conhecimentos que surgem da integração dos saberes de cada disciplina. Ou seja, nesse caso, o resultado do conhecimento também é disciplinar. Já os estudos interdisciplinares envolvem duas ou mais disciplinas previamente não relacionadas para investigar o mesmo objeto, cruzando suas fronteiras de conhecimento com o objetivo explícito de criar novos conhecimentos e novas teorias que vão além do escopo de cada disciplina isolada. Por fim, os estudos transdisciplinares integram não apenas disciplinas acadêmicas, mas também participantes não acadêmicos, seus conhecimentos e visões de mundo em direção a um objetivo de pesquisa comum e/ou mudanças transformadoras visando a sustentabilidade (O’BRIEN e SYGNA, 2013).

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[1] Uma reflexão pessoal sobre os desafios enfrentados na minha transição da formação disciplinar para a inter-transdisciplinar pode ser vista no texto “*O poder do não-lugar: desafios e oportunidades na pesquisa inter-transdisciplinar em Ecologia e Conservação*” no meu blog pessoal Medium.com/@carenqueiroz.

No clássico artigo “*What is Conservation Biology?*” SOULÉ (1985) afirma que a Biologia da Conservação é uma disciplina orientada por missão e que dialoga com outros campos de conhecimento. No entanto, existe um predomínio de estudos e de pesquisadores no campo que têm formação disciplinar nas ciências naturais. Nesse sentido, diversos desafios para extrapolar as barreiras disciplinares se fazem presentes como, por exemplo, a carência de habilidades e técnicas para utilizar e aplicar teorias e métodos de outros campos e a dependência epistêmica (ANDERSEN, 2016) – conceito que se refere a ideia de que, em atividades de pesquisa colaborativa – como as inter-transdisciplinares – os cientistas que trabalham em um campo distante de sua formação acadêmica são dependentes epistemicamente de outros para compartilhar ideias, aprender e aplicar métodos e interpretar resultados. Isso se constitui um desafio, pois via de regra, as instituições e pesquisadores não estão acostumados e/ou não são incentivados a dialogar fora de sua área de formação. Por sua vez, a inter- e transdisciplinaridade constituem excelentes oportunidades para avançar os esforços de conservação, pois estimulam a criação em ambientes colaborativos a partir do intercâmbio de saberes, desenvolvem melhores habilidades de comunicação e, potencialmente, aumentam o sucesso da implementação de ações de conservação (IRWIN et al., 2018; ROCHA et al., 2019).

O diálogo interdisciplinar entre Conservação e Ciências Humanas

A relação entre Ciências Humanas e Conservação (em inglês “*Conservation Social Science*”) é bastante benéfica para promover uma melhor compreensão da relação humano-natureza, uma vez que, esta abordagem propõe o desenvolvimento do conhecimento a partir do diálogo interdisciplinar entre Ciências Humanas e Naturais (BENNETT 2016). Essa abordagem surgiu principalmente com o reconhecimento de que as ciências naturais não são suficientes para resolver os problemas ambientais, ou melhor, socioambientais. O diálogo com as Ciências Humanas é inevitável para a solução dos problemas socioambientais que estamos vivendo, pois, essas disciplinas fornecem métodos, ferramentas e conhecimentos para reconhecer aspectos relacionados à tomada de decisão por seres humanos como, por exemplo, comportamentos, valores, conhecimentos etc. Essa abordagem também defende a ideia de que, ao negligenciar os conhecimentos das Ciências Humanas, conservacionistas estão deixando de (re)conhecer fatores contextuais que são extremamente importantes para a efetivação de soluções ambientais podendo sugerir a soluções inadequadas ou desconexas da realidade (BENNETT, 2016).

A abordagem Conservação e Ciências Humanas propõe o diálogo com inúmeras disciplinas como, por exemplo, sociologia, antropologia, economia, psicologia etc (BENNETT; ROTH, 2015). Mais especificamente, a Psicologia da Conservação e, dentro desta, a Psicologia Social – campo de interesse desta tese – tem como objetivos fundamentais compreender quais são os pensamentos, opiniões, valores, comportamentos das pessoas em relação ao meio ambiente, o que determina a forma como pensam e se comportam, bem como, como são influenciadas pelo seu contexto social (TEEL et al. 2015).

Estado da arte sobre a conservação de polinizadores a partir do diálogo interdisciplinar entre Conservação e Ciências Humanas

No caso da conservação de polinizadores, as mais de 70 ações pró-polinizadores presentes, por exemplo, no IPBES (2016) (*e.g.*, restaurar habitats, acessar o status das populações etc.) não são possíveis de serem efetivadas sem a inclusão das pessoas como parte da solução, incluindo tomadores de decisão, cientistas, agricultores, educadores e sociedade civil, entre outros. Embora esse pensamento seja cada vez mais consensual dentro da comunidade acadêmica, a maioria dos estudos sobre conservação de insetos polinizadores é focada nos efeitos de variações ambientais nas populações e comunidades (HALL; MARTINS, 2020), e a proposição de soluções efetivas é pouco baseada em conhecimentos sobre como aspectos humanos (conhecimentos, opiniões, atitudes etc.) relacionados à conservação de polinizadores funcionam. Em outras palavras, isso significa que há um corpo de evidências muito relevantes sobre a dinâmica ecológica de polinizadores que não está sendo complementado por pesquisas focadas na implementação (efetiva), criação e discussão de soluções com as partes interessadas.

Os poucos estudos sobre conservação de insetos polinizadores no âmbito da Conservação e Ciências Humanas têm uma grande variação de objetos de pesquisa, abordagens metodológicas e de diálogo interdisciplinar (com ciência política, psicologia, economia etc). Podemos observar trabalhos sobre percepção de cientistas sobre a importância da ciência cidadã na conservação de polinizadores (VIANA; QUEIROZ-SOUZA; MOREIRA, 2020), fatores que influenciam no comportamento pró-polinizadores (KNAPP et al., 2021), relação entre experiências no manejo agrícola e conhecimento e percepção de polinizadores e práticas de manejo (OSTERMAN et al., 2021), contribuição de polinizadores nativos para produção agrícola (HANES et al., 2013), aprendizado sobre polinizadores e polinização (RATNIEKS et al., 2016), engajamento no monitoramento de polinizadores, especialmente, no contexto da ciência cidadã que será discutido mais a frente (E.G., BIRKIN e GOULSON 2015; GAZDIC; GROOM 2019).

Pesquisas focadas na conservação de polinizadores dentro desse escopo são oportunas e necessárias para o momento de rápidas transformações em que estamos vivendo, especialmente devido à expansão do modelo agrícola da chamada “revolução verde”, às mudanças climáticas e à perda de habitat (LECLÈRE et al., 2020). Considerar aspectos sociais e psicológicos implica ter na devida conta fatores contextuais que podem estar obscurecidos no conhecimento disciplinar das ciências naturais, permitindo a criação de orientações mais efetivas e direcionadas que potencializem a efetividade de ações das ações de conservação. De modo mais amplo, isso pode ser também uma forma de evitar injustiça social, pois ao dar voz às pessoas é possível enxergar a disputa de interesses que podem impedir a efetivação de ações de conservação, da justiça ambiental, e da participação democrática (BENNETT 2016).

Embora haja um reconhecimento da necessidade de pesquisas envolvendo o diálogo interdisciplinar entre Conservação e Ciências Humanas, ainda há algumas barreiras a serem superadas. SANDBROOK e colaboradores (2013), por exemplo, apontam para problemas metodológicos, epistêmicos, de entendimento e de linguagem que dificultam o diálogo entre as Ciências Naturais e Humanas. BENNETT e ROTH (2015) destacam também as diferenças ontológicas desses campos, o treinamento e a experiência de pesquisadores, a organização cultural entre outros aspectos.

Para enfrentar e superar tais desafios, é preciso um esforço coletivo da comunidade acadêmica. Por exemplo, sabe-se que há uma grande lacuna de dados que dificulta o estabelecimento de qual o status dos polinizadores em regiões fora da Europa e América no Norte (EUA e Canadá), bem como, há uma grande demanda por aumentar a consciência sobre a importância de insetos polinizadores e da polinização (MAYER et al., 2011; IPBES, 2016b). BARTOMEUS e DICKS (2019) sugerem que, para superar este problema, é necessário investir em estruturas inter- e transdiciplinares que promovam a colaboração de cientistas e sociedade visando acelerar a investigação sobre o status dos polinizadores, avaliar a efetividade de ações propostas e, consequentemente, fomentar sua conservação.

No contexto mais amplo da sociedade civil, tais estruturas podem ser fomentadas, por exemplo, por meio da ciência cidadã. As iniciativas e pesquisas sobre ciência cidadã[2] têm contribuído com estudos sobre polinizadores e angariado resultados positivos para a percepção e o conhecimento do público sobre insetos polinizadores (GHILARDI-LOPES; ZATTARA, 2022; WHITEHORN et al., 2022). Já no contexto agrícola, estruturas inter- e transdisciplinares podem ser estabelecidas através da proposição e/ou co-criação de estratégias de manejo de base agroecológica, que se utilizam de diversos campos de conhecimento para efetivar ações pró-polinizadores (e.g., criação de áreas de refúgio ou plantio de flores). Todavia, o estabecimento dessas estruturas, a aplicação das ações propostas e a manutenção do seu uso são atravessadas por aspectos sociopsicológicos dos atores sociais envolvidos (na ciência cidadã, coordenadores de projetos e participantes; na agricultura, os próprios agricultores) (BREEZE et al., 2019; TARAKINI; CHEMURA; MUSUNDIRE, 2020). Assim, é necessário considerar as percepções, intenções, atitudes, relações sociais, entre outros aspectos das partes interessadas.

Por fim, considerando os argumentos supramencionados, a efetivação da conservação de insetos polinizadores só será factível a partir do momento que outros modos de pensar e de produzir conhecimento sejam considerados e praticados. Especificamente, a partir da compreensão dos fatores relacionados aos seres humanos que incentivam ou restringem a efetivação de ações de conservação aos polinizadores e das evidências sobre as discrepâncias sociais das causas e consequências da perda de polinizadores

[2] No presente trabalho, em termos conceituais, entendemos a ciência cidadã de acordo com o conceito proposto pela Rede Brasileira de Ciência Cidadã (RBCC) – “uma abordagem científica que abrange uma gama de tipos de parcerias entre cientistas e interessados em ciência, para produção compartilhada de conhecimentos com potencial para promover (i) o engajamento do público em diferentes etapas do processo científico; (ii) a educação científica e tecnológica, e (iii) co-elaboração e implementação de políticas públicas sobre temas de relevância social e ambiental”.

para as partes interessadas, estaremos caminhando para uma transformação efetiva frente aos riscos à estabilidade e manutenção espaço-temporal dos polinizadores e bem-estar humano.

Objetivos

Objetivo geral

Investigar à luz de abordagens interdisciplinares entre Conservação e Ciências Humanas fatores sociopsicológicos relacionados à conservação de polinizadores considerando dois contextos: Ciência Cidadã e Agricultura.

Objetivos específicos

1) Apresentar a Ciência Cidadã como um modelo de co-produção para conservação de polinizadores
2) Analisar pontos de vista de coordenadores de projetos de ciência cidadã focados em polinizadores sobre as contribuições da ciência cidadã para a conservação de polinizadores.
3) Apresentar uma breve revisão narrativa sobre o estado da arte sobre o papel de fatores sociopsicológicos relacionados à adoção de comportamentos pró-polinizadores por agricultores, dando ênfase a importância da interdisciplinaridade entre Psicologia e Conservação no fomento à práticas agrícolas pro-polinizadores.
4) Avaliar determinantes sociopsicológicos da intenção de agricultores em plantar flores em áreas de cultivo como recursos de pólen e néctar para insetos polinizadores.

Estrutura da tese

Esta tese está dividida em Parte I: *Ciência Cidadã e polinizadores – insights do Brasil e do Reino Unido,* com dois capítulos; e Parte II: *Adoção de estratégias de base agroecológica para conservação de polinizadores*, com dois capítulos. Esta divisão foi feita de acordo com os contextos de estudo (ciência cidadã e agricultura). Um detalhamento sobre a relação entre ciência cidadã e suas contribuições à conservação de polinizadores será apresentado no Capítulo I, enquanto práticas de manejo e conservação de polinizadores serão abordados no Capítulo III. A *Figura 1* ilustra a estrutura da tese.

Na Parte I: *Ciência Cidadã e polinizadores – insights do Brasil e do Reino Unido,* inicio apresentando o Capítulo I – *Apresentando a ciência cidadã como um modelo de co-produção para aumentar o uso da ciência na conservação de insetos polinizadores* – trata-se de uma revisão sobre os debates, conceitos e evidências atuais sobre a ciência cidadã para conservação de polinizadores no Brasil e no Reino Unido. Os países foram escolhidos para ilustrar diferentes cenários de tradição no engajamento das pessoas na ciência. Neste capítulo, sintetizo as evidências sobre as contribuições da ciência cidadã para a ciência, os sistemas socio-ecológicos e os indivíduos, considerando a moldura teórica (*framework*) de Shirk et al. (2016), e, indico, também, a lacuna sobre avaliação quantitativa da percepção de coordenadores de projetos de ciência cidadã, que será empiricamente abordada no Capítulos II , como descrito a seguir.

O Capítulo II – *Unveiling perspectives: exploring coordinator's perspectives about the role of citizen science in pollinator conservation* – é um artigo que será submetido à revista *Conservation Biology*. Trata-se de um estudo para identificar os pontos de vista de coordenadores de projetos sobre a importância da ciência cidadã para conservação de polinizadores. Para isso utilizamos a Metodologia Q, um método quali-quantitativo útil para acessar opiniões compartilhadas entre pessoas sobre um assunto controverso. Encontramos três pontos de vista que apresentam opiniões conflitantes sobre a qualidade e o uso de dados, a acessibilidade e a inclusão de pessoas nos projetos.

Na Parte II – *Lacunas na adoção de práticas agrícolas amigáveis aos polinizadores* – apresento aos leitores, no Capítulo III – *Determinantes sociopsicológicos à conservação de polinizadores em ambientes agrícolas* –, uma revisão narrativa sobre a abordagem utilizada (Psicologia (Social) da Conservação e Teoria do Comportamento Planejado), bem como, o estado da arte do conhecimento sobre fatores sociopsicológicos determinantes para a adoção de ações pró-polinizadores por agricultores, atores cruciais no manejo e na conservação de insetos, bem como, o estado da arte sobre o tema. Ainda nessa parte apesento, no Capítulo IV – *Why plant flowers? Exploring the psychological factors that motivate fruit growers to take up a key pro-pollinator behaviour* –, um estudo de caso sobre a percepção de agricultores do Reino Unido acerca da importância dos polinizadores para a produção de alimentos e sobre determinantes pesicológicos relacionados à sua intenção (ou não) de plantar flores como recursos de pólen e néctar para insetora polinizadores em áreas de cultivo. Este artigo será submetido à revista People and Nature. Foi utilizada neste estudo a Teoria do Comportamento Planejado (*Theory of Planned Behaviour*, TPB, sigla em inglês) como modelo teórico explicativo da relação entre as variáveis determinantes e o comportamento. Encontramos que a percepção sobre o controle da ação (plantar flores), bem como, as atitudes em relação à plantar flores, foram determinantes à intenção. De modo contrário, as normas sociais não influenciaram as intenções dos agricultores entrevistados. Detalhes conceituais sobre as variáveis de interesse e a estrutura da TPB são especificadas nos capítulos correspondentes. O artigo se encerra com uma apresentação sobre algumas estratégias recomendadas para incentivar a prática de plantar flores entre agricultores em diferentes contextos, bem como, uma indicação de perspectivas para pesquisas futuras.

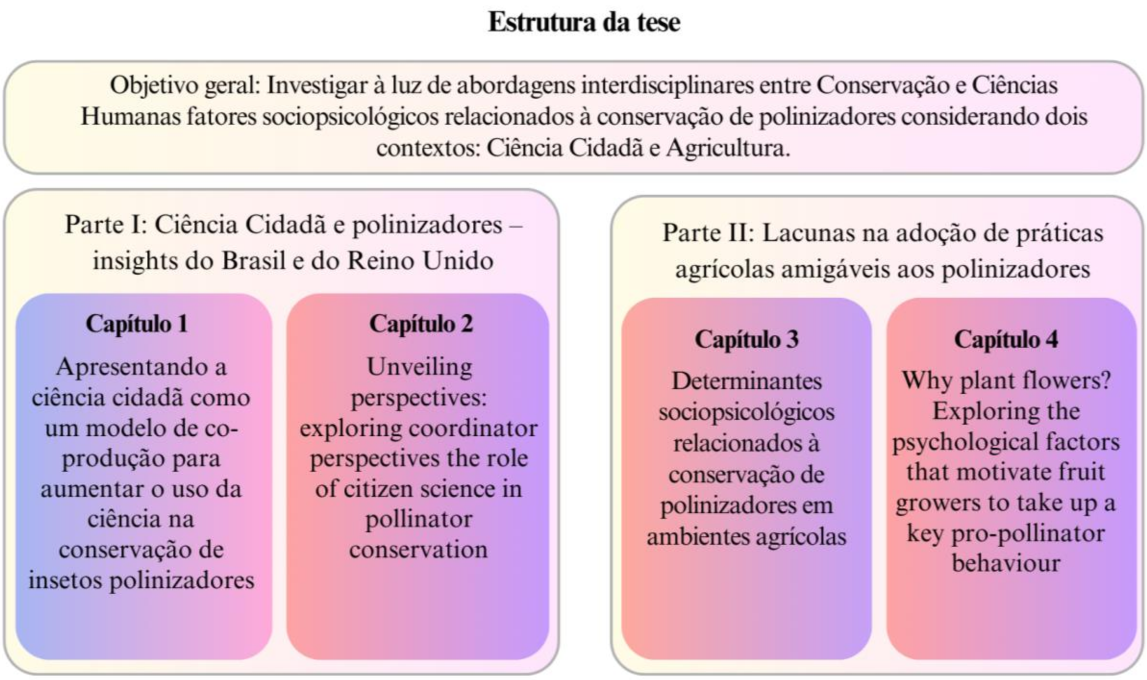

Figura 1: Estrutura da tese.

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Parte I: Ciência Cidadã e polinizadores – insights do Brasil e do Reino Unido

Capítulo I – Conceituando a ciência cidadã como um modelo de co-produção para aumentar o uso da ciência na conservação de insetos polinizadores

Autora: Caren Queiroz-Souza

Este capítulo tem como objetivo conceituar a Ciência Cidadã como um modelo de co-produção que pode rapidamente aumentar o impacto na conservação de polinizadores. Assim, visamos contribuir para um melhor entendimento desses impactos e apresentar áreas que precisam de melhor progresso.

Perda de polinizadores – um problema-modelo, mas não um problema qualquer

Antes de partir para o trabalho empírico desenvolvido nesta tese é preciso apresentar e elaborar alguns conceitos e pontos importantes sobre a ciência cidadã enquanto um modelo de co-produção de conhecimento, as lacunas no campo sobre isso, e a relevância desse modo de produzir conhecimentos úteis para a conservação de insetos polinizadores. Insetos polinizadores são responsáveis pela reprodução de 90% das angiospermas e 75% de plantas cultivadas (OLLERTON; WINFREE; TARRANT, 2011). A perda de insetos polinizadores representa, portanto, a perda de funções ecossistêmicas essenciais à vida na Terra, bem como, a sobrevivência humana, configurando-se assim como um problema socioambiental que demanda por ações urgentes (KLEIJN et al., 2015). Existem evidências – baseadas em dados das últimas cinco décadas de que a riqueza, o range geográfico e a abundância de insetos polinizadores está diminuindo (GOULSON, 2021). As principais causas do declínio de polinizadores são a perda de hábitat, principalmente por causa da expansão e intensificação agrícola, uso de agrotóxicos, mudanças climáticas e parasitas (IPBES, 2016). Para reverter este cenário diversas frentes de atuação são recomendadas na literatura e indicadas como cruciais para a conservação desses insetos, entre elas estão: preencher lacuna de dados sobre insetos polinizadores e engajar a sociedade civil na conservação. Em outras palavras tais recomendações visam fazer o conhecimento sobre polinizadores mais usável e usado (LEMOS et al., 2018).

Co-produção como um modelo necessário para o enfrentamento à perda de insetos polinizadores

Para alcançar tais objetivos as ciências ambientais precisam superar o modelo linear e adotar os modelos de co-produção de conhecimento científico que orientem e produzam conhecimento usável no sentido de contribuir com a resolução de problemas socioambientais, a partir da democratização do conhecimento, participação pública e estímulo ao engajamento nas atividades científicas e também em comportamentos pro-ambientais (LEWENSTEIN, 2015; LEMOS et al., 2018). Co-produção é, por sua vez, definida como a interação entre produtores e usuários do conhecimento que resulta em conhecimento usável e que, portanto, atende ao contexto da decisão (LEMOS; MOREHOUSE, 2005; MACH, 2020). A co-produção abrange diversas formas de interação entre cientistas e partes interessadas onde há intercâmbio de saberes e produção de novos saberes (MACH, 2020).

O interesse na co-produção de conhecimento é crescente, embora receba poucos incentivos para sua institucionalização (LEMOS et al., 2018). Esse interesse parte da realização de que os problemas socioambientais precisam de soluções rápidas e adequadas a diferentes contextos e devem ser criados a partir do reconhecimento dos fatores que afetam as partes interessadas. Isso resulta numa hipótese central da co-produção de que o aumento do engajamento na ciência também aumenta o uso do conhecimento pelas partes interessadas (PARDINI et al., 2013; IRWIN et al., 2018). Essa resposta prevista na hipótese é extremamente necessária para fomentar a sustentabilidade e a conservação da biodiversidade, pois permite que soluções baseadas no conhecimento científico sejam efetivadas e também construídas por quem vai ser afetado pelo seu uso e aplicação. De fato, algumas evidências têm mostrado que a interação entre cientistas e partes interessadas é bem sucedida em aplicar o conhecimento usável (RAMIREZ-ANDREOTTA et al., 2014), mas existem lacunas sobre a quantidade e dimensão desse sucesso.

Considerando portanto que a co-produção funciona no sentido de fomentar a conservação (KALAFATIS et al., 2015; NEL et al., 2016), é evidente que haja demanda por aumento de iniciativas que fomentem a co-produção, principalmente, devido às rápidas transformações socioambientais que testemunhamos e a complexidade das possíveis soluções aos mesmos. LEMOS et al (2019) defende a ideia de que isso pode ser feito através do aumento dos mecanismos de participação na co-produção de conhecimento usável como, por exemplo, a ciência cidadã ou ciência comunitária, que tem sido muito crescente nas últimas décadas (KULLENBERG; KASPEROWSKI, 2016). A ciência cidadã, considerando os variados tipos de interação entre cientistas e partes interessadas visando a produção de conhecimento científico, é um modelo de co-produção de conhecimento que, potencialmente, aumenta em escala o uso do conhecimento. Via de regra, esta abordagem é vista como bastante benéfica pois aumenta rapidamente o número de participantes na ciência, então espera-se que também aumente rapidamente o volume de conhecimento usável.

No entanto, devido às inúmeras formas de interação entre cientistas e voluntários em pesquisas científicas desenvolvidas no âmbito da ciência cidadã , bem como, a diversidade de objetos de interesse, problemas abordados, diversidade de pessoas participantes etc (SCHÄFER; KIESLINGER, 2016), há lacunas sobre como esta abordagem está contribuindo para a conservação (no caso desta tese a ênfase é na conservação de insetos polinizadores). Além disso, é necessário ter um melhor entendimento sobre quais são as contribuições que o engajamento na ciência cidadã fornece. Nesse sentido, as perguntas que surgem são: em que direção(ções) a ciência cidadã está promovendo o engajamento e fomentando a conservação de insetos polinizadores? Quais são as barreiras e motivações para isso? Também, como esse engajamento se reflete em termos de ações pró-polinizadores e conhecimento?

Ciência cidadã: debates conceituais

Faz-se necessário explorar algumas especificidades da ciência cidadã, enquanto modelo de co-produção. Primeiramente, definir ciência cidadã não é uma tarefa simples. O termo foi apresentado concomitante e independentemente em 1995 por dois autores: Alan Irwin e Rick Booney (COOPER; LEWENSTEIN, 2016). O primeiro, motivado pelos debates sobre a relação ciência e sociedade, propunha que ciência cidadã se refere a cidadania científica, advogando por uma prática científica democrática que deve atender às necessidades dos cidadãos, no sentido dessas necessidades influenciarem a agenda científica. Ele também defendia a ideia de que o processo de produzir conhecimento científico confiável pode ser desenvolvido e promulgado pelos próprios cidadãos. Já Booney atribuiu ao termo a ideia de contribuição de voluntários para o método científico e que, especificamente, foi usado para descrever as contribuições de observadores de aves para pesquisas científicas no Cornell Lab of Ornithology nos Estados Unidos tornando-se popular posteriormente nos projetos do laboratório e aplicado em outros contextos em que as pessoas contribuíam, notadamente, com a parte metodológica de trabalhos científicos (COOPER; LEWENSTEIN, 2016).

Na prática, essas duas definições orientam iniciativas com imensas variedades de formas e estruturas e, portanto, podem ser vistas como extremos complementares num contínuo em que a ciência cidadã é definida pela prática, considerando o contexto onde está sendo desenvolvida. HAKLAY et al (2014) realizaram um estudo baseado em casos (*vignetty study*) e pediu para que os respondentes ranqueassem os casos numa escala de concordância sobre ser ou não ser ciência cidadã. Eles encontraram que poucos casos se encaixam nos extremos “ser” ou “não ser”, indicando que o conceito é predominantemente contexto-específico e, via de regra, características das práticas executadas ou planejadas nos projetos e da relação do voluntário com a pesquisa que vai definir o que é ciência cidadã. A diversidade de conceitos de ciência cidadã é bastante benéfica, pois abrange uma variedade de práticas que promove a interlocução entre cientistas e voluntários em pesquisas científicas e, direta ou indiretamente, na resolução de problemas socioambientais que é beneficiada pela informação científica.

Isso nos leva a outra pergunta: quais são os tipos de ciência cidadã? Na literatura é possível encontrar classificações baseadas em diferentes critérios, a saber tipo ou nível de colaboração (HAKLAY et al., 2014), objetivos e tarefas do projeto (WIGGINS; CROWSTON, 2011), nível de participação (SHIRK et al., 2012), natureza das atividades (BONNEY et al., 2015), contribuição científica para o manejo natural (COOPER et al., 2007) e participação em monitoramento da biodiversidade (DANIELSEN et al., 2017). Paralelamente ao uso das tipologias, uma forma de unificar a ciência cidadã é a partir do uso de princípios valorativos que servem de base para orientar as práticas dos projetos, sendo o conjunto de princípios mais usados o da Associação Europeia de Ciência Cidadã (ECSA (EUROPEAN CITIZEN SCIENCE ASSOCIATION), 2015).

Em termos conceituais para esta tese compreende-se a ciência cidadã de acordo com o conceito adotado pela Rede Brasileira de Ciência Cidadã (RBCC) : “uma abordagem científica que abrange uma gama de tipos de parcerias entre cientistas e interessados em ciência, para produção compartilhada de conhecimentos com potencial para promover

(i) o engajamento do público em diferentes etapas do processo científico; (ii) a educação científica e tecnológica, e (iii) co-elaboração e implementação de políticas públicas sobre temas de relevância social e ambiental".

Estado da arte sobre contribuições da ciência cidadã para a conservação de insetos polinizadores

Uma vez que o conceito foi apresentado, é importante compreender o quão importante é a ciência cidadã para a conservação da biodiverdade, notadamente de insetos polinizadores, que se reflete no crescente interesse da comunidade científica nesse campo do conhecimento (KULLENBERG; KASPEROWSKI, 2016). Há na literatura *frameworks* que visam descrever quais são os impactos da ciência cidadã para a conservação. MCKINLEY et al (2017), por exemplo, propõem que a ciência cidadã aumenta a conservação, manejo de recursos naturais e proteção ambiental através da aquisição de conhecimento científico e fomento ao engajamento do público, direta e indiretamente, em processos de tomada de decisão, o que afeta a formulação de políticas e o manejo de recursos naturais. Já PHILLIPS et al (2019) e SHIRK et al (2012) utilizam a estrutura do Modelo de Abordagem de Resultados (*Outcome Approach Model* da W. K. Kellogg Foundation) para descrever como a ciência cidadã gera impactos diversos.

Na estrutura proposta por PHILLIPS et al (2019), os impactos são voltados para o público, nesse sentido o *framework* apresentado destaca o aumento da alfabetização cívica e científica, melhoria da relação ciência e sociedade e melhoria das condições ambientais, como um efeito do aumento do aprendizado e conscientização ambiental. Enquanto que SHIRK et al (2012) sugerem impactos para além dos participantes e considera que a ciência cidadã gera contribuições para ciência (acrescento aqui, cientistas), sistemas socio-ecológicos e indivíduos.

A teoria da mudança por trás de todos esses modelos indica que a ciência cidadã, como um modo de co-produção, gera transformações em diferentes níveis (não hierarquicamente organizados) e, potencialmente, produz impacto para conservação e sustentabilidade (SHIRK et al 2012). Dentre esses *frameworks*, aqui considero que o SHIRK et al (2012) é o mais abrangente e, por isso, a seguir irei explorar algumas evidências, exemplos de projetos e expectativas que indicam as contribuições para cada uma das dimensões apresentados nesta referência (ciência, sistemas socio-ecológicos e indivíduos), destacando, sempre que disponível, os casos para a conservação de polinizadores.

Contribuições para a ciência

Começando pelas contribuições científicas, vamos abordar aqui o problema da perda de insetos polinizadores que, como já foi mencionado, irá trazer consequências drásticas para a produção de alimentos e estabilidade dos ecossistemas (POTTS et al., 2010). Diante da celeridade das ameaças é extremamente urgente compreender a magnitude e o status dos polinizadores, principalmente em regiões fora dos Estados Unidos e Europa. Para isso, é preciso preencher a lacuna de dados sobre a ocorrência e abundância de polinizadores.

A ciência cidadã pode contribuir com isso, pois, via de regra, envolve várias pessoas no levantamento e monitoramento de espécies. Além do volume de dados, também permite a cobertura de áreas que podem estar fora da atuação de cientistas. Como a maioria dos projetos de ciência cidadã utiliza registro fotográfico para levantar espécies, isso também facilita e amplia a escala espaço-temporal dos dados. No iNaturalist®, talvez a plataforma de ciência cidadã mais conhecida mundialmente, o número de registro de abelhas, por exemplo, passa de 2 milhões, em 2024. Este é um volume de dados que seria inalcançável sem a participação das pessoas. De modo mais amplo, a ciência cidadã também contribui para pesquisas sobre aspectos não biológicos, no que se chama ciência da ciência cidadã em que pesquisas interdisciplinares são desenvolvidas a partir da colaboração com ecologia e outras áreas como, por exemplo ciências sociais, matemática, computação etc (JORDAN et al., 2015; VOHLAND et al., 2021). Os dados de ciência cidadã sobre polinizadores tem sido usados para endereçar diversas questões, KOFFLER e colaboradores (2021) propõem uma revisão sobre estudos que focaram em abelhas. destacamos alguns exemplos na Tabela 1.

Tabela 1: lista de contribuições da ciência cidadã focada para a ciência sobre polinizadores e polinização e respectivas referências.

Tema de pesquisa	**Referências/Projetos**
Distribuição e manejo de espécies invasoras	(ISHII et al., 2008; KADOYA; WASHITANI, 2010)
Avaliação do serviço de polinização	(BIRKIN; GOULSON, 2015; KLEINKE et al., 2018)
Efeito de mudanças climáticas e do hábitat na abundância e riqueza de polinizadores ou em funções ecossistêmicas	(ASHCROFT; GOLLAN; BATLEY, 2012; PAUW; LOUW, 2012; WHITEHORN et al., 2022)
Tendências, status, ocorrência de espécies	(BLOOM; CROWDER, 2020; WHITEHORN et al., 2022)
Desenvolvimento de novos protocolos de pesquisa	(ASHCROFT; GOLLAN; BATLEY, 2012; ROY et al., 2016; LEOCADIO et al., 2021)
Interação planta-polinizador	(GAZDIC; GROOM, 2019; GROOM et al., 2021)

Para além do volume de dados, a ciência cidadã potencialmente pode permitir o registro de espécies raras, descoberta de espécies novas, rastreio e detecção de espécies invasoras (KADOYA et al 2010). Os projetos de ciência cidadã também podem assegurar o monitoramento a longo prazo, o que é particularmente relevante para acessar quais são as tendências das populações e detectar mudanças a exemplo de declínios populacionais (WHITEHORN et al 2022). Sob a perspectiva da ecologia das comunidades e dos ecossistemas, a ciência cidadã permite o endereçamento de questões sobre rede de interações em proporções mais amplas, bem como, de monitoramento de variáveis ambientais (POCOCK et al., 2016).

Embora haja todo esse potencial é necessário compreender qual a abrangência real desses dados em termos espaciais, temporais e taxonômicos. Baseado no *framework* de variáveis essenciais da biodiversidade (EBV, em inglês), CHANDLER et al. (2017) descreveram o status de contribuições de dados da ciência cidadã e indicaram em que áreas existem oportunidades de crescimento. Os autores mostraram que ciência cidadã (e outros projetos de monitoramento comunitário) fornecem dados em amplas escalas para distribuição de espécies, abundância populacional, fenologia de espécies e funções ecossistêmicas, no entanto existe um viés taxonômico para plantas, Lepidópteros e aves, e um viés espacial para Europa, América do Norte, Africa do Sul, India e Austrália.

Há lacunas de estudos mostrando os status e tendências de dados de ciência cidadã para pesquisas com insetos polinizadores ou insetos de modo geral. FELDMAN et al. (2021) avaliaram quantitativamente a representação de diferentes táxons, regiões e outros tipos de dados de ciência cidadã para pesquisas com modelagem de distribuição de espécies. Lepidópteros e Himenópteros têm bastante representação na literatura nessas pesquisas.

Embora todo esse potencial seja alvo de grande interesse e entusiasmo entre praticantes da ciência cidadã, existe também um debate intenso e importante sobre a qualidade dos dados produzidos por esses projetos (SERRET et al., 2019), já que a coleta de dados por pessoas não especializadas apresenta desafios de viés taxonômico e geográfico, por exemplo. Esse debate também inclui questões éticas e de privacidade acerca de informações pessoais.

Contribuições para os sistemas socioecológicos

As contribuições para os sistemas socioecológicos podem ser evidenciadas a partir dos estudos relacionados à ciência da ciência cidadã (VOHLAND et al., 2021) que, via de regra, reportam casos sobre a influência da ciência cidadã na formulação de políticas públicas, desenvolvimento de capacidades, engajamento do público, promoção da cidadania, inovação tecnológica etc (CRAIN; COOPER; DICKINSON, 2014; MADERSON; WYNNE-JONES, 2016). A Tabela 2 abaixo reúne alguns estudos que evidenciam tais contribuições.

Tabela 2: lista de contribuições da ciência cidadã para aspectos relacionados aos sistemas socioecológicos e polinizadores com respectivas referências.

Tema	**Referência**
Políticas públicas	(MADERSON; WYNNE-JONES, 2016)
Relação humano-natureza	(TOOMEY; DOMROESE, 2013a; SHARMA et al., 2019)
Compreensão de fatores relacionados ao engajamento	(GEOGHEGAN et al., 2016; DOMROESE; JOHNSON, 2017; KLEINKE et al., 2018; RICHTER et al., 2018)
Estabelecimento de novas redes, fomento a sustentabilidade e compreensão de sistemas socioecológicos	(CHEN et al., 2017; QUEIROZ-SOUZA, 2017; KOFFLER et al., 2021; QUEIROZ-SOUZA et al., 2023; VIANA et al., 2023)

Contribuições para os indivíduos

Evidências sobre as contribuições para os indivíduos, e aqui me refiro aos cientistas e aos participantes envolvidos como voluntários nos projetos. As contribuições podem ser de diversas ordens como, por exemplo, educacionais, psicológicas, sociais, de carreira etc., e, via de regra, essas não acontecem de maneira isolada (PETER et al, 2021). Também estimulam atividades ao ar livre e melhoram o bem-estar, conexão com a natureza (HUSK et al 2016) É extremamente difícil mensurar, avaliar e sistematizar essas contribuições e identificar se elas possuem uma relação causal direta com a conservação. Na literatura, os estudos costumam fazer um recorte temático e investigar um conjunto específico de variáveis, mas raramente se baseiam em um modelo teórico que possa explicar as relações causais dessas contribuições para a conservação.

Primeiramente destaco o envolvimento e a contribuição com a ciência, bem como, aprendizado que potencialmente implica em educação e alfabetização científica (KREMEN et al 2011). Pesquisas que investigam o aprendizado dos participantes indicam o ganho de habilidades científicas formulação de hipóteses e proposição de questões) (Peter et al 2021). Outra contribuição versa sobre conexão com a natureza, o que para insetos é particularmente importante, pois as pessoas costumam ter muito medo ou nojo. A apreciação pela diversidade e beleza dos insetos pode ser bastante benéfica para sua conservação, pois isso agrega ao discurso de conservação. No livro *Silent Earth* (Terra Silenciosa em tradução literal), Dave Goulson, dedica um capítulo inteiro para falar sobre como a apreciação por insetos pode despertar o interesse pela conservação de insetos. A ciência cidadã com insetos polinizadores é uma forma de canalizar e catalisar isso. Estudos sobre o tema indicam que as pessoas têm mais apreciação pelos insetos polinizadores ao participarem dos projetos (TOOMEY; DOMROESE, 2013b).

Tabela 3: lista de contribuições da ciência cidadã focada em polinizadores para os indivíduos e polinizadores com respectivas referências.

Tema	**Referências**
Novas habilidades	(BLOOM; CROWDER, 2020) (ASHCROFT; GOLLAN; BATLEY, 2012; BLOOM; CROWDER, 2020)
Aprendizado sobre polinizadores e polinização	(KREMEN; ULLMAN; THORP, 2011; DOMROESE; JOHNSON, 2017; PETER et al., 2021)
Bem-estar, sentimentos positivos, motivações, atitudes e comportamentos pró-polinizadores	(TOOMEY; DOMROESE, 2013b; DEGUINES; PRINCÉ, 2020; STURM et al., 2021)
Alfabetização científica	(KREMEN; ULLMAN; THORP, 2011; MCKINLEY et al., 2017; PETER et al., 2021)

Habilidades de pesquisa inter-transdisciplinar entre cientistas, uso da ciência	(VIANA; SOUZA; MOREIRA, 2020)

O contexto e o desenvolvimento da ciência cidadã em cenários distintos - Status da ciência cidadã focada em polinizadores no Brasil e no Reino Unido

No Brasil, há dez anos não se falava em ciência cidadã com polinizadores. O interesse é bastante recente com registro de teses e dissertações focadas no tema a partir de 2017 com crescente interesse ao longo dos anos (QUEIROZ-SOUZA et al., 2023; RUMENOS et al., 2023). Por exemplo, o projeto Guardiões da Chapada iniciou-se em 2015. Muitos projetos têm como origem em Universidades Públicas e são financiados por projetos de pesquisa. No Reino Unido, os projetos são mais antigos e com diferentes fontes de financiamento e origem (ONG's, Universidades etc.), por exemplo, Butterfly Conservation que se originou com um grupo de naturalistas no ano de 1968.

Tabela 4: Lista não exaustiva de projetos de ciência cidadã focados em polinizadores do Brasil e Reino Unido.

País	**Projetos de ciência cidadã focados em polinizadores**	**Fonte**
Reino Unido	B lines Scotland	https://www.buglife.org.uk/our-work/b-lines/b-lines-scotland/
	Bee Saviour Behaviour	https://saviourbees.co.uk/
	Bee Watch	https://beewatch.abdn.ac.uk/beewatch/index.php?r=user/auth
	Bees of Bensham	https://www.inaturalist.org/projects/uk-ivy-bees
	Bees Wasps and Ants Recording Scheme	https://www.bwars.com/
	Blooms for bees	https://twitter.com/ynuorg
	British Bee	https://twitter.com/britishbee
	British moths	https://www.ukbutterflies.co.uk/index.php
	BumbleBee Conservation Trust	https://www.bumblebeeconservation.org/

Bumblebee Monitoring Scheme	https://biodiversityireland.ie/surveys/bumblebee-monitoring-scheme/
Butterfly Conservation	https://butterfly-conservation.org/
Butterfly Conservation Yorkshire	https://butterfly-conservation.org/in-your-area/cumbria-branch
Butterfly Monitoring Scheme (Butterfly Monitoring Scheme and Wider Countryside Butterfly Survey)	https://ukbms.org/
Cumbria Butterflies	https://friendsoftheearth.uk/bee-count
Helping Scotland's Pollinators	https://www.nature.scot/scotlands-biodiversity/helping-scotlands-pollinators
Moth Night	https://www.mothnight.info/
National wasp Survey	https://www.bigwaspsurvey.org/
Pollenize	https://www.pollenize.org.uk/
Polli:Nation (OPAL Surveys)	https://www.imperial.ac.uk/opal/surveys/pollinationsurvey/
Pollinator Project	https://twitter.com/Blooms_For_Bees
Team Pollinate	https://www.teampollinate.co.uk/
The Buzz Club	https://www.thebuzzclub.uk
The Great British Bee Count	https://twitter.com/BritishMoths
The Hoverfly Recording Scheme	https://dipterists.org.uk/home
The Insect Survey	https://www.rothamsted.ac.uk/insect-survey
Thriving Hive	https://twitter.com/HiveThriving
UK Butterflies	https://twitter.com/pollinatorproj
UK Ladybird Survey	https://www.coleoptera.org.uk/coccinellidae
UK Pollination Monitoring Scheme	https://ukpoms.org.uk/
Urbanbees	https://www.urbanbees.co.uk/
Wider Countryside Butterfly Survey	https://butterfly-conservation.org/our-work/recording-and-monitoring/wider-countryside-butterfly-survey
Wild live trust	https://twitter.com/WildlifeTrusts
Yorkshire Naturalists	https://twitter.com/BC_Yorkshire

Brasil	Abelha Procurada	http://abelhaprocurada.com.br/
	Abelhas de Uberlândia	https://www.inaturalist.org/projects/abelhas-de-uberlandia
	Bee Alert	https://www.semabelhasemalimento.com.br/plataforma-bee-alert/
	Bee Keep	https://www.instagram.com/beekeep.life/
	Guardiões da Chapada	https://guardioes.cria.org.br/
	Guardiões dos Sertões	https://guardioes.cria.org.br/
	SOS Abelhas sem Ferrão	https://sosabelhassemferrao.com.br
	Listas Ecológicas de Espécies de Borboletas (LEEB)	leeb-mab-ictbio.blogspot.com
	New record of the threatened butterfly *Drephalys mourei* (Hesperiidae) in a heavily disturbed area in Southeastern Brazil	https://bioone.org/journals/the-journal-of-the-lepidopterists-society/volume-71/issue-4/lepi.71i4.a1/New-Record-of-the-Threatened-Butterfly-Drephalys-mourei-Hesperiidae-in/10.18473/lepi.71i4.a1.full
	Plantas visitadas por abelhas africanizadas na Região Sul do Tocantins	https://revistas.aba-agroecologia.org.br/cad/article/view/4542

Em que direção a ciência cidadã aumenta o uso da ciência na conservação de polinizadores?

Em suma, a tese de que a ciência cidadã contribui para a conservação de polinizadores parece ser bastante positiva na literatura, mas isso é pouco embasado em evidências empíricas do seu alcance (BELA et al., 2016). Nesse sentido, investir em formas de avaliar como a ciência cidadã, um modo de co-produção, está contribuindo para aumento do uso do conhecimento e, consequentemente, conservação de polinizadores é uma questão essencial para fundamentar e orientar ações que permitam ampliar as iniciativas. Do mesmo modo, investigar quais são as barreiras e motivações para o engajamento das pessoas na ciência cidadã focada em polinizadores é essencial para subsidiar o desenho de estratégias, reconhecer interesses do público e orientar iniciativas. Diante dessas lacunas, a seguir no Capítulo II endereçamos estas questões perguntando a coordenadores de projetos quais são suas percepções sobre o impacto da ciência cidadã na conservação de polinizadores.

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Capítulo II – Unveiling Perspectives: Exploring Coordinators' Perspectives on the role of Citizen Science in Pollinator Conservation

Artigo submetido no periódico *Conservation Biology*

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Abstract

Pollinators and the ecosystem services they deliver are under threat. Citizen science is viewed as a way to rapidly improve insect conservation, by helping with knowledge production and public engagement in conservation actions, among other outcomes. However, understanding how the potential of citizen science is perceived among citizen science coordinators is lacking. Here, we used Q Methodology to investigate how citizen science coordinators from UK and Brazil think about the importance of citizen science to the conservation of pollinating insects. We found three viewpoints present among the interviewees: (1) citizen science has a dual purpose, delivering both scientific and public engagement outcomes, (2) citizen science can be limited in scope; and (3) citizen science for citizens with limited outcomes. The first one is more broadly defined and understands that citizen science is useful for both science and society. The second one considers citizen science a good approach for conservation, but is more critical about its scope, for both conservation decisions and education or engagement.

The third one considers that citizen science is only useful as a way to engage or educate people. The viewpoints differ mainly over the role of citizen science in pollinator conservation to provide useful scientific data that can be used to inform pollinator conservation. The idea that citizen science promotes people's engagement with and awareness of pollinators, helping them to be connected with nature and enhancing their interest in pollinator science was consensual among the viewpoints. On the other hand, the data quality for knowledge production and decision making were controversial among viewpoints. Unveiling these perspectives is key to understanding how citizen science is approached by coordinators who take decisions in the projects, and helps to inform how can we upscale this approach to promote effective conservation of pollinating insects.

Introduction

Pollinators and the ecosystem services they deliver are under threat due to anthropogenic drivers (Potts et al., 2010, 2016; Dicks et al 2021). The IPBES (2016) synthetised evidence about the main threats to pollinators and highlighted over 70 responses to those threats. The application and effectiveness of these responses, or pollinator conservation actions, depend on a collective effort involving various social actors (*e.g.*, scientists, farmers, civil society) who can directly or indirectly take action towards pollinator conservation. Pollinator conservation requires coordinated, integrated strategies implemented at a range of scales and levels of governance, with key elements including long-term monitoring, raising public awareness, and encouraging public participation in pro-pollinator actions (Stout & Dicks, 2022).

Citizen science, a term applied to describe a variety of public engagement in science, is often viewed as a way to achieve or encourage pollinator conservation action (Haklay et al., 2014). Diverse initiatives around the world aim to increase awareness about the importance of pollinators, especially insect pollinators, while contributing data for ecological research across ranges of time and space that are unachievable by other means. There are, however, some concerns about the scientific quality and usability of these data (Kremen et al., 2011). For example, species monitored in more accessible areas – geographical bias –, and more conspicuous species monitored – taxonomic bias (Pereira et al 2024).

Citizen science projects have a variety of ways to engage people in science. Shirk et al. (2016) presented a typology of projects based on the level of participation, dividing them into contractual (professional scientists are asked by communities to conduct specific research), contributory (projects designed by scientists in which the public help with data collection), collaborative (projects designed by scientists in which the public help with data, design, analyses, etc.), co-created (projects designed by scientists and the public), and collegial projects (non-scientists conduct research independently from scientific institutions and their recognition).

Citizen science initiatives can deliver different impacts or outcomes (Shirk et al., 2012; Wall et al., 2017). Literature shows that the approach can contribute to expanding scientific evidence about pollinator species and how environmental changes affect them (Whitehorn et al., 2022), help to improve public perception and knowledge of insect pollinators (Domroese & Johnson, 2017; Ratnieks et al., 2016), foster pro-pollinator actions (Toomey & Domroese, 2013a) and can be used to investigate pollination services and plant-pollinator interactions (Birkin & Goulson, 2015; Gazdic & Groom, 2019). In a broad way, citizen science is viewed as an approach to achieve sustainable development (SDGs) goals (Koffler et al., 2021). By requiring that scientists work with non-academic stakeholders, it also represents the kind of inter- or transdisciplinary approach that Bartomeus and Dicks (2019) (Bartomeus & Dicks, 2019) argue is needed to improve pollinator conservation efforts.

Realising these impacts of citizen science depends on strategies that project coordinators use to engage participants (recruitment and training), to answer scientific questions (data collection protocols), to communicate results (scientific communication and sharing the project results) and so on (Lewandowski and Specht 2015). Strategies, in turn, are based on the viewpoint of citizen science coordinators, who are – usually – responsible for making or managing decisions inside the projects. In general, studies about coordinators' views are less frequent in comparison to those that investigate volunteer outcomes (Wehn & Almomani, 2019a). Recent literature has been exploring how citizen science coordinators think about citizen science theory and practice, using case studies, focal groups, and surveys. This research has shown how coordinators can facilitate volunteer recruitment and retention (Bell et al., 2008), coordinator's views about public engagement (Golumbic et al., 2017), their perspectives on definitions of citizen science (Haklay et al., 2014), their engagement and beliefs in citizen science monitoring and data management (Viana, Queiroz-Souza, and Moreira 2020; When and Almomani 2019b) or how they conceive of participants' motivations to be involved in citizen science (Hobbs & White, 2012).

None studies that we know quantitatively address how coordinators perceive the contribution of citizen science to biodiversity conservation and how these perceptions are shared among coordinators working in different contexts (Haklay et al. 2014; When and Almomani 2019a). For example, there is an expectation that a citizen science approach has the potential to contribute to the learning of both scientists and participants. However, Bela et al. (2016) showed that much of the contribution of citizen science is not based on, or evaluated by empirical observation, but rather on positive assumptions made by coordinators about the potential of citizen science. Investigating how coordinators think about citizen science can allow us to make these assumptions explicit and to understand how they influence the practices and strategies of citizen science project coordinators.

In our study we investigate how citizen science coordinators of pollinator-focused projects from Brazil and the UK evaluate the impact of citizen science for pollinator conservation. Understanding their viewpoints is a starting point to highlight the supporting ideas that targets citizen science projects efforts and, consequently, their current impacts on pollinator conservation (e.g., data collection or raise public awareness). We use Q-methodology, a powerful quali-quantitative approach useful to access people's shared opinions about a specific controversial subject (Watts & Stenner 2012). Using Q-methodology, we analyse how coordinators rate the relative importance of the different impacts of citizen science projects in relation to the conservation of pollinators. We believe this method is a suitable to address our question, because there are controversial opinions around the potential of citizen science to achieve reliable impacts for the conservation of pollinators.

In this methodology, participants rate a set of previously selected statements (Q-set) in relation to each other, using an agreement scale, thus generating a Q sort. A Q sort is a pattern of distribution of statements that can be analysed in order to express a person's opinion about the subject under study. Once all Q sorts are collected their patterns are compared through factor analysis for identifying the common variance and then the similarities and differences among all participants' opinions (Zabala et al 2008).

For each of the viewpoints found, we drew a Theory of Change to make explicit its supporting ideas. For the sake of clarity, a Theory of Change visually represents the causal connections and order of events required for an activity or intervention to result in a desired outcome or impact. It works by providing a systematic and logical framework for understanding and planning the process of creating a change, in our case, a change in the priorities identified in each viewpoint factor. Additionally, it explicitly states the assumptions that underpin each stage of the process (Center for Theory of Change, 2013). By proposing a Theory of Change for each viewpoint we can make explicit the underlying assumptions and highlight the associated activities, strategies, and their potential outcomes in pollinator citizen science projects. It also helps other projects to plan their activities grounded in a logical framework, to increase the chances of obtaining expected outcomes and impacts.

Methods

Concourse and Q-set: design and content

We used relevant body of literature identified in a previous review (made in 2016, Queiroz-Souza, 2017), grey literature, pollinators citizen science project websites, conference talks (2020 and 2021), and the authors' prior knowledge as sources to collect a list of items (statements) that suggest a subjective viewpoint about the importance of citizen science to the conservation of pollinators (concourse). We classified these statements according to different potential impacts of citizen science (Table 1) and selected a representative sample of statements (Q-set). Figure 1 illustrates the stages followed. For each citizen science impact, we included more than one statement in the Q-set, because it might represent a different aspect of the impact. We invited a third expert to evaluate the original collection of statements (BFV). Two authors (CQS and LVD) followed the criteria suggested in Watts & Stenner (2012) and piloted the statements to review and reduce the Q-set when necessary. The final Q-set had 46 statements which were different answers to the question "*What is the purpose of citizen science focused on pollinators?"* (Appendix S1).

After that, we classified the statements in different themes, interpreted under the light of frameworks available in the literature (e.g., Shirk et al. 2012). We used a translation/back-translation procedure to ensure the statements were sufficiently similar to both Portuguese and English speakers. The statements were originally written in English and reviewed by an English native speaker. Then they were translated into Portuguese and a professional bilingual translator back-translated them into English. Then, both English versions were compared to check if the meanings were sufficiently similar, which was the case. We also used a script to standardize the interviews and ensure that all participants understand the procedure clearly.

Participants

To find potential participants, i.e., coordinators of pollinator citizen science projects in Brazil and the United Kingdom, we made an active search of citizen science projects in social media, scientific and grey literature, conferences, and by asking key informants through a webform (other citizen science practitioners and academics, nine in total).

We choose those countries due the huge differences in relation to citizen science tradition, for example in Brazil citizen science is more recent (Queiroz-Souza et al 2023). We found 30 projects focused on pollinators from Brazil and the UK and then emailed their coordinators to explain the research aims and invite them to take part in the study. Fourteen accepted to participate, but, among these, two declined later. Therefore, we interviewed 12 participants in total (7 from UK and 5 from Brazil). We arranged a convenient time for the interview, in which the coordinators participated after receiving the Participation Information Sheet and the Consent Form. The study followed the ethical procedures recommended by the legislation and was approved by ethical committees in both countries (UK: PRE.2021.101 and BR: CAAE: 55529621.0.0000.5531).

Administering the Q-sort

All the interviews were conducted online over Zoom® from February to July of 2022. The sorting procedure was conducted using *QSortware*®. Following a Q method online can create specific challenges for participants, for example understanding how the software works. In order to mitigate these difficulties, we made a short tutorial presentation showing how the Q methodology and the software work before they started sorting the statements. This presentation was also useful to standardize the interviews both in English and Portuguese. To start the procedure, the participants read all the statements and divided them into three piles (disagree, neutral, agree) in answer to the question: "*What is the purpose of citizen science focused on pollinators?*". All 46 statements had to be distributed following a normal distribution (Figure 2). After that, they made a fine distribution of the statements using a scale ranging from – 4 (strongly disagree) through 0 (neutral) to +4 (strongly agree). They had to follow a forced-choice distribution, i.e., each scale value had a pre-determinate number of statements that could be sorted into it (Figure 2). Although the interview overall took around one hour, we allowed participants to use the time they needed to do the sorting phase. The final result of this procedure was the Q sort, which was then used to carry out the quantitative analyses.

Once the participant finished the sorting, we asked them about the decisions made during the sorting which helped us to interpret the viewpoints. We also asked about the project typology according to the Shirk et al (2016) classification. Although we recognise this is not a general and definitive classification, we used it as a proxy to understand how coordinators established the relationship with participants. (Table 2)

Analyses

Quantitative analyses

The quantitative analyses were divided in two main phases: i. from Q sorts to factors; and ii. from the factors to factor arrays (Watts & Stenner, 2021; Zabala, 2008). We used R version 4.3.1 (R Core Team 2023) and the following R packages: paran v. 1.5.2 (Dinno 2018), corrplot v. 0.92 (Wei and Simko 2021), psych v. 2.3.12 (William Revelle 2023), qmethod v. 1.8.4 (Zabala 2014), tidyverse v. 2.0.0 (Wickham et al. 2019). The final purpose of this set of analyses was to create typical Q sorts (factor arrays) that represent shared viewpoints about the role of citizen science in pollinator conservation. Typical Q sorts were then used to interpret the qualitative interview data and to derive a proposed Theory of Change that describes the causal relations about citizen science mechanisms and impacts in each viewpoint.

To start the analyses, we digitised the data in a spreadsheet with the statements (rows) and participants (columns), in which for each cell we put the score attributed for each statement by each participant during the sorting phase. This means that each column represented one participant Q sort. The participants' Q sorts are considered as variables in the Q-Methodology rather than as samples. After that, we analysed the correlation between each pair of Q sorts (using Pearson's *r*). Then we used the correlation matrix (Q sort *x* Q sort) to identify the common variance between Q sorts (high values of correlation). We then used the correlation values between Q sorts to reduce them into a few components through principal component analysis (PCA) (Zabala 2014). At this point, we extracted seven unrotated factors – the default number in Q studies – with decreasing explanatory power. For each factor extracted we calculated the unrotated factor loadings, i.e., the coefficient correlations, between the Q sort and the unrotated factor. Those measures allowed us to understand the extent to which each Q sort was typical of each factor. At the end of these analyses, we obtained a matrix representing the correlations between each Q sort and all factors extracted. A calculation of the explanatory potential of each factor was made through eigenvalues by summing the squared loadings of all Q sorts on one factor.

Once we got the unrotated factors, we followed with the second phase of analysis. First, following Watts & Stenner (2021) we applied Eigenvalues (Kaiser-Guttman), Humphrey's rule, scree test and parallel analysis criteria (Appendix S2) to decide how many factors would be rotated. These methods differ in the subjacent information used to decide the number of factors to be included in final analysis. For example, Kaiser cut-off criteria states that the factors with eigenvalues over 1.00 should be considered, in the other hand, scree test suggests a visual analysis of the relationship between number of factors and eigenvalues. To avoid an arbitrary decision based on only one method, we used four methods combined, giving more robustness to our decision.

We then followed to the factors' rotation. The rotation procedure essential to approximate factors to a particular group of Q sorts such that the best explanation of the viewpoints of each factor can be obtained. The abovementioned criteria applied indicated that three factors would be enough for rotation. We did a varimax rotation of three factors, keeping an orthogonal relation between them to keep a zero-correlation between factors (Brown 1986). This is appropriate because we want to find group of non-correlated opinions. We also calculated the rotated factors loadings and flagged both the Q sorts with significant loads on only one factor and the Q sorts with the square loading on a factor larger than the sum of the squared loadings on every other factor (See Zabala, 2014).

The next step was calculating the scores of the statements for each factor (z-scores and factor scores) to achieve the factor array, i.e., a typical Q sort that represents the viewpoint expressed by that factor. Finally, we compared the factors to identify and explain similarities and dissimilarities between the viewpoints. Two statistics were calculated: i. salience – how strongly in terms of either agreement or disagreement each statement was ranked across typical Q sorts; and ii. level of disagreement – differences in the ranking of each statement across typical Q sorts. Statements with above-average salience and above-average standard deviation show disagreement. Statements with above-average salience and low standard deviation show agreement (Bertuol-Garcia et al., 2018; Neff & Larson, 2014).

Qualitative Analysis

Factor Interpretation and proposition of a Theory of Change

To interpret each factor, we used a systematic procedure proposed by Watts & Stenner (2012). For each factor we filled a token classifying the statements in four categories (items ranked at +4 ranked higher in each factor array than in other factors arrays, items ranked lower in each factor array than in other factors arrays ranked at -4) (Appendix S4). This procedure allowed us to understand how one factor viewpoint was polarized by itself and relative to the other factors. At the end of the interpretation, we gave a general name and summary for each factor viewpoint. Finally, we proposed a Theory of Change that explains how each viewpoint potentially influences projects aims, decisions, and efforts. The Theory of Change was based on the interpretation procedure and the general idea of each viewpoint to make explicit the preconditions and causal pathways that promote citizen science having the expected impacts on pollinators conservation according to each viewpoint.

Results

We interviewed 12 citizen science coordinators (7 from the UK and 5 from Brazil). Three factors emerged from our analysis that together explained 74% of the variance.

Table 3 summarises the Q sorts that loaded significantly with each factor (flagged Q sorts), the variance explained by each factor individually, and the correlation coefficient between factors.

Here we describe the viewpoint associated with each factor and present a Theory of Change that makes explicit the causal connections leading from a particular citizen science project to the expected impacts.

Viewpoint 1: Citizen science has a dual purpose, delivering both scientific and public engagement outcomes

Factor 1 (Figure 3) had an eigenvalue of 4.2 and explained 35% of the variance. Six participants were significantly associated with this factor. Four of them were from Brazil (three females and one male) and two from the UK (one male and one female). Four of these were classified by coordinators as both contributory and collaborative projects, one as collaborative and one as co-created by public members, without scientists.

For these participants, citizen science is definitely a good way to improve pollinator conservation, because it produces good data (13: -2; 12: -1, indicating *statement number :scale rank* in Table 4), and also because it is an approach that makes people part of scientific knowledge production (1: +4). From their perspective, the purpose of citizen science focused on pollinators is, in the first place, to improve people's understanding of how science works (2 : +4), as well as ensuring their access to knowledge about pollinators (3: +3). Secondly, it also helps us to understand how pollinators use resources in the landscape (11: +1) and encourages people to protect native species (22: +2).

This viewpoint also includes the idea that citizen science focused on pollinators is open to everybody, not only to privileged people (17: -4), although people who already have an interest in nature are potentially more likely to engage in such projects (30: 0). It is committed to the idea that even though citizen science focused on pollinators does not necessarily encourage people's involvement in decision making (21: 0), the knowledge and data produced can be useful and usable to both scientists and other stakeholders (32: -1; 33: -3). Accordingly, data quality in citizen science is good, being neither imprecise nor biased (12: -1; 13: -2), and the diversity of protocols does not make integration difficult (37: -2).

These participants also considered citizen science as an approach that neither burdens scientists (6: -4) nor overwhelms participants (19: -3). For them, citizen science projects play multiple roles, promoting people's understanding of scientific methods and science (5: -4), increasing positive emotions (45: +1), helping with open data (20: +4), and promoting inclusivity (29: -3). However, they endorse the idea that this approach can lead only to the protection of the most well-known species (16: +3).

Potential Theory of Change for viewpoint 1:

Factor 1 highlights that the public participation in citizen science projects leads to more awareness and knowledge among participants and this also implies more pro-pollinators actions. In parallel this viewpoint agrees that citizen science produces good scientific data and consequently creates more scientific information, especially ecological knowledge that informs conservation. Here, citizen science focused on pollinators has impacts on both public engagement and science.

Viewpoint 2: Citizen Science can be limited in scope

Factor 2 (Figure 4) had an eigenvalue of 3.1 and explained 26% of the variance. Five participants loaded significantly with this factor, four from the UK (two males, two females) and one from Brazil (female). Three projects were classified as contributory, one as collaborative and one as mixed, considering that during the project varied from co-created to collaborative, to contributory.

Clearly, concerns about biases are important in this perspective, either because of conspicuous species and geographic monitoring biases that can affect data quality, or because of the profile of people engaging in citizen science pollinator projects (8: +4; 38: +4). Despite these concerns, the participants associated with factor 2 perceived citizen science data as useful for science and decision making (14: -4). Also, they agreed that this is an approach that goes beyond scientific goals (4: +3), helping to achieve urgent demands related to pollinator conservation (18: -4; 31: -4) and informing policy (15:+2). However, they recognize that data integration from different projects protocols can constrain the usability of data (37: +3).

In this factor we find a neutral perspective concerning whether citizen science can help the protection of the best known species (16:0), the formulation of pro-pollinator policies (35:0), the promotion of open data (20:0). Such a neutral standpoint was also found in relation to the understanding of citizen science as a two-way tool for scientific communication (25: 0). In comparison with the other factors, participants associated with factor 2 tended to disagree more with the use of different academic disciplines to conserve pollinators (9: -1).

A perception that citizen science engages richer and more highly educated people (29: +2), but it is not open only to the privileged ones, was also related to this factor (17: -1). Moreover, it was considered that citizen science increases public awareness of the importance of pollinators in general, but can be less applicable when it represents a target action, such as, for example, controlling invasive species (23: -3). Statements related to pro-pollinator actions had minimal representation in this factor.

Potential theory of change for factor 2:

For this factor, citizen science data has an impact on the scientific information that leads to improved ecological knowledge and, then, informs conservation. However, the data quality and range are questionable and need careful attention.

Viewpoint 3: Citizen Science for citizens with limited outcomes

Factor 3 (Figure 5) had an eigenvalue of 1.3 and explained 13% of the variance. Only one participant from UK (female) loaded significantly with this factor. Here the project was classified as collegial, with some limitations within this.

In some aspects, this factor amounts to an intermediary point of view between factors 1 and 2. It highlights the purpose of citizen science as an interactive and inclusive science engagement practice, as found in factor 1 (1: +4), but also considers that it engages people who is already interested in environment or nature (30: +4), similarly to factor 2. At the same time, the viewpoint associated with this factor perceives that citizen science increases public awareness of pollinators' importance (46: +4), which is a consensus among the three factors.

Critics of the use of citizen science data for pollinator research are clearly situated here. The person who correlated with this factor presented a strong agreement with the imprecision and unreliability of citizen science data (13: +3; 14: +3) and also slightly agreed that citizen science is useful as an engagement strategy, but it is not for science (18: +1). This viewpoint regards the usefulness of citizen science data for decision making as limited (33: +1) and is neutral about the production of knowledge through citizen science (10: 0). However, it also considers citizen science as a good way of fundraising for pollinator research (43: +2).

In this factor citizen science is viewed as a way to improve science communication (25: +2) and to reduce the knowledge gap about pollinators in society (27: +2). However, this approximation between science and society is perceived as showing limitations. For example, citizen science is regarded as not capable of increasing public understanding or appreciation of scientific knowledge or how science works (3: -1; 5: 0). Citizen science is also considered unable to help make science more transparent or to overcome denialism (26: -3).

Clearly, from the perspective associated with this factor, citizen science does not promote targeted and practical pro-pollinator action (34: -4; 40: -4; 44: -4) and does not incentivise people to talk more about pollinator science (24: -2). Also, citizen science is regarded as limited in its ability to bridge the gap between science and policy (35: -2) and less effective than conventional science in achieving pollinator conservation goals (36: -3).

Potential Theory of Change for viewpoint 3:

Viewpoint 3 presented a causal relation between outreach and public awareness of pollinating insects. The connections between citizen science data and scientific information are not established, and citizen science is focused mainly on public engagement.

Consensus and conflicting statements across factors

Based on the salience and standard deviation, nine and thirteen statements were central for consensus and conflicting opinions across factors, respectively (Appendix S3). Among the three factors there was a consensual idea that citizen science promotes people’s engagement with and awareness of pollinators, helping them to be connected with nature and enhancing their interest in pollinator science. Also, it was consensual among factors that the knowledge produced by citizen scientists is open to scientists and other stakeholders and does not overwhelm people. Citizen science was not regarded as more effective than traditional science in achieving pollinator conservation goals, although it might help meet the urgent conservation demands.

Thirteen statements had conflicting status between pairs of factors. For example, the understanding that “citizen science burdens scientists” (statement 6) was less divergent between factors 1 (“Citizen science has a dual purpose”) and 2 ("Citizen Science can be limited in scope”) in comparison to factor 3 ("Citizen Science for citizens with limited outcomes”). Other aspects with conflicting opinions were: the bias towards conspicuous species in citizen science, data usefulness, data quality for decision making or scientific knowledge production, and accessibility and inclusiveness of citizen science projects (Table 4).

Discussion

In our study three viewpoints about the role of citizen science in relation to the conservation of pollinators were found among project coordinators: citizen science has a dual purpose, delivering both scientific and public engagement outcomes (viewpoint 1); citizen science can be limited in scope (viewpoint 2); and citizen science is useful for citizens with limited outcomes (viewpoint 3). Here we will link the identified viewpoints with the existing conceptualizations of citizen science theory and practice (e.g., R. Bonney et al. 2015; Rick Bonney et al. 2009; Dickinson et al. 2012; Shirk et al. 2012).

One common conceptualization organizes citizen science projects into types based on the level of participants’ engagement, describing them as contributive, collaborative and co-created, among others (e.g., Shirk et al 2011). Different outcomes and impacts are expected from each project type for science, socioecological systems and individuals (Shirk et al. 2016). For the first viewpoint (“*citizen science has a dual* *purpose, delivering both scientific and public engagement outcomes"*) scientific outputs and learning outcomes are the main roles of citizen science focused on pollinators. This viewpoint was associated to the majority of interviewed coordinators. It is well aligned with the idea of pollinator-focused citizen science having a win-win purpose, i.e., scientists and volunteers receiving benefits, while projects outcomes and impact help pollinator conservation (Cooper & Lewenstein, 2016). This viewpoint includes the idea that citizen science provides good data, which are greatly needed to understand the status of pollinators, especially in regions like Africa where the evidence is lacking (IPBES, 2016; Dicks et al 2021). It also embraces the idea that citizen science increases people's knowledge about how science works, which is considered a good outcome for volunteer participants (R. Bonney et al., 2015; Toomey & Domroese, 2013b). Although knowledge is a fundamental aspect, Phillips et al. (2019) propose that engagement is multidimensional and involves not only knowledge, but also emotions, behaviour, and social connections.

A more critical view about the purpose of citizen science is presented by viewpoint 2 (*"citizen science can be limited in scope"*). Although this viewpoint agrees that citizen science is good for pollinator conservation, concerns about the data generated by the projects are clear here. Citizen science data quality is one of biggest concerns among the scientific community, due to the fact that they are collected by people with no or low scientific training. Strategies focusing on people's scientific training are quite important, then, to allow data use and integration (Danielsen et al. 2014; Lewandowski and Specht 2015). It is important to mention that biases are also present in traditional research and modelling can be used to solve it (Sobral-Souza et al 2021). In terms of engagement, this viewpoint embraces the idea that citizen science has limited capacity to find new audiences and that additional efforts are necessary to engage people who are not interested in nature in the first place. Although it is claimed that citizen science is democratic and open to all, many barriers can limit people's engagement (Lynch et al. 2023).

Finally for the third viewpoint, citizen science is more focused on engaging people in pollinator conservation but does not inform science as much as needed. For this viewpoint a conciliation between scientific and engagement outcomes is hard to achieve and, accordingly, the important role of citizen science in promoting people's awareness about pollinators and pollination is achieved at the expense of scientific outputs. Literature says that although environmental awareness is an important aspect for pollinator conservation, in a citizen science context it is expected that people participate in genuine scientific investigation (Queiroz-Souza et al 2023), which is in contrast to what this viewpoint presents.

Differences and complexity across viewpoints about pollinator citizen science

We found three main areas of conflict across the viewpoints. The first concerns the potential of citizen science for engagement and inclusiveness. This is well discussed in the literature, which shows that sociodemographic factors are quite important determinants for recruitment and retention in citizen science projects (Lynch & Miller, 2023; Pateman et al., 2021). Usually, project volunteers are biased towards male, retired, and middle-class participants. The second area of conflict is over whether citizen science can reach and influence decision making. The literature points to some pathways and evidence for citizen science informing decision making, through individual and collective policy actions (Mckinley et al., 2017; Ramirez-Andreotta et al., 2014). This conflicting viewpoint can be associated with other projects aspects, such as, for example, typology and project aims and intentions to apply scientific knowledge in decision-making (Lewandowski & Oberhauser, 2016)

The third conflicting stance is about the real contribution of citizen science to scientific knowledge in terms of data quality, and the balance between engagement and volunteer knowledge acquisition, and scientific advances. This is also a non-consensual aspect in scientific literature. On one side, there is a perspective that citizen science fosters data at the expense of people learning and on the other side that citizen science prioritizes education and outreach instead of data or scientific knowledge. Most of this discussion relies on the roots of the citizen science concept and practice (Ceccaroni et al., 2016) and usually draws on the citizen science concept adopted by specific projects under consideration and its influence on the practices adopted (Cooper & Lewenstein, 2016; Lewenstein, 2015).

Exploring these viewpoints quantitatively and qualitatively allows us to identify different expectations about the potential of citizen science for pollinator conservation and helps to inform practices that the projects can adopt. We made explicit the preconditions and causal pathways through which citizen science can have the expected impacts on pollinator conservation. We investigated two contrasting contexts (Brazil and UK) as examples, but due to the huge variety of contexts in which citizen science can be applied, we expect that different viewpoints might arise in different scenarios. From the three viewpoints we found in our study, the outcomes and impact of citizen science will have different contributions to pollinator conservation.

From these results, and considering this as one of the most important contributions of this work, we recommend that citizen science coordinators pay attention to the theory of change underlying their projects. We believe such attention will direct the design and management of projects, help team members understand why and how some decisions are made, and potentially serve to align different viewpoints within a team. The viewpoints explicated in our study might act as a starting point, however it is worth mentioning that, as expected in Q-methodology studies, the inclusion of other participants from different contexts (e.g., citizen science coordinators from other countries) could highlight other different viewpoints than the ones found here.

Conclusions

This study presents a novel use of Q-methodology to investigate citizen science coordinators' viewpoints about the role of citizen science in pollinator conservation. We have shown how different viewpoints prioritise different impacts of citizen science. To the best of our knowledge this is the first study that quantitatively explores citizen science experts' views about their practices and expectations about pollinator conservation through citizen science, using Q methodology.

It is important to note that the majority of our coordinators were associated with the first viewpoint, indicating that citizen science efforts intended to engage in conservation *and* produce scientific outputs probably represent the majority of citizen science projects focused on pollinators. We believe that the conflicting aspects across viewpoints can be used as a source of discussion within projects. It seems important to make explicit the priorities that are driving decisions and expected impacts; arguably, this is more important than understanding a project's position in a typology.

We found that project coordinators have really different views about the role of pollinator citizen science in generating useful scientific data. This is important because pollinator data from citizen science approaches is increasingly being used to inform pollinator conservation, and embedded into monitoring programmes at national level. From some perspectives, this is the main purpose, rather than having an engagement/educational role. Therefore, it seems really important to understand why some coordinators hold the view that the data are low quality, while others do not.

Future research aiming to understand the factors driving this perception related to data quality is much needed.

Finally, understanding perspectives among experts highlights the underlying assumptions of citizen science theory and practice. Most of the current literature in this area aims to understand and describe the diverse definitions of the term “citizen science”, rather than its link to practices and impacts on conservation. We recommend that future research focuses on understanding whether different concepts of citizen science affect the design of projects or the expected outcomes and impacts. The same set of statements can be used to test how viewpoints are shared among citizen science coordinators in other regions of the globe. Although the Q-methodology is very useful to understand shared viewpoints, other methods, e.g., expert judgment, can help to understand what outcomes and impacts from citizen science projects are more important to conserve pollinators (e.g. Dicks et al 2015).

Support Information

Additional supporting information may be found in the online version of the article at the publisher’s website. Appendix S1 provides the statements list. Appendix S2 reports the analytical tests. Appendix S3 reports true and false for conflicting or consensus among statements. Appendix S4 provides crib sheet for the three factors interpretation.

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Table 1: Different impacts of citizen science for conservation.

General Impact	Description	References
Education	Improves knowledge gain (e.g., learn about pollinators)	(Burns et al., 2021; Jordan et al., 2011; Land-Zandstra et al., 2016)
Data provision	Helps to find rare organisms, to identify species declines, etc.	(Birkin & Goulson, 2015; Kadoya et al., 2009; Kadoya & Washitani, 2010)
Environmental behaviour	Promotes changes in intentions or behaviours	(Sturm et al., 2021; Toomey & Domroese, 2013a)
Science literacy	Improves science understanding	(Roger et al., 2018)
Scientists' learning	Improves communication skills and learning with communities (non-scientists)	(Kleinke et al., 2018; Roger & Klistorner, 2016)
Scientific knowledge	Produces new statistical tools, protocols, identifies new patterns, leads to data storage and understanding of socioecological systems	(Donovall et al., 2008; Whitehorn et al., 2022)
Science practice	Provides funding, infrastructure	(IPBES, 2016; Stout & Dicks, 2022)
Policy	Informs and promotes pro-pollinators policies	
Social	Helps public participation, democratization of knowledge, accessibility	(Lynch & Miller, 2023; Richter et al., 2018)

Table 2: Semi-structured interview questions

Questions
How did you find the statements?
What do you think about the statements? Did them make sense for you?
Do you think the statements are well-related with the main question about citizen science and pollinators?
What did you have in mind while sorting the statements?
Could you please give me a rationale for raking items in the extreme columns?
Would you create a new statement for this set if you could?
Are there any items that you did not understand?
What is the type of your citizen science project? If your project does not fill in one type only, which one is predominant? (we displayed one slide presenting the typology based on Shirk et al 2016).

Table 3: Q-sorts that loaded significantly with each one of the factors. Numbers represents Q-sorts.

Factor	Flagged Q-sort	Eigen values	Explained variance	Correlation with other factors		
				F1	**F2**	**F3**
F1: Citizen Science has a dual purpose	$4_{(UK)}$; $6_{(UK)}$; $8_{(BR)}$; $9_{(BR)}$; $10_{(BR)}$; $11_{(BR)}$ (6 Q-sorts)	4.2	35%	-	0.48	0.24
F2: Citizen Science can be limited in scope	$1_{(UK)}$; $3_{(UK)}$; $5_{(UK)}$; $7_{(UK)}$; $12_{(BR)}$ (5 Q-sorts)	3.1	26%	-	-	0.33
F3: Citizen Science for citizens with limited outcomes	$2_{(UK)}$ (1 Q-sort)	1.6	13%	-	-	-
Total explained variance			74%			

Table 4: The 46 statements sorted by standard deviation. z-scores and respective factor arrays, salience and standard deviation are also presented. High salience indicates that the statement had a high contribution to the conflicts and agreements in perspectives across factors (either consensus or conflicting). High standard deviation indicates conflicting opinions across factors. Bold rows represent statements with above-average salience. [a] consensus across factors (above-average high salience and below-average standard deviation). [b] conflicting viewpoints across factors (above-average salience and below-average standard deviation).

No	Statements	Factors						Salience	Standard deviation
		F1		F2		F3			
		z-score	rank	z-score	rank	z-score	rank		
41	Citizen science helps people achieve their own environmental ambitions	0.22	0	0.17	0	0.00	0	0.13	0.12
45	Citizen science increases positive emotions towards pollinators	0.68	1	0.86	2	0.90	2	0.81	0.12
39	**Citizen science helps to spark interest and involvement in pollinator science [a]**	**1.07**	**3**	**1.24**	**3**	**1.35**	**3**	**1.22**	**0.14**

7	**Citizen science makes people feel more connected to pollinators [a]**	**1.08**	**3**	**1.39**	**3**	**1.35**	**3**	**1.27**	**0.17**
42	Citizen science is a good approach for getting funding for pollinator research	-0.17	0	0.21	0	0.00	0	0.12	0.19
4	**Citizen science successfully combines public engagement in pollinator conservation and outreach goals with scientific goals [a]**	**0.89**	**2**	**1.24**	**3**	**0.90**	**2**	**1.01**	**0.20**
27	Citizen science helps to reduce knowledge gap about pollinators in society	0.49	1	0.53	1	0.90	2	0.63	0.23
19	**Citizen science makes people feel overwhelmed [a]**	**-1.29**	**-3**	**-0.80**	**-1**	**-0.90**	**-2**	**0.99**	**0.26**
22	Citizen science encourages people to protect native pollinator species	0.93	2	0.44	1	0.45	1	0.60	0.28
11	Citizen science enhances our understanding of how pollinators use resources in the landscape	0.51	1	0.06	0	0.00	0	0.19	0.28
15	Citizen science informs policies on pollinators	0.29	0	0.77	2	0.00	0	0.35	0.39
25	Citizen science is a two-way tool for scientific communication	0.74	1	0.15	0	0.90	2	0.59	0.40
16	Citizen science can reinforce the protection of the most known pollinator species	1.01	2	0.21	0	0.45	1	0.55	0.41
32	**Citizen science knowledge is only used by researchers and not by other stakeholders [a]**	**-0.65**	**-1**	**-1.38**	**-3**	**-1.35**	**-3**	**1.12**	**0.41**
9	Citizen science may use knowledge from different academic disciplines and from other types of knowledge to conserve pollinators	0.67	1	-0.16	-1	0.45	1	0.42	0.43
46	**Citizen science increases public awareness of the importance of pollinators [a]**	**1.10**	**3**	**0.85**	**2**	**1.80**	**4**	**1.24**	**0.49**
36	**Citizen science is more effective than conventional science at achieving pollinator conservation [a]**	**-0.31**	**-1**	**-0.89**	**-2**	**-1.35**	**-3**	**0.85**	**0.52**

10	Citizen science helps to estimate historic trends in pollinator presence or abundance	0.85	2	1.05	2	0.00	0	0.63	0.56
21	Citizen science increases people's involvement in decision making	0.36	0	-0.72	-1	-0.45	-1	0.51	0.56
23	Citizen science encourages people to control invasive pollinator species	-0.56	-1	-1.48	-3	-0.45	-1	0.83	0.57
20	Citizen science promotes open data	1.20	4	0.02	0	0.45	1	0.55	0.60
31	**Citizen science projects are time-consuming and cannot meet the urgent demands of pollinator conservation [a]**	**-1.09**	**-2**	**-1.64**	**-4**	**-0.45**	**-1**	**1.06**	**0.60**
34	**Citizen science reduces the introduction of invasive species [a]**	**-0.57**	**-1**	**-1.36**	**-3**	**-1.80**	**-4**	**1.24**	**0.63**
12	Citizen science data are biased by the way data are collected	-0.82	-1	0.38	0	0.45	1	0.54	0.71
43	Citizen science is a good approach for fundraising for pollinator research	-0.47	-1	-0.46	-1	0.90	2	0.61	0.79
1	**Citizen science is a genuinely interactive and an inclusive science engagement activity [b]**	**1.71**	**4**	**0.39**	**1**	**1.80**	**4**	**1.30**	**0.79**
3	Citizen science increases accessibility to scientific knowledge about pollinators	1.19	3	0.48	1	-0.45	-1	0.70	0.82
6	**Citizen science burdens scientists [b]**	**-1.58**	**-4**	**-1.33**	**-3**	**0.00**	**0**	**0.97**	**0.85**
30	**Citizen science attracts people who already have an interest in the environment and nature [b]**	**0.23**	**0**	**1.80**	**4**	**1.80**	**4**	**1.27**	**0.91**
26	Citizen science makes science more transparent and helps to overcome science denialism	0.46	0	-0.29	-1	-1.35	-3	0.70	0.91
17	**Citizen science only engages privileged people in pollinator conservation [b]**	**-1.89**	**-4**	**-0.06**	**-1**	**-0.90**	**-2**	**0.95**	**0.92**
24	Citizen science makes people talk more about pollinator science	0.75	1	0.69	1	-0.90	-2	0.77	0.94

35	Citizen science helps to formulate pro-pollinators policies	0.97	2	0.28	0	-0.90	-2	0.71	0.95
44	**Citizen science helps people understand their civic roles in society** [b]	**0.13**	**0**	**-0.84**	**-2**	**-1.80**	**-4**	**0.92**	**0.97**
5	**Citizen science pollinator projects are not particularly successful in increasing knowledge of scientific methods and science in general** [b]	**-1.95**	**-4**	**-0.95**	**-2**	**0.00**	**0**	**0.96**	**0.98**
33	**Citizen science data have limited usefulness for decision making** [b]	**-1.39**	**-3**	**-1.18**	**-2**	**0.45**	**1**	**1.00**	**1.01**
40	**Citizen science helps the society in overcoming environmental conflicts** [b]	**0.16**	**0**	**-1.30**	**-2**	**-1.80**	**-4**	**1.08**	**1.02**
37	The diversity of citizen science protocols makes it difficult to integrate data among projects	-0.87	-2	1.18	3	0.00	0	0.68	1.03
2	Citizen science increases public understanding of how science works	1.61	4	0.44	1	-0.45	-1	0.83	1.03
38	Citizen science data are geographically biased	-0.48	-1	1.40	4	-0.45	-1	0.77	1.08
28	Citizen science increases the appreciation for scientific knowledge	0.77	1	0.38	1	-1.35	-3	0.83	1.13
29	**Citizen science is more accessible to richer and more highly educated people** [b]	**-1.39**	**-3**	**1.05**	**2**	**-0.45**	**-1**	**0.96**	**1.23**
13	**Citizen science data to inform the conservation of pollinators are imprecise** [b]	**-0.98**	**-2**	**-0.53**	**-1**	**1.35**	**3**	**0.95**	**1.24**
18	**Citizen science is a useful engagement strategy, but it is not useful for science** [b]	**-1.42**	**-3**	**-2.03**	**-4**	**0.45**	**1**	**1.30**	**1.29**
8	**Citizen science data are biased towards conspicuous species** [b]	**-1.21**	**-2**	**1.49**	**4**	**-0.90**	**-2**	**1.20**	**1.48**
14	**Citizen science data to inform the conservation of pollinators are unreliable** [b]	**-0.98**	**-2**	**-1.74**	**-4**	**1.35**	**3**	**1.35**	**1.61**

Figure 1: Q methodology research stages followed. Adapted from Zabala et al 2018.

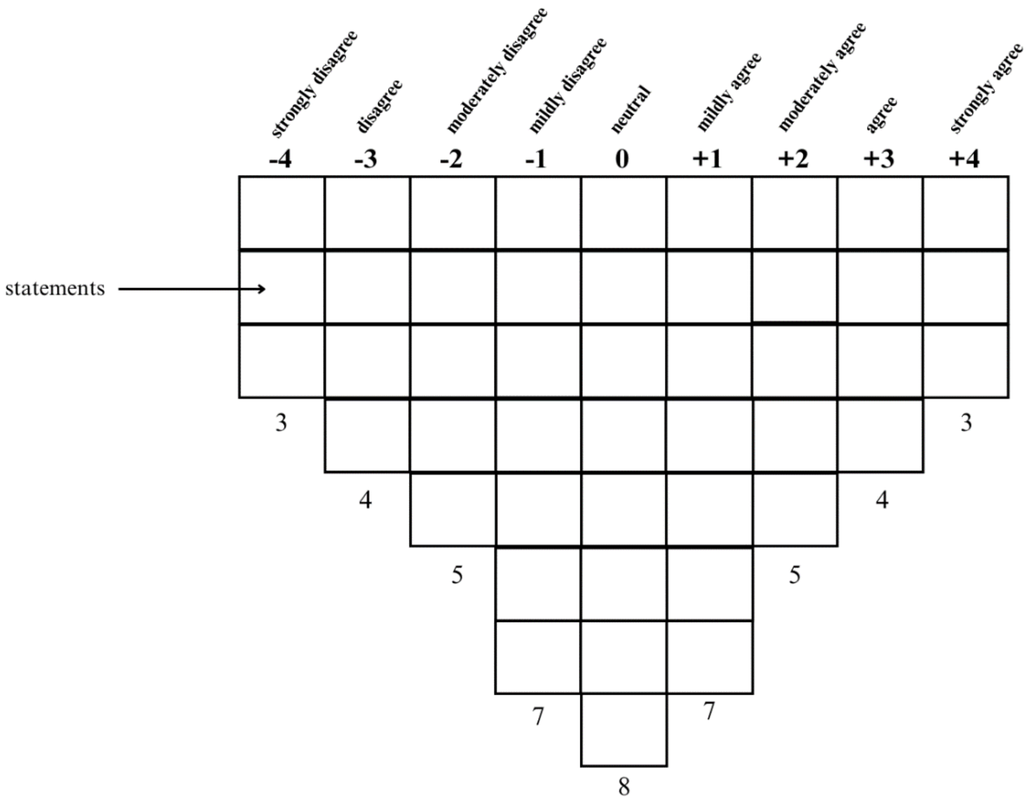


Figure 2: Ranking grid representing forced-choice frequency distributions. Levels (-4 to +4): Strongly disagree, disagree, moderately disagree, mildly disagree, neutral, mildly agree, moderately agree, agree, strongly agree. Numbers at the bottom of each column represents the quantity of statements that the participant had to fill in at each level.

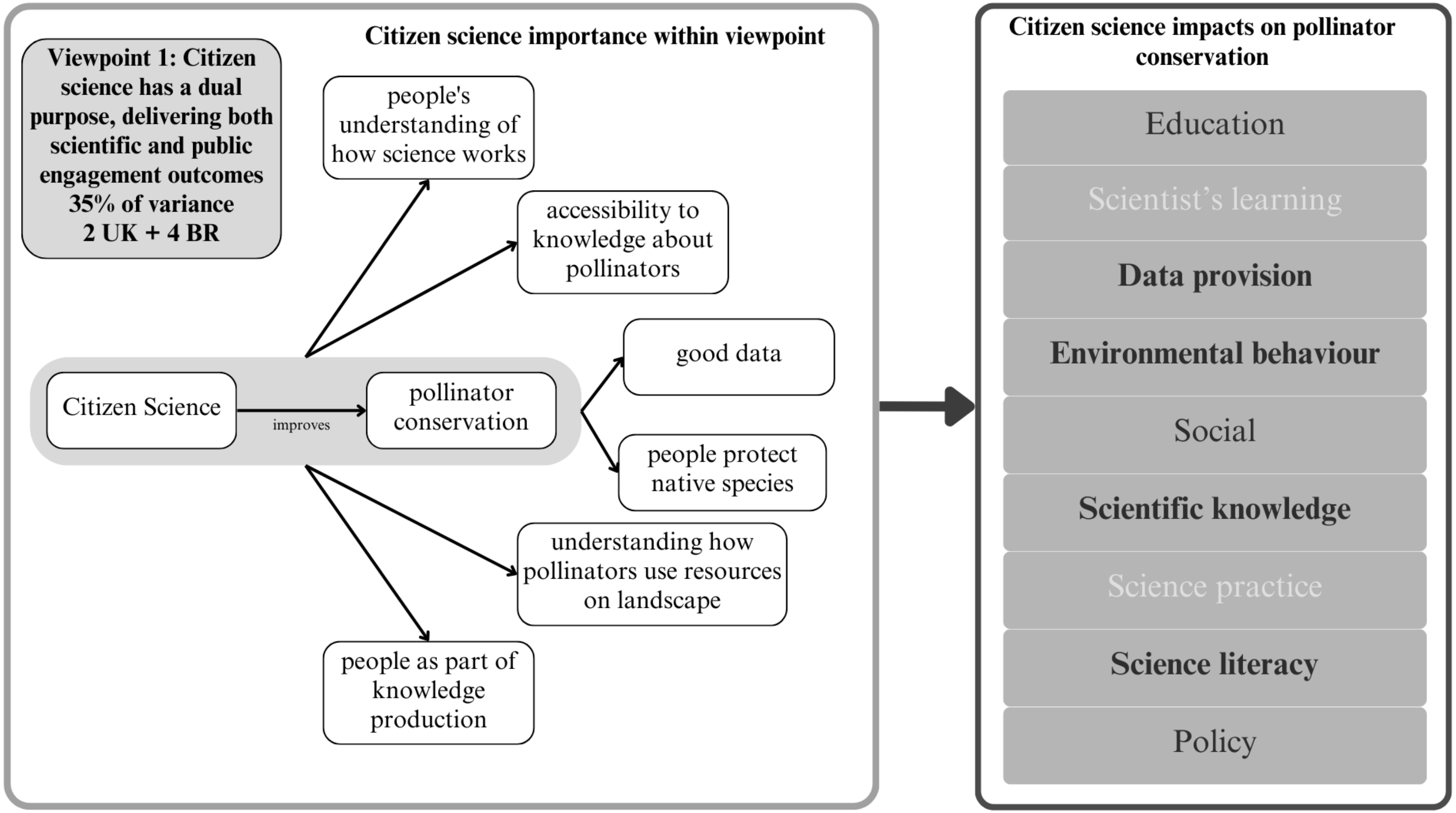
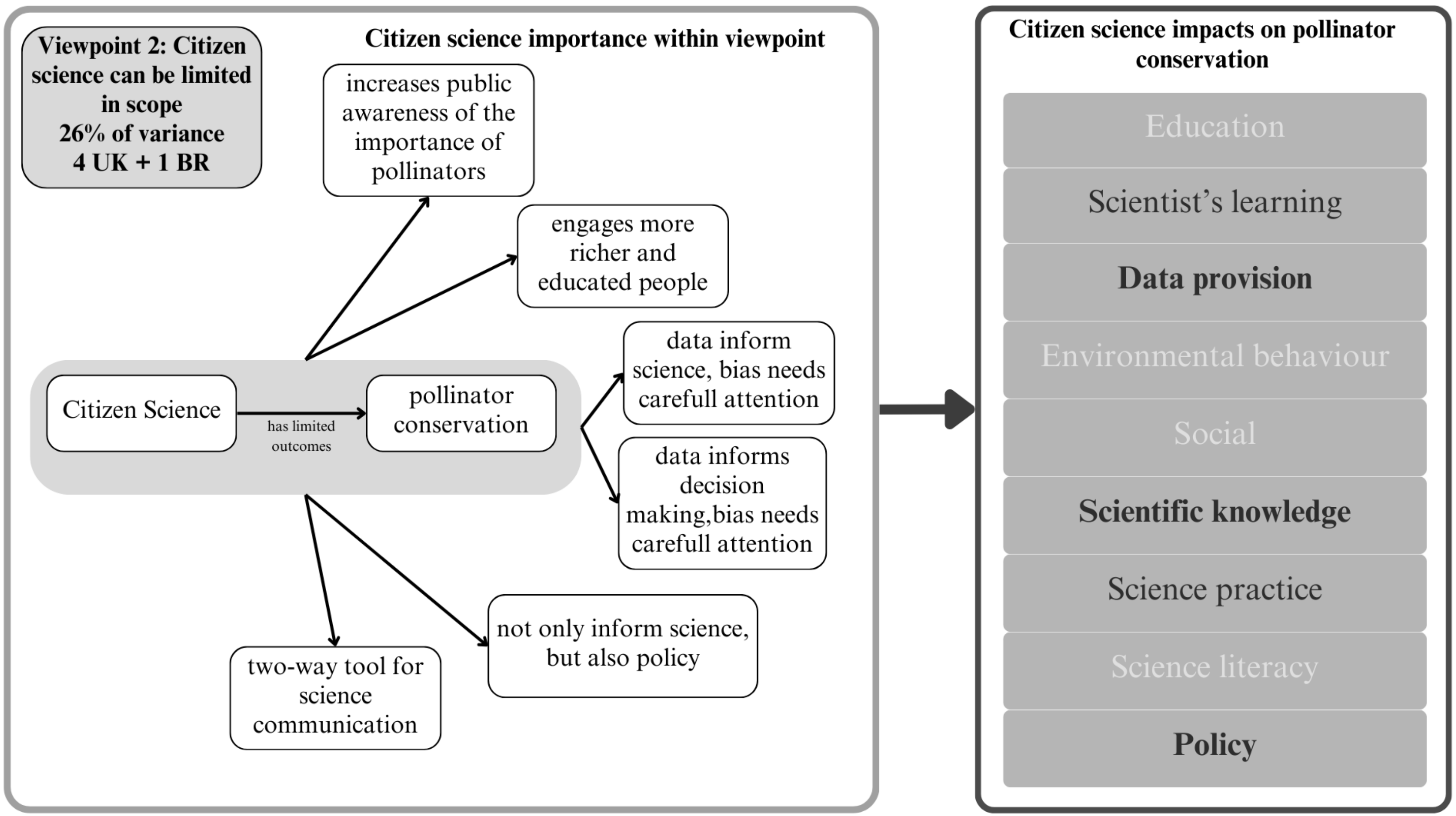


Figure 2 to 5: Viewpoints representations. The general impacts on the right box represent the Theory of Change for each viewpoint. Bold letters indicate that this is an expect impact within the viewpoint, non-bold is less strong and grey letters indicates the viewpoint does not highlight the impact.



Viewpoint 2: Citizen science can be limited in scope
26% of variance
4 UK + 1 BR
Citizen science importance within viewpoint
increases public awareness of the importance of pollinators
engages more richer and educated people
Citizen Science
has limited outcomes
pollinator conservation
data inform science, bias needs carefull attention
data informs decision making,bias needs carefull attention
two-way tool for science communication
not only inform science, but also policy
Citizen science impacts on pollinator conservation
Education
Scientist's learning
Data provision
Environmental behaviour
Social
Scientific knowledge
Science practice
Science literacy
Policy

Figure 3

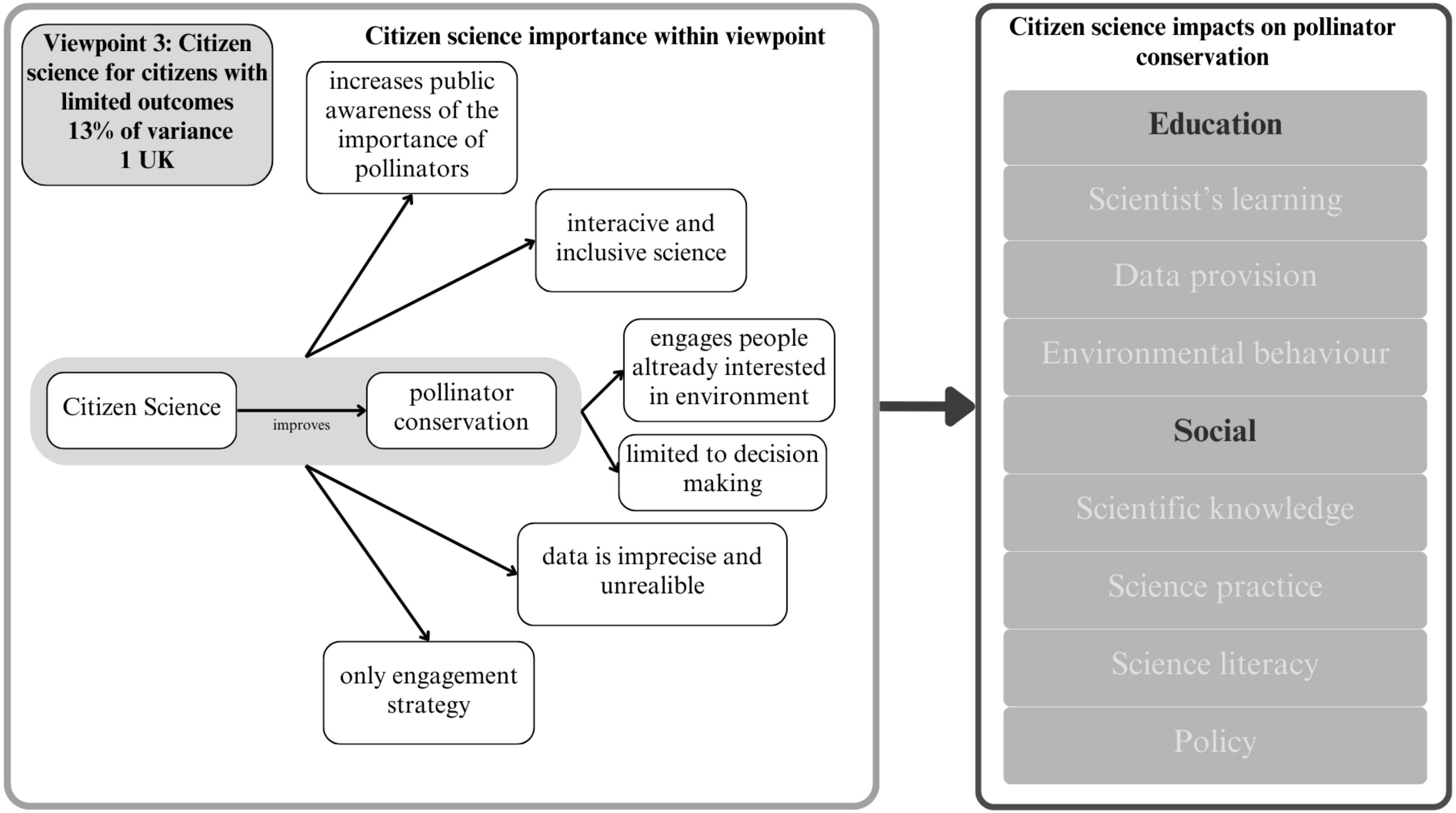

Viewpoint 3: Citizen science for citizens with limited outcomes
13% of variance
1 UK
Citizen science importance within viewpoint
increases public awareness of the importance of pollinators
interacive and inclusive science
engages people altready interested in environment
Citizen Science
improves
pollinator conservation
limited to decision making
data is imprecise and unrealible
only engagement strategy
Citizen science impacts on pollinator conservation
Education
Scientist's learning
Data provision
Environmental behaviour
Social
Scientific knowledge
Science practice
Science literacy
Policy

Figure 4

Parte II - Lacunas na adoção de práticas agrícolas amigáveis aos polinizadores

Capítulo III – Determinantes sociopsicológicos à conservação de polinizadores em ambientes agrícolas

Autora: Caren Queiroz Souza

Este capítulo tem como objetivo apresentar uma revisão narrativa sobre o estado da arte sobre o papel de fatores sociopsicológicos relacionados à adoção de comportamentos pró-polinizadores por agricultores, dando ênfase a importância da interdisciplinaridade entre Psicologia e Conservação no fomento à práticas agrícolas pro-polinizadores.

Importância dos polinizadores na Agricultura

Polinizadores são essenciais para a produção de alimentos. É sabido que mais de 75% de plantas cultivadas dependem em algum grau da polinização animal (KLEIN et al., 2007; GARRATT et al., 2014). Contraditoriamente, a expansão e intensificação agrícola estão entre as principais causas de declínio dos polinizadores (GARIBALDI et al., 2011; POTTS et al., 2016). Visando reduzir os impactos da agricultura e também conciliar a produção de alimentos com a conservação dos polinizadores algumas soluções baseadas em conhecimento ecológico já foram propostas (IPBES, 2016a). No entanto, para a efetivação dessas soluções é necessário aproximar o conhecimento científico da prática considerando as barreiras e motivações de agricultores, atores-chave na adoção de práticas amigáveis aos polinizadores (IRWIN et al., 2018). Nesse sentido, faz-se necessário o uso de abordagens interdisciplinares que permitam acessar como aspectos humanos estão relacionados à conservação dos polinizadores (MARSELLE; SHWARTZ, 2020).

Psicologia da Conservação como uma abordagem para promover a conservação de polinizadores

O que faz as pessoas se comportarem em relação à natureza é uma pergunta fundamental na Conservação (VAN VALKENGOED; ABRAHAMSE; STEG, 2022). A Psicologia da Conservação é um campo do conhecimento interdisciplinar que se debruça a investigar esta pergunta a partir da compreensão da influência de variáveis subjetivas no comportamento pro-ambiental dos seres humanos (e.g., sentimentos, valores, crenças) (CLAYTON; MEYERS, 2015). Tradicionalmente, a Psicologia da Conservação visa entender porque as pessoas adotam um comportamento ou não e parte da premissa de que todos os indivíduos são responsáveis pelos problemas ambientais que enfrentamos (SCHULTZ, 2011). Atualmente, diante dos debates sobre Ecologia Decolonial e do reconhecimento sobre as desigualdades sociais é preciso ter muito cuidado em como esse campo é usado, pois os danos ambientais causados e as consequências são desproporcionais entre os seres humanos a depender de sua raça, origem, gênero e/ou classe social (FERDINAND, 2022). Ainda mais, sabe-se também que o modo de produção capitalista é a força motriz do desencadeamento e intensificação dos problemas socioambientais que testemunhamos, causando desastres ambientais de grandes proporções, afetando a vida e estabilidade dos sistemas socioecológicos.

Mesmo diante dessa crítica, a Psicologia da Conservação pode agregar bastante à Conservação, pois (i) fornece ferramentas metodológicas para avaliar o comportamento dos indivíduos e, potencialmente, seu engajamento em mudanças sistêmicas, (ii) evidencia áreas que precisam de mais atenção para ações de educação, (iii) é uma abordagem inerentemente interdisciplinar e, potencialmente, contribui para estudos transdisciplinares, pois ajuda no entendimento do papel que diferentes atores sociais tem no uso e manejo dos recursos, (iv) evidencia motivações e barreiras de partes interessadas em problemas socioambientais e, (v) pode subsidiar recomendações de adoção de comportamentos com maior impacto como, por exemplo, mudanças políticas (BALMFORD et al., 2021; MARSELLE et al., 2021; NIELSEN et al., 2021).

Dentro da Psicologia da Conservação, destaco aqui a subdisciplina Psicologia Social – a qual é de interesse desta tese –, que é uma área dedicada ao comportamento interpessoal e na forma como indivíduos são afetados por outros indivíduos (CLAYTON; MEYERS, 2015). A Psicologia Social fornece alguns recursos importantes para a Conservação, pois nesta área são realizados estudos sobre como valores, normas, crenças, conhecimentos e sentimentos se relacionam entre si nos indivíduos dentro do seu contexto social específico e como essa relação também interfere no comportamento social (CLAYTON; MEYERS, 2015). Vários modelos teóricos já foram propostos no campo da Psicologia Social visando compreender o que determina um comportamento pro-ambiental. Dentre os existentes, destacam-se (i) o modelo Valor-Crença-Norma (em inglês, Value-Belief-Norm, VBN) (STERN et al., 1999) que indica a relação causal entre valores e comportamentos, (ii) o modelo abrangente de determinação de ação (em inglês, the comprehensive action determination model) (KLÖCKNER, 2013), que baseando-se em uma metanálise reúne fatores determinantes ao comportamento de várias teorias (valor-crença-norma, teoria do comportamento planejado e teoria de ativação da norma) e, (iii) o modelo do comportamento planejado (em inglês, Theory of Planned Behaviour - TPB) (AJZEN, 1991) que tem apresentado bastante robustez em pesquisas com comportamento pro-ambiental.

Teoria do Comportamento Planejado

A TPB foi proposta por (AJZEN, 1991) (Figura 1). A estrutura do modelo é útil para quantitativamente indicar as principais variáveis determinantes a um comportamento específico, bem como, mensurar qual é a força das relações causais entre as variáveis, já que essas são contexto-dependentes e tem contribuições relativas a depender do comportamento de interesse. De acordo com a TPB, o comportamento é a manifestação de uma ação, geralmente observável em uma dada situação. O comportamento, segundo a TPB, é diretamente afetado pela intenção (INT) e pelo controle real do comportamento (ABC). Intenção por sua vez, é uma indicação da disposição que o indivíduo tem para realizar o comportamento. E, controle real do comportamento pode ser descrito como o conjunto de condições e percepções do indivíduo que permitem a realização do comportamento (tempo, recursos, habilidades etc) (AJZEN, 2020).

O controle real do comportamento dificilmente é mensurável, nesse sentido, via de regra, a percepção de controle do comportamento (PBC) que é usada como um proxy para essa variável (AJZEN, 2006). Como o próprio nome sugere, a PBC é a percepção que o indivíduo tem sobre sua capacidade de realizar o comportamento. Também segundo a TPB, um comportamento específico pode ser determinado pela avaliação positiva ou negativa que o indivíduo faz sobre o comportamento – atitudes (ATT) –, e pela pressão social percebida sobre a realização do comportamento – normas sociais (SN). Cada um desses três fatores (ATT, SN e PBC) é resultado de crenças comportamentais, sociais e de controle, respectivamente.

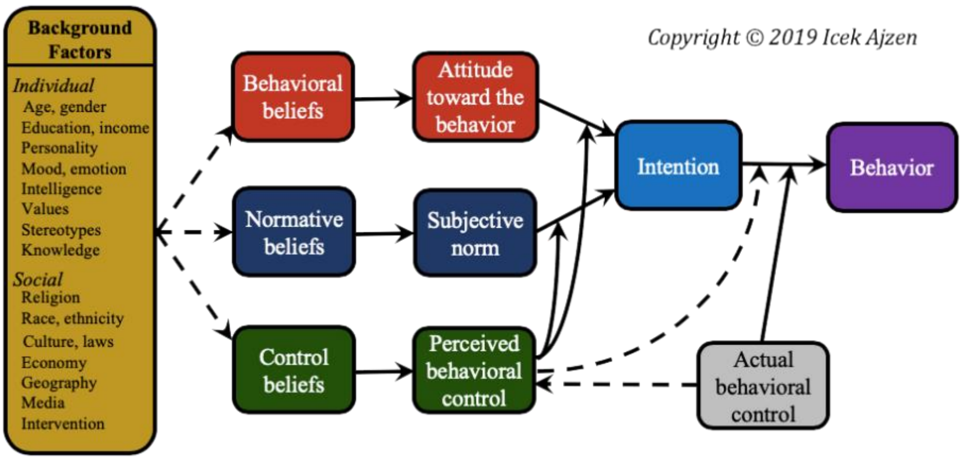


Figura 1: Esquema mostrando as variáveis e respectivas relações da Teoria do Comportamento Planejado (AJZEN, 1991).

Tendências atuais e lacunas em estudos sobre fatores sociopsicológicos e conservação de polinizadores na agricultura

As evidências ecológicas sobre o declínio dos polinizadores vêm acompanhadas de recomendações que visam recuperar suas populações e/ou reduzir e mitigar os efeitos nocivos à sua existência (IPBES, 2016b). Por exemplo, evidências ecológicas sobre o efeito de agrotóxicos para insetos polinizadores implicam em recomendações de aplicação em períodos fora do período da florada, redução ou extinção do uso de agrotóxicos. Todavia, a adoção dos comportamentos perpassa pelas motivações e barreiras das partes interessadas, nesse sentido, a Psicologia Social e os modelos propostos nesse campo se fazem úteis para endereçar essa questão (HALL; MARTINS, 2020).

De modo geral, existem poucos estudos que têm se debruçado a compreender a importância relativa de construtos psicológicos na adoção de comportamentos pro-polinizadores (Tabela 3). Na literatura, a maioria dos estudos não apresenta um arcabouço teórico para explicar as variáveis ou ainda para modelar a relação entre as mesmas (NALEPA et al., 2020; OSTERMAN et al., 2021). Além disso, há variação entre métodos ou variáveis entre as pesquisas (questionário, grupo focal, entrevista), o que dificulta a generalização. Outro aspecto observado é que, embora a percepção e o conhecimento sejam variáveis muito comuns (BREEZE et al., 2019; TARAKINI; CHEMURA; MUSUNDIRE, 2020), essas variáveis não estão originalmente presentes nos modelos conceituais que explicam o comportamento, como é o caso da TPB. O conhecimento ainda é visto como algo muito determinante à ação na Biologia da Conservação, apesar das evidências apontarem para a importância de outros fatores como, por exemplo, atitudes, percepção de controle e normas sociais (KNAPP et al., 2021).

Na literatura, existe uma ênfase significativa em compreender como agricultores percebem a importância das abelhas, em contrate com outros polinizadores (HANES et al., 2013; HEVIA et al., 2020). A percepção e o conhecimento sobre os polinizadores e sua importância varia entre os locais (MUNYULI, 2011; TARAKINI; CHEMURA; MUSUNDIRE, 2020) e é influenciada pela educação e experiência com manejo agrícola (HEVIA et al., 2020). Estudos também evidênciam que abelhas são percebidas como os mais importantes insetos polinizadores, sendo os demais insetos complementares às abelhas mesmo em culturas não dependentes de abelhas (OSTERMAN et al., 2021). A disposição na adoção de práticas amigáveis também varia entre os estudos. (OSTERMAN et al., 2021). Por exemplo, em Uganda, observou-se uma menor disposição em adotar tais práticas, uma vez que os agricultores percebem a polinização como um serviço gratuito ou bem público (MUNYULI, 2011). Em contrste em outros países, a maioria dos agricultores adota ao menos uma prática de manejo ecológico pró-polinizadores, e em alguns casos, sem necessariamente ter a intenção específica de beneficiar os polinizadores (BREEZE et al., 2019) (BREEZE et al., 2019). Em síntese, a compreensão sobre fatores sociopsicológicos associados à adoção de práticas amigáveis aos polinizadores na agricultura destaca a crescente relevância dessa abordagem.

Embora as pesquisas recentes tenham demonstrado algum avanço, ainda existem diversas lacunas a serem preenchidas como, por exemplo, compreender de que maneira incentivos podem facilitar ou modificar a intenção de agricultores em adotar comportamentos pró-polinizadores. Pesquisas futuras desempenharão um papel extremamente relevante para aproximar a pesquisa da prática, uma vez que evidências nesse campo são fundamentais para o desenvolvimento de estratégias mais eficientes.

Além disso, é de suma importância também apresentar definições claras das variáveis de interesse e sua relação causal.

Uma das principais dificuldades identificadas nesta revisão foi a integração dos resultados entre os estudos. Para superar esse desafio é necessário endereçar questões sob arcabouços teóricos explícitos, como a TPB e outros modelos que já foram propostos no campo da Psicologia Social. Além disso, é fundamental investigar como os fatores sociopsicológicos podem influenciar ou contribuir para a formulação de políticas públicas. Essas reflexões ressaltam a importância do diálogo interdisciplinar entre a psicologia e conservação, sendo essencial para orientar uma agricultura que concilie produção de alimentos, conservação de polinizadores e participação entre as partes interessadas.

Tabela 5: Lista não exaustiva de estudos que avaliaram fatores sociopsicológicos relacionados a conservação de polinizadores na Agricultura.

Referência	**Arcabouço teórico**	**Variáveis de interesse**	**Local**	**Principal resultado**
Knapp et al. 2021.*	TPB	Vários	Reino Unido	O conhecimento não é um bom preditor do comportamento pró-ambiental em relação aos polinizadores. Em vez disso, os fatores comportamentais explicaram 45% da variação no comportamento de conservação pro-polinizadores.
Tarakini et al 2020	Não apresenta	Percepção de agricultores, conhecimento e atitudes	Zimbabue	Identificação de abelhas foi influenciado pelo grau de educação e tempo na atividade agrícola e negativamente pelo medo de abelhas. A maioria dos entrevistados demonstrou conhecimento sobre polinização.
Hevia et al 2020	Não apresenta	Percepção, conhecimento e práticas de manejo para promover polinização	Espanha	A maioria dos entrevistados reconhece o declínio em suas áreas e a necessidade de polinizadores para produção agrícola. Também apresentam algum conhecimento sobre polinizadores e realizam práticas pró-polinziadores (reduzir uso de agrotóxico e diversificação de cultivos). Eduação, idade, gênero e dedicação à agricultura influenciam fortemente o conhecimento e a adoção de práticas pró-polinizadores.
Hanes et al 2013	Não apresenta	Percepção sobre efetividade de polinizadores nativos e sua contribuição para a frutificação.	Estados Unidos	Polinizadores nativos são importantes, mas não são suficientes para substituir Apis melífera. Percebem incerteza na eficiência de polinizadores nativos e dificuldade de manejo.
Nalepa et al 2020	Não apresenta	Como características da área e percepção sobre abelhas influencia a probabilidade de adotar práticas	Canadá (75)	A adoção de práticas pró-polinizadores é influenciada pela consciência de abelhas silvestres, seu benefícios e pela percepção das ameaças às suas populações. O percepção de custo das práticas reduz a adoção.

		amigáveis aos polinizadores		
Osterman et al 2021	Não apresenta	Percepção da importância relativa de diferentes grupos de polinizadores, fontes de informação, manejo da polinização	México, Guatemala, Reino Unido, Bélgica, Alemanha, Polônia, Eslovênia, Espanha, Israel (definido pelo estudo), Austrália e Nova Zelândia	Agricultores percebem abelhas como sendo mais importantes que outros insetos polinizadores, mesmo sendo de cultivos não dependentes de abelhas. Entendem que outros insetos são complementares e não substitutos de abelhas. A disposição em plantar flores nas margens e dentro dos cultivos para aumentar a visitação de polinizadores estava relacionada com conhecimento ecológico sobre insetos polinizadores e sobre subsídios do governo.
Breeze et al 2019*	Não apresenta	Percepção e motivação relacionada a polinização agrícola assistida	Chipre, Estônia, Grécia, Itália, Malta, Holanda, Portugal, Eslovênia, Sérvia, Reino Unido	Metade dos agricultores entrevistados acredita que tinha déficit de polinização e menos de 1/3 alugam caixas de abelhas. Em contrapartida, a maioria adota alguma prática de manejo que beneficia os polinizadores, embora alguns não o façam com a intenção de beneficiar os polinizadores.
Munyuli 2011	Não apresenta	Percepção e conhecimento e importância dos polinizadores e polinização	Uganda	A maioria (>90%) não estava ciente do papel das abelhas para a produção. Também não estavam cientes da importância de hábitats semi-naturais para conservação de polinizadores. Os agricultores não apresentaram muita disposição para adotar práticas de manejo pró-polinizadores, pois consideram a polinização um serviço gratuito, ou bem público.

Misganaw et al 2017	Não apresenta	Percepção da importância de insetos polinizadores, seu status e distribuição e conhecimento sobre o seu papel na agricultura.	Etiópia	A maioria dos agricultores carece de conhecimentos sobre polinização e da importância de polinizadores na agricultura para a produção de alimentos.

2

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Capítulo IV – Why plant flowers? Exploring the psychological factors that motivate fruit growers to take up a key pro-pollinator behaviour

Target journal *People and Nature.*

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Abstract

1. Agricultural expansion and intensification are the main drivers of pollinator decline. To reverse the negative effects of agriculture on pollinators, key stakeholders' engagement in pro-pollinator conservation actions is crucial. Although farmers are recognized as key stakeholders in pollinator conservation, psychological research about what determines their pro-pollinator actions is lacking.
2. We interviewed 89 farmers of pollinator-dependent fruit crops across the UK, with the majority of interviews carried out in person. A combination of closed and open questions was used to analyse farmer perceptions of the importance of pollinators, and the crop yield and quality outcomes they deliver. We used Likert-scale statements to measure psychological factors based on the Theory of Planned Behaviour, and tested the determinants of the intention to plant flowers as nectar and pollen sources for pollinating insects with multiple linear regression.
3. We found that fruit farmers who perceived a high importance of pollinators also perceived high dependence. Compared to values of crop pollinator dependence reported in the literature, farmers perceptions of their crop's pollinator

dependence were the same or lower for apple farmers, and the same or greater, for blackcurrant farmers.

4. Fruit farmers in our sample were motivated to plant flowers for pollinating insects more by what they believed to be the benefits of doing so, and their ability to do so, than by their beliefs about social approval, for example from other farmers or customers. In accordance with this result, direct attitudes and direct perceived behavioural control were the major determinants of apple and blackcurrant farmers' intentions to perform the behaviour.
5. Given the importance of perceived behavioural control, we recommend outreach activities that provide training, guidance and field demonstration on the practicalities of planting flowers for pollinators in fruit farms.

Keywords: pro-pollinator behaviour, Theory of Planned Behaviour, farmers behaviour, ecological intensification

Introduction

The main drivers of pollinator decline are related to agricultural expansion and intensification (Dicks et al. 2021; IPBES 2016; Stout and Dicks 2022). Although ecological research on how agriculture practices impact pollinator structure and dynamic is necessary to provide biological evidence for decision making (Klein et al. 2007; Potts et al. 2010), it is equally important to understand the psychological factors that determine whether key agricultural stakeholders take pro-pollinator actions. Environmental psychology is essential to inform conservation strategies that upscale conservation benefits to people and nature (Nalepa et al. 2020). Farmers are direct agents in pollinator conservation. They make decisions about land management at the local scale and, collectively, can have a positive impact in restoring and regenerating environments at the landscape scale (Dicks et al. 2019).

Pollinators' economic importance for agriculture has already been calculated (Gallai et al. 2009) and management practices to benefit pollinators (*e.g.*, providing flower-rich habitat) are supported by policy incentives in many countries (Dicks et al. 2016, Hipólito et al. 2021). For example, actions to help insect pollinators can be subsided by agri-environment schemes, which are effective for conserving wildlife on farmland, but expensive and in need of careful design (Batáry et al. 2015). Stout & Dicks (2022) recently summarised pro-pollinator initiatives at different scales, showing that national and, mainly, local initiatives have a greater influence on land management actions for pollinator conservation than international initiatives. These authors also argued that local actions have the potential to reduce direct drivers of pollinator decline, while reinforcing the benefits to people and nature.

A detailed synthesis of practical actions designed as responses to the risks posed to pollinators can be found in the IPBES report (2016) (*e.g.*, to conserve or sow field margins with non-crop flowers, to reduce pesticide use, to diversify farming systems). Among those practices, to plant flowers as nectar and pollen sources within farms is a key local pro-pollinator action, because it amounts to feeding pollinators from a diversified plant community. Giving food to pollinators ensures they will have enough energy to visit wild and cultivated plants, reproduce and, potentially, increase their abundance (Scheper et al. 2013). A vast literature documents the ecological effects of pro-pollinator conservation actions in agricultural environments, largely looking at effects on pollinators themselves (reviewed by Dicks et al. 2010, Scheper et al. 2013, Kovács-Hostyánszki et al. 2017, for example), but in some cases also on pollination services (e.g., Albrecht et al. 2020).

Although pro-pollinator actions (*e.g.*, planting flowers) within farms bring benefits to people and nature, the uptake of these actions is still low, particularly among fruit farmers (Kleijn et al. 2019). Time, availability of resources, perceptions, social context, experience, among others, are factors that influence whether a person takes up an action or not (Campos Tisovec-Dufner et al. 2019; Yuriev et al. 2020). To understand these factors, Conservation Social Science studies, especially under interdisciplinary environmental psychology approach, are needed (Balmford et al 2021). Such studies integrate different knowledges, and can help to build effective guidance and reduce the knowledge-implementation gap in this domain (Marselle and Shwartz 2020; Nielsen et al. 2021; Pardini et al. 2013).

In this study, we aim to understand two sets of psychological drivers that influence farmers' decisions. First, how farmers perceive the importance of pollinators for their crops. Farmers' perceptions provide important information underpinning their beliefs and behaviour (Breeze et al. 2019; Hanes et al. 2013). It is crucial to characterize their level of understanding of the importance of pollinators, to provide an underlying rationale for further analyses testing the relation among different psychological drivers.

Second, we aim to understand the psychological determinants related to the uptake of pro-pollinator actions. A broad scope of theories in social psychology models how psychological factors influence people's actions (Ajzen 1991; Klöckner 2013; Stern 2000). Among those, the Theory of Planned Behaviour (TPB) contains well-supported models useful to explain the determinants of specific behaviours (Ajzen 1991; Yuriev et al. 2020). TPB assumes that one specific behaviour is directly influenced by people's intentions and by three other direct factors: attitudes (the positive or negative evaluation of the behaviour), social norms (the perception of approval from social referents such as family, friends or colleagues, to perform the behaviour) and perceived behavioural control (perceived capability to perform the behaviour) (1 and 2 at Figure 1) (Ajzen, 1991). These direct factors (attitudes, social norms and perceived behavioural control) are influenced by people's behavioural, social and control beliefs, respectively (numbers 3, 4 and 5 at Figure 1). Beliefs are peoples' subjective views about the consequences, social approval and level of control associated with the target behaviour.

An expectancy-value model is an equation applied in different fields to quantify the extension of a person evaluation of their success in one task. At TPB, the equation describes the relation between direct factors and beliefs so that each direct factor is assumed to be a function of a set of accessible beliefs (Fishbein & Ajzen, 1975). For example, people's attitudes towards a behaviour are a function of the expectations about the behaviour's outcomes (outcome beliefs) and the evaluation of each expected outcome (outcome evaluation). The sum of the product between a set of outcome beliefs and outcome evaluation is proportional to the direct attitudes (3 in Figure 1). The same model represents other direct factors. Social norms (4 in Figure 1) are represented as the sum of the perceived evaluations of specified social referents multiplied by motivation to comply with the opinions of these referents; perceived behaviour control (5 in Figure 1) is represented as the sum of the products of beliefs about the presence of specified enablers or barriers to the behaviour (control factor) and the perceived control over those factors (Figure 1).

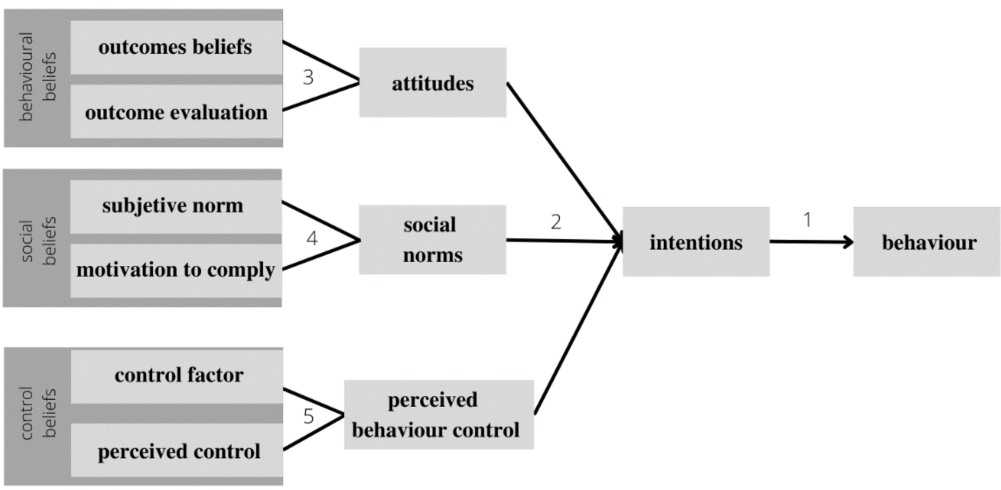

Figure 2: Theory of Planned Behaviour scheme. Adapted from Ajzen 1991.

The TPB assumes that the uptake of a specific behaviour is context-dependent, due to the complexity of the factors related to the behaviour under analysis and also to the specificities of target social actors. Under this framework, a diverse range of pro-environmental actions among farmers and landowners have previously been analysed, investigating factors related to land use, soil, water management and preservation of forest remnants (Wauters et al 2010, Wauters & Mathijs 2012, Poppenborg & Koellner, 2013, Campos Tisovec-Dufner et al. 2019). Prokopy et al. (2019) reviewed scientific knowledge of factors affecting the adoption of conservation practices among farmers in the United States of America. They identify studies covering nutrients, livestock or habitat management and organic adoption, but did not document any studies addressing conservation practices aimed directly at pollinators.

The TPB is a particularly useful approach for understanding farmer behaviour, because farmers are an easily defined social group, with shared characteristics, making a predictable repertoire of decisions that are context-dependent. Some studies have focused on pro-pollinator behaviour among farmers, but they either do not use TPB, or they don't focus specifically on farmers. Osterman et al. (2021) found that pro-pollinator management practices among farmers – specifically, planting flower strips and managing hedgerows for pollinators - are influenced by their ecological knowledge or linked to government subsidies. However, they don't present an explicit theoretical background. Knapp et al. (2021), using the TPB, found that socio-psychological factors (attitudes, perceived control and nature exposure) played a more important role than knowledge in determining a range of pro-pollinator actions among different social actors, mainly from UK, including farmers. Studies addressing the TPB to investigate the determinants to pro-pollinator behaviour still rare (Sturm et al. 2021).

Using TPB in a quantitative way, as originally designed by Ajzen et al (1991), requires a focus on a very specific behaviour, and cannot easily be applied across several behaviours, or a generalised set of pro-pollinator actions. Here we focus on planting flowers. Of four pro-pollinator behaviours relevant to UK fruit growers that we identified during our pilot survey (see Methods), this action is the one for which there is the most evidence of potential benefits, both to pollinator populations and, in some cases, to pollination services and crop yields For this reason, we consider planting flowers to be a key pro-pollinator behaviour for growers of pollinator-dependent crops(e.g., Albrecht et al. 2020; Campbell et al. 2017).

We aim to investigate psychological factors related to pollinator conservation actions, among UK growers of pollinator-dependent fruit crops. We expect our research to inform interventions aimed at changing farmer behaviour, in favour of people and pollinators. We focus on the following questions:

1. How do fruit farmers perceive their crop’s dependence on pollinators?
    a. How do UK fruit farmers evaluate the importance of pollinators to the quality and quantity of crops they can produce?
    b. How do farmer's perceptions towards pollinator dependence differ from scientifically reported pollinator dependence ratios?
2. What psychological factors drive the decision to plant flowers or not?
    a. Do UK fruit farmers believe that planting flowers helps pollinators and their business? How do their behavioural, social and control beliefs vary?
    b. What are the psychological determinants of the intention to plant flowers as nectar and pollen sources for pollinating insects, among UK fruit farmers?

Methods

Study design

Sampling design

We focused on farmers of pollinator-dependent fruit crops across the UK. From a full list of commercial growers of apples (England), cider apples (Somerset and Herefordshire) and blackcurrant (UK) a sample was randomly selected and random numbers for each sample were generated by the last author. For ethical reasons, key informants (the companies Suntory, Worldwide Fruit, ONE Network) has provided contact details for the selected growers to the lead researcher and the relevant interviewer only. From an estimation of 150 commercial top fruit growers, 200 commercial cider growers and 39 commercial blackcurrant growers, we calculated a representative sample size of 67, 76 and 31, respectively, according to formula in Barlett et al. (2000). We interviewed 89 farmers across the UK who cultivate pollinator-dependent crops and classified the data by the main crop reported by them (apples and cider apples (N=53), blackcurrant (N= 30), cherry (N = 02), strawberry (N= 1), raspberry (N= 1). Two questionnaires were not identified by crop. For the purpose of this study, we just considered 83 growers (19 apple, 34 cider apple and 30 blackcurrant), as those crop types had enough samples to run the analysis. From that sample, 95.2% (N= 79) were male and 4.8% (N=4) female farmers.

Questionnaire design

The first step of designing a TPB questionnaire is to identify the beliefs associated with a specific behaviour, in the target population (Ajzen, 2006). We designed an open-ended pilot questionnaire (Supplementary Material I) to decide whether a behavioural category (e.g., ‘pollinator conservation actions’) would be appropriate, or whether the full final questionnaire needed to focus on a single specific behaviour, and if so, which one. We identified four recommended pro-pollinator actions in agroecosystems: (i) planting flowers as nectar and pollen sources for pollinating insects, in the fruit-growing areas, (ii) managing native hedges for pollinators, (iii) allowing areas to regenerate naturally for pollinators, (iv) allowing actively managed grassy areas to flower for pollinators. We sent the pilot online survey structured at Qualtrics™ software, via e-mail to UK blackcurrant, cider and fruit growers, to identify the accessible beliefs amongst the grower community for each behaviour. There was a different version of the pilot survey for each of the four specific behaviours. The Qualtrics survey software randomly allocated one behaviour to each respondent, allocating them equally across respondents. In total, 53 growers answered the pilot questionnaire.

Outcome beliefs, referent groups and control factors from the pilot survey were coded manually into categories for each behaviour, and each mention of a category was recorded. This was done independently by two researchers, a technique called researcher triangulation (Denzin, 1970). After seeing the results of the pilot questionnaire, we elected to focus the full questionnaire on one specific behaviour – *planting flowers as nectar and pollen sources for insect pollinators within 500 m of the fruit growing areas of the farm*. This decision was made for two reasons. Firstly, the lists of outcome beliefs and control factors from the pilot questionnaire varied across the behaviours, with some factors appearing prominently only for one behaviour. Secondly, the pilot survey showed little variation in the take-up of three of the actions, with the majority of growers (76-92%) reporting that they already did them. Planting flowers as nectar and pollen sources was carried out by about half (57%) of the 51 respondents who answered this part of the pilot questionnaire.

We used the list of the elicited behavioural, social and control beliefs towards planting flowers to design Likert-scale items in order to measure its variation among the farmers during research phase (Table 2). From beliefs elicited at the pilot phase (outcome beliefs and outcome evaluation, normative beliefs and motivation to comply, power control factor and control belief) as well direct constructs (attitude, social norms, perceived behaviour control and intentions), we developed a set of (3 to 7) items using 7-point Likert scales. We access the previous uptake of the planting flowers behaviour through a yes or no item: *"In the last 12 months, did you plant flowers as nectar and pollen sources to help pollinators within 500 m of the fruit-growing areas of your farm"*. The full questionnaire was then composed of closed and open-ended items distributed into four sections (Supplementary Material II): (i) basic information (gender, educational level, years growing fruits, fruit area, fruit varieties cultivated, payment for ecosystem services, management type), (ii) farmers' knowledge about pollination and pollinators, (iii) uptake of pro-pollinator conservation actions and (iv) determinants of behaviour related to planting flowers as nectar and pollen sources.

Variables and data analyses

Farmers' perceptions of pollinator importance

To evaluate how fruit farmers perceive their crop's dependence on pollinators, we used data from farmer's knowledge about pollinators and pollination section. Closed items were used to measure perceived dependence, perceived importance and perceived quality (Table 1). Crops' dependence ratings from Klein et al. (2007) were used as a comparison reference with farmers' perceived dependence. We coded closed items and for each level of perceived importance (very important; may play a small role; not important at all; don't know), we first calculated the proportion of perceived quality levels and perceived dependence of pollinators levels, for blackcurrant and apple farmers. We also compared the proportion of farmers perceived crop's dependence on pollinators with the dependence ratings presented by Klein et al. (2007).

We sorted the answers given to the open-ended item asking for quality outcomes they perceived into four categories of expected quality outcomes of animal pollination present in literature, using clustering technique and calculated the frequency of each category mentioned.

Table 6: variables and respective items from *farmer's knowledge about pollinators and pollination section* of the questionnaire.

Variable	**Item**	**Options**
Perceived crops' dependence of pollinators	Without pollinating insects such as bees, how much of your harvestable crop (yield) would you lose? If you think the harvest would be the same without insects, choose 0 (no loss). If you think there would be no harvest at all without insects, choose 100% (complete loss)	5 options 0 (no loss); 0-10%(little); 10-40%(modest); 40-70% (great); 70-100% (essential)
Perceived importance of pollinators to quantitative outcomes	Do you think bees and other pollinators may play an important role in fruit set and increase the yield of [insert selected fruit variety]?	Closed question; 4 options (Very important; may play a small role; not important at all; don't know)
Perceived quality	Now we are going to talk about quality, rather than quantity, of fruit produced. What effect do pollinating insects such as bees have on the quality of your harvestable crop?	Likert scale; 5-points (Very negative; negative; neutral; positive; very positive)
Quality outcomes	Which quality parameters do you expect are affected?	Open question

Farmers' psychological drivers to the uptake of plant flowers

In order to understand the determinants of planting flowers as nectar and pollen sources to pollinating insects within 500m of fruit-growing areas two set of analyses were performed. First, we calculated the variation of behavioural, social and control beliefs among farmers running descriptive analyses of Likert items. Second, we calculated the Cronbach's alpha of items addressing direct measures (attitude, social norms and perceived control) to test their internal consistency and with the remaining ones, we calculated the mean for each variable, accessing then the scores of direct measures. Cronbach's alpha is commonly used index that evaluates the redundancy among items measuring one latent variable (Heo et al. 2015). Third, we tested the expectancy-value model of each paired beliefs *x* direct measure using Pearson correlation in order to confirm we could use the direct measures to test the main model based on TPB. We reversed all scores in order to put the positive pole at the right, and negative ones at the left.

Finally, we calculated the variance inflation factor (VIF) to test the collinearity between variable and, after that, we used multiple linear regression to test the determinants of intentions to planting flowers as nectar and pollen sources within 500m of fruit-growing areas in that case, with intention as a response variable and attitudes, social norms and perceived control as predictor variables (I~ ATT + SN + PBC). We also tested if the intentions to perform the behaviour varied among farmers who already perform the behaviour in the past and farmers who did not with t test. All analysis were performed using R (R Core Team, 2020). We did not test the determinants to behaviour, because we only had the past behaviour data. Although past behaviour is commonly used as a proxy for actual behaviour, sociopsychological conditions of actors under analysis might vary through time. In our case, we measured future intention and past behaviour, for that reason the behaviour wasn't tested directly.

Ethics

This study has been reviewed and received approval by the University of Cambridge Psychology Research Ethics Committee (reference code: PRE.2014.41).

Results

Farmers' perceptions of pollinators' importance

Most of farmers perceived the importance of pollinators to quantitative outcomes (fruit set and yield) as “very important” (apple 83.1%; blackcurrant 60%), followed by “may play a small role” (apple 16.9%; blackcurrant 33.3%). Two blackcurrant farmers said they don’t know about the importance of pollinators (6.6%) (Figure 2). Most farmers who perceived that pollinator “may play a small role” also perceived quality as neutral or negative (apple N= 5, 9.4%; blackcurrant N=7, 23.3%).

Apple farmers who mentioned that pollinators play a very important role to quantity outcomes were slightly more positive and very positive in relation to their perceived quality than blackcurrant growers, with half of the latter being neutral about perceived quality.

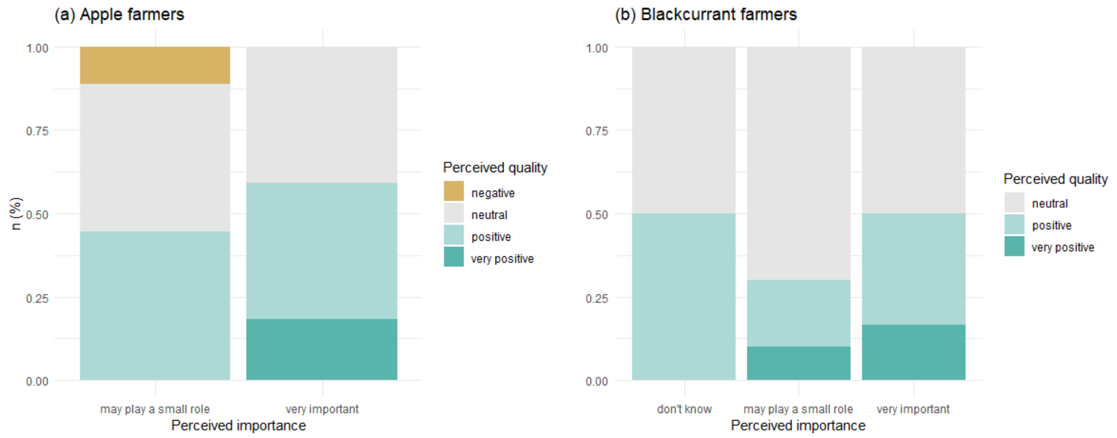

Figure 3: proportion of perceived quality for each level of perceived importance of pollinators for quantity outcomes (fruit set and yield). (a) apple farmers (N= 53) have not responded “very negative” to the effect that pollinating insects have on the quality of their harvestable crop. Total for each level of perceived quality: negative (N= 1, 1.9%), neutral (N=22, 41.5%), positive (N= 22, 41.5%), very positive (N= 18, 15.1%). (b) blackcurrant farmers (N=30) have not responded for negative levels (negative or very negative) to the perceived quality. Total for each level was neutral (N=17, 56.6%), positive (N= 9, 30%), very positive (N= 10, 33.3%). Neither apple or blackcurrant farmers reported pollinators as “not important at all”.

When we compared the perceived importance of pollinators to quantitative outcomes with the perceived crops’ dependence on pollinators (Figure 3), we found that most of farmers who perceive that pollinator “may play a small role” also ranked their crops to lower levels of pollinator dependence (apple: *0 to 10% dependence* (N=3, 5.7%), *10 to*

40% dependence (N=3, 5.7%); blackcurrant: *0 to 10% dependence* (N=2, 6.7%), *10 to 40% dependence* (N=5, 16.7%)). Also, farmers who perceive that pollinators play a very important role ranked higher levels of dependence for their crops (apple: *40 to 70% dependence* (N= 17, 24.5%); *70 to 100% dependence* (N= 11, 20.8%); blackcurrant: *40 to 70% dependence* (N=6, 20%), *70 to 100% dependence* (N= 5, 16.7%). The two blackcurrant farmers who mention that they “don’t know” also ranked high levels of dependence.

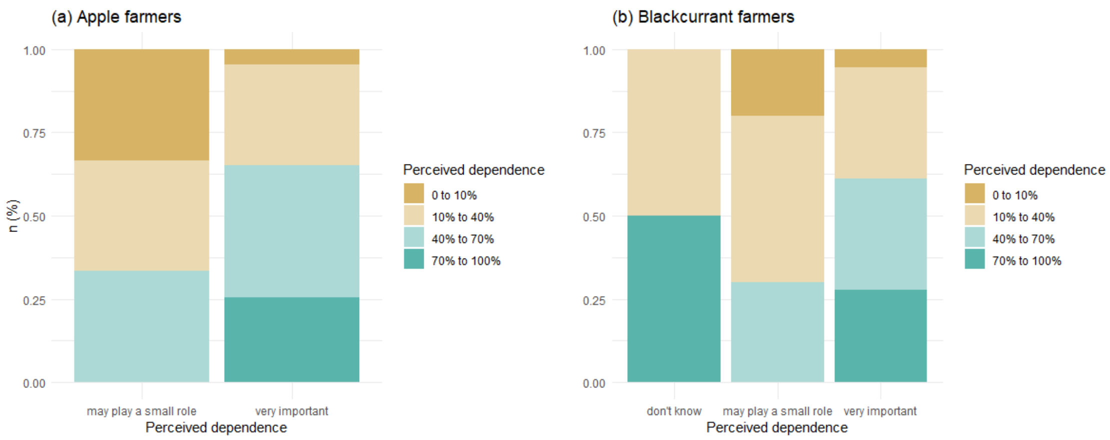

Figure 4: proportion of perceived dependence of pollinators by apple and blackcurrant farmers for each level of perceived importance of pollinators for quantity outcomes (fruit set and yield). (a) apple farmers. They have not responded “don’t know” for perceived importance. (b) blackcurrant farmers.

Apple and blackcurrant farmers (N= 43, 51% of total) reported 11 outcomes they think pollinators impacts on crops, which we classified as aesthetic (61.7%, N= 37) (firmness, shape, size, uniformity), yield (23.3%, N= 14) (fruit set, harvest, seeds), pest control (8.3%, N=5) (botrytis reduction), and flavour (6.7%, N=4) (flavour, sugar). When asked about the crop dependence on pollinators, 38.5% (N=20) of the apple farmers and 40% (N=12) of the blackcurrant farmers perceived crops’ pollinator dependence as the same ratings presented in Klein et al. (2007) for each crop (Figure 4).

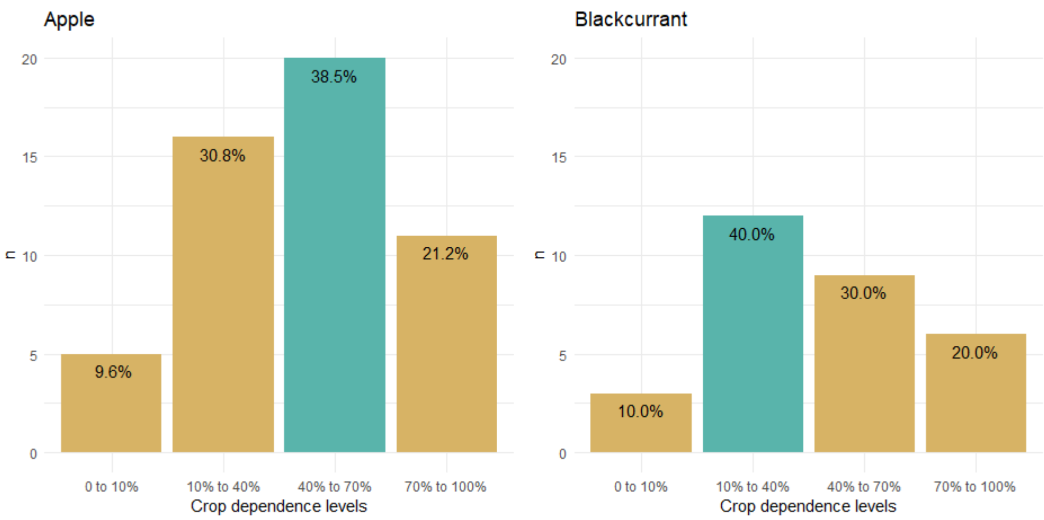

Figure 5: Perceived dependence among apple (N=52) and blackcurrant farmers (N=30). Dark green bars represent ratings of pollinator dependence for each crop in Klein et al. (2007). Percentage values inside bars represent the relative proportion of farmers' responses for each level.

Farmers' psychological drivers to the uptake of plant flowers

From pilot questionnaire we elicited 19 beliefs towards plant flowers presented by farmers of pollinator-dependent crops (Table 2).

Table 7: Set of elicited beliefs towards plant flowers as nectar and pollen sources.

Belief	**Elicited beliefs**
Outcome beliefs	makes my farm looks more attractive
	increases the number of natural pollinators
	improves my yield of marketable fruit
	leads to reduction of pest numbers
	helps other wildlife, including birds and mammals
	represents a loss of productive land that could be used to grow fruit
	encourages establishment of unwanted weeds
Social referents	other farmers and growers
	retail customers
	government bodies
	environmental organisations
	other farmers and growers
	retail customers
Control beliefs	areas with appropriate soil
	financial support
	good advice or guidance
	to buy appropriate and affordable seed mix
	are easy to establish
	quick and easy to manage

Behaviour beliefs

We separated behavioural beliefs in advantageous and disadvantageous as it came from the pilot questionnaire. Farmers (N=82, one questionnaire missing data) presented high positive perception towards advantageous outcome beliefs, showing that they do believe that plant flower might bring the outcome and massively ranked those as good for their business (Figure 5, a and b). "Makes farm more attractive" was ranked as neutral by 44% of farmers. They also think that plant flowers as nectar and pollen sources for pollinating insects can bring disadvantageous outcomes, among which loss of productive areas was more perceived as unlikely (48%) and establishment of unwanted weeds as more likely to happen (68%). Both outcomes were evaluated as bad for their business by most of the farmers (Figure 5, d and c).

Figure 6: proportion of farmers perceptions towards outcome beliefs and outcome evaluation of planting flowers as nectar and pollen sources for pollinating insects in fruit-growing areas.

Normative beliefs and motivations to comply

From the list of social referents, farmers have tended to disagree with the perceived evaluation of social referents and the motivations to comply with their opinions, except for other farmers and growers, who might play a more important role in relation to farmers' social beliefs. Most of the farmers presented a neutral perception of other farmers and growers; however, 57% of them presented a high motivation to comply with this referent group (Figure 6, b).

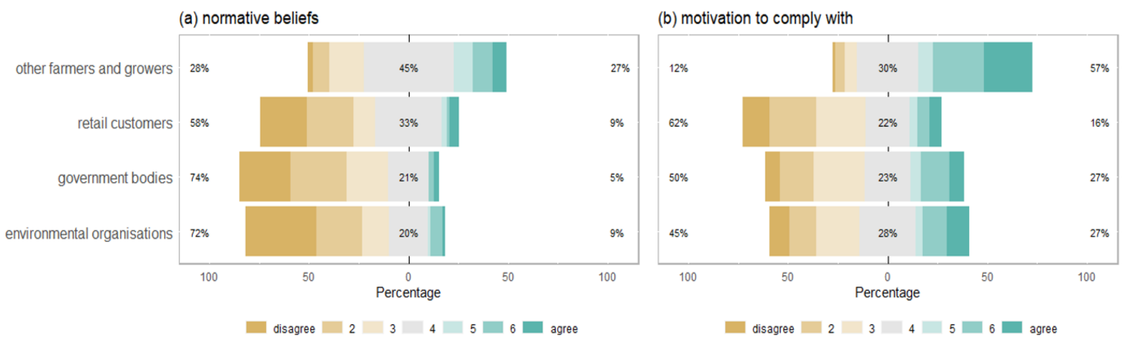

Figure 7: proportion of farmers agreement with normative beliefs of social referents and motivation to comply with them.

Control beliefs and perceived control factor

We separated control beliefs as perceived needs (Figure 7, a and b) and perceived facility (Figure 7, c and d). In general, paired control beliefs (*i.e.*, perception of what is needed to perform the behaviour) and power control factor (*i.e.*, perception of resources available to perform the behaviour) presented more variation. Areas with appropriate soil and appropriate and affordable seed mix were high ranked among farmers (82% and 72% of agreement, respectively), followed by good advice or guidance (46% of agreement) and financial support (21% of agreement). Power control towards these control factors tended to be more positive (44%, 63%, 82% and 50%, respectively). Control factors towards perceived facility presented less variation (easy to establish (47% agreement) and "quick and easy to manage non-crop flowering plants" (48%

agreement). Respective power control factors were oppositely ranked, with 83% and 6% of agreement, respectively (Figure 7, d).

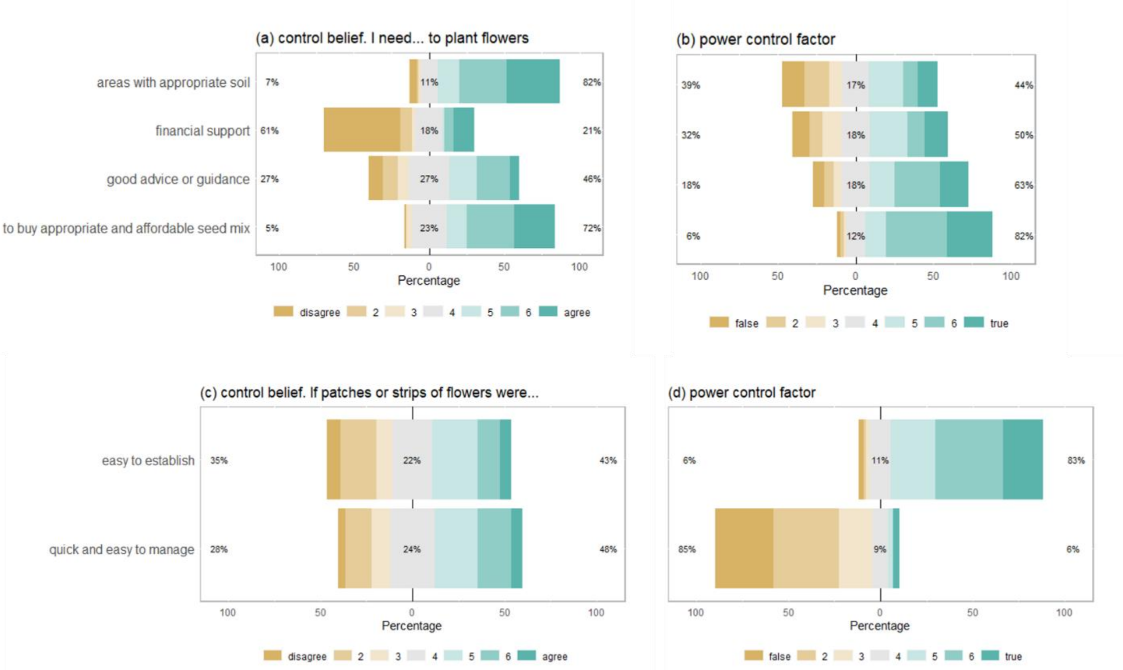

Figure 8: proportion of farmers' perceptions of control beliefs and their perceived power control towards each elicited factor that might enable or constrain the target behaviour.

Determinants of intentions to plant flowers as nectar and pollen sources for pollinating insects

We tested the internal consistency reliability of scales measuring TPB direct constructs using Cronbach's alpha (Cronbach, 1951). In total, we removed 2 out 12 items from direct control and direct norm because they had a low correlation with the total scale (r.drop < 0.3) and decreased the overall alpha value when kept. The remaining items presented satisfactory alpha values for all scales, ranging from 0.55 to 0.85, which means that the scores on the items of the scale could be used to average for the underlying construct.

Constructs	Number of items (k)	α
Behaviour intention	3	0.85
Direct attitude	3	0.63
Direct control	2 out of 3	0.63 (0.46)
Direct norm	2 out of 3	0.55 (0.48)

We found positive correlations between behaviour beliefs and direct attitude (r= 0.72, $p< 0.05$), normative beliefs and direct social norm (r= 0.68, $p< 0.05$), and control beliefs and direct control (r=0.44, $p< 0.05$), which allow us to use direct measures to test the determinants of intentions and behaviour. The collinearity test showed that VIF values were below the threshold 5 (ATT= 1.40, SN = 1.43, PBC= 1.44), indicating that our variables were suitable for the multiple linear regression. Multiple linear regression testing the influence of direct measures on intentions (Table 2) showed that attitudes and perceived control were the main determinants of intention to plant flowers as nectar and pollen sources for pollinating insects among apple and blackcurrants farmers (R^2 = 0.4582, F =23.83, $p <0.001$).

Table 8: model output testing determinants of farmers' intention to plant flowers as nectar and pollen sources for pollinating insects.

Response	Model statistics	Predictors	Estimate	SE	p-value
Intentions	R^2 0.45	attitude	0.731	0.193	0.0003
	p-value= 4.77^{-11}	social norms	0.155	0.132	0.243
		perceived control	0.463	0.126	0.0004

We tested if intention of planting flowers differs between farmers who already adopted and non-adopted the behaviour. We found no significant difference between these groups (t= 1.39, $p > 0.05$).

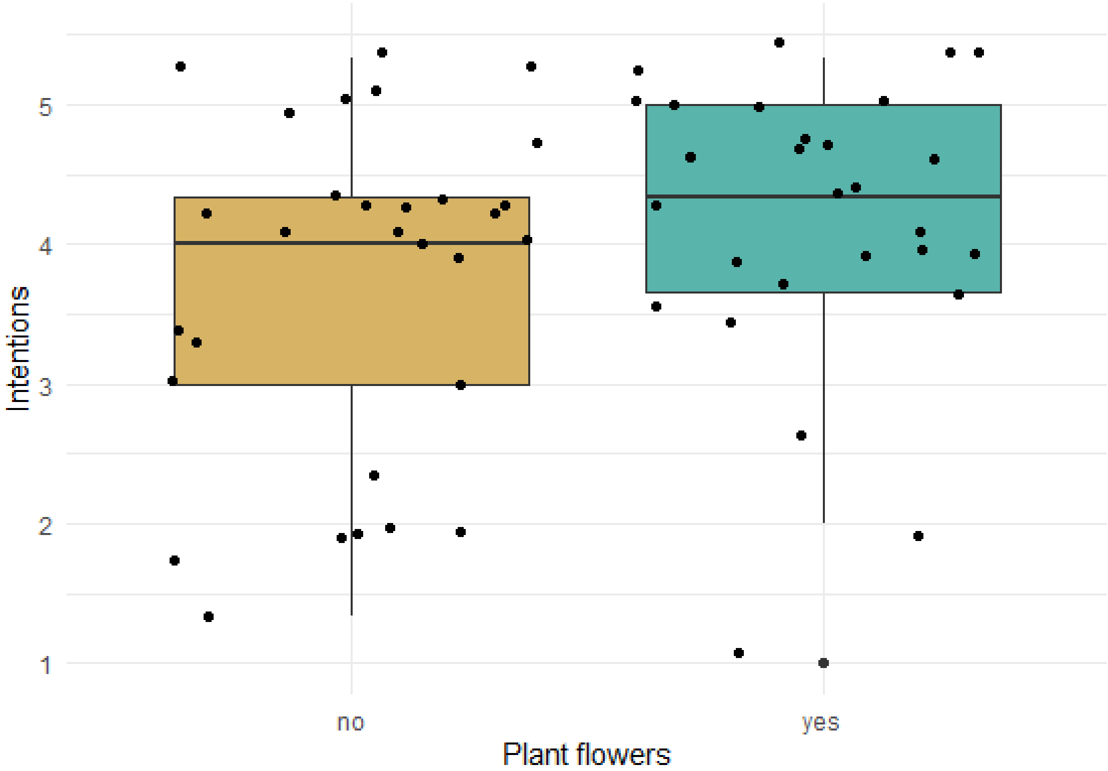

Figure 9: boxplot showing variation among farmers' intentions to plant flowers as nectar and pollen sources.

Discussion

In our study we made three sets of analyses in order to (1) describe farmers' understanding of pollinators importance, (2) describe their beliefs towards planting flowers as nectar and pollen sources for pollinating insects, and (3) test the psychological determinants towards intentions to plant flowers. Our study showed that farmers have a high perception of the importance of pollinators in general and understand that their crops have a high dependence of pollinators which also brings outcomes to quantity and quality of the yield. Perceived crop's dependence ratings of pollinators, is the same (38,5%) or less (total: 40,4%) than reported by Klein et al (2007), for apple farmers while, for blackcurrant farmers, is the same (40%) or above (total: 50%). We also showed that behaviour and control beliefs played a more positive role than normative beliefs towards planting flowers as nectar and pollen sources and, in accordance with this result, direct attitudes and direct perceived behaviour control were important determinants of apple and blackcurrant farmers' intentions to perform the behaviour.

In our study, when farmers reported high perceived importance of pollinators, they also reported high perceived dependence, while more variation was found in relation to the perceived quality. In different contexts, either high or low perceived importance of pollinators to crops' production were found in previous studies (Hevia et al. 2020; Misganaw, Mengesha, and Awas 2017; Munyuli 2011; Park et al. 2018). Breeze et al (2019) showed a high perception of pollination deficit among farmers from twelve crops, although low evidence of pollination deficit magnitude is available in the literature (Breeze et al. 2019). Regardless of diverging results concerning perceived importance, scientific and local knowledge can be useful to quantitatively predict pollinators' importance for crops, but this requires careful design (Smith et al. 2017). On-farms experience shaping farmers' perceptions and the relation of perceived importance to yield positively influencing the adoption of low-cost pollinator friendly practices was already documented (Nalepa et al. 2020; Osterman et al. 2021). Studies comparing the relative perceived importance of pollinators in relation to other farming inputs might help to identify how much pollinators (and pollination services) are considered a priority among farmers.

Our results also presented four main categories of farmers' perceived outcomes (aesthetic, yield, pest control, and flavour). From those, only pest control was a surprising result. We suggest this derives from previous knowledge about bio-vectoring – a technique that combines the use of bees to provide pollination services while dispersing pathogenic fungi for crops pests (e.g., Hokkanen, Menzler-hokkanen, and

Lahdenperä 2015). Most of apple farmers' perceived pollinator dependence was the same (38,5%) or less (total: 40,4%) than reported by Klein et al (2007), while blackcurrant farmers' perceived pollinator dependence was the same (40%) or above (total: 50%). Previous comparison showed that there is substantial difference between farmers' perceptions and what is reported in the scientific literature (Breeze et al 2019), which we think is the same case here.

Farmers were highly positive about the outcome beliefs (*i.e*., outcomes produced by the behaviour) and outcome evaluation (*i.e*., impact the behaviour causes on their business). Although, the evaluation of "makes farm looks more attractive" – an advantageous outcome for their business – were positively ranked for only 52% of farmers, with 45% being neutral about it. We expect then that farm's appearance is not a priority for them as it might demands a lot of effort with a low cost-benefit. Although "loss of productive land" was perceived as a likely outcome by 30% of farmers in contrast to 68% that pointed to the outcome "establishment of unwanted weeds", both were clearly evaluated as bad for their business, as expected. However, the occupation of farmland with non-crop flowering plants can bring a trade-off for pest control and pollination services that those farmers seem not to be aware of. Recently, Albrecht et al. (2020) showed that flower strips enhance pest control services in adjacent fields by 16% on average and species-rich and older planting deliver more pollination services (*e.g.,* fruit and seed set). Weeds, in turn, can enhance crop productivity and attract more diversity of pollinators to crops areas (Carvalheiro et al. 2011).

In general, normative beliefs (i.e., perceptions of social referents' normative expectations) and motivations to comply (i.e., comply with the opinions of these referents) played a more negative role for farmers, indicating that farmers might act without taking other opinions into account. Other farmers and growers, however, were the only referent group with slightly positive influence on normative beliefs among farmers, with this referent group's opinions playing a pivotal role in the motivations to comply for 57% of our sample. Although, social beliefs may vary for each group under analysis according to the TPB framework (Ajzen 1991),in our case, due the influence of other farmers and growers founded, we believe that reinforcing contact and communication among farmers might be helpful to influence each other and, probably, enhance their collective impact, as the opinion of some of them can stimulate other farmers through sharing experiences and pro-environmental values.

More contrasting tendencies were found between paired control beliefs (*i.e*., perception of what is needed to perform the behaviour) and respective power control factor (*i.e.*, perception of resources available to perform the behaviour) for the following aspects: areas with appropriate soil (high control belief, low power control), financial support (low control belief, high power control), facility to establish (low control belief, high power control) and celerity and facility to manage (high control belief, low power control). Curiously, financial support is perceived not as much as a need and is available for farmers, which can be a result of agri-environmental schemes supporting farmers to implement pro-pollinators management actions (Dicks et al. 2019).

The facility to establish might be perceived as high, because of farmers' experience which influence their knowledge as found by Osterman et al. (2021). Future research analysing factors influencing farmers' control beliefs is needed and might clarify the tendencies we found here, potentially indicating which control factors needs more investment and have more better cost-benefit to farmers.

Our model explains 45% of the farmers intentions to plant flowers within crops, which we consider high explanation for a psychological perspective. Attitudes and perceived behaviour control contributed positive and significantly to the intention to plant flowers as nectar and pollen sources among UK farmers. Our result is different from that obtained by Knapp et al. (2021), who found, when testing the determinants of a set of pro-pollinator actions (not intentions), that attitude to pollinator conservation was not significant to predict peoples' actions, but, instead, attitude to pollinators was a significant predictor. Based on our results, we expect that, in the future, initiatives aiming to encourage UK farmers to adopt or keep adopting the same behaviour (plant flowers) may focus on attitudes factors, as we have some evidence of its positive role.

The attitude was 1.58 times more important for intentions than the perceived behaviour control and, surprisingly, social norms was not significant. These results were different of what we expect because, from the TPB perspective, the perceived control use to be more influential in people's intentions and behaviour. Second, we would expect that farmers use to take actions influenced by others social references. One possible explanation for our result is the sample distribution is very broad (UK scale) and the contact among them is not very influential. On the other side, is really interesting to see that attitude (i.e., positive evaluation of a pro-pollination action) is strongly influencing fruit growers. Future research can quantitatively address whether awareness strategies is improving their attitudes and actions.

Recommendations

We know pollinators are essential for life. However, they are declining mainly because of agriculture intensification and expansion. A set of practical responses to pollinators' declines has already been proposed (IPBES, 2016), and we urgently need to promote key stakeholders' engagement in pro-pollinators actions. Also, every environmental problem is a *socio*environmental problem, so take people into account in the solution is the most coherent way to revert this scenario. To do so, we need inter- and transdisciplinary approaches that conciliate ecological knowledge with stakeholders' perceptions, beliefs, intentions, values and knowledge in order to create effective and straightforward behaviour change strategies (Bartomeus and Dicks 2019; Marselle and Shwartz 2020). Behaviour change strategies might also include people's awareness of public policy and market lobby that affects people and biodiversity.

In our study we explored UK farmers' perceptions of pollinator importance, their beliefs towards a key pro-pollinator action, and tested the determinants for their intentions of planting flowers. From the TPB, it is possible to draw specific action aiming at behaviour change. Based on the beliefs supporting significant direct psychological determinants (i.e., attitudes and control), we recommend target actions that might be taken by farmers organisations, universities, public and private sectors in order to promote and encourage the uptake of pro-pollinator behaviours among farmers (Table 5).

Table 9: Recommended conservation actions to encourage the uptake of pro-pollinator actions focused on people and nature in agroecosystems.

Beliefs	**Strategies**	**Key social actors who might co-produce/interact with farmers**
Behavioural beliefs	Outreach activities aiming to present and discuss with farmers ecological networks, ecological evidence of the effects of diversified environments in comparison with less diversified environments in order to clarify the underlying biological mechanisms and the benefits for their businesses. Include farmers in genuine scientific research, for example, using citizen science models and / or giving feedback to farmers who take part in scientific research.	Universities (ecologists and conservationists, social scientists), educators/ teachers, farmers associations
Control beliefs	Control beliefs can be quite constraining to behaviour uptake. From the set of beliefs we found, non-farmer stakeholders can have more influence in keeping financial support, training and guidance or give guidance it in cases where is lacking. Financial support can be the focus not only to buy seeds or soil inputs, but also to pay people to manage non-crop flowering areas.	Universities (ecologists and conservationists, social scientists), educators/ teachers, farmers associations, private and public sector.

Farmers, in turn, can persuade others in order to encourage the use of areas to plant flowers and share experiences about the management.

3

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Considerações Finais

Esta tese teve como objetivo principal investigar à luz de abordagens interdisciplinares entre Conservação e Ciências Humanas fatores sociopsicológicos relacionados à conservação de polinizadores considerando dois contextos: Ciência Cidadã e Agricultura, os quais foram organizados em Parte I e II, respectivamente. Na Parte I, a partir da proposição teórica da ciência cidadã como um modelo de co-produção que rapidamente por aumentar a conservação de polinizadores e do estudo empírico sobre os pontos de vista de coordenadores de projetos sobre a importância da ciência cidadã foi possível evidenciar que a ciência cidadã é vista como muito benéfica para aproximar a ciência da sociedade e fomentar o objetivo principal da Conservação: reverter danos antrópicos ao meio ambiente agregando a isso a participação coletiva das partes interessadas. No entanto, a direção e o tamanho desse impacto não são consensuais. Os benefícios para a quantidade e qualidade de dados não é vista de maneira similar entre coordenadores de projetos e, em alguns casos, a ciência cidadã é vista como estratégia de engajamento das pessoas, contribuindo para o seu aprendizado científico ou educação ambiental. Por outro lado, a ciência cidadã fomenta a criação de estruturas inter-transdisciplinares que são cruciais para a conservação dos polinizadores.

A partir desses resultados recomendo que iniciativas atuais e futuras de ciência cidadã se debrucem em compreender e explicitar qual a teoria da mudança esperada pelas partes envolvidas. Coordenadores de projetos especialmente precisam explicitar quais são os principais objetivos do projeto e, muitas vezes, definir isso conjuntamente com as pessoas com quem pretende-se colaborar.

Na Parte II, em que foi avaliado fatores sociopsicológicos relacionados à conservação de polinizadores na Agricultura, encontrei que essa questão é ainda pouco endereçada na literatura. Uma possível explicação para isso é que nesse contexto é comum o estabelecimento de recomendações para serem aplicadas na prática. Por não haver *a priori* um mecanismo que possa aproximar cientistas ambientais dos agricultores, a aproximação é feita de maneira não sistemática. Nesse sentido, iniciativas de ciência cidadã podem servir para fomentar a adoção de práticas amigáveis aos polinizadores. Com base no estudo empírico apresentado no Capítulo IV, encontramos que as atitudes e a percepção de controle dos agricultores são os determinantes à intenção de plantar flores como recurso de néctar e polén para insetos polinizadores. Pesquisas futuras podem se debruçar a entender o mesmo comportamento para fins de comparação e compreensão de fatores locais que podem fomentar ou restringir a adoção.

Vale ressaltar também as limitações que esta tese possui. Por exemplo, no estudo sobre coordenadores de projetos (Capítulo II) falta compreender como características dos projetos ou experiência dos coordenadores interferem em seus pontos de vista. Entender quais as motivações e barreiras dos participantes de projetos de ciência cidadã focados em polinizadores é também algo que não foi investigado aqui e que pode agregar bastante à compreensão das contribuições da ciência cidadã. Já, em relação aos agricultores (Capítulo IV), embora o estudo revele aspectos importantes dos determinantes à intenção dos agricultores, não podemos afirmar que isso irá determinar o seu comportamento, pois é previsto que há uma lacuna intenção-comportamento na própria TPB que precisa ser empiricamente testada.

Os resultados desta tese podem ser usados como norteadores do planejamento de ações de engajamento de atores sociais, formulação de políticas públicas, design e implementação de projetos de ciência cidadã, orientação de redes de pesquisa, elaboração de materiais educativos, bem como, referência para futuras pesquisas na interface entre Conservação e Ciências Humanas.

Por fim, compreender fatores sociopsicológicos relacionados a conservação de polinizadores requer esforço na compreensão de teorias e métodos das Ciências Humanas, especificamente da Psicologia Social. Mas, considero que isso não deve ser visto como impeditivo. A pesquisa inter-transdisciplinar focada na conservação de polinizadores está em sua infância e é bastante promissora para gerar mudanças transformadoras. Pesquisas que foquem em questões relacionadas a pessoas e natureza sob a abordagem da Conservação e Ciências Humanas estarão caminhando na direção de pensar a conservação dos polinizadores e para além dos polinizadores, tendo assim, grande potencial de promover justiça ambiental, luta social engajada e mudança política cientificamente informada.

Supporting information – Capítulo II

Appendix S1 provides the statements list.

Statement number	What do you think the purpose of citizen science focusing on pollinators is? Please rank the following statements relative to each other, according to their importance	O que você pensa sobre o propósito da ciência cidadã focada em polinizadores? Por favor, faça um ranqueamento das frases relacionando-as entre si, de acordo com sua importância
	statements ENG	**afirmações PT**
1	Citizen science is a genuinely interactive and an inclusive science engagement activity	A ciência cidadã é genuinamente uma atividade inclusiva de engajamento em ciência
2	citizen science increases public understanding of how science works	a ciência cidadã aumenta o entendimento do público sobre como a ciência funciona
3	citizen science increases accessibility to scientific knowledge about pollinators	a ciência cidadã aumenta o acesso ao conhecimento científico sobre polinizadores
4	Citizen science successfully combines public engagement in pollinator conservation and outreach goals with scientific goals	A ciência cidadã combina objetivos de engajamento na conservação dos polinizadores e de extensão com objetivos científicos
5	Citizen science pollinator projects are not particularly successful in increasing knowledge of scientific methods and science in general	Projetos de ciência cidadã são particulamente mal sucedidos em aumentar o conhecimento de métodos científicos e ciência no geral
6	Citizen science burdens scientists	A ciência cidadã sobrecarrega cientistas
7	Citizen science makes people feel more connected to pollinators	A ciência cidadã faz as pessoas se sentirem mais conectadas com os polinizadores
8	Citizen science data are biased towards conspicuous species	Os dados de ciência cidadã são tendenciosos para espécies mais visíveis
9	Citizen science may use knowledge from different academic disciplines and from other types of knowledge to conserve pollinators	A ciência cidadã pode usar abordagens transdisciplinares para conservar os polinizadores
10	Citizen science helps to estimate historic trends in pollinator presence or abundance	A ciência cidadã ajuda a estimar tendências históricas de presença ou abundância dos polinizadores

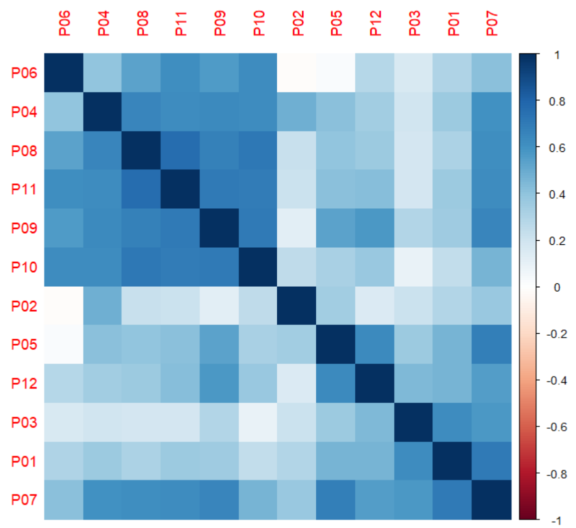
11	Citizen science enhances our understanding of how pollinators use resources in the landscape	A ciência cidadã melhora nosso entendimento de como os polinizadores usam os recursos na paisagem
12	Citizen science data are biased by the way data are collected	Os dados de ciência cidadã são enviesados pela maneira como são coletados
13	Citizen science data to inform the conservation of pollinators are imprecise	Os dados de ciência cidadã que informam sobre a conservação de polinizadores são imprecisos
14	Citizen science data to inform the conservation of pollinators are unreliable	Os dados de ciência cidadã que informam sobre a conservação de polinizadores são inconfiáveis
15	Citizen science informs policies on pollinators	A ciência cidadã informa políticas em prol os polinizadores
16	Citizen science can reinforce the protection of the most known pollinator species	A ciência cidadã pode reforçar a proteção das espécies de polinizadores mais conhecidas
17	Citizen science only engages privileged people in pollinator conservation	A ciência cidadã engaja apenas pessoas privilegiadas na conservação dos polinizadores
18	Citizen science is a useful engagement strategy, but it is not useful for science	A ciência cidadã é uma estratégia útil para o engajamento, mas é inútil para a ciência
19	Citizen science makes people feel overwhelmed	a ciência cidadã faz as pessoas se sentirem sobrecarregadas
20	Citizen science promotes open data	a ciência cidadã promove dados abertos
21	Citizen science increases people's involvement in decision making	a ciência cidadã aumenta o envolvimento das pessoas nas tomadas de decisão
22	Citizen science encourages people to protect native pollinator species species	a ciência cidadã encoraja as pessoas a proteger espécies nativas de polinizadores
23	Citizen science encourages people to control invasive pollinator species	a ciência cidadã encoraja as pessoas a controlar espécies de invasoras de polinizadores
24	Citizen science makes people talk more about pollinator science	a ciência cidadã faz as pessoas falarem mais sobre pesquisa com polinizadores
25	Citizen science is a two-way tool for scientific communication	a ciência cidadã é uma ferramenta bidirecional da comunicação científica
26	Citizen science makes science more transparent and helps to overcome science denialism	a ciência cidadã faz a ciência ser mais transparente ajudando a superar o negacionismo científico

27	Citizen science helps to reduce the knowledge gap about pollinators in the society	a ciência cidadã ajuda a reduzir lacunas de conhecimento na sociedade
28	Citizen science increases the appreciation for scientific knowledge	a ciência cidadã aumenta a valorização do conhecimento científico
29	Citizen science is more accessible to richer and more highly educated people	a ciência cidadã é mais acessível às pessoas ricas e com maior grau de educação
30	Citizen science attracts people who already have an interest in the environment and nature	a ciência cidadã atrai pessoas que já possuem interesse no meio-ambiente
31	Citizen science projects are time-consuming and cannot meet the urgent demands of pollinator conservation	os projetos de ciência cidadã consomem tempo e não podem atender às demandas urgentes para conservação dos polinizadores
32	Citizen science knowledge are only used by researchers and not by other stakeholders	os conhecimentos oriundos da ciência cidadã são usados apenas pelos pesquisadores e não por tomadores de decisão
33	Citizen science data have limited usefulness for decision making	os dados da ciência cidadã são limitados, o que reduz sua utilidade para o processo de tomada de decisão
34	Citizen science reduces the introduction of invasive species	a ciência cidadã reduz introdução de espécies invasoras
35	Citizen science helps to formulate pro-pollinators policies	a ciência cidadã ajuda a formular políticas pró-polinizadores
36	Citizen science is more effective than conventional science at achieving pollinator conservation	a ciência cidadã é mais efetiva na conservação de polinizadores do que a ciência convencional
37	The diversity of citizen science protocols makes it difficult to integrate data among projects	A diversidade dos protocolos de ciência cidadã torna difícil a integração dos dados entre diferentes projetos
38	Citizen science data are geographically biased	Os dados de ciência cidadã são geograficamente enviesados
39	Citizen science helps to spark interest and involvement in pollinator science	a ciência cidadã ajuda a despertar interesse e envolvimento em pesquisa sobre polinizadores
40	Citizen science helps the society in overcoming environmental conflicts	a ciência cidadã ajuda a sociedade na superação de conflitos ambientais
41	Citizen science helps people achieve their own environmental ambitions	a ciência cidadã ajuda as pessoas a alcançarem seus próprios objetivos pró-ambientais
42	Citizen science is a good approach for getting funding for pollinator research	a ciência cidadã é uma boa abordagem para conseguir recursos para a pesquisa com polinizadores
43	Citizen science is a good approach for fundraising pollinator research	a ciência cidadã é uma boa abordagem para conseguir doações para pesquisa com polinizadores

44	Citizen science helps people understand their civic roles in society	A ciência cidadã ajuda as pessoas a entenderem seu papel civil na sociedade
45	Citizen science increases positive emotions towards pollinators	Ciência cidadã aumenta as emoções positivas das pessoas em relação aos polinizadores
46	Citizen science increases public awareness of the importance of pollinators	A ciência cidadã aumenta a conscientização pública sobre a importância dos polinizadores

Appendix S2 reports the analytical tests.

1. Correlation matrix before factor extraction



2. How many factors?
   I tested all the criteria presented at Watts and Stenner 2012.

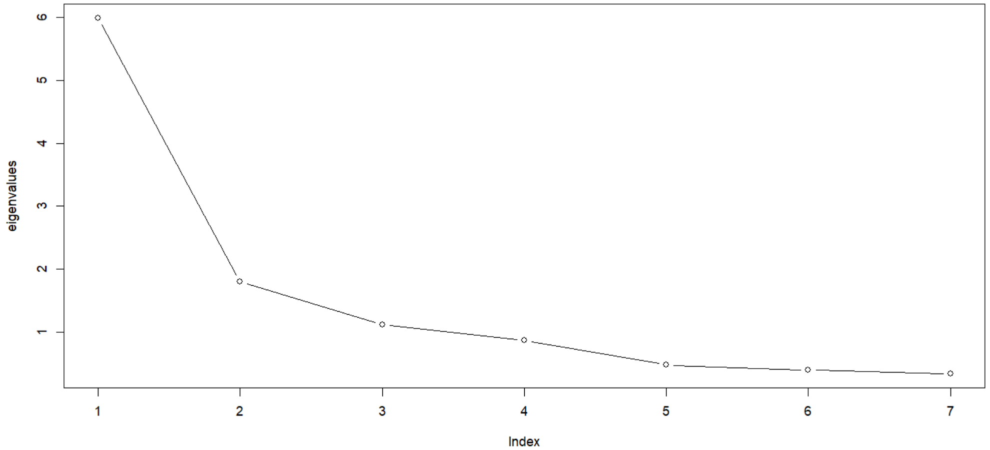
a. Kaiser-Gutmann criteria

PC1	**PC2**	**PC3**	PC4	PC5	PC6	PC7
TRUE	TRUE	TRUE	FALSE	FALSE	FALSE	FALSE

b. Two or more significant loadings (##See which components have 2 or more.)

PC1	**PC2**	**PC3**	PC4	PC5	PC6	PC7
12	3	2	0	1	1	0

c. Scree test



Correlation between factor z-scores:

	zsc_f1	zsc_f2	zsc_f3
zsc_f1	1.00	**0.48**	**0.24**
zsc_f2	0.48	1.00	**0.33**
zsc_f3	0.24	0.33	1.00

Appendix S3 reports true and false for conflicting or consensus among statements.

No	statements	F1 z-score	F1 rank	F2 z-score	F2 rank	F3 z-score	F3 rank	Salience	Standard deviation	Consensus	Conflicting
41	Citizen science helps people achieve their own environmental ambitions	0.22	0	0.17	0	0.00	0	0.13	0.12	FALSE	FALSE
45	Citizen science increases positive emotions towards pollinators	0.68	1	0.86	2	0.90	2	0.81	0.12	FALSE	FALSE
39	Citizen science helps to spark interest and involvement in pollinator science	1.07	3	1.24	3	1.35	3	1.22	0.14	TRUE	FALSE
7	Citizen science makes people feel more connected to pollinators	1.08	3	1.39	3	1.35	3	1.27	0.17	TRUE	FALSE
42	Citizen science is a good approach for getting funding for pollinator research	-0.17	0	0.21	0	0.00	0	0.12	0.19	FALSE	FALSE
4	Citizen science successfully combines public engagement in pollinator conservation and outreach goals with scientific goals	0.89	2	1.24	3	0.90	2	1.01	0.20	TRUE	FALSE
27	Citizen science helps to reduce the knowledge gap about pollinators in the society	0.49	1	0.53	1	0.90	2	0.63	0.23	FALSE	FALSE
19	Citizen science makes people feel overwhelmed	-1.29	-3	-0.80	-1	-0.90	-2	0.99	0.26	TRUE	FALSE

22	Citizen science encourages people to protect native pollinator species species	0.93	2	0.44	1	0.45	1	0.60	0.28	FALSE	FALSE
11	Citizen science enhances our understanding of how pollinators use resources in the landscape	0.51	1	0.06	0	0.00	0	0.19	0.28	FALSE	FALSE
15	Citizen science informs policies on pollinators	0.29	0	0.77	2	0.00	0	0.35	0.39	FALSE	FALSE
25	Citizen science is a two-way tool for scientific communication	0.74	1	0.15	0	0.90	2	0.59	0.40	FALSE	FALSE
16	Citizen science can reinforce the protection of the most known pollinator species	1.01	2	0.21	0	0.45	1	0.55	0.41	FALSE	FALSE
32	Citizen science knowledge are only used by researchers and not by other stakeholders	-0.65	-1	-1.38	-3	-1.35	-3	1.12	0.41	TRUE	FALSE
9	Citizen science may use knowledge from different academic disciplines and from other types of knowledge to conserve pollinators	0.67	1	-0.16	-1	0.45	1	0.42	0.43	FALSE	FALSE
46	Citizen science increases public awareness of the importance of pollinators	1.10	3	0.85	2	1.80	4	1.24	0.49	TRUE	FALSE
36	Citizen science is more effective than conventional science at achieving pollinator conservation	-0.31	-1	-0.89	-2	-1.35	-3	0.85	0.52	TRUE	FALSE
10	Citizen science helps to estimate historic trends in pollinator presence or abundance	0.85	2	1.05	2	0.00	0	0.63	0.56	FALSE	FALSE

21	Citizen science increases people's involvement in decision making	0.36	0	-0.72	-1	-0.45	-1	0.51	0.56	FALSE	FALSE
23	Citizen science encourages people to control invasive pollinator species	-0.56	-1	-1.48	-3	-0.45	-1	0.83	0.57	FALSE	FALSE
20	Citizen science promotes open data	1.20	4	0.02	0	0.45	1	0.55	0.60	FALSE	FALSE
31	Citizen science projects are time-consuming and cannot meet the urgent demands of pollinator conservation	-1.09	-2	-1.64	-4	-0.45	-1	1.06	0.60	TRUE	FALSE
34	Citizen science reduces the introduction of invasive species	-0.57	-1	-1.36	-3	-1.80	-4	1.24	0.63	TRUE	FALSE
12	Citizen science data are biased by the way data are collected	-0.82	-1	0.38	0	0.45	1	0.54	0.71	FALSE	FALSE
43	Citizen science is a good approach for fundraising pollinator research	-0.47	-1	-0.46	-1	0.90	2	0.61	0.79	FALSE	FALSE
1	Citizen science is a genuinely interactive and an inclusive science engagement activity	1.71	4	0.39	1	1.80	4	1.30	0.79	FALSE	TRUE
3	citizen science increases accessibility to scientific knowledge about pollinators	1.19	3	0.48	1	-0.45	-1	0.70	0.82	FALSE	FALSE
6	Citizen science burdens scientists	-1.58	-4	-1.33	-3	0.00	0	0.97	0.85	FALSE	TRUE
30	Citizen science attracts people who already have an interest in the environment and nature	0.23	0	1.80	4	1.80	4	1.27	0.91	FALSE	TRUE

26	Citizen science makes science more transparent and helps to overcome science denialism	0.46	0	-0.29	-1	-1.35	-3	0.70	0.91	FALSE	FALSE
17	Citizen science only engages privileged people in pollinator conservation	-1.89	-4	-0.06	-1	-0.90	-2	0.95	0.92	FALSE	TRUE
24	Citizen science makes people talk more about pollinator science	0.75	1	0.69	1	-0.90	-2	0.77	0.94	FALSE	FALSE
35	Citizen science helps to formulate pro-pollinators policies	0.97	2	0.28	0	-0.90	-2	0.71	0.95	FALSE	FALSE
44	Citizen science helps people understand their civic roles in society	0.13	0	-0.84	-2	-1.80	-4	0.92	0.97	FALSE	TRUE
5	Citizen science pollinator projects are not particularly successful in increasing knowledge of scientific methods and science in general	-1.95	-4	-0.95	-2	0.00	0	0.96	0.98	FALSE	TRUE
33	Citizen science data have limited usefulness for decision making	-1.39	-3	-1.18	-2	0.45	1	1.00	1.01	FALSE	TRUE
40	Citizen science helps the society in overcoming environmental conflicts	0.16	0	-1.30	-2	-1.80	-4	1.08	1.02	FALSE	TRUE
37	The diversity of citizen science protocols makes it difficult to integrate data among projects	-0.87	-2	1.18	3	0.00	0	0.68	1.03	FALSE	FALSE
2	citizen science increases public understanding of how science works	1.61	4	0.44	1	-0.45	-1	0.83	1.03	FALSE	FALSE

38	Citizen science data are geographically biased	-0.48	-1	1.40	4	-0.45	-1	0.77	1.08	FALSE	FALSE
28	Citizen science increases the appreciation for scientific knowledge	0.77	1	0.38	1	-1.35	-3	0.83	1.13	FALSE	FALSE
29	Citizen science is more accessible to richer and more highly educated people	-1.39	-3	1.05	2	-0.45	-1	0.96	1.23	FALSE	TRUE
13	Citizen science data to inform the conservation of pollinators are imprecise	-0.98	-2	-0.53	-1	1.35	3	0.95	1.24	FALSE	TRUE
18	Citizen science is a useful engagement strategy, but it is not useful for science	-1.42	-3	-2.03	-4	0.45	1	1.30	1.29	FALSE	TRUE
8	Citizen science data are biased towards conspicuous species	-1.21	-2	1.49	4	-0.90	-2	1.20	1.48	FALSE	TRUE
14	Citizen science data to inform the conservation of pollinators are unreliable	-0.98	-2	-1.74	-4	1.35	3	1.35	1.61	FALSE	TRUE

Appendix S4 provides crib sheet for the three factors interpretation

Supplementary Material – Factor Interpretation

We conducted a holistic factor's interpretation following the method presented by Watts and Stern (2012). This procedure consists in sorting items in four basic categories for each factor (see below) in order to identify the items that make the most profound or important contributions within a factor array.

Crib sheet for factor 1 – draft 1 pink is bad for science / yellow good for science / green engagement / blue policies

Category	Items number	Item wording
Items ranked at + 4	1	Citizen science is a genuinely interactive and an inclusive science engagement activity (+4)
	2	citizen science increases public understanding of how science works (+4)
	20	Citizen science promotes open data (+4)
Items Ranked higher in factor 1 array than in other factor arrays		
	3	citizen science increases accessibility to scientific knowledge about pollinators (+3)
	11	Citizen science enhances our understanding of how pollinators use resources in the landscape (+1)
	16	Citizen science can reinforce the protection of the most known pollinator species (+2)
	21	Citizen science increases people's involvement in decision making (0)
	22	Citizen science encourages people to protect native pollinator species (+2)
	32	Citizen science knowledge are only used by researchers and not by other stakeholders (-1)
Items ranked lower in factor 1 array than in other factor arrays		
	12	Citizen science data are biased by the way data are collected (-1)
	13	Citizen science data to inform the conservation of pollinators are imprecise (-2)
	19	Citizen science makes people feel overwhelmed (-3)
	29	Citizen science is more accessible to richer and more highly educated people (-3)
	30	Citizen science attracts people who already have an interest in the environment and nature (0)
	33	Citizen science data have limited usefulness for decision making (-3)
	37	The diversity of citizen science protocols makes it difficult to integrate data among projects (-2)
	45	Citizen science increases positive emotions towards pollinators (+1)
Items ranked at -4		
	6	Citizen science burdens scientists (-4)
	5	Citizen science pollinator projects are not particularly successful in increasing knowledge of scientific methods and science in general (-4)
	17	Citizen science only engages privileged people in pollinator conservation (-4)

Crib sheet factor 2

Category	**Items number**	**Item wording**
Items ranked at + 4		
	8	Citizen science data are biased towards conspicuous species (+4)
	30	Citizen science attracts people who already have an interest in the environment and nature (+4)
	38	Citizen science data are geographically biased (+4)
Items Ranked higher in factor 2 array than in other factor arrays		
	4	Citizen science successfully combines public engagement in pollinator conservation and outreach goals with scientific goals (+3)
	15	Citizen science informs policies on pollinators (+2)
	29	Citizen science is more accessible to richer and more highly educated people (+2)
	37	The diversity of citizen science protocols makes it difficult to integrate data among projects (+3)
	17	Citizen science only engages privileged people in pollinator conservation (-1)
Items ranked lower in factor 2 array than in other factor arrays		
	9	Citizen science may use knowledge from different academic disciplines and from other types of knowledge to conserve pollinators (-1)
	16	Citizen science can reinforce the protection of the most known pollinator species (0)
	20	Citizen science promotes open data (0)
	23	Citizen science encourages people to control invasive pollinator species (-3)
	25	Citizen science is a two-way tool for scientific communication (0)
	35	Citizen science helps to formulate pro-pollinators policies (0)
	46	Citizen science increases public awareness of the importance of pollinators (+2)
Items ranked at -4		
	14	Citizen science data to inform the conservation of pollinators are unreliable (-4)
	18	Citizen science is a useful engagement strategy, but it is not useful for science (-4)
	31	Citizen science projects are time-consuming and cannot meet the urgent demands of pollinator conservation (-4)

Crib sheet Factor 3 ***Factor 3: Citizen Science for citizens with limited outcomes***

Category	Items number	Item wording
Items ranked at + 4		
	1	Citizen science is a genuinely interactive and an inclusive science engagement activity
	30	Citizen science attracts people who already have an interest in the environment and nature
	46	Citizen science increases public awareness of the importance of pollinators (+4)
Items Ranked higher in factor 3 array than in other factor arrays		
	12	Citizen science data are biased by the way data are collected (0)
	13	Citizen science data to inform the conservation of pollinators are imprecise (+3)
	14	Citizen science data to inform the conservation of pollinators are unreliable (+3)
	18	Citizen science is a useful engagement strategy, but it is not useful for science (1)
	25	Citizen science is a two-way tool for scientific communication (+2)
	27	Citizen science helps to reduce the knowledge gap about pollinators in the society (+2)
	28	Citizen science increases the appreciation for scientific knowledge (-3)
	33	Citizen science data have limited usefulness for decision making (+1)
	43	Citizen science is a good approach for fundraising pollinator research (+2)
Items ranked lower in factor 3 array than in other factor arrays		
	2	citizen science increases public understanding of how science works (-1)
	3	citizen science increases accessibility to scientific knowledge about pollinators (-1)
	5	Citizen science pollinator projects are not particularly successful in increasing knowledge of scientific methods and science in general (0)
	10	Citizen science helps to estimate historic trends in pollinator presence or abundance (0)
	24	Citizen science makes people talk more about pollinator science (-2)
	26	Citizen science makes science more transparent and helps to overcome science denialism (-3)
	35	Citizen science helps to formulate pro-pollinators policies (-2)
	36	Citizen science is more effective than conventional science at achieving pollinator conservation (-3)
Items ranked at -4		
	34	Citizen science reduces the introduction of invasive species (-4)
	40	Citizen science helps the society in overcoming environmental conflicts (-4)
	44	Citizen science helps people understand their civic roles in society (-4)

Supporting information – Capítulo IV

Questionnaire

Understanding the uptake of pollinator conservation measures on UK fruit farms: breaking the barriers and informing choice

Part 1 BASIC INFORMATION

1. Gender of grower: Male ______________ Female _____________ [No need to ask this]

2. What is the highest educational qualification or level of school you have completed?

No formal qualifications	GCSE/O level/Scottish Standard Grade	A level/Scottish Higher	University degree or equivalent	Masters	PhD

3. How many years have you been involved in growing fruit?

____

4. How large is the area of fruit on your farm?

10 ha or less	11-40 ha	41-70 ha	71-100 ha	>100 ha

5. Which of the following fruit crops do you grow?
6. Which are the main varieties of these fruits (excluding pollinator or trial varieties)?

	Grown?	Main varieties
Eating apples or pears		
Cider apples or pears		
Plums or cherries		
Other tree fruit		
Blackcurrant		
Strawberries		
Raspberries		
Other soft fruit		

7. Do you pay for pollination services?

[If yes, ask which type of bees are paid for, but do not suggest types]

	Honey bees	Bumblebees	Other bees (red mason bees)	Type of bee unknown
YES				
NO				

8. Do you grow fruit organically?

Entirely organic	Partially organic, or in conversion to organic	Not organic

Part 2 FARMER KNOWLEDGE ABOUT POLLINATORS and POLLINATION

[Show the interviewee the picture card].

9. Do you have these insects in the fruit growing areas of your farm? Please point to those you have definitely seen. If you know what they are, you can name them on the sheet, but there is no need to do so.

	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
Seen on farm?									

10. In your experience, are numbers of *any* of these insects on your farm increasing, decreasing or staying the same over time? [Point out that 'don't know' is an acceptable answer]

11. If you perceive a change, how many years has the change been happening? Can you explain how you know? [Note down main points only. Continue on a separate sheet of paper if more insect types are needed]

INSECT CODE	No. years	Observations

12. We need to select a *main* fruit crop and variety for the following set of questions. Which of your main fruit crops do you feel you know the most about?

    ____

[Check that this is widely grown on the farm, or important in the business due to its value. Note any other reason for choice below].

____

The following set of questions all apply to the fruit variety you have selected in question 12.

13. Thinking about [insert selected fruit variety], please look again at the pictures. Can you pick the ones that are pollinators of your fruit crop and mark them with the letter 'P'?

14. Do you think bees and other pollinators may play an important role in fruit set and increase the yield of [insert selected fruit variety]?

    very important : may play a small role : not important at all : don't know

15. Without pollinating insects such as bees, how much of your harvestable crop (yield), would you lose? If you think the harvest would be the same without insects, choose 0 (no loss). If you think there would be no harvest at all without insects, choose 100% (complete loss)

0	0-10%	10-40%	40-70%	70-100%

16. Now we are going to talk about quality, rather than quantity, of fruit produced. What effect do pollinating insects such as bees have on the *quality* of your harvestable crop?

very positive : positive : neutral : negative : very negative

17. Where the previous answer was not neutral, a supplementary open question: Which quality parameters do you expect are affected? [If necessary, suggest examples such as size, shape, sugar content].

18. Look at the insect pictures again. Apart from crop flowers, what other things in the environment do you think pollinating insects need to survive?

[An open question. The interviewer matches against the following checklist:]

Areas of scrub	
Bare soft earth/soil/ground (for nesting or overwintering)	
Cavities/hollow stems/tubes for nesting	
Ditches	
Flowers at times when crops are not flowering	
Hedgerows	
Larval food plants for moths and butterflies	
Refuge from pesticide/pesticide free areas	
Rough grassland or naturally regenerating areas	
Walls or masonry for nesting	
Water	
Woodland edge	
Don’t know	
Other	

Part 3 CONSERVATION ACTIONS

19. In the last 12 months, did you do any of the following to help pollinators within 500 m of the fruit-growing areas of your farm:

	YES/NO	Checked by site visit?	
Plant flowers as nectar and pollen sources. These could be wild flowers or agricultural varieties such as clover. They could be planted in blocks, margins, strips, field corners or inter-row. It does not include flowering crops.		Is there a site within 500 m of the fruit?	
		Are there flowers in it?	
Allow areas to regenerate naturally over several years. This can include allowing woody plants such as hawthorn and blackthorn to develop into scrub.		Is there a site within 500 m of the fruit?	
		Is it obviously naturally regenerating?	
Allow actively managed grassy areas to flower. This involves infrequent mowing, avoiding fertilizer use and only using selective spring herbicides.		Is there a site within 500 m of the fruit?	
		Is it clearly managed differently/not closely mown?	
Manage hedges for wildlife. Keeping hedges at least 2 m high, cutting them no more than once every three years and leaving 2 m from the hedge centre unsprayed. Hedges should be at least 80% native shrubs.		Is there a site within 500 m of the fruit?	
		Is there a 2 m unsprayed strip?	
		Is the hedge 2 m high and 80% native?	

[Note to interviewer – be sure to highlight the following points:

- Hedges must be 80% native and cut no more than once every three years
- If visiting, check areas area with 500 m of fruit growing areas.
- If they have done some but not all of the things described, UNDERLINE what they did, answer NO]

20. Do you currently receive agri-environment payments (Entry Level or Higher Level Stewardship) for doing any of these?

No	ELS	HLS

21. Do you currently do anything else to benefit pollinators, which we have not mentioned already?

[An open question. The interviewer matches against the following checklist:]

Bee boxes (not already stocked with bees)	
Leave areas of bare ground	
Introduce other habitat features (banks, woodland belts, piles of logs, ponds)	
Early food provision (planting flowers that flower early)	
Deliberate consideration of pollinator safety in spray regimes	
Other (please specify)	

22. Finally, what sources of guidance or advice have you used to get information about pollinators?

[An open question. Use the checklist to code the response, but do not prompt the interviewee, unless they have clearly used one of the sources, but can't remember what it was called enough to categorise it].

Operation pollinator or Operation bumblebee – Syngenta	
NFU	
Campaign for the Farmed Environment	
Defra	
LEAF	
Bumblebee Conservation Trust	
Soil Association	
Horticultural Development Company	
RSPB	
Buglife	
Natural England	
Farming press	
Other farmers or growers	
Agricultural Advisors; Agrovista, Agrii etc	
Other	

Part 4 DETERMINANTS OF BEHAVIOUR

Now we'd like to ask about just one of the actions - **planting flowers as nectar and pollen sources.**

As you know this action is strongly recommended by many conservation organisations, and by Natural England, as an option to help pollinating insects. It is also likely to be a core part of a Government advice package that will accompany the National Pollinators Strategy, to be released this summer. Some fruit growers plant flowers for pollinators every year. In this survey, we are trying to discover some of the reasons that growers do, or do not, plant flowers for pollinating insects.

Specifically, we are interested in your personal opinions about planting flowers within 500 m of the fruit growing areas of your farm. They could be wild flowers or agricultural varieties such as clover, but they must be actively planted, rather than areas managed to produce more flowers. They could be planted in blocks, margins, strips, field corners or inter-row. We do not include flowering crops.

Please read each question carefully, and answer it to the best of your ability. There are no correct or incorrect responses; we are just interested in your personal point of view.

The questions use rating scales with seven places. You are to circle the number that best describes your opinion. For example, if you were asked to rate 'Drinking wine' on such a scale, the seven places would be interpreted as follows:

Drinking wine is:

good:	1	:	2	:	3	:	4	:	5	:	6	:	7	: bad
	extremely		quite		slightly		neither		slightly		quite		extremely	

If you think drinking wine is quite good, you would circle number 2, as follows:

Drinking wine is:

good:	1	:	2	:	3	:	4	:	5	:	6	:	7	: bad

If you have no idea what wine is, so you don't know whether it is good or bad, provide a neutral answer by circling number 4, as follows:

Drinking wine is:

good:	1	:	2	:	3	:	4	:	5	:	6	:	7	: bad

- Be sure to answer all items – do not omit any
- Never circle more than one number on a single scale
- Don't spend too long on each question
- If you don't understand a question, please discuss it with your interviewer at the end.

[Outcome beliefs]

1. Planting flowers as nectar and pollen sources for pollinating insects, in fruit-growing areas of my farm, makes my farm look more attractive.

likely: 1 : 2 : 3 : 4 : 5 : 6 : 7 : unlikely

2. My farm looking more attractive is:

good for my business: 1 : 2 : 3 : 4 : 5 : 6 : 7 : bad for my business

3. Planting flowers as nectar and pollen sources for pollinating insects, in fruit-growing areas of my farm, increases the number of natural pollinators.

likely: 1 : 2 : 3 : 4 : 5 : 6 : 7 : unlikely

4. Increasing the number of natural pollinators is:

good for my business: 1 : 2 : 3 : 4 : 5 : 6 : 7 : bad for my business

5. Planting flowers as nectar and pollen sources for pollinating insects, in fruit-growing areas of my farm, improves my yield of marketable fruit.

likely: 1 : 2 : 3 : 4 : 5 : 6 : 7 : unlikely

6. Improved yield of marketable fruit is:

good for my business: 1 : 2 : 3 : 4 : 5 : 6 : 7 : bad for my business

7. Planting flowers as nectar and pollen sources for pollinating insects, in fruit-growing areas of my farm, leads to reduced pest numbers by increasing the number of predatory insects.

likely: 1 : 2 : 3 : 4 : 5 : 6 : 7 : unlikely

8. Reduced pest numbers, through increased numbers of predatory insects, is:

good for my business: | 1 : 2 : 3 : 4 : 5 : 6 : 7 | : bad for my business

9. Planting flowers as nectar and pollen sources for pollinating insects, in fruit-growing areas of my farm, helps other wildlife, including birds and mammals.

likely: | 1 : 2 : 3 : 4 : 5 : 6 : 7 | : unlikely

10. Helping other wildlife, including birds and mammals, is:

good for my business: | 1 : 2 : 3 : 4 : 5 : 6 : 7 | : bad for my business

11. Planting flowers as nectar and pollen sources for pollinating insects, in fruit-growing areas of my farm, represents a loss of productive land that could be used to grow fruit.

likely: | 1 : 2 : 3 : 4 : 5 : 6 : 7 | : unlikely

12. Losing productive land that could be used to grow fruit is:

good for my business: | 1 : 2 : 3 : 4 : 5 : 6 : 7 | : bad for my business

13. Planting flowers as nectar and pollen sources for pollinating insects, in fruit-growing areas of my farm, encourages establishment of unwanted weeds such as thistle and dock.

likely: | 1 : 2 : 3 : 4 : 5 : 6 : 7 | : unlikely

14. Unwanted weeds, such as thistle and dock, are:

good for my business: | 1 : 2 : 3 : 4 : 5 : 6 : 7 | : bad for my business

[Direct attitude scale]

15. Planting flowers as nectar and pollen sources for pollinating insects, in fruit-growing areas of my farm, is:

good for my business: 1 : 2 : 3 : 4 : 5 : 6 : 7 : bad for my business

16. Planting flowers as nectar and pollen sources for pollinating insects, in fruit-growing areas of my farm, is:

harmful: 1 : 2 : 3 : 4 : 5 : 6 : 7 : beneficial

17. Planting flowers as nectar and pollen sources for pollinating insects, in fruit-growing areas of my farm, will make me feel:

bad about myself: 1 : 2 : 3 : 4 : 5 : 6 : 7 : good about myself

[Normative beliefs and motivation to comply]

18. Other farmers and growers think I should plant flowers as nectar and pollen sources for pollinating insects, in fruit-growing areas of my farm.

agree: 1 : 2 : 3 : 4 : 5 : 6 : 7 : disagree

19. When it comes to managing the fruit-growing areas of my farm, I want to do what other farmers and growers think I should do.

agree: 1 : 2 : 3 : 4 : 5 : 6 : 7 : disagree

20. Retail customers who buy my fruit think I should plant flowers as nectar and pollen sources for pollinating insects, in fruit-growing areas of my farm.

agree: 1 : 2 : 3 : 4 : 5 : 6 : 7 : disagree

21. When it comes to managing the fruit-growing areas of my farm, I want to do what retail customers who buy my fruit, think I should do.

agree: 1 : 2 : 3 : 4 : 5 : 6 : 7 : disagree

22. Government bodies (such as Defra or Natural England) think I should plant flowers as nectar and pollen sources for pollinating insects, in fruit-growing areas of my farm.

agree: 1 : 2 : 3 : 4 : 5 : 6 : 7 : disagree

23. When it comes to managing the fruit-growing areas of my farm, I want to do what Government bodies (such as Defra or Natural England) recommend.

agree: 1 : 2 : 3 : 4 : 5 : 6 : 7 : disagree

24. Environmental organisations (such as the Wildlife Trusts or RSPB) think I should plant flowers as nectar and pollen sources for pollinating insects, in fruit-growing areas of my farm.

agree: 1 : 2 : 3 : 4 : 5 : 6 : 7 : disagree

25. When it comes to managing the fruit-growing areas of my farm, I want to do what environmental organisations (such as the Wildlife Trusts or RSPB) recommend.

agree: 1 : 2 : 3 : 4 : 5 : 6 : 7 : disagree

[Direct perceived norm scale: injunctive]

26. Most people whose opinions I value would approve of me planting flowers as nectar and pollen sources for pollinating insects, in fruit-growing areas of my farm.

agree: 1 : 2 : 3 : 4 : 5 : 6 : 7 : disagree

27. Most people who are important to me think I should plant flowers as nectar and pollen sources for pollinating insects, in fruit-growing areas of my farm.

agree: 1 : 2 : 3 : 4 : 5 : 6 : 7 : disagree

[Direct perceived norm scale: descriptive – belief strengths not measured]

28. Most fruit growers like me plant flowers as nectar and pollen sources for pollinating insects, in fruit-growing areas of their farms.

agree: 1 : 2 : 3 : 4 : 5 : 6 : 7 : disagree

[Perceived behavioural control]

29. To plant flowers as nectar and pollen sources for pollinating insects, in the fruit-growing areas of my farm, I need to have areas with the appropriate soil type.

agree: 1 : 2 : 3 : 4 : 5 : 6 : 7 : disagree

30. I have areas with appropriate soil for planting flowers as nectar and pollen sources for pollinating insects, in the fruit-growing areas of my farm.

true: 1 : 2 : 3 : 4 : 5 : 6 : 7 : false

31. Financial support, such as through agri-environment schemes, is needed to enable me to plant flowers as nectar and pollen sources for pollinating insects, in the fruit-growing areas of my farm.

agree: 1 : 2 : 3 : 4 : 5 : 6 : 7 : disagree

32. I receive financial support, such as through agri-environment schemes, for planting flowers as nectar and pollen sources for pollinating insects, in the fruit-growing areas of my farm.

true: 1 : 2 : 3 : 4 : 5 : 6 : 7 : false

33. I need good advice or guidance, to enable me to plant flowers as nectar and pollen sources for pollinating insects, in the fruit-growing areas of my farm.

agree: 1 : 2 : 3 : 4 : 5 : 6 : 7 : disagree

34. I receive good advice or guidance on how to plant flowers as nectar and pollen sources for pollinating insects, in the fruit-growing areas of my farm.

true: 1 : 2 : 3 : 4 : 5 : 6 : 7 : false

35. I need to buy an appropriate and affordable seed mix, to enable me to plant flowers as nectar and pollen sources for pollinating insects, in the fruit-growing areas of my farm.

agree: 1 : 2 : 3 : 4 : 5 : 6 : 7 : disagree

36. Appropriate and affordable seed mixes are available for planting flowers as nectar and pollen sources for pollinating insects, in the fruit-growing areas of my farm.

true: 1 : 2 : 3 : 4 : 5 : 6 : 7 : false

37. If patches or strips of flowers were easy to establish as nectar and pollen sources for pollinating insects, I would plant them in the fruit-growing areas of my farm.

true: 1 : 2 : 3 : 4 : 5 : 6 : 7 : false

38. Patches or strips of flowers, planted as nectar and pollen sources for pollinating insects, in the fruit-growing areas of my farm, are easy to establish.

agree: 1 : 2 : 3 : 4 : 5 : 6 : 7 : disagree

39. If patches or strips of flowers, planted as nectar and pollen sources for pollinating insects were quick and easy to manage, I would plant them in the fruit-growing areas of my farm.

agree: 1 : 2 : 3 : 4 : 5 : 6 : 7 : disagree

40. Patches or strips of flowers, planted as nectar and pollen sources for pollinating insects in the fruit-growing areas of my farm, are not easy to manage and take up a lot of time.

agree: 1 : 2 : 3 : 4 : 5 : 6 : 7 : disagree

[Direct perceived control]

41. If I wanted to, I could easily plant flowers as nectar and pollen sources for pollinating insects, in the fruit-growing areas of my farm.

true: 1 : 2 : 3 : 4 : 5 : 6 : 7 : false

42. Whether I plant flowers as nectar and pollen sources for pollinating insects, in the fruit-growing areas of my farm is completely up to me.

agree: 1 : 2 : 3 : 4 : 5 : 6 : 7 : disagree

43. I am confident that I can plant flowers as nectar and pollen sources for pollinating insects, in the fruit-growing areas of my farm.

true: 1 : 2 : 3 : 4 : 5 : 6 : 7 : false

[Behavioural intention]

44. I intend to plant flowers as nectar and pollen sources for pollinating insects, in fruit-growing areas of my farm, in the next 12 months

definitely not: 1 : 2 : 3 : 4 : 5 : 6 : 7 : definitely

45. I am willing to plant flowers as nectar and pollen sources for pollinating insects, in fruit-growing areas of my farm, in the next 12 months

true: 1 : 2 : 3 : 4 : 5 : 6 : 7 : false

46. I plan to plant flowers as nectar and pollen sources for pollinating insects, in fruit-growing areas of my farm, in the next 12 months

agree: 1 : 2 : 3 : 4 : 5 : 6 : 7 : disagree